Pasture-associated influence on the udder health of dairy herds in Northern Germany

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Abstract

The purpose of this investigation was to compare herd-level udder health regarding the extend of access to pasture and other management factors associated with pasturing and to determine pasture-associated risk factors. Data were provided by monthly dairy herd improvement test and collected over a period of 3 years and 4 months from 60 commercial dairy farms located in Lower Saxony, Germany. Farms were separated into 4 pasture groups depending on the extend of access to pasture of lactating cows. The proportion of udder-healthy animals of all lactating cows, the new infection rate of lactating cows and the heifer mastitis rate were derived from cow-level somatic cell counts and used as herd-level udder health indicators. Linear mixed models were applied. The udder health indicators were significantly associated with the time of year dry cows were given access to pasture indicating that dry cows should not be pasturing from October to March. Pasturing young livestock was beneficial if the animals were not younger than 3 months. The results of the research indicate that hygiene and management of dry cows and young livestock have a major influence on udder health of dairy cattle. The climatic and hygienic conditions during pasturing contribute to whether access to pasture has a positive or negative effect on the udder health.

Key words: production groups, heifers, calves, mastitis, new infection rate

Introduction

Mastitis is one of the major diseases in modern dairy herds. It has a significant impact on the economic success of a farm [8, 26] and is one of the most important causes for antibiotic treatment in adult dairy cattle [21, 23]. Management of the animals and arrangement of the environment that they are kept in largely influence the epidemiology in a herd and provide crucial starting points to improve udder health using a preventive approach [31].

In 2009 about 42% of all German dairy cows and about 69% of all dairy cows in Lower Saxony, Northern Germany, where nearly 19% of all German dairy cattle are kept, were given access to pasture [10]. Only little is known about the influence of pasturing on udder health and only few studies comparing pure indoor-housing to pasturing have been conducted.

In some former studies the effects of management and hygiene of pasture on udder health of dairy cattle were investigated [3, 12, 13, 19, 29]. Keeping herds on damp pasture and grazing under bad weather conditions increases the risk of a higher bulk milk somatic cell count [3]. The animals should also not be able to drink out of rivers or similar sources of water [3]. A stocking rate of <3.3 cows per hectare reduces the incidence rate of clinical mastitis [19]. It is recommended for grazing dry cows to execute pasture rotation, in which the animals are kept for two weeks on the same acreage and the land shall not be grazed for at least four weeks after [12, 13]. Regarding the udder health of heifers it was found that individual SCC was lower in the first dairy herd improvement test (DHIT) if the heifers calve on pasture, rather than if they were taken into the barn at the day of calving [29].

Research comparing farms that provide pasture with farms that keep their cows in stalls all the time leads to diverge results [1, 4, 5, 25, 28]. Tied-stalled herds with access to pasture were reported to have lower incidences of mastitis than herds that were kept year-round in tie-stalls, whereas non-grazing free-stalled herds had the same level of incidences as tied-stalled herds with access to pasture [4]. Positive effects on clinical mastitis (CM) could be shown for herds that were on pasture at night [1]. For heifers a lower rate of subclinical mastitis was detected when the lactating cattle grazed day and night [25]. In two studies no impact of pasturing on the bulk milk somatic cell count could be found [5, 28]. In contrast to these results conventional farms that practice year-round stabling had a lower incidence of CM than conventional farms with grazing in another investigation [22].

It seems to be crucial for the evaluation of pasturing, which udder pathogens predominate in the context of the respective investigation. As pasture-grazing reduces the risk of intramammary infection and inflammation by *Escherichia* (*E.*) *coli* [1, 6, 18], *Staphylococcus* (*S.*) *aureus* [9] and streptococci other than *Streptococcus* (*Sc.*) *uberis* [18], it increases the risk of those caused by *Sc. uberis* [6, 9, 18] and coagulase-negative staphylococci (CNS) [24].

This demands a differentiated consideration to compare and evaluate farming systems and it is also essential to identify specific risk factors

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for different housing systems in order to take adequate preventative measures in the future to improve udder health on dairy farms.
The aim of this study is to determine factors of pasture management, which are associated with the proportion of udder-healthy animals (UH), the rate of new intramammary infections in lactating cows (NIR) and the heifer mastitis rate (HMR) in Northern German dairy herds.

