RESEARCH ARTICLE

Welfare of dairy cattle in summer and winter – a comparison of organic and conventional herds in a farm network in Germany

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HIGHLIGHTS

- **On average, dairy cows on organic farms showed a better welfare status in the Welfare Quality® principles 'Good Housing', 'Good Health' and 'Appropriate Behaviour'.**
- **Pasturing, high space allowance and littering might be crucial for high animal welfare levels.**

KEYWORDS **dairy cows, animal welfare, farming system, Welfare Quality®**

Abstract

Dairy cow welfare in 19 organic and 15 conventional farms in distinct soil climate regions of Germany was examined using the Welfare Quality® assessment protocol for dairy cattle (WQ®). In comparison to other studies, this one is outstanding in that (a) the WQ® protocol was carried out twice per farm (in the winter period 2014/2015 and in the following summer period) and that (b) some parameters were measured directly on pasture, if pasture access was provided on the farm during the summer period. At the level of WQ® principles, significantly lower scores (Mann-Whitney U test, $P<0.05$) were found in the summer period for 'Good Feeding' (more very lean cows and insufficient water provision). Higher scores for 'Good Housing' (reduced duration of lying down movements and more cleanliness of cows) were recorded in summer compared to the winter period. Furthermore, significantly higher mean scores were found in organic herds at the level of the WQ® principles in 'Good Housing' (in summer period), 'Good Health' and 'Appropriate Behaviour' (in both periods). For the underlying criteria and measures, the organic farms had, on average, higher scores for resting comfort (lying behaviour, not parameters of cleanliness) especially in summer, fewer lame animals (in both periods) and fewer animals with ocular discharge (especially in the summer period). Also, the better scores for 'Absence of pain induced by management procedures' which are related to disbudding of calves and the respective pain management on the farms influenced this result. Additionally, less agonistic behaviour (number of head butts) and a lower avoidance distance (in terms of more 'cows that can be touched') were observed in organic farms in both periods. The ranges of all values and scores of WQ® assessment were broad in both periods and farming systems. Generally, the results show that the impact of management factors individual to farms on animal welfare is high.

1 Introduction

Animal welfare is understood as a multidimensional concept with three superordinate dimensions: i) basic health and function, ii) natural living, and iii) affective states (Fraser, 2008). Although the importance attributed to each of the three dimensions of animal welfare is controversial, it is widely accepted that all of them should be considered for a comprehensive assessment of animal welfare (BMEL, 2017).

Especially in recent years, animal welfare has gained much attention from the general public in debates about sustainable livestock farming, including in Germany. Animal welfare, including that of dairy cows, is a high priority in organic farming, as explicitly stated in the organic standards of the European Union (Commission Regulation (EC) No 889/2008 and Regulation (EU) 2018/848). For example, the stocking density in buildings should provide for the comfort, the well-being, and the species-specific behavioural needs of the animals, and animal-health management should focus mainly on disease prevention. Hence, several conditions are set

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in organic farming to support a high standard of dairy cow welfare. The question, however, arises whether dairy cow welfare is better on organic farms compared to conventional farms in practice. So far, published studies investigating the effect of the farming system on this topic have mostly focused on particular aspects of welfare, such as lameness (Weller and Cooper, 1996; Rutherford et al., 2009; Barker et al., 2010). Studies involving a comprehensive assessment of overall dairy cow welfare on organic and conventional farms are very rare in the literature. One exception is from March et al. (2017), who assessed dairy cow welfare using the Welfare Quality® assessment protocol for dairy cattle (WQ®, 2009) on 46 organic farms and on 69 conventional farms in two federal states. They conducted this only during the winter period (i.e. indoor housing period) and in two federal states of Germany (North Rhine-Westphalia and Mecklenburg-Western Pomerania). The authors concluded that organic farming can have higher standards of dairy cow welfare since organic farms achieved better scores in all of the four WQ® principles (i.e. 'Good Feeding', 'Good Housing', 'Good Health', and 'Appropriate Behaviour').

In organic farming, it is mandatory to provide cattle access to pasture whenever the conditions allow this, i.e. at least during the summer period. Zero-grazing is allowed only with the extra permission of local control bodies. In a recent study of major farm types, 95 % of organic dairy farms in Germany offered pasture access for 11.9 (±6.8) hours per day on average (Ivemeyer et al., 2018). However, in conventional farming, pasture access for dairy cows is not mandatory and thus determined mainly by regional and organisational preferences. According to official census data of 2010, 42 % of all German dairy cows (organic farms included) had access to pasture (Statistisches Bundesamt, 2011). 50 % of herds between 50 and 99 cows had pasture access compared to only 30 % of herds with more than 100 cows (Lindena et al., 2017). Several reviews have highlighted potential beneficial effects of pasture on behaviour (e.g. facilitation of natural behaviour) and improved performance (Smid et al., 2020), but smaller milk yield and better health (with lower levels of lameness, hoof pathologies, hock lesions, mastitis, uterine disease, and mortality (e.g. Arnott et al., 2017). Furthermore, Armbrecht et al. (2019) showed that dairy herds with high daily pasture access were scored higher in 'comfort around resting' and 'absence of injuries' compared to farms without pasture access or with only a few hours of daily pasture access when assessed using the WQ® protocol directly after the end of the grazing season. These effects were not maintained over the winter housing period. Therefore, pasture access is a major factor in determining differences between organic and conventional farms in the outcome of WQ® assessment in behaviour and health parameters especially in the summer period.

The WQ® protocol prescribes that the assessment of the animals and of equipment is to be performed in the housed environment (called 'in the barn' in the following text) to depict the general situation under comparable conditions. However, we were also interested in a comparison of farms with and without pasture access in the actual environment of cows in the summer period. At least in most organic farms this environment is an important part of the cows' lives. To be able to show possible differences, we modified the WQ® procedure in summer: We expected the indicators 'lying behaviour', 'water provision', 'social behaviour', and 'qualitative behaviour assessment' to be different on pasture compared to the barn environment. Hence, we assessed these indicators on pasture, if offered on the farm, instead of in the barn.

The hypotheses of our study were that (1) dairy cow welfare is especially enhanced in the summer period where many farms provide pasture access, and (2) a higher level of dairy cow welfare is achieved in the organic farms compared to conventional farms in both winter and summer due to the standards of organic farming which were designed to support animal welfare.

2 Materials and methods

This study was carried out within the framework of the project entitled 'Increasing Resource Efficiency by Optimizing Crop and Milk Production on Whole Farm Level under Consideration of Animal Welfare Quality Aspects' (www.pilotbetriebe.de). This project developed from another project that ran between 2008 and 2014 and dealt with greenhouse gas emissions in agricultural systems. A total number of 80 farms in various climatic and soil regions in Germany (Bavarian Tertiary Hill Country and Allgaeu, the North Sea and Baltic Sea coastal areas, the Rhine basin, the Westphalian basin and low mountain areas, and the East German inland area) were analysed. 44 of the farms were dairy farms. These regions correspond with the typical structure and management on German dairy farms, as for example, described by Ivemeyer et al. (2018) for the organic sector, Lindena et al. (2017), and DLQ (2017). These authors characterise the dairy farms in the regions as follows: South Germany with high farm numbers, small herds, low milk yield and, in conventional farms, low pasturage; West Germany with medium to low farm numbers, medium herd size, high milk yield and, in conventional farms, frequent pasturage; North Germany with medium farm numbers, medium to large herds, high milk yields and, in conventional farms, frequent pasturage; and East Germany with low farm numbers, large herds, high milk yield and, in conventional farms, low pasturage.

