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The effects of farming systems (organic vs. conventional) on dairy cow welfare, based on the Welfare Quality® protocol

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ABSTRACT

Animal welfare in livestock production is of great interest to consumers. The organic farming approach strives to ensure animal welfare based on preventive measures, but there are very few scientific studies that compare the actual differences in animal welfare between organic and conventional farms. Those studies that have been carried out frequently focus on specific aspects of animal welfare, mostly health issues. The aim of the present study, therefore, was to investigate the effects of the farming system on the welfare of dairy cows in a more holistic way. Although this study was carried out in just two federal states of Germany, the results could serve as a suitable model for the whole country. We used the Welfare Quality assessment protocol to measure welfare for dairy cattle (Welfare Quality®, 2009) and the results showed significant differences ($P < 0.05$) between organic and conventional farms, but there was also considerable variance between individual farms of the same farming system. Organic farms scored higher in all four Welfare Quality® principles: "Good Feeding", "Good Housing", "Good Health" and "Appropriate Behavior" compared to conventional farms. In particular, organic farms obtained higher scores with respect to Welfare Quality® measures of resting comfort, which contributes to a lower percentage of lameness; organic farms also implemented less painful methods for disbudding, or indeed carried out no disbudding, and provided access to pasture and outdoor exercise. However, organic farms still have room for improvement, especially with respect to animal health. Therefore, outcome-based specifications should be included in the current (purely action-oriented) European regulation of organic production (EC, 2008; EU, 2018) to safeguard the health-related aspects of animal welfare.

Implications

Aim of the study was to investigate the effects of farming system on the welfare of dairy cows. Organic farms showed better results with respect to comfort around resting, less lameness, less painful disbudding methods, provision of pasture and outdoor exercise. However, organic farms still have room for improvement, especially with respect to animal health. Even though European regulations of organic production offer great potential for good animal welfare, they cannot provide a guarantee. These regulations, which at present focuses only on action-based demands, should therefore be supplemented by outcome-based assessments to consider and safeguard health-related aspects of animal welfare.

Introduction

The most common definitions of animal welfare are based on two concepts. Firstly, the concept of the five freedoms, which was defined by the British Farm Animal Welfare Council (FAWC, 1979); and, secondly, the multidimensional concept, defined by Fraser et al. (1997) and Fraser (2008). Based on these concepts, the World Organisation for Animal Health (**OIE**) has published the following definition: "Animal welfare means the physical and psychological condition of an animal in relation to the conditions in which it lives and dies. An animal experiences good welfare when the animal is healthy, comfortable, well-fed, safe, not suffering from unpleasant conditions such as pain, fear and distress, and able to express behaviors that are important to its physical and psychological condition" (OIE, 2019).

Animal welfare in livestock production is of great interest to consumers (European Commission, 2016) and dairy farming needs to make changes in animal welfare to accommodate public expectations (Weary and von Keyserlingk, 2017). In organic farming, the

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fundamental objectives are high animal-welfare standards and requirements that ensure the feasibility of species-appropriate behavior (IFOAM, 2014). This importance of animal welfare is reflected in the European regulation of organic production (EC, 2008; EU, 2018). To achieve these goals, organic livestock farming not only dictates minimal use of allopathic medicinal products, but also focuses on preventive measures for animal housing, feeding, breeding and (herd) management. In organic dairy production (routine) dehorning of cattle is prohibited; farmers have to provide 100% organic feed; tethering or isolating of livestock is prohibited in principle; an adequate stocking density needs to be ensured; ample bedding for the resting areas is required, as well as regular access to pasture and outdoor exercise, whenever it is possible. Therefore, organic farming meets a number of conditions with the potential for achieving high scores in dairy cow welfare. However, the question we seek to address is whether organic or conventional farming systems differ with regard to their animal welfare level. To date, there are only few reviews available that compare and evaluate the animal welfare situation on organic and conventional farms (Sundrum, 2001; Hovi et al., 2003; Lund and Algers, 2003; Van Wagenberg et al., 2017; Åkerfeldt et al., 2021). These studies found no fundamental differences between the two farming systems, apart from parasitic diseases (Sundrum, 2001; Hovi et al., 2003; Lund and Algers, 2003), udder health and antibiotic resistance (Van Wagenberg et al., 2017). However, the comparative studies mostly focused on the presence of animal diseases, such as mastitis, ketosis and milk fever (Hardeng and Edge, 2001; Roesch et al., 2007; Valle et al., 2007), or lameness (Dippel et al., 2009; Rutherford et al., 2009; Barker et al., 2010), or targeted only individual aspects of animal welfare, such as lying behavior and aggression (Langford et al., 2011). Furthermore, organic livestock systems and management have changed over time, and continue to do so (Åkerfeldt et al., 2021). Therefore, this study explores a comprehensive comparative assessment of animal welfare in dairy farming. In order to investigate a broader approach to animal welfare considering its multidimensional nature and to focus on more than one aspect of animal welfare, such as animal health, we used the Welfare Quality® assessment protocol for dairy cattle (WQ®, 2009).