Material and Methods

Herd Selection:
60 dairy farms were selected in the context of a joint research project. This corresponds to about 0.45% of all dairy farms in Lower Saxony [10]. Selection criteria were that all farms were commercial farms from the Northern German region Lower Saxony and herd size was at least 60 dairy cows, in which mainly Holstein breed was represented. In addition, the animals should be kept in free-stalls with cubicles. Participation in dairy herd improvement testing was also a prerequisite.

Table 1: Farm-level pasture groups

Pasture group	1	2	3	4
Access to pasture per day	>10 hours*	6 to 10 hours*	<6 hours*	no access

*at least 120 days per year

Herd sizes were between 62 and 620 cows (arithmetic mean: 143.4; median: 116.5), the average milk yield on farm level ranged from 7,500 to 11,750 liters (arithmetic mean: 9437.4; median: 9500.0) per cow per year at the start of the study.
The farms were selected according to the extent to which the lactating cows had access to pasture and were assorted to one of four different groups of 15 farms each (Table 1). All farms remained in those groups throughout the experimental period.

Udder Health Data:
The udder health data have been calculated on farm-level using the individual somatic cell counts from monthly DHIT in the period from January 2012 to April 2015. For the percentage of udder-healthy animals the percentage of animals with ≤100,000 somatic cells per ml milk of all lactating animals was calculated. The new infection rate of lactating cows is derived from the percentage of lactating animals with >100,000 somatic cells per ml milk, that were ≤100,000 in the previous month. In heifers the proportion of those with >100,000 somatic cells per ml milk at the first test day could be determined as heifer mastitis rate. Those three parameters are defined for DHIT in Germany [7] and were provided monthly for each farm. From these monthly udder health data arithmetic means were calculated for the years 2012, 2013, 2014 and summer (May to October) as well as winter seasons (November to April) in 2012, 2013, 2014 and 2012/2013, 2013/14 and 2014/2015 respectively.

Farm Data:
Trained scientists using structured questionnaires collected additional farm-specific data regarding management of the farm and the animals during the investigation period. For this purpose, the farmers were interviewed once and the livestock facilities were examined at this opportunity. Pasture-associated information was taken to consideration for this particular study (Table 2).

Statistical Analysis:
Data was gathered and analysed using the programmes Excel, Access 2013 (Microsoft Corporation), and SPSS (IBM SPSS 24.0, Chicago USA).

Table 2: Farm-level pasture-associated variables considered in the univariate analysis of their associations with the proportion of udder-healthy cows of lactating cows, new infection rate of lactating cows and heifer mastitis rate of lactating heifers at first dairy herd improvement test

Animal group	Variable
Lactating cows	access to pasture (yes/no)
	access to pasture in winter (yes/no)
	time access to pasture per year (months)
	time access to pasture per day in March/April/May/June/Juli/August/September/October/November (hours)
	selection gates (yes/no)
	type of additional feed
	type of watering place
	consolidation material of livestock trails
Dry cows	access to pasture (yes/no)
	days of access to pasture during dry period
	start of the pasture-season (month)
	end of the pasture-season (month)
	duration of the pasture-season (months)
	requirements (weather, grass growth) for access to pasture
Young stock	age group first time access to pasture (heifers/young heifers/calves)
	heifers/young heifers/calves: access to pasture (yes/no)
	heifers/young heifers/calves: age first time access to pasture (months)
	heifers/young heifers: start of the pasture-season (month)
	heifers/young heifers: end of the pasture-season (month)
	heifers/young heifers: duration of the pasture-season (months)

The dairy herd in a year or in a season was the statistical unit. Year or season means of udder health key figures from DHI data (UH, NIR, HMR) were used as outcome variables. Explanatory variables were pasture associated management variables. First, all variables were assessed in univariate models, and all those with a P-value <0.10 in an F-test were offered to a multivariate model. Predictors showing a strong correlation with each other (r >0.7) had to be excluded from the model to avoid multicollinearity. For each dependent variable, the model with the lowest Akaike information criterion was chosen as the final model. After identifying a positive definite Hesse matrix, model assumptions of the final models were checked by plotting deviance residuals against fitted values. Estimates for ß with 95% confidence intervals (95% CI) were calculated. Statistical significance was assumed at p ≤0.05.