In addition to representing regional aspects, selected farms were run full-time, each was twinned with a comparative farm (organic paired with conventional; however, since 2008, some twins stopped participating in the farm network, e.g. because of stopping farming altogether), and each passed a test for data availability and willingness to cooperate in the longer term. In addition, all organic farms had to have practiced organic farming for at least seven years before the start of the farm network to avoid interference from the effects of conversion. According to the expert knowledge of the project group and in comparison with agro-structural data, the farms represented typical organic and conventional management in German dairy and arable production. The main characteristics of the farms are presented in *Table 1*.

TABLE 1
Main characteristics of the analysed farm sample

Region	Organic farms				Conventional farms			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
South:	5	5883	34	4 (10)	5	7626	52	0 (0)
West:	6	7185	91	2 (8)	4	9074	134	3 (7)
North:	4	6559	68	4 (13)	3	8712	148	2 (8)
East:	3	6248	85	2 (6)	4	9375	501	0 (0)

(1) numbers of farms in the sample [n]; (2) average milk yield [kg cow^{-1} year^{-1}]; (3) herd size [n]; (4) number of farms with pasturage [n] and, in brackets, hours per day with pasture access on these farms in the summer period [h day^{-1}]

In this paper, dairy cow welfare based on the WQ® protocol (2009) was analysed for the 34 (19 organic, 15 conventional farms) of the farms that were still in the network and offered loose housing systems.

We also assessed the resting environment and lying conditions (i.e. type of lying area, litter, lying surface and softness of bedding) in the winter period. Softness was determined by the knee test (according to McFarland and Graves (1995), with the scale (1=hard, 2=medium/intermediate, 3=soft) on five randomly chosen places in the lying areas. This information together with details of the disbudding procedures in the dairy farms are presented in the results section to allow a deeper discussion on the possible role of these factors for the outcome of WQ® assessment. The data on milk yield per cow and year were generated from data from the milk recording scheme (MLP) or from farm records.

The farms were neither randomly selected from all farms in Germany nor within the regions. The results of this study therefore cannot be regarded as representing Germany or its regions. But they can be used to draw attention to and explain differences in the results of dairy cow welfare assessment between summer and winter in typical German farming situations and to discuss the effects of general management in organic and conventional farming systems on dairy cow welfare.

2.1 Assessment of animal welfare

Assessment of dairy cow welfare was done by applying the WQ® protocol (2009). It is based mainly on animal-related measures (i.e. measures that are taken directly from the animal). It uses a 'bottom-up' approach (*Table 2*). About 30 indicators (so-called measures) were assessed on a representative number of animals. The results were aggregated to define a score value for 12 criteria, which in turn were aggregated into scores for four principles (*Table 2*). The 'overall welfare score' is not presented in this study because it does not add information needed for dealing with our hypotheses.

At the levels of criteria and principles in the WQ® protocol, a value of 0 corresponds to the worst and a value of 100 to the best of all possible values.

TABLE 2
Principles, criteria, and measures (indicators) of the Welfare Quality® assessment protocol for dairy cattle (2009)

Principles	Criteria	Measures
Good Feeding	1. Absence of prolonged hunger	Body condition score
	2. Absence of prolonged thirst	Water provision, cleanliness of water points, water flow, functioning of water points
Good Housing	3. Comfort around resting	Time needed to lie down, animals colliding with housing equipment during lying down, animals lying partly or completely outside the lying area, cleanliness of udders, flank/upper legs, and lower legs
	4. Thermal comfort	*As yet, no measure is developed*
	5. Ease of movement	Presence of tethering, access to outdoor loafing area or pasture
Good Health	6. Absence of injuries	Lameness, integument alterations
	7. Absence of disease	Coughing, nasal discharge, ocular discharge, hampered respiration, diarrhoea, vulvar discharge, milk somatic cell count, mortality, dystocia, downer cows
	8. Absence of pain induced by management procedures	Disbudding/dehorning, tail docking
Appropriate Behaviour	9. Expression of social behaviours	Agonistic behaviours (assessed by observation of head butts and displacements)
	10. Expression of other behaviours	Access to pasture
	11. Good human-animal relationship	Avoidance distance
	12. Positive emotional state	Qualitative behaviour assessment (assessed by observation of cows' 'body language')

As yet, no measure is developed to assess the criterion 'Thermal comfort', and the missing criterion-score is currently replaced by the best score among the criteria 'Comfort around resting' and 'Ease of movement' (WQ®, 2009). The criterion 'Ease of movement' has five classes according to different housing systems, with possible scores between 0 (continuously tied) and 100 (loose housing). In this study all farms provided loose housing systems and therefore had a score of 100. Thus all farms got a value of 100 in 'Thermal comfort'. Therefore the values are not further discussed or listed in the following.

The whole WQ® assessment procedure set out in the protocol was conducted twice on each farm: once during winter 2014/2015 and once during summer 2015. In accordance with the instructions, animal-related assessments were carried out at each farm in a fixed order and, except for the assessment of behavioural measures, a sample of cows was chosen at random. Number of cows chosen depended on the herd size.

Indicators relating to disease were generated from MLP data and the German central data base on identification and information on animals as well as from farmer interviews and some animal-related measures. As defined by WQ®, cows with milk somatic cell counts equal or above 400,000 were counted as cows with mastitis. The data on the parameters '% of dystocia' and '% of downer cows' as well as information regarding management routines (e.g. disbudding of calves and access to pasture) were gathered during farmer interviews.

During the winter survey, all other WQ® data were collected in the barn. During the summer survey, water supply, lying behaviour, social behaviour, and qualitative behaviour assessment (QBA; defined by 20 terms of body language) were recorded on pasture where pasture was provided on the farm. As mentioned in the introduction, this assessment procedure differs from the guidelines given in the WQ® protocol. Assessing these measures on pasture might be a double counting of advantages in the WQ® principle 'Appropriate Behaviour' because pasturing is already included in the criterion 'Expression of other behaviour' (*Table 2*). However, especially measures determining the 'Comfort around resting' were expected to be different in the barn compared to the outdoor situation on pasture and also influence parameters such as lameness and cleanliness which is supposed to other welfare principles such as 'Good Health'. As we were interested in comparing differences between dairy management systems, we decided to diverge from the WQ® protocol in these points. However, all other data of the WQ® protocol (e.g. assessment of avoidance distance) in the summer period were collected in the barn.

Thus, only the results of our assessment in the winter period are comparable to other studies following the WQ® protocol.

Three different assessors collected data. They were experienced in evaluating dairy cattle before and were trained intensively by a qualified person with many years of experience in the methodology of the WQ® protocol for dairy cattle. Multiday training courses consisted of theoretical exercises with photographs and videos as well as practical exercises on different dairy cattle farms. Inter-observer reliability testing took place after each of the training courses before data survey in the summer and winter period. To estimate inter-observer reliability in the this study, prevalence-adjusted bias-adjusted kappa (PABAK) values were calculated for all animal-related measures (e.g. scoring of body condition) based on observation of 20 animals in two practical farms with > 70 dairy cows. The PABAK values averaged 0.5 to 0.9 and, thus, indicated an adequate to very good alignment (Fleiss et al., 2003; Dippel et al., 2009) between all assessors for all animal-related measures. Regarding the assessment of lying behaviour and of social behaviour on the basis of video material, inter-observer reliability, measured as Pearson correlation coefficient, ranged from 0.4 to 0.7 and from 0.4 to 0.8 (arithmetic mean of 0.6 for both), respectively.