The Welfare Quality® protocols have a comprehensive assessment system and reflect the multidimensional concept of animal welfare (Fraser et al., 1997; Fraser, 2008) in four principles that are essential for ensuring and improving animal welfare in livestock production: "Good Housing", Good Feeding", "Good Health" and "Appropriate Behavior" (WQ®, 2009). These four principles complement and extend the "Five Freedoms" (FAWC, 1979) and form the basis of the Welfare Quality® assessment system. Within these four principles, there are in turn twelve independent, complementary criteria (WQ®, 2009; Table 1). The criteria are calculated from 30 to 50 (depending on species) measures with strong emphasis on animal-based measures. Once all the measures have been evaluated for an animal unit, a bottom-up approach is followed to determine an overall assessment of animal welfare. The aim of the present evaluation was to compare organic and conventional dairy farms with regard to animal welfare using the Welfare Quality® assessment protocol for dairy cattle (2009). Our hypothesis was that, in comparison with conventional farms, organic farming would achieve a higher level of dairy cow welfare, a result of the higher standards set out in the European regulation of organic production (EC 2008; EU 2018).

Material and methods

As part of the research project entitled "Indicators for a Payment-by-Results Approach for Animal Welfare Measures and Organic Farming", the status quo of animal welfare was recorded for 115 (46 organic and 69 conventional) dairy farms in North Rhine-Westphalia (**NRW**) and Mecklenburg-Western Pomerania (**MV**) between November 2013 and May 2014. All farms had loose housing systems. More information about the participating farms by farming system and by federal state are detailed in Table 2.

Table 1
Principles, criteria, and measures of the Welfare Quality® assessment protocol for cattle (2009).

Principles	Criteria	Measures
Good Feeding	1. Absence of prolonged hunger	Body condition score
	2. Absence of prolonged thirst	Water provision (number/length in cm of water troughs, bowls), 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, diarrhea, vulvar discharge, milk somatic cell count, mortality, dystocia, downer cows
	8. Absence of pain induced by management procedures	Disbudding/dehorning, tail docking
Appropriate Behavior	9. Expression of social behaviors	Agonistic behaviors (head butts, displacements)
	10. Expression of other behaviors	Access to pasture
	11. Good human-animal relationship	Avoidance distance
	12. Positive emotional state	Qualitative behavior assessment (defined by 20 terms of body language)

Assessment of animal welfare

The entire Welfare Quality® assessment protocol for dairy cattle (WQ®, 2009) was recorded during farm visits. During a single farm visit, all 30 measures according to the WQ® protocol (WQ®, 2009) were recorded via interviews, database calculations and direct observations in the barn at the animal, herd or stable equipment. Information regarding the measures "Percentage of dystocia" and "Percentage of downer cows", as well as information regarding management (e.g., disbudding/dehorning, access to pasture), was collected during the interviews. Figures for "Percentage of cows with milk somatic cell count of 400 000 or above" as an indicator of udder health disorders/mastitis were generated from the milk recording scheme. "Percentage of mortality" was calculated from the German central database on identification and information on animals. All other measures were recorded in the barn based on the WQ® protocol (WQ®, 2009), i.e., resource-based measures and the assessment of animal based indicators, such as body condition, cleanliness, integument alterations, lying behavior, social behavior, avoidance distance and qualitative behavior assessment. Table 1 gives information about the assessed indicators following WQ® (2009) in the column "Measures". The results of these recordings were classified and merged with different algorithmic opera-

Table 2
Herd size and milk yield (kg/cow/year) in average (minimum–maximum) and information about housing system and access to pasture for all 115 dairy farms, by farming system (organic and conventional farms) and within these by federal state (Mecklenburg-Western Pomerania and North Rhine-Westphalia) 2014.