Results

Udder Health Data:
Based on the data collected during the period between January 2012 and April 2015 the udder health indicators varied very much between farms (Table 3).
The mean percentages of the proportion of udder-healthy cows during the experimental period of cows with an individual SCC ≤100.000 cells per ml ranged between herds from 38.8 to 83.0. The arithmetic mean and the median of all farms were 57.8 and 58.4%. The mean farm-level new infection rates of lactating cows were between 8.71 and 35.47%,

Table 3: Farm-level udder-health data per pasture group* (15 farms each) calculated from individual somatic cell counts from monthly DHIT in the period from January 2012 to April 2015

Udder health indicator	Pasture group	Minimum	Lower Quartile	Median	Upper Quartile	Maximum	Mean
Udder-healthy cows (UH) [%]	all	38.8	51.9	58.4	65.1	83.0	57.8
	1	38.8	52.7	55.8	63.7	72.8	57.8
	2	42.6	52.6	59.3	65.3	83.0	58.9
	3	39.6	45.7	57.0	66.2	74.8	55.7
	4	41.6	54.9	59.4	63.1	75.0	58.7
New infection rate (NIR) [%]	all	8.7	16.2	18.9	24.2	35.5	20.6
	1	12.9	15.8	18.3	23.4	29.1	20.0
	2	8.7	16.2	18.5	22.8	33.1	19.6
	3	12.2	17.1	19.0	28.0	35.5	22.0
	4	12.0	16.1	19.3	23.9	31.9	20.9
Heifer mastitis rate (HMR) [%]	all	10.9	21.5	27.6	32.9	48.2	27.5
	1	12.8	21.3	27.8	31.7	48.2	27.3
	2	10.9	21.1	27.3	31.1	37.4	25.8
	3	17.9	24.0	31.4	35.5	44.2	30.0
	4	13.1	21.2	26.9	31.3	38.5	26.3

* Pasture group 1 = >10 hours, pasture group 2 = 6 to 10 hours, pasture group 3 = <6 hours and pasture group 4 = 0 hours of access to pasture per day in at least 120 days per year
UH = percentage of animals with ≤100,000 somatic cells per ml milk of all lactating animals at dairy herd improvement test
NIR = percentage of lactating animals with >100,000 somatic cells per ml milk of all lactating animals at monthly dairy herd improvement test having had ≤100,000 somatic cells per ml milk at the previous dairy herd improvement test
HMR = percentage of heifers with >100,000 somatic cells per ml milk of all heifers at the first test of monthly dairy herd improvement test

arithmetic mean and the median of all herds 20.6 and 18.9%. Overall arithmetic mean and the median of the heifer mastitis rate were 27.4 and 27.5% with farms ranging from 10.9 to 48.2%.

Univariate analysis: Several pasture-associated factors were statistically associated ($p < 0.1$) with the dependent udder health variables in the univariate analysis (Table 4), although no factor was regularly significant in the different periods (years, summer- or winter-season) of the investigation.

In summary, the udder health indicators were associated with time and extend of access to pasture of different age and production groups of the animals. Furthermore, pasture management factors like the consolidation material of the livestock trails and access to additional feed for the lactating cows were associated. The results are shown in detail in Table 4.

Multivariate analysis:

If the end of the pasture-season was in November for dry cows, the proportion of udder-healthy cows was lower compared to farms whose dry cows were kept in stalls year-round. When calves (0 to <6 months of age) had access to pasture in the first three months, the UH was significantly lower compared to herds, in which access was either only given to calves older than three months or never. Also farms, whose livestock trails are consolidated with slatted floor or paving stones, had more udder-healthy cows than those with tared trails (Table 5).

In Summer 2012 the new infection rate of lactating cows was significantly higher than in other periods. If dry cows had access to pasture from March on, the NIR was higher than in herds with the dry cows having no access at all. But on the other hand NIR was lower, if they were on pasture the whole year or from May on. If the end of the pasture-season of dry cows was in October or November, more new infections in the lactating cows could be found than in herds, in which dry cows were kept in stalls the whole year. There was no difference between herds with no access to pasture for dry cows compared to herds with dry cows being kept on pasture the whole year or to herds with dry cows, whose pasture-season ended in September. The NIR was higher when young heifers (6 to <12 months of age) were never on pasture compared to young heifers on pasture at the age of 6 months (Table 6).