2.2 Statistical analysis

Statistical analyses were conducted using the software JMP® 15.0.0 (SAS Institute Inc., Cary, NC, USA). All parameters of animal welfare were evaluated at herd level. To avoid merging the results gained with the different assessment technique by diverging from the standards of the WQ® protocol in the summer period, we did not analyse and compare mean values of results for the organic and conventional farming systems over both periods.

Normal distribution of data was analysed by the Anderson-Darling test and visual analysis of QQ-Plots. Data on milk yields per year in organic and conventional farms were normally distributed. When looking at the data distribution in all groups of interest (groups are: all farms, organic farms, conventional farms in summer or winter, see groups in *Table 3*), normal distribution was only given in 42 % of cases for the different measures, in 45 % of cases for the different criteria and in 62 % of cases for the different principles. We were not able to reduce the error of the residues with any type of data transformation within the different groups when comparing to normal distribution in most of the cases, therefore the original data were used for the analyses.

Mann-Whitney U tests were conducted throughout for one-factorial comparisons of means of WQ® data obtained in the two periods of the year: for all farms and for the two farming systems (i.e. organic and conventional). Categorical data we gained for the types of the resting environment (lying area, litter, lying surface and its softness) and for procedures used for disbudding of calves were analysed with contingency tables and Chi^2-tests. The Fishers exact test was used in the latter parameters when the observation numbers were low in the groups (Everitt, 1992). Effects of the farm type on the number of lactating cows kept in the farms and farming systems and in both periods were analysed with one factorial analysis of variance (F-test). Here and for differences between the average milk yields or the number of days on pasture between the periods, or farming systems in the periods, group means were compared by the Tukey test. Significance of group differences was declared at $P<0.05$ for all comparisons mentioned above. Pearson correlation coefficients between average milk yields per cow on the farms and the results in scores on 'Welfare Principles' were calculated. To visualise trends and data distributions, scattergrams with density ellipses are given.

3 Results

In the milk record year October 2014 to September 2015, the mean milk yield per cow and year was 6,513 kg for organic farms and 8,579 kg for conventional farms. The mean herd size was 125 and 115 cows at the time of the winter and the summer survey, respectively. 17 of the organic farms and only six of the conventional farms provided access to pasture. The average number of days with pasture access was 136.5 on organic and 71.5 on conventional farms. There were significant differences between all the means for the organic and conventional farming systems (*Table 3*).

The lactating cows were mostly kept in cubicle barns (13 organic and 13 conventional farms) or had free deep litter lying areas (6 organic and 2 conventional farms). Deep litter bedded cubicles were more frequent on organic farms (11 organic and 4 conventional farms). Rubber and comfort mattresses were more frequent on conventional farms (1 organic farm and 8 conventional farms). The other farms offered littered concrete lying surfaces (5 organic farms and 2 conventional farms) (*Table 4*). The softness of the lying surface was best on straw deep litter beds (in free lying areas or cubicles). The softness of straw deep litter beds (in free lying areas or cubicles) was predominantly categorised as soft, and in some cases as medium. Straw deep litter beds were found on 13 organic (68 % of farms) and 5 conventional (33 %) farms. Soft and medium soft surfaces in the lying areas were significantly more frequent in organic farms (*Table 4*).

Table 5 shows data on the practice of disbudding found in the winter and summer period and the farming systems.

TABLE 3

Comparison of average milk yields, days with pasture access and number of cows in the analysed farming systems and periods (means and extreme values; Tukey test)

Period:	Winter	Summer	P-value	Winter		P-value	Summer		P-value
Farm Type:	All farms (n = 34)			Organic (n = 19)	Conventional (n = 15)		Organic (n = 19)	Conventional (n = 15)	
Number of lactating cows	125 (24–661)	115 (16–726)	0.736	65 (16–200)	178 (35–726)	**0.044**	74 (24–230)	189 (39–661)	**0.032**
Milk yield per cow kg	7425 (4303–10947)			**Both periods:** Organic: 6514 (4303–9257) Conventional: 8579 (5887–10947)					**<0.001**
Number of days on pasture per year	136.5 (0–290)			**Both periods:** Organic: 187.8 (0–290) Conventional: 71.5 (0–230)					**<0.001**

TABLE 4

Data scores for resting environment and lying conditions for dairy cows found in the analysed farming systems in the winter period (contingency table analysis, Chi^2-test or Fishers exact test)

	Housing		P-value	Softness, knee test			P-value
	Organic	Conventional		hard	medium	soft	
Lying area			**0.007**				**0.046**
Free	6	2		0	1	7	
Cubicle high	2	9		5	4	2	
Cubicle deep litter bed	11	4		3	4	8	
Litter			**0.014**				0.726
No	0	4[+]		1	2	1	
Straw short	8	7		4	4	7	
Straw long	11	4		3	3	9	
Lying surface			**0.013**				**0.012**
Concrete (with straw litter)	5	2		4	2	1	
Rubber (most with straw litter)	1	8[*]		4	3	2	
Straw deep litter bed, free lying area	6	2		0	1	7	
Straw deep litter bed, cubicle	7	3		0	3	7	
Softness, knee test			**0.039**				
hard	2	6					
medium	4	5					
soft	13	4					

[+] rubber mattresses; [*] including one farm with comfort rubber mattresses

Disbudding of calves was the only horn reduction practice used. Dehorning of cows or tail docking were not reported in the interviews with the farmers. 100 % of cows on the conventional farms had been disbudded as calves whereas in the mean of organic farms only 21 or 24 % of calves (winter and summer period) had undergone this procedure (P<0.001). 13 organic farms (68 % of farms) used no disbudding of calves and had horned herds. Lots of farm managers reported that that they are increasingly introducing genetically polled (hornless) types into their dairy herds through breeding. Thermocautery was the main disbudding practice used on the farms. Use of anaesthetics, analgesics or both was much more frequent in organic farms. This practice increased in both farming systems in the summer survey.

The mean scores over all farms differed significantly in the WQ® principles 'Good Feeding' and 'Good Housing' between winter and summer (P=0.005 and P=0.034, *Table 6*). There were no significant differences between the periods for the criterion 'Absence of prolonged hunger' or for the parameter 'Percentage of very lean cows' (*Table 7*). But there were significant differences in the criterion 'Absence of prolonged thirst' with a significant lower average score apparent in the summer compared to the winter period (*Table 6*). Although means for all above mentioned parameters were higher in organic herds compared to the conventional herds in both periods, differences in means between organic and conventional farms are not significant (P>0.05, *Table 6* and *Table 7*).

The inclusion of data for 'Thermal Comfort' and 'Ease of movement' (as described above, the scores were similar in all farms) into the calculation of the scores for 'Good Housing' resulted in significant higher values over all farms in the summer period (P=0.005). This is due to differences in the data relevant to the criterion 'Comfort around resting' (*Table 7*). In the summer period the mean 'Duration of lying down movements' of cows was significantly shorter (P<0.001) and the mean 'Percentage of cows with dirty flank/upper legs' was significantly lower (P=0.002) than in the winter period. Similarly, the scores for the WQ® principle 'Good housing' and the underlying criterion 'Comfort around resting' were significantly higher on the organic farms in the summer period (P=0.017), but not in the winter period (P=0.377, *Table 6*). In summer the mean values of 'Percentage of cows colliding with housing equipment' (P=0.003) and the 'Number of cows lying outside the lying areas' (P=0.038) were significantly reduced in the mean of the organic farms compared to the conventional farms (*Table 7*).