Item	All farms (n = 115)	Organic farms (n = 46)		Conventional farms (n = 69)	
		Mecklenburg-Western Pomerania	North Rhine-Westphalia	Mecklenburg-Western Pomerania	North Rhine-Westphalia
Herd size (cows)	155(21–1 495)	108(21–278)	66(30–150)	313(67–1 495)	77(34–161)
Farms	n = 115	n = 16	n = 30	n = 37	n = 32
Milk yield* (kg/cow/year)	8 137(4 405–11 988)	6 143(4 405–9 248)	7 202(4 571–9 601)	9 100(5 636–11 988)	8 807(5 963–10 913)
Farms	n = 107	n = 15	n = 26	n = 34	n = 32
Housing system:					
– Deep litter	40	10	15	2	13
– Cubicle	75	6	15	35	19
Access to pasture					
– Yes	97	16	30	21	30
– No	18	0	0	16	2

* Yearly moving average milk yield (from milk recording data: n = 107 farms in total, 41 organic and 66 conventional farms)

tors (e.g., a decision tree or a weighted sum) to describe twelve animal welfare criteria. These criteria in turn were combined with different algorithmic operators into four animal welfare principles. Finally, an "overall welfare score" was calculated using a mathematical model and grouped into four categories: "excellent", "enhanced", "acceptable" and "not classified" (for details of the calculations see WQ®, 2009). These categories can also be applied at all levels with the following values except at the "measures" level (according to WQ®, 2009): a value from 0 to 20 was considered as "unacceptable" ("not classified"), improvement was required for values between 20 and 50 ("acceptable"), improvement was sought for values between 50 and 80 ("enhanced"), whereas values between 80 and 100 ("excellent") represented a very good situation (WQ®, 2009).

Before data collection began on the farms, our project observers underwent intensive training in the methodology for recording animal-related indicators of the WQ® to ensure sufficient inter-observer-reliability. These training courses, based on photographs, videos and practical exercises in dairy cow farms, were led by two qualified practitioners with many years' experience in WQ® assessment methodology. To estimate inter-observer reliability for the four observers, prevalence-adjusted bias-adjusted kappa (**PABAK**) values were calculated for all animal-related measures (e.g., scoring of lameness) based on observation of 20 animals in two farms with >70 dairy cows. The PABAK values averaged 0.41–0.90 and, thus, indicated an acceptable to very good alignment (Fleiss et al., 2003; Dippel et al., 2009) between all assessors (for details see Table 3). Regarding the assessment of behavior on the basis of video material, inter-observer reliability (measured as Pearson correlation coefficient) ranged from 0.84 to 0.99 (arithmetic mean of 0.93, n = 86) for lying behavior and from 0.82 to 0.92 (arithmetic mean of 0.86) for social behavior, indicating good to very good alignment.

Statistical analysis

Statistical analyses were carried out with the program SAS® 9.4 (SAS Institute Inc., Cary, NC, USA). The "ITB-Controlling" software from dsp-Agrosoft GmbH was used to process and transform the data from the monthly milk performance test in ADIS-format. For the descriptive representation of the status quo, the procedures PROC MEANS and PROC UNIVARIATE were carried out. All parameters were evaluated at herd level and were not normally distributed. Group comparisons (organic vs. conventional) were carried out with the non-parametric Wilcoxon-Mann-Whitney test (SAS-procedure PROC NPAR1WAY; option Wilcoxon). The data for "Thermal comfort" and "Ease of movement" criteria were excluded from the statistical analyses, as their values were the same for all farms. This can be explained by the fact that – as yet – the WQ® protocol does not have a way of assessing "Thermal comfort" (WQ®, 2009 protocol page 97). In accordance with WQ® practice (WQ®, 2009 protocol page 108), the missing score for this WQ® criterion should be replaced by the best score among the WQ® criteria "Comfort around resting" and "Ease of movement". All farms in our study provided loose housing; as such, all achieved the maximum score of 100 for the WQ® criterion "Ease of movement". This same score was transferred, as previously explained, to the WQ® criterion "Thermal comfort". Having the same, maximum, score across both WQ® criteria for all farms lead to a statistical error in the comparison within the WQ® criteria evaluation. Therefore, these two parameters will not be considered in detail in further sections. The significance limit was assumed at $P < 0.05$.