In pasture-groups 1 and 2 the heifer mastitis rate was significantly lower than in pasture-group 4. A pasture-season of six or seven months in heifers (≥12 months of age) resulted in a lower HMR compared to a length of at least eight months. If access to pasture in lactating cows was limited to less than six hours per day in October, six to less than twelve hours per day in October or if no access was given in October, the HMR was lower than in groups with access to pasture in October of at least twelve hours. Concrete and especially sand as consolidation materials resulted in higher HMRs than tar (Table 7).

Discussion

The aim of this study was to investigate the relationship of pasture-associated factors on the udder health of dairy cattle in Lower Saxony, Germany. This was the first investigation dealing with this matter in this particular region. The regional impact on the results has to be considered in the interpretation. The number of herds was limited by the study design of the joint research project and was low compared to the number of examined variables. Nevertheless, the collected data provide good evidence which factors may be relevant for the udder health under the given conditions in this region.

In this study, UH tended to be better in the winter than in the summer. The effect of season on udder health was shown in several studies [5, 11, 18, 27]. Bulk milk somatic cell count increased in summer and decreased in winter in organic and conventional herds in the United States [5], in herds in the United Kingdom [11] and was higher between July and October in Dutch dairy farms compared to the rest of the year [18]. In the same study the incidence of clinical mastitis caused by *Sc. uberis*

Table 4: Farm-level variables from the univariate analysis considered in the multivariate analysis of their associations with the proportion of udder-healthy cows of lactating cows, new infection rate of lactating cows and heifer mastitis rate of lactating heifers at first dairy herd improvement test and exhibiting a significant association ($p \leq 0.1$) in at least one period (year, summer season or winter season) of the investigation

Udder health indicator	Variable	Period with p ≤ 0.1*
Udder-healthy cows (UH)	end of the pasture-season of dry cows	2014 2013/2014W
	age first time access to pasture of young heifers	2013S
	age first time access to pasture of calves	2012 2012S
	consolidation material of livestock trails	2012 2012S
New infection rate (NIR)	time access to pasture per day in March of lactating cows	2013S
	time access to pasture per day in August of lactating cows	2013 2012/2013W
	start of the pasture-season of dry cows	2013/2014W
	end of the pasture-season of dry cows	2014 2014S 2013/2014W
	age first time access to pasture of young heifers	2013 2014 2013S 2014/2015W
	age first time access to pasture of calves	2012 2012S 2013/2014W
Heifer mastitis rate (HMR)	pasture group	2014S
	time access to pasture per day in March of lactating cows	2012/2013W
	time access to pasture per day in April of lactating cows	2012/2013W
	time access to pasture per day in May of lactating cows	2012S
	time access to pasture per day in August of lactating cows	2012S
	time access to pasture per day in September of lactating cows	2013
	time access to pasture per day in October of lactating cows	2012/2013W 2014/2015W
	time access to pasture per day in November of lactating cows	2013 2012/2013W
	type of additional feed	2012/2013W
	end of the pasture-season of dry cows	2014/2015W
	duration of the pasture-season of dry cows	2013/2014W
	age group first time access to pasture	2014 2014S
	duration of the pasture-season of heifers	2014S
	age first time access to pasture of young heifers	2013/2014W
	age first time access to pasture of calves	2012 2014/2015W
	consolidation material of livestock trails	2012 2013/2014W

UH = percentage of animals with ≤100,000 somatic cells per ml milk of all lactating animals at dairy herd improvement test
NIR = percentage of lactating animals with >100,000 somatic cells per ml milk of all lactating animals at monthly dairy herd improvement test having had ≤100,000 somatic cells per ml milk at the previous dairy herd improvement test
HMR = percentage of heifers with >100,000 somatic cells per ml milk of all heifers at the first test of monthly dairy herd improvement test
*year, summer season or winter season in which the respective factor was statistically associated ($p \leq 0.1$)
S = summer-season (May to October)
W = winter-season (November to April)

peaked in August, whereas clinical mastitis caused by other agents was highest in January and December. Another Dutch investigation showed that the incidence of clinical mastitis in heifers and multiparous cows was lower from April to September than October to March [27]. Vitali et al. [30] also showed that occurrence of clinical mastitis was highest in summer. Possible seasonal effects have to be kept in mind evaluating other risk factors.