Also, lower mean values for 'Duration of lying down movements' (P=0.036) and 'Collisions with housing equipment' (not significant) were apparent on the organic farms in winter, whereas means for the measures 'Cows lying outside the lying area' and for some parameters of 'Cleanliness' were partly but not significantly higher in this farming system (*Table 7*).

In contrast to the latter two WQ® principles, we found no significant differences between the average scores of the principle 'Good Health' and its underlying criteria over all farms between summer and winter period (*Table 6*).

However, 'Good Health' was found to be significantly enhanced in the mean of organic herds in comparison to the conventional herds in both separate periods (*Table 6*). At the level of criteria that are determining 'Good Health' (i.e. 'Absence of injuries', Absence of disease' and 'Absence of pain induced by management procedures'), all mean scores were higher on organic farms in both periods. But the differences in means were only significant for the 'Absence of pain induced by management procedures' (P<0.001, *Table 6*). Concerning the measures influencing 'Good Health' (*Table 8*), the 'Percentage of cows with at least one hairless patch but no lesion' was found to be increased in winter (P=0.008). On the other hand, 'Ocular discharge' (P=0.009) and 'Diarrhoea' (P=0.005) occurred more frequently in summer.

TABLE 5

Data on the practice of disbudding of calves and the methods of pain relief used in winter and the following summer period on the analysed organic and conventional dairy farms (Mann-Whitney U test, contingency table analysis, Chi^2-test, Fishers exact test)

Period:	Winter	Summer	P-value	Winter			Summer		P-value
Farm Type:	All farms (n = 34)			Organic (n = 19)	Conventional (n = 15)	P-value	Organic (n = 19)	Conventional (n = 15)	
Disbudded cows in herd (%)	54.4 (0–100)	57.5 (0–100)	0.8	21.1 (0–100)	96.7 (50–100)	**<0.001**	24.0 (0–100)	100 (100–100)	**<0.001**
Number of farms not disbudding calves and if, method used:			1.000			**<0.001**			**<0.001**
No disbudding	13	13		13	0		13	0	
Thermocautery calves	20	20		6	14		6	14	
Caustic paste calves	1	1		0	1		0	1	
Number of farms with the use of: Anaesthetics	6	17	**0.002**	5	1	**0.002**	6	11	0.281
Analgesics	8	16	**0.028**	5	3	**0.014**	6	10	0.262
Both	4	15	**0.002**	4	0	**0.003**	6	9	0.123

TABLE 6
Scores (mean (min–max)) for the four Welfare Quality® principles with the underlying twelve criteria in winter and summer period on all farms and comparison of the scores on organic and conventional farms (Mann-Whitney U test, n: 19 organic farms, 15 conventional farms)

Periods:	Winter	Summer	P-value	Winter		P-value	Summer		P-value
Farm Type:	All farms			Organic	Conventional		Organic	Conventional	
Good Feeding	46.5 (5.9–99.9)	33.50 (6.3–99.9)	**0.034**	51.7 (11–99.9)	39.8 (5.9–99.9)	0.298	36.2 (6.6–99.9)	30 (6.3–99.9)	0.282
1. Absence of prolonged hunger	70.2 (23.4–99.9)	65.7 (30.9–99.9)	0.479	73.2 (30.9–99.9)	66.4 (27.3–99.9)	0.384	68.7 (33.1–99.9)	61.9 (30.9–99.9)	0.273
2. Absence of prolonged thirst	50.6 (3.0–100)	32.9 (3.0–100)	**0.041**	58.1 (3.0–100)	41 (3.0–100)	0.216	36.4 (3.0–100)	28.5 (3.0–100)	0.57
Good Housing	61.6 (42.4–72.1)	67.9 (37–86.3)	**0.005**	63.1 (42.4–70.9)	59.7 (42.4–72.1)	0.377	72.7 (47.3–86.2)	61.8 (37–86.3)	**0.017**
3. Comfort around resting	39.1 (8.6–55.7)	49.1 (0–78.2)	**0.005**	41.5 (8.6–53.8)	36 (8.6–55.7)	0.377	56.7 (16.4–78.2)	39.4 (0–78.2)	**0.017**
Good Health	44.1 (27.6–70.6)	48.4 (27.6–83.9)	0.098	49.3 (35.9–70.6)	37.6 (27.6–51.7)	**<0.001**	52.3 (33.2–83.9)	43.5 (27.6–59.5)	**0.043**
6. Absence of injuries	65.5 (28.6–90.3)	67.1 (29.8–98.1)	0.816	68 (45.4–84.4)	62.3 (28.6–90.3)	0.218	71.6 (54.7–95.2)	61.4 (29.8–98.1)	0.08
7. Absence of disease	40.6 (22.2–64.6)	41.9 (17.8–86.0)	0.716	40 (22.3–64.6)	41.3 (27.4–64.6)	0.780	43.9 (17.8–86.0)	39.4 (20–56.6)	0.561
8. Absence of pain induced by management procedures	64.7 (20.0–100)	78.1 (28.0–100)	0.108	89.5 (49.0–100)	33.3 (20.0–52.0)	**<0.001**	92.1 (75.0–100)	60.3 (28.0–75.0)	**<0.001**
Appropriate Behaviour	52.7 (26.7–83. 9)	52.4 (23.4–86.5)	0.980	64.8 (33.5–83.9)	37.3 (26.7–71)	**<0.001**	64.8 (35.8–86.5)	36.6 (23.4–66)	**<0.001**
9. Expression of social behaviours	69.2 (13.3–97)	72.9 (2.3–100)	0.202	74.8 (40.7–97)	62.1 (13.3–91.4)	0.067	79.2 (29.6–100)	64.9 (2.3–91.7)	0.15
10. Expression of other behaviours	47.5 (0–89.9)	47.5 (0–89.9)	1.000	66.1 (0–89.9)	23.9 (0–82.4)	**0.001**	66.1 (0–89.9)	23.9 (0–82.4)	**0.001**
11. Good human–animal relationship	58.3 (31.7–87.9)	56.7 (28.5–89.6)	0.699	66.8 (34.7–87.9)	47.6 (31.7–71)	**0.002**	65.1 (31.4–89.6)	46 (28.5–66.3)	**0.004**
12. Positive emotional state	84 (57.6–97.3)	83.5 (40.4–97.3)	0.581	85.8 (57.6–97.3)	81.6 (62.7–94.6)	0.150	86.1 (40.4–96.6)	80.2 (44.2–97.3)	0.306

Table 8 shows that the mean 'Percentage of moderately lame cows' in the organic herds was significantly lower in both periods compared to the conventional herds (summer: 3.2 % vs. 9.0 % of cows, P=0.008; winter: 3.6 % vs. 8.5 % of cows, P=0.014, respectively). In the measures that were quantified to characterise the 'Absence of injuries' or the 'Absence of disease', significant differences between the two farming systems in the two periods were not revealed (*Table 7*). But the scores of the criterion 'Absence of pain induced by management procedures' were significantly higher on organic farms compared to conventional farms in both periods (P<0.001, *Table 6*).