Results

From the 115 studied farms in total, regarding the "overall welfare score" (WQ®, 2009) eight farms (7%) were rated "excellent", 64

Table 3
Results of reliability tests (prevalence-adjusted bias-adjusted kappa = PABAK) for the different parameters presented in range (min–max) with sample size (n). The tests are based on experiences in dairy cow farms (live) and videos, photographs (video/photo).

Parameter	Reliability test			
	Live (PABAK)	n	Video/photo (PABAK)	n
Lameness	0.70 (0.44–1.00)	20	0.72 (0.64–0.77)	39
Body condition	0.85 (0.78–0.93)	20	0.78 (0.72–0.81)	32
Cleanliness of udder	0.90 (0.80–1.00)	20	0.77 (0.64–0.85)	60
Cleanliness of flank/upper leg	0.67 (0.50–0.90)	20	0.74 (0.65–0.82)	57
Cleanliness of lower leg	0.41 (0.20–0.50)	20	0.51 (0.17–0.71)	43

farms (56%) "enhanced", 42 farms (36%) "acceptable" and one farm "not classified". Comparing organic vs. conventional farms, 15% of the 46 organic farms achieved an "excellent", 61% an "enhanced", 22% an "acceptable" and one farm the "not classified" status/situation (2%), while one conventional farm was classified as "excellent" (2%), just over half of the farms (52%) were "enhanced" and 46% "acceptable". No conventional farm was deemed "not classified".

At the underlying level, we found significant differences between organic and conventional farms for all four WQ® principles (see Table 4). The situation on organic farms was on average "enhanced" in WQ® principle "Good Feeding", while "acceptable" for the conventional farms. Concerning the underlying WQ® criteria, in "Absence of prolonged thirst" there was a significant difference between the farming systems, whereas no significant differences were found in "Absence of prolonged hunger" or in the WQ® measure "Percentage of very lean cows", respectively (Table 5).

Concerning the WQ® principle "Good Housing" both farming systems had on average an "enhanced" welfare (Table 4). Regarding the levels below, in the WQ® criterion "Comfort around resting", organic farms reached higher scores compared to conventional farms. Cows in organic farms laid down faster, had fewer collisions with the equipment and laid less outside the lying area than cows in conventional farms (Table 5). In contrast, the cows in the organic farms were dirtier at the udder, flank/upper legs and lower legs than cows in conventional herds (Table 5).

With regard to the WQ® principle "Good Health", the situation was on average "enhanced" for organic farms and "acceptable" for conventional farms (Table 4). With respect to the WQ® criteria within this WQ® principle we only found a significant difference between the farming systems for WQ® criterion "Absence of pain induced by management procedures", not for "Absence of injuries" or "Absence of disease".

However, at the level of WQ® measures we found that, compared to conventional herds, organic farms had significantly fewer moderately lame cows, fewer cows coughed, fewer cows had vulvar discharge and also mortality was lower (Table 6). In all other measures of the WQ® principle "Good Health" we found no differences ($P > 0.05$).

With regards to the WQ® principle "Appropriate Behavior", organic farms performed on average in an "enhanced" range, whereas conventional farms were on average in an "acceptable" range. Furthermore, there were significant differences in the WQ® criteria "Expression of other behavior" and "Good human-animal relationship", but not in the WQ® criteria "Expression of social behavior" or "Positive emotional state" ($P > 0.05$, Table 4). Concerning the underlying WQ® measures, organic farms provided more frequent and longer access to pasture than conventional farms (Table 7). In addition, cows in organic herds had a lower avoidance distance and could be touched more compared to cows in conventional herds.