Several pasture-season-associated effects were found in this analysis.

Table 5: Final multivariate analysis of the proportion of udder-healthy cows of all lactating cows*

	Coefficient	Standard error	t	p	Confidence interval 2.5%	Confidence interval 97.5%
Konstant Term	49.181	5.457	9.012	0.000	38.446	59.916
Season						
Summer	-3.720	1.978	-1.881	0.061	-7.611	0.170
Winter	0					
Period						
Summer 2012	2.368	1.903	1.244	0.214	-1.376	6.111
Winter 2012/13	-0.039	1.896	-0.021	0.984	-3.769	3.691
Summer 2013	0.775	1.984	0.391	0.696	-3.128	4.677
Winter 2013/14	-1.982	1.953	-1.015	0.311	-5.824	1.859
Summer 2014	0					
Winter 2014/15	0					
End of the pasture season of dry cows						
August	5.176	3.255	1.590	0.113	-1.227	11.578
September	0.506	2.116	0.239	0.811	-3.656	4.667
October	-2.166	1.576	-1.374	0.170	-5.267	0.935
November	-8.636	2.220	-3.891	0.000	-13.002	-4.270
All year	-3.581	3.773	-0.949	0.343	-11.003	3.841
Never	0					
Age first time access to pasture of young heifers						
6 months	2.466	1.718	1.435	0.152	-0.914	5.845
>6 months	-1.106	1.983	-0.558	0.577	-5.007	2.795
Never	0					
Age first time access to pasture of calves						
<3 months	0					
≥3 months	6.264	2.404	2.605	0.010	1.535	10.993
Never	5.558	2.029	2.739	0.006	1.567	9.550
Consolidation material of livestock trails						
Concrete	4.085	4.551	0.898	0.370	-4.867	13.038
Paving stones	9.511	4.705	2.021	0.044	0.256	18.766
Sand	-1.546	6.344	-0.244	0.808	-14.025	10.933
Slatted floor	11.960	5.895	2.029	0.043	0.365	23.556
Tar	0					

* percentage of animals with ≤100,000 somatic cells per ml milk of all lactating animals at dairy herd improvement test
young heifers = 6 to <12 months of age
calves = 0 to <6 months of age

The start of the pasture-season of dry cows had an influence on the NIR and the end of the pasture-season on NIR and the proportion of udder-healthy animals. Compared to herds without dry cows on pasture the NIR was higher, when the start of the pasture-season was in March and lower when it was in May. Herds with dry cows on pasture year-round also had a lower NIR. For the NIR ending access to pasture before October or keeping dry cows in stalls all year seemed to be better than keeping dry cows outside until October or November. The proportion of udder-healthy animals declined continuously with prolonging the pasture-season from August to November. The udder-health status was significantly worse if dry cows where kept outside on pasture until November in comparison to dry cows kept in confined areas the whole year. These results concerning dry cows differ from those of Green et al. [13], in which keeping dry cows only outside stalls on pasture was positively related to a lower SCC.

However, the length of the pasture-season of prepartum heifers seemed to be associated to HMR. A length of eight months or more meant that HMR was higher in these farms. The HMR was significantly lower when lactating cows were less than twelve hours per day on pasture in October compared to when they were more than twelve hours per day on pasture.

These effects of the extend of access to pasture of dry cows and young stock indicate that a prolonged pasture-season and pasturing in early spring or late autumn are risk factors for a worse health of the mammary gland, whereas access to pasture in the late spring and the summer-months can provide better udder health compared to pure indoor-housing. This may have to do with the weather conditions and the condition of the soil as well as other epidemiological reasons. Barnouin et al. [3] showed that non-damp pastures were related to very low somatic cell scores in French herds and that keeping cows in stalls

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Table 6: Final multivariate analysis of the new infection rate of lactating cows*