For 'Appropriate Behaviour', the mean scores for this WQ® principle and the scores in the underlying criteria (i.e. 'Expression of social behaviours' or 'of other behaviours', 'Good human-animal relationship' and 'Positive emotional state') did not differ significantly between the summer and winter period over all farms (*Table 6*). But the mean scores for the principle 'Appropriate Behaviour' were significantly higher on organic farms in both periods (P<0.001 each, *Table 6*, *Table 9*). The scores of the criteria 'Expression of other behaviour' (both seasons P<0.001) and 'Good human-animal relationship' (summer P=0.004, winter P=0.002) were higher in this farming system throughout.

These enhanced scores were influenced by the measures of 'Frequency of head butts per cow per hour', which were significantly lower in organic than in conventional herds in summer and winter (P=0.012 and P=0.018 respectively, *Table 9*). The average scores for 'Good human-animal relationship' were significantly higher in organic herds in both periods (P=0.004 and P=0.002, *Table 6*). This is attributed to lower avoidance distances at the feeding rack in the organic herds. Significantly more cows could be touched (P=0.017 and P=0.005) and fewer cows showed early signs of withdrawal or an avoidance distance greater than 100 cm in summer and winter (P=0.006 and P=0.007, respectively).

Finally, the WQ® principle scores were only weakly but slightly negatively correlated with the annual milk yield of cows across both farming systems (*Figure 1*). The correlations for the separate groups of organic and conventional farms did not differ substantially.

TABLE 7
Scores (mean (min–max)) for Good Feeding and Good Housing parameters as affected by farm type and timing of the assessment (Mann-Whitney U test, n: 19 organic farms, 15 conventional farms)

Period:	Winter	Summer	P-value	Winter		P-value	Summer		P-value
Farming system: / Measures	All farms			Organic	Conventional		Organic	Conventional	
% of very lean cows	5.9 (0.0–23.5)	6.6 (0.0–19.4)	0.479	5.3 (0.0–19.3)	6.7 (0.0–23.5)	0.384	5.8 (0.0–17.2)	7.6 (0.0–19.4)	0.273
Duration of lying down movements (s)	5.4 (3.7–9.2)	4.5 (3.1–6.5)	**<0.001**	5.0 (3.7–8.8)	5.8 (4.1–9.2)	**0.036**	4.0 (3.1–4.9)	5.1 (3.8–6.5)	**<0.001**
% of cows colliding with housing equipment during lying down	22.1 (0.0–71.4)	15.6 (0.0–80.0)	0.133	16.3 (0.0–66.6)	29.4 (0–66.7)	0.109	3.6 (0.0–36.8)	30.7 (0–80.0)	**0.003**
% of cows lying partly or completely outside the lying area	2.5 (0.0–33.3)	3.9 (0.0–41.9)	0.536	3.7 (0.0–33.3)	0.9 (0.0–12.6)	0.339	3.0 (0.0–41.9)	5.1 (0.0–36.3)	**0.038**
% of cows with dirty udder	34.0 (3.8–92.5)	25.4 (0.0–80.6)	**0.064**	33.8 (3.8–76.4)	34.2 (6.6–92.5)	0.755	24.6 (0.0–73.9)	26.6 (0.0–80.6)	0.627
% of cows with dirty flank or upper legs	60.6 (8.6–100)	41.4 (8.5–95.7)	**0.002**	63.4 (11.5–100)	57.1 (8.6–100)	0.51	42.2 (9.4–95.7)	40.3 (8.6–80.5)	0.64
% of cows with dirty lower legs	89.1 (54.3–100)	84.1 (12.9–100)	0.782	92.3 (60.0–100)	85.0 (54.3–100)	**0.056**	82.2 (12.9–100)	86.6 (57.5–100)	0.393

TABLE 8
Scores (mean (min–max)) for Good Health parameters as affected by farm type and timing of the assessment (Mann-Whitney U test, n: 19 organic farms, 15 conventional farms)

Period:	Winter	Summer	P-value	Winter		P-value	Summer		P-value
Farming system: / Measures	All farms			Organic	Conventional		Organic	Conventional	
% of moderately lame cows	5.8 (0.0–17.8)	5.8 (0.0–31.1)	0.956	3.6 (0.0–12.9)	8.5 (0.0–22.4)	**0.014**	3.2 (0.0–8.8)	9 (0.0–31.1)	**0.008**
% of severely lame cows	1.3 (0.0–10.2)	1.2 (0.0–6.7)	0.922	1.0 (0.0–4.0)	1.8 (0.0–10.2)	0.463	0.8 (0.0–4.3)	1.7 (0.0–6.7)	0.268
% of cows with at least one hairless patch, no lesion	46.6 (13.3–70.0)	35.4 (2.9–76.5)	**0.008**	49.3 (20.5–70.0)	43.3 (13.3–69.6)	0.155	30 (2.9–59.6)	42.3 (8.6–76.5)	0.069
% of cows with at least one lesion	20.2 (3.3–40.0)	21.5 (0.0–63.3)	0.864	20.1 (3.2–38.4)	20.3 (3.3–40.0)	0.959	20.6 (0.0–51.4)	22.6 (0.0–63.3)	0.69
Frequency of coughing per cow per 15 min	0.8 (0.0–2.3)	0.8 (0.1–3.6)	0.668	0.7 (0.0–2.2)	0.9 (0.1–2.3)	0.340	0.7 (0.1–2.2)	1 (0.2–3.6)	0.08
% of cows with nasal discharge	10.5 (0.0–34.6)	11.5 (0.0–44.4)	0.547	8.1 (0.0–15.7)	13.5 (2.2–34.5)	0.089	8.3 (0.0–31.3)	15.6 (0.0–44.4)	0.07
% of cows with ocular discharge	1.6 (0.0–9.2)	4.4 (0.0–17.3)	**0.009**	1.4 (0.0–7.6)	1.9 (0.0–9.2)	0.627	3.4 (0.0–17.3)	5.8 (0.0–14.6)	0.089
% of cows with hampered respiration	0.0 (0.0–0.0)	0.1 (0.0–2.2)	0.317	0.0 (0.0–0.0)	0.0 (0.0–0.0)	1.000	0.0 (0.0–0.0)	0.1 (0.0–2.2)	0.261
% of cows with diarrhoea	0.5 (0.0–18.1)	2.3 (0.0–13.7)	**0.005**	0.7 (0.0–8.8)	0.2 (0.0–3.0)	0.439	2.8 (0.0–13.7)	1.8 (0.0–7.3)	0.698
% of cows with vulvar discharge	0.8 (0.0–6.6)	0.3 (0.0–3.2)	0.091	1.1 (0.0–6.6)	0.5 (0.0–2.4)	0.348	0.4 (0.0–3.2)	0.3 (0.0–2.4)	0.888
% of cows with mastitis	15.5 (0.0–62.5)	13.7 (0.0–34.3)	0.893	15.9 (0.0–40.0)	14.9 (0.0–62.5)	0.267	14.2 (0.0–30.0)	13.1 (0.0–34.3)	0.51
% of mortality	2.8 (0.0–14.4)	2.9 (0.0–16.6)	0.658	3.4 (0.0–14.4)	2.0 (0.0–6.1)	0.382	3.0 (0.0–16.6)	2.7 (0.0–6.8)	0.930
% of dystocia	4.0 (0.0–17.1)	5.8 (0.0–23.8)	0.576	3.5 (0.0–17.1)	4.5 (0.0–10)	0.234	7.2 (0.0–23.8)	4.0 (0.0–16.7)	0.459
% of downer cows	5.6 (0.0–18.6)	4.3 (0.0–17.1)	0.05	5.3 (0.0–9.6)	6.0 (1.0–18.6)	0.972	3.5 (0.0–16.7)	5.3 (0.0–17.1)	0.143