Discussion

Although farms of just two federal states of Germany were evaluated in this study, these states could nevertheless reflect the dual agricultural structure in Germany (West/East) – a result of the post-World War II division of Germany and the consequent differing developments in the agricultural sectors, such as collectivization in the eastern part of Germany. NRW as a western federal state has many medium-sized farms (on average 65 dairy cows; Federal Statistical Office, Germany, 2017) with family labor (54%; Information.medien.agrar e.V. (i.m.a.), 2013), which are "typical" for the western federal states. In MV, milk production is dominated by large farms with large herds (on average 250 dairy cows; Federal Statistical Office, Germany, 2017) and wage labor (family labor 18%; Information.medien.agrar e.V. (i.m.a.), 2013), which are typical for dairy farms in the eastern federal states. With respect to milk production in Germany, in our study these differences in agricultural structure between west and east are quite well represented by the two federal states.

Welfare Quality® approach

The Welfare Quality® project has set standards in animal welfare research and has become a widely used reference for the overall assessment of animal welfare. Even though it does not cover all dimensions of animal welfare (described in Fraser et al., 1997; Fraser 2008) in detail, it is currently the most comprehensive approach to assessing animal welfare on farms.

Welfare Quality® overall welfare score

In line with other studies, the farms in the present study showed large differences in animal welfare between the individual

Table 4
Overall assessment of the animal welfare of the dairy cows according to the farming system (organic vs. conventional) presented as Welfare Quality® principles and criteria in mean values, range (min–max), and significance of the group differences. *P*-values smaller than 0.05 are marked in bold ($P < 0.05$).

Welfare Quality® principles and criteria	All farms (n = 115)	Organic farms (n = 46)	Conventional farms (n = 69)	*P*-value
Good Feeding	49.0 (4.2–100)	59.5 (4.2–100)	42.0 (5.9–100)	**0.006**
1. Absence of prolonged hunger[1]	74.5 (13.1–100)	72.6 (13.1–100)	75.7 (27.4–100)	0.544
2. Absence of prolonged thirst[2]	51.7 (3.0–100)	68.0 (3.0–100)	40.8 (3.0–100)	**<0.001**
Good Housing	66.7 (37.0–100)	69.9 (37.0–100)	64.7 (42.4–100)	**0.003**
3. Comfort around resting	47.2 (0.0–100)	52.2 (0.0–100)	43.9 (8.6–100)	**0.003**
4. Thermal comfort	100 (100–100)	100 (100–100)	100 (100–100)	-
5. Ease of movement	100 (100–100)	100 (100–100)	100 (100–100)	-
Good Health	49.3 (30.0–78.8)	56.2 (34.3–78.8)	44.8 (30.0–67.6)	**<0.001**
6. Absence of injuries	62.4 (21.3–97.2)	65.7 (27.9–97.2)	60.1 (21.3–95.6)	0.079
7. Absence of disease	51.3 (30.2–86.0)	53.0 (30.2–100)	50.1 (30.2–86.0)	0.191
8. Absence of pain induced by management procedures	63.1 (20.0–100)	84.0 (52.0–100)	49.2 (20.0–100)	**<0.001**
Appropriate Behavior	57.7 (17.0–90.8)	68.8 (27.0–90.8)	50.4 (17.0–83.8)	**<0.001**
9. Expression of social behavior	83.4 (21.5–100)	83.0 (50.0–100)	83.6 (21.5–98.1)	0.424
10. Expression of other behavior[3]	51.8 (0.0–100)	71.8 (0.0–100)	44.5 (0.0–90.1)	**<0.001**
11. Good human-animal relationship	60.8 (27.4–95.4)	67.7 (32.4–95.4)	56.2 (27.4–84.5)	**<0.001**
12. Positive emotional state	84.7 (0.7–100)	84.1 (0.7–100)	85.2 (1.3–100)	0.706

[1] Based on body condition score (very lean cows), animal-based measure.
[2] Based on water provision, resource-based measure.
[3] Based on the availability of pasture, management-based measure.

Table 5
Results at the level of Welfare Quality® measures for the Welfare Quality® principles "Good Feeding" and "Good Housing" in dairy cows presented in mean values, range (min–max), and significance of the group differences. *P*-values smaller than 0.05 are marked in bold ($P < 0.05$).