	Coefficient	Standard error	t	p	Confidence interval 2,5%	Confidence interval 97,5%
Konstant Term	18.775	2.791	6.728	0.000	13.285	24.264
Season						
Summer	1.828	1.116	1.638	0.102	-0.367	4.023
Winter	0					
Period						
Summer 2012	4.258	1.293	3.293	0.001	1.715	6.801
Winter 2012/13	-0.692	1.093	-0.633	0.527	-2.841	1.458
Summer 2013	-0.037	1.179	-0.032	0.975	-2.357	2.282
Winter 2013/14	0.895	1.127	0.794	0.428	-1.322	3.111
Summer 2014	0					
Winter 2014/15	0					
Time access to pasture per day in March of lactating cows						
0 hours	0.088	1.867	0.047	0.963	-3.584	3.760
>0 to 6 hours	0					
Time access to pasture per day in August of lactating cows						
0 hours	-0.311	1.591	-0.196	0.845	-3.442	2.819
>0 to 6 hours	-1.127	1.674	-0.673	0.501	-4.419	2.165
>6 to12 hours	2.013	1.233	1.633	0.104	-0.412	4.438
>12 hours	0					
Start of the pasture-season of dry cows						
March	8.124	3.472	2.340	0.020	1.294	14.954
April	-2.316	1.860	-1.245	0.214	-5.975	1.342
May	-4.281	1.573	-2.721	0.007	-7.376	-1.186
June	-3.875	2.413	-1.606	0.109	-8.621	0.871
July	-0.325	2.087	-0.156	0.876	-4.432	3.781
All year	-4.112	2.045	-2.011	0.045	-8.135	-0.090
Never	0					
End of the pasture-season of dry cows						
August	-1.730	2.611	-0.663	0.508	-6.866	3.405
September	0					
October	3.677	1.381	2.663	0.008	0.960	6.395
November	10.423	1.951	5.341	0.000	6.584	14.261
All year	0					
Never	0					
Age first time access to pasture of young heifers						
6 months	-4.686	1.210	-3.873	0.000	-7.066	-2.306
>6 months	1.091	1.541	0.708	0.480	-1.941	4.122
Never	0					
Age first time access to pasture of calves						
<3 months	0					
≥3 months	3.076	1.646	1.868	0.063	-0.163	6.315
Never	1.379	1.365	1.010	0.313	-1.306	4.064

*NIR = percentage of lactating animals with >100,000 somatic cells per ml milk of all lactating animals at monthly dairy herd improvement test having had ≤100,000 somatic cells per ml milk at the previous dairy herd improvement test
young heifers = 6 to <12 months of age
calves = 0 to <6 months of age

Table 7a: Final multivariate analysis of the heifer mastitis rate*

	Coefficient	Standard error	t	p	Confidence interval 2.5%	Confidence interval 97.5%
Konstant Term	46.580	13.378	3.482	0.001	20.262	72.899
Pasture group						
1	-15.619	5.100	-3.063	0.002	-25.652	-5.585
2	-12.457	4.822	-2.584	0.010	-21.943	-2.972
3	0.060	3.978	0.015	0.988	-7.767	7.886
4	0					
Time access to pasture per day in October of lactating cows						
0 hours	-14.639	4.585	-3.193	0.002	-23.658	-5.619
>0 to 6 hours	-20.377	5.365	-3.798	0.000	-30.932	-9.822
>6 to 12 hours	-8.941	3.657	-2.445	0.015	-16.136	-1.746
>12 hours	0					
Time access to pasture per day in November of lactating cows						
0 hours	1.353	3.960	0.342	0.733	-6.438	9.145
>0 hours	0					
End of the pasture-season of dry cows						
August	-11.405	8.510	-1.340	0.181	-28.147	5.337
September	2.573	6.568	0.392	0.695	-10.348	15.495
October	3.184	5.787	0.550	0.583	-8.201	14.569
November	-7.010	6.395	-1.096	0.274	-19.591	5.572
All year	0					
Never	0					
Duration of the pasture-season of dry cows						
0 months	-8.916	5.396	-1.652	0.099	-19.532	1.700
>0 to <6 months	-7.454	4.730	-1.576	0.116	-16.759	1.850
6 months	-6.385	4.690	-1.361	0.174	-15.612	2.842
>6 months	0					
Duration of the pasture-season of heifers						
0	-9.786	4.999	-1.958	0.051	-19.619	0.048
>0 to <6 months	-5.029	3.818	-1.317	0.189	-12.541	2.483
6 months	-8.112	2.833	-2.863	0.004	-13.685	-2.538
7 months	-14.975	4.202	-3.564	0.000	-23.241	-6.709
≥8 months	0					
Age first time access to pasture of young heifers						
6 months	-2.371	5.277	-0.449	0.654	-12.751	8.010
>6 months	-0.166	5.194	-0.032	0.975	-10.384	10.052
Never	0					