TABLE 9
Scores (mean (min–max)) for Appropriate Behaviour parameters as affected by farm type and timing of the assessment (Mann-Whitney U test, n: 19 organic farms, 15 conventional farms)

Period:	Winter	Summer	P-value	Winter		P-value	Summer		P-value
Farming system: / Measures	All farms			Organic	Conventional		Organic	Conventional	
Frequency of head butts per cow per hour	0.6 (0.0–3.1)	0.7 (0.0–4)	0.769	0.4 (0.0–1.0)	0.9 (0.1–3.1)	**0.018**	0.4 (0.0–1.6)	1.1 (0.2–4.0)	**0.012**
Frequency of displacements per cow per hour	0.3 (0.0–1.9)	0.3 (0.0–2.3)	0.051	0.4 (0.0–0.8)	0.5 (0.0–1.9)	0.358	0.3 (0.0–1.2)	0.5 (0.0–2.3)	0.591
% of cows that can be touched	30.8 (2.9–76.6)	26.1 (2.2–75.8)	0.262	40.4 (9.0–76.6)	18.7 (2.9–33.3)	**0.005**	34.5 (6.0–75.8)	15.5 (2.2–35.7)	**0.017**
% of cows that can be approached up to 50 cm, but not touched	49.4 (20.0–78.5)	52.8 (24.2–83.6)	0.394	46.8 (20.0–78.5)	52.6 (32.3–72.2)	0.26	53.1 (24.2–83.6)	52.3 (28.6–81.3)	0.849
% of cows that can be approached to between 50 and 100 cm	14.8 (0.0–50.0)	14.8 (0.0–47.6)	0.830	10.3 (0.0–50.0)	20.6 (3.3–38.4)	**0.002**	9.0 (0.0–32.0)	22.2 (4.8–47.6)	**0.004**
% of cows with an avoidance distance greater than 100 cm	5.0 (0.0–23.5)	6.3 (0.0–24.2)	0.686	2.5 (0.0–9.5)	8.1 (0.0–23.5)	**0.007**	3.4 (0.0–20.0)	10 (0.0–24.2)	**0.006**

4 Discussion

With regard to our first hypothesis that dairy cow welfare is especially enhanced in the summer period, we observed improved animal welfare at the level of principles and criteria in the area of 'Good Housing'. Contrary to our hypothesis, the opposite was confirmed in the area of 'Good Feeding', where a lower score was achieved for the summer compared to the winter period. This was strongly influenced by the criterion 'Absence of prolonged thirst'. In the other principles and criteria, no differences between summer and winter were found.

Concerning our second hypothesis that a higher level of animal welfare is achieved on the organic farms compared to conventional farms in both winter and summer period, we found a better rating in the principles of 'Good Housing', 'Good Health' and 'Appropriate Behaviour' for the organic farms especially in summer. A detailed discussion about these findings will follow for each principle at all levels.

In this study, average scores in the WQ® principle 'Good Feeding' were generally lower in summer than in winter. Obviously, this value was mainly influenced by suboptimal water provision in the grazing season wherein both farming systems reached lower values (*Table 6*). Especially on pasture, the number of water points and its accessibility were found frequently low on the farms (detailed assessment data are not listed). This situation may have been influenced by the additional efforts farmers have to make to provide more watering options on pasture due to technical difficulties under outdoor conditions, long distances and additional time they would need for maintenance and control.

The differences in the means for 'Absence of prolonged hunger' and 'thirst' suggest better water and feed supply on organic farms in both periods, but these differences were not significant. The results on sufficient feeding are in line with the findings in other studies of March et al. (2017) in Germany, Roesch et al. (2005) in Switzerland and Bergman et al. (2014) in the United States where body condition of cows in organic and conventional dairy herds did not differ significantly.

Looking at the water provision, March et al. (2017) reported that organic farms achieved a better score for the WQ® principle 'Good Feeding'. This was due to a higher score for the WQ® criterion 'Absence of prolonged thirst'. In contrast, Langford et al. (2009) observed no differences in the water supply (i.e. number of troughs per group of cows, height of troughs, and surface area of troughs per 10 cows) in lactating cow housing on organic and conventional farms in the United Kingdom. However, the lowest score values for 'Absence of thirst' were observed in the summer period in our study (all farms: 32.9, organic farms: 36.4 and conventional farms: 28.5). These are all below the threshold level of 40 suggested by Kirchner et al. (2014) for the identification of on-farm welfare problems. Also, a high proportion of animal groups had no sufficient access to drinking water in the winter period (i.e. in the barn, mean score values of 58.1 on organic and 41.0 on conventional farms, *Table 6*). Therefore, there is potential for improvement of dairy cow welfare with regard to sufficient water supply, particularly during the grazing period. But it must also be considered that water provision is a resource-based measure and actual water intake is not only determined by numbers of water points and dimensions of troughs and their cleanliness, but also by climate and the available feedstuffs. Therefore water provision according to WQ® should not determine the final outcome of WQ® assessment by masking animal based measures that are more relevant to characterise the actual welfare situation of cows (de Vries et al., 2013). Especially on grassland it has to be considered that water-rich feedstuff is consumed by the cows. This influences their water demand.

In our study, the percentage of cows with low body condition scores did not differ significantly between summer and winter or between farm types (*Table 6*). This shows that the interrelations of resource-based measures (such as water provision) and animal-based ones (body condition score) are

not so clear in multifaceted livestock systems. But low scores reached in resource-based measures should be used to check the actual situation of animals without bias and evaluate possibilities for improvements.

The distribution of data (*Figure 1*) showed that low scores for 'Good feeding' occurred at the full range of milk productivity and in both farming systems. The wide range of data for 'Good Feeding' in both periods and farming systems reveals the potential for improvement on farm individual level.

Organic farms scored higher in the WQ® principle 'Good Housing' and in the criterion 'Comfort around resting' in the summer period (*Table 6*). The observation of more lying comfort in summer was surely due to the greater access to pasture that was provided to cows on the organic farms (89 % vs. 40 % of farms). Over all farms, the lying down movements were shorter in summer and cows were cleaner. Also, when grouping the data on grazing time from zero to high in an extended dataset (Wagner et al., 2018) the WQ® criterion 'Comfort around resting' was positively influenced by increased time spent on pasture. Several other studies show evidence of improved lying behaviour at pasture compared to housing conditions (O'Connell et al., 1989; Olmos et al., 2009; Corazzin et al., 2010).