Welfare Quality® principle and measures	All farms (n = 115)	Organic farms (n = 46)	Conventional farms (n = 69)	*P*-value
Good Feeding				
Percentage of very lean cows	4.7 (0.0–46.3)	5.9 (0.0–46.3)	3.9 (0.0–23.3)	0.544
Good Housing				
Duration of lying down movements (s)	4.8 (2.9–7.6)	4.5 (3.0–7.1)	4.9 (2.9–7.6)	**0.006**
Percentage of cows colliding with housing equipment during lying down	17.8 (0.0–100)	6.4 (0.0–42.8)	25.5 (0.0–100)	**<0.001**
Percentage of cows lying partly or completely outside the lying area	2.0 (0.0–33.3)	1.2 (0.0–19.2)	2.5 (0.0–33.3)	**0.001**
Percentage of cows with dirty udder	26.6 (0.0–100)	34.6 (0.0–100)	21.3 (0.0–82.1)	**0.006**
Percentage of cows with dirty flank/upper legs	47.7 (0.0–100)	56.9 (0.0–100)	41.5 (2.5–100)	**0.004**
Percentage of cows with dirty lower legs	79.1 (0.0–100)	85.1 (0.0–100)	75.0 (11.1–100)	**0.006**

Table 6
Results at the level of Welfare Quality® measures for the Welfare Quality® principle "Good Health" in dairy cows presented in mean values, range (min–max), and significance of the group differences. *P*-values smaller than 0.05 are marked in bold ($P < 0.05$).

Welfare Quality® principle and measures	All farms (n = 115)	Organic farms (n = 46)	Conventional farms (n = 69)	*P*-value
Good Health				
Percentage of moderately lame cows	13.0 (0.0–60.0)	10.2 (0.0–35.1)	14.8 (0.0–60.0)	**0.009**
Percentage of severely lame cows	1.6 (0.0–12.5)	1.4 (0.0–10.7)	1.7 (0.0–12.5)	0.526
Percentage of cows with at least one hairless patch. no lesion	37.8 (0.0–97.3)	42.5 (0.0–97.3)	34.6 (1.9–78.4)	0.053
Percentage of cows with at least one lesion	17.5 (0.0–79.7)	15.2 (0.0–64.2)	19.1 (0.0–79.7)	0.135
Frequency of coughing per cow per 15 min	0.3 (0.0–1.8)	0.1 (0.0–0.8)	0.4 (0.0–1.8)	**<0.001**
Percentage of cows with nasal discharge	0.8 (0.0–9.3)	0.7 (0.0–9.3)	0.8 (0.0–9.0)	0.528
Percentage of cows with ocular discharge	0.8 (0.0–8.9)	0.8 (0.0–8.9)	0.8 (0.0–5.8)	0.300
Percentage of cows with hampered respiration	0.0 (0.0–2.5)	0.0 (0.0–2.0)	0.0 (0.0–2.5)	0.812
Percentage of cows with diarrhea	0.3 (0.0–5.6)	0.3 (0.0–5.2)	0.3 (0.0–5.6)	0.507
Percentage of cows with vulvar discharge	0.4 (0.0–3.8)	0.2 (0.0–3.2)	0.5 (0.0–3.8)	**0.018**
Percentage of cows with milk somatic cell count of 400 000 or above	15.1 (0.0–32.3)	14.2 (0.0–28.5)	15.7 (4.3–32.3)	0.519
Percentage of mortality	2.7 (0.0–31.2)	2.0 (0.0–5.6)	3.2 (0.0–31.2)	**0.004**
Percentage of dystocia	5.7 (0.0–33.0)	4.9 (0.0–20.0)	6.3 (0.0–33.0)	0.234
Percentage of downer cows	5.0 (0.0–22.1)	5.2 (0.0–17.2)	4.9 (0.0–22.1)	0.497
Percentage of disbudded/dehorned cows*	81.8 (0.0–100)	55.6 (0.0–100)	99.2 (85.0–100)	**<0.001**

* For information only. Additional other measures are required for the calculation of the criterion "Absence of pain induced by management procedures".