* HMR = percentage of heifers with >100,000 somatic cells per ml milk of all heifers at the first test of monthly dairy herd improvement test
Pasture group 1 = >10 hours, pasture group 2 = 6 to 10 hours, pasture group 3 = <6 hours and pasture group 4 = 0 hours of access to pasture per day in at least 120 days per year
heifers = 12 months of age to calving
young heifers = 6 to <12 months of age
calves = 0 to <6 months of age

during bad weather was positive, too. Multiple studies showed that access to pasture increases the risk of intramammary infection with *Sc. uberis* [6, 9, 18]. Especially in the winter-season the cows seem to be exposed to *Sc. uberis* on pasture in high traffic areas [17]. On the other hand, *E. coli* seems to be more stall-associated and providing pasture can reduce the infection pressure of this and other pathogens such as *S. aureus* or streptococci other than *Sc. uberis* [1, 6, 9, 18]. In summer *E. coli* counts rise in bedding material and may lead to an elevated risk of intramammary infection [14].

Another hygiene-related factor is the confinement-material of livestock trails. The differences of the materials are hard to interpret. Maybe the data lack of power in this case and should not be overrated. It can be

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Table 7b: Final multivariate analysis of the heifer mastitis rate*

	Coefficient	Standard error	t	p	Confidence interval 2,5%	Confidence interval 97,5%
Age first time access to pasture of calves						
<3 months	0					
≥3 months	3.420	4.281	0.799	0.425	-5.003	11.842
Never	3.225	6.991	0.461	0.645	-10.528	16.977
Age group first time access to pasture						
Calve	0					
Young heifer	-1.712	7.022	-0.244	0.808	-15.527	12.103
Heifer	-5.228	4.310	-1.213	0.226	-13.707	3.251
Pregnant	0					
Never	0					
Consolidation material of livestock trails						
Concrete	17.703	8.640	2.049	0.041	0.705	34.701
Paving stones	14.350	8.150	1.761	0.079	-1.685	30.384
Sand	32.653	11.330	2.882	0.004	10.363	54.943
Slatted floor	-1.726	9.813	-0.176	0.861	-21.032	17.581
Tar	0					

* HMR = percentage of heifers with >100,000 somatic cells per ml milk of all heifers at the first test of monthly dairy herd improvement test
Pasture group 1 = >10 hours, pasture group 2 = 6 to 10 hours, pasture group 3 = <6 hours and pasture group 4 = 0 hours of access to pasture per day in at least 120 days per year
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assumed that a consolidation of trails is beneficial for udder health if it improves the cleanliness of the traffic area. Many studies show that this can provide improved udder health [2, 3, 15, 20, 32].

Results from Canada could not show an association between pasture access and udder health [16]. In this study the pasture-group also seemed to be no very important factor. Only for HMR a significant effect of pasture-group was found, indicating that access to pasture in a larger extend was beneficial. This accords with a Dutch investigation in which pasturing day and night lowered the incidence of subclinical mastitis in heifers in the first 100 days of lactation [25]. This may be due to a lower infection pressure outside than inside. However, correlations in this matter need further investigation.

Management practices of young livestock showed some associations with udder-health parameters. The proportion of udder-healthy animals was higher in herds without giving calves younger than three months access to pasture. Access to pasture from three months of age was not disadvantageous. Optimizing the rearing period and the management of young dairy cattle may lead to a better udder-health of the adult livestock. This could be an approach of improving udder health in the future.

Conclusions

Whether pasturing has positive or negative effects on the udder health of dairy cattle must be estimated in a differentiated manner. In particular, the given climatic conditions seem to play a crucial role in whether pasture access has a positive or negative impact on udder health.

Independently of that and of the extent of access to pasture given to the animals, the results of this study indicate that hygiene-associated factors have a major impact on herd-level udder health. Optimizing husbandry management especially regarding environmental hygiene not only for lactating cows but also for dry cows and young livestock can be a purposeful tool for the improvement of the udder health of a herd. The results of this research suggest granting dry cows access to pasture at the earliest from April until the end of September and not to give calves younger than 3 months of age access to pasture.

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