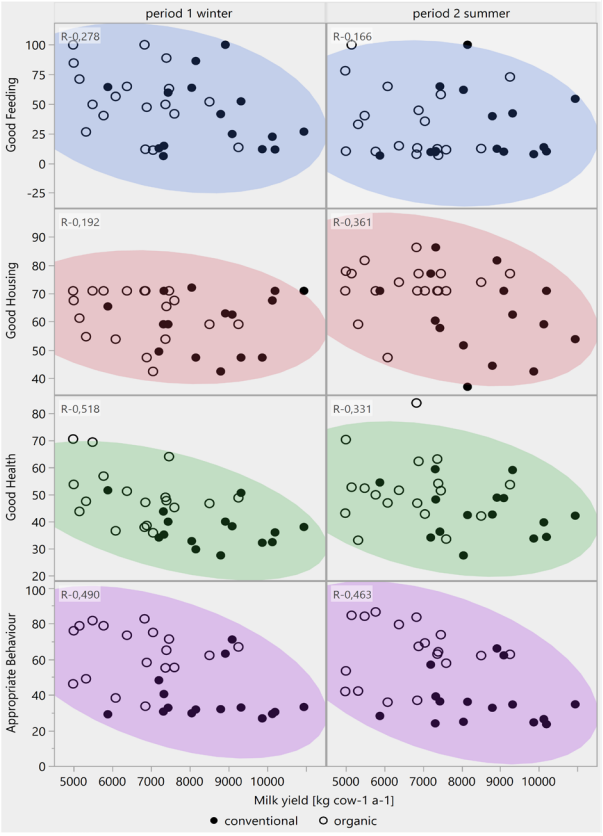

FIGURE 1
The score values for the welfare principles on the monitored farms (org: n=19; conv: n=15) in the summer and winter period plotted in relation to the average annual milk yield per cow for each farm (density ellipses are covering 95 % of data, R values are correlation coefficients of data with the following P-values in the summer period: Milk yield and: 'Good Feeding' 0.348, 'Good Housing' 0.036, 'Good Health' 0.056, 'Appropriate Behaviour' 0.006, and in the winter period of P=0.112, 0.277, 0.002 and 0.003, respectively.)

Cows prefer clean, dry and soft surfaces for lying down and resting (Rushen et al., 2007). In more technical detail, cows prefer deep-bedded free stalls compared to mattresses topped with minimal bedding (Tucker et al., 2003). Our observations on type and comfort of lying areas, as well as the results of the knee-test we performed in all lying areas in the barns (*Table 4*), reflect the organic farming practice of littered bedding as required in the organic standards of the European Community (Commission Regulation (EC) No 889/2008 and Regulation (EU) 2018/848). Within a scale of 1 to 3 (from hard to soft bedding) significantly more organic farms offered soft lying areas for the cows in lactation. But in the winter period the overall score for 'Good Housing' and 'Comfort around resting' were not significantly elevated in organic farms as should be expected (*Table 6*). In the outcome of WQ® assessment for 'Good Housing' only the shorter 'Lying down behaviour' and lower means for 'Percentage of cows colliding with housing equipment during lying down' hint to more lying comfort for the mean of organic cows in the winter period.

Figure 1 indicates that high milk yields are not associated with 'Good Housing' scores, especially in winter, whereas in summer the values for 'Good Housing' seemed to decrease with increasing milk yield. Mainly conventional herds were found in the lower right quarter of data where low scores for 'Good Housing' and higher milk yields coincide. It is interesting to note that the four lowest scores for 'Good Housing' in summer (see *Figure 1*) occurred on farms without or with only short grazing access (0, 0, 5 or 2.5 hours per day, the latter value was found on an organic farm). The three highest producing herds (milk yield >10,000 kg cow^{-1} a^{-1} were all conventionally managed without pasturing in summer) had high 'Good Housing' scores of around 70 in winter and were among the best farms for this parameter in this period.

Higher 'Comfort around resting' seemed to manifest in parameters determining the data for the WQ® principle 'Good Health'. Here organic farms had better scores compared to the conventional farms in both periods, whereas significant differences over all farms between summer and winter were not found. This indicated more general differences between the farming systems probably driven by legal standards and orientation towards higher welfare management in organic farming. The described differences in the use of disbudding, pain and sedation management were obvious (*Table 5*) and influenced the results. They were also in line with those observed by March et al. (2017). The new legal requirements on pain regulation which were enforced for all farming systems in the summer period of this study drastically increased the use of anaesthetics and analgesics especially in conventional herds, showing the power of legal regulations to change agricultural management. However, some remaining conventional farms performed disbudding by administering only anaesthetics or analgesics in that summer period. Some used neither.

Lower percentages of moderately lame cows were found on the organic farms, both in winter and in summer (*Table 8*).

These results were in line with other studies on lameness prevalence in dairy herds in Germany (March et al., 2017), England and Wales (Barker et al., 2010), and in the United Kingdom (Weller and Cooper, 1996; Rutherford et al., 2009). Housing and feeding are major risk factors associated with the development of claw and leg disorders and, thus, more preferable conditions by demands of the organic standards might benefit hoof and limb health in organic in comparison to conventional dairy farming. In more detail, the Commission Regulation (EC) No 889/2008 and Regulation (EU) 2018/848 on organic farming demand (i) the provision of a bedded lying area, (ii) the maximum use of grazing at pasture, or (iii) the requirement of a minimum forage proportion in daily rations of herbivores, consequently restricting the use and the dietary proportion of concentrates. Several studies have highlighted the importance of lying comfort with respect to claw lesions (Barker et al., 2009) and lameness in dairy cows (Dippel et al., 2009; Solano et al., 2015). Also, access to pasture has been shown to be beneficial in terms of reducing lameness (Hernandez-Mendo et al., 2007; Rutherford et al., 2009; Burow et al., 2013; Sjöström et al., 2018). Manson and Leaver (1988) and Livesey et al. (1998) reported that feeding a higher forage-to-concentrate ratio was associated with lower lameness prevalence in lactating dairy cows and lower lameness incidence in heifers, respectively.

The reduced 'Percentage of cows with at least one hairless patch and no lesion' found in the summer period also hints to better conditions for cows during the grazing season. But the maximal values we found for the measures of injuries show risks in both farming systems (*Table 8*). Other expectations, like significant negative correlations between 'Percentage of cows with no lesions' and the presence of horned cows in the herd were analysed but could not be verified by the data obtained in this study (correlation matrices are not presented). More cows found with 'ocular discharge' and 'diarrhoea' in the summer period over all farms might reflect the more windy and chilly conditions outside the stable and the increased intake of fresh green fodder. Means and range differences between the farming systems in the two analysed periods of the year were not obvious and would also lack explanation for most other measures influencing the WQ® criterion 'Absence of disease' (e.g. for mortality). However, the averages found in both farming systems and in both periods for 'Percentage of cows with nasal discharge' were well above the warning threshold given in the WQ® protocol (2009) (i.e. 5 % of cows) in the organic herds and were overriding the alarm value (i.e. > 8 % of cows) on the conventional farms. This justifies careful consideration as follows. A view on the data shows (*Table 8*) that the mean values found on organic farms are lower than in the mean of all farms in both periods, although not significant at the 5 % level. The means and maximum values seemed to be lower on the organic farms in both periods (P=0.07, P=0.089). Reports of investigation of bovine respiratory disorders in adult cows are rare in the literature. Richert et al. (2013) reported that dairy herds on organic and conventional farms with access to grazing had four-fold decreased rates in pneumonia compared with non-grazing conventional herds in the United States. Access to pasture was more common on organic farms than on conventional farms within our study (89 vs. 40 %). However, the percentage of cows with nasal discharge was found not to differ significantly between the periods, suggesting that the farming system might be the important explanatory factor. Coignard et al. (2013) have found that the overall health score in French dairy cattle herds, measured through the WQ® protocol, was significantly better in herds equipped with straw yards (no more details are given in this study) than in herds housed in cubicles, which was, inter alia, due to a lower frequency of nasal discharge. Although cubicles were the dominant housing system in both of the farming systems within our study (57 and 80 % on organic and conventional farms, respectively), free deep litter lying areas were more common on the organic farms compared to the conventional farms (43 vs. 20 %). In addition, the total space allowance per cow in the barn on the organic farms was, on average, higher (8.3 vs. 7.1 m^2 per cow) than on the conventional. Also access to an outdoor loafing area (excluding pasture) was more often provided on organic farms (74 vs. 33 % of farms; data not presented), which might have ensured better ventilation and air quality for the cows in the barn.

Back to the general outcome in the WQ® principle 'Good Health': When comparing the scattergram of the dataset in winter and summer (*Figure 1*), the improved situation in summer on the conventional farms by the legally forced introduction of pain relief during disbudding is evident. Concerning milk yields, the three most productive herds had only moderate scores in the WQ® principle 'Good Health' in both periods. Conventional herds with higher scores for 'Good Health' tended to have lower yields (within the conventional category), but even these did not compare favourably with the better (but mostly still moderate) scores reached on most of the organic farms.

The better scoring in organic herds in both periods for the WQ® principle 'Appropriate Behaviour' and in the underlying criteria 'Expression of other behaviours' and 'Good human-animal relationship' were in line with the findings of March et al. (2017) for the winter half-year. Better scores for the WQ® criterion 'Expression of other behaviours' on organic farms vs. conventional farms in our study were related to pasture access. In addition, it is worth noting again that organic farms offered, on average, longer grazing periods compared to the six conventional farms offering pasture access in our farm sample (i.e. on 210 vs. 179 days per year when including all farms providing access to pasture or on 214 vs. 180 days per year when including only those farms providing access to pasture for at least 6 hours per day, respectively). Under most farming conditions, farm animals interact with carers in several ways (e.g. at feeding and milking times) and human-animal relationships are of great importance, both for carers and for animals (Waiblinger et al., 2006). Waiblinger and Menke (1999) and Ebinghaus et al. (2018) found some correlation between herd size and the human-animal relationship, with herd size being correlated negatively with the percentage of cows that can be touched and positively with the percentage of cows showing an avoidance distance of greater than 100 cm, respectively. Additionally, Ebinghaus et al. (2018) reported

that the percentage of dehorned cows in the herd was associated with a higher median avoidance distance. Indeed, on our organic farms, herd sizes (sum of lactating and dry cows) were, on average, lower (*Table 3*) and horned herds were only found on organic farms (10 farms). These points offer a possible explanation for the higher scores found in the WQ® criterion 'Good human-animal relationship' on the organic farms. Compared to the above-mentioned factors, the personality and attitudes of caretakers forming a basis for their behaviour and the quality of human-animal-interactions (Ebinghaus et al., 2018), seems to be of great importance for this WQ® criterion (Waiblinger and Menke, 1999; Windschnurer et al., 2009; de Boyer des Roches et al., 2016). The higher scores found on organic farms in our study and also in the study of March et al. (2017) suggest effects of technical aspects mentioned above. But the possible differences in human animal interactions which might be related with different attitudes of different farmers – or in farming systems with commitments to achieve high animal welfare in their standards – were not explored here. Although scores in the WQ® criterion 'Expression of social behaviours' were unaffected by the farming system in both periods of our study, cows on organic farms showed less agonistic behaviour. On this topic, Fregonesi and Leaver (2002) and Schütz et al. (2015) reported that agonistic interactions were less frequent with increasing space allowances for dairy cows housed in cubicles, as well as for non-lactating dairy cattle managed temporarily on rubber matting for up to 18 hours per day. In our study, the organic farms offered higher total space allowance per cow in the barn as well as in the outdoor loafing area (data not listed) compared to conventional farms. This might have enabled low ranked cows to cope with dominant cows and avoid conflicts and, thus, could represent one reason for the lower frequency of head butts observed for cows on the organic farms. In addition, the more frequent use of free lying areas in organic farms with fewer bottlenecks and dead ends than in cubicle houses could have influenced the results.

The sample sizes within the two farming systems (e.g. regarding housing system) were too small to examine some effects in detail. For this, we recommend further studies with a higher number of farms that include potential factors of interest. With increasing political interest in animal welfare status and its assessment and documentation, more routine data might be available in near future.

Conducting this study over the winter and summer period revealed differences in water provision and lying behaviour between summer and winter which would not have been disclosed by a study of only one of these periods (in summer: less drinking water availability, shorter duration of lying down movements, fewer cow collisions with housing equipment). This was particularly obvious when comparing the data of the two analysed periods on organic farms, where most of the herds had pasture access (*Table 6*, *Table 7*). In contrast, the scores for 'Social behaviour' and 'Expression of other behaviours' and the results on the underling measures showed smaller differences between the winter and summer period (*Table 6*, *Table 9*), thus supporting the view of Broom and Johnson (2019) that animal behaviour is a long term response to the complete farming system. Evaluation of the welfare status of cows on pasture have been reported by various authors (O'Connell et al., 1989; Nguyen and Kilgour, 2013). We were aware that double counting might pose a potential problem for a proper evaluation if assessing WQ® data on pasture as opposed to the barn (the latter is a requirement by the WQ® protocol). However, it seems not to make perceptible differences in the results on 'Appropriate Behaviour' and in its underlying criteria.

5 Conclusions

For our first hypothesis, we found some clear differences in dairy cow welfare performance between the summer and winter period based on measurements made for the WQ® protocol in our network of organic and conventional farms in Germany: The water provision on pasture did not meet the requirements of high welfare standards in many of the farms. The mean body condition of cows and scores for 'Good Feeding' generally decreased in summer and in both farming systems across different rates of pasture access. 'Comfort around resting' was especially enhanced in summer in the mean of organic farms (where 83 % of herds had pasture access). Scores for 'Good Health' and 'Appropriate Behaviour' responded to longer term management aspects in farming systems and did not change between the periods. Differences found in measures, i.e. in 'Percentage of cows with ocular discharge' or in 'Percentage of cows with diarrhoea', could be explained by the grazing environment and fodder resources used in summer. For our second hypothesis, we found significant differences in animal welfare between organic farms and conventional farms in our network in both winter and summer period. More generous space provision, softer lying surfaces, less painful management procedures and more access to pasture were provided to the organic dairy cows compared to conventional farms. The requirements of the organic farming standards obviously make a difference in practical farming. They affect comfort, health and behaviour in a positive way (i.e. in lying down behaviour, lameness, suffering painful procedures, agonistic behaviour, human-animal relationship).

Looking at the productivity of cows, highest milk yields (>10,000 kg cow^{-1} a^{-1}) were only achieved in the farms with conventional management. However in comparison to all farms (average milk yield 7,425 kg cow^{-1} a^{-1}) or to the two organic farms with highest milk yields (8,500 and 9,250 kg cow^{-1} a^{-1}) scores for 'Good Health' and 'Appropriate Behaviour' in these high yielding dairy herds were generally low. Also in the principles 'Good Housing' and 'Good Feeding' the values only sometimes approached those of farms with lower average milk yields.

To state it clearly: All the dairy farms we analysed in this study had the potential to improve animal welfare. In order to achieve this, interventions that are specific to the individual farm are required, as the data of this study showed very obviously: The ranges of all values were wide in both periods of the year and in both farming systems showing that the impact of farm-individual management on animal welfare

can be very high. Even though EU regulations on organic farming offer great potential for good animal welfare, they cannot offer a guarantee. Therefore, we recommend the implementation of outcome-based assessments in organic standards and other legal provisions for livestock farming in general to address and improve all dimensions of animal welfare.

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