Table 7
Results at the level of Welfare Quality® measures for the Welfare Quality® principle "Appropriate Behavior" in dairy cows presented in mean values, range (min–max), and significance of the group differences. *P*-values smaller than 0.05 are marked in bold ($P < 0.05$).

Welfare Quality® principle and measures	All farms (n = 115)	Organic farms (n = 46)	Conventional farms (n = 69)	*P*-value
Appropriate Behavior				
Frequency of head butts per cow per hour	0.3 (0.0–1.6)	0.2 (0.0–0.8)	0.3 (0.0–1.6)	**0.002**
Frequency of displacements per cow per hour	0.1 (0.0–1.3)	0.2 (0.0–0.8)	0.1 (0.0–1.3)	**0.004**
Number of days on pasture per year*	164.2 (0.0–365)	205.0 (150.0–365)	137.0 (0.0–365)	**<0.001**
Number of hours on pasture per day*	10.2 (0.0–24)	15.0 (4.0–24)	7.1 (0.0–20.0)	**<0.001**
Number of days with access to outdoor loafing area per year*	93.4 (0.0–365)	163.2 (0.0–365)	46.9 (0.0–365)	**<0.001**
Number of hours with access to outdoor loafing area per year*	6.2 (0.0–24)	10.5 (0.0–24)	3.4 (0.0–24)	**<0.001**
Percentage of cows that can be touched	30.2 (0.0–89.7)	39.5 (0.0–89.7)	24.0 (0.0–66.6)	**0.001**
Percentage of cows that can be approached up to 50 cm but not touched	52.4 (10.2–95.8)	48.9 (10.2–95.8)	54.7 (21.2–94.1)	**0.041**
Percentage of cows that can be approached to between 50 and 100 cm	13.9 (0.0–50.6)	9.2 (0.0–41.9)	17.0 (0.0–50.6)	**<0.001**
Percentage of cows with an avoidance distance greater than 100 cm	3.3 (0.0–23.5)	2.1 (0.0–15.5)	4.1 (0.0–23.5)	**0.037**

* For information only. These measures are included in the criteria "Ease of movement" and "Expression of other behavior".

farms within one farming system (Dippel et al., 2009; Gratzer et al., 2011; Ivemeyer et al., 2012; Brenninkmeyer et al., 2013; Kirchner et al., 2014; Tremetsberger et al., 2014). For example, most of the 46 organic farms reached a very high overall welfare score (about 75% "enhanced" or excellent"), but one of the organic farms got the worst rating in our study and had a very poor welfare status (according to WQ® "not classified"). Differences between the farming systems will be discussed in more detail in the following for each WQ® principle.

Welfare Quality® Principle "Good Feeding"

The divergence between the two types of farming in relation to this principle is due to differences in the drinking water supply, which affects the WQ® criterion "Absence of prolonged thirst". Langford et al. (2009) found no differences in water trough dimensions (i.e., number of troughs per group of cows, height of troughs, and surface area of troughs per 10 cows) in housing for lactating cows on organic and conventional farms in the United Kingdom. Moreover, it is important to note that water provision is described as a resource-based measure in WQ®: the actual water intake is not measured, and neither are climate and water content of feed taken into account. The influence of these three points should be considered, since the number of water points and the dimensions of troughs and their cleanliness alone cannot comprehensively determine water provision. Therefore, the water provision assessment according to WQ® should be reconsidered to include, for example, animal-related measures that are more relevant for the

characterization of the actual welfare situation of the cows (de Vries et al., 2013). Apart from this, there is great potential for improvement in both farming systems with little effort required on behalf of the farmers.

With regards to the WQ® criterion "Absence of prolonged hunger", which was measured by the "Percentage of very lean cows" measure, there were no significant differences between the farming systems. This was in line with further studies, which also found no differences in the assessment of body condition score between the two farming systems (Roesch et al., 2005; Sato et al., 2005; Fall et al., 2008).

Welfare Quality® Principle "Good Housing"

The high score (on average "enhanced") reached in both farming systems was due to the fact that all the farms visited kept their cows in loose housing systems. The significantly better evaluation for organic farms is a result of a better performance in the WQ® criterion "Comfort around resting". Although the organic farm animals showed a lower level of cleanliness in all three body regions (Table 5), they achieved an overall higher score in this WQ® criterion. This was due to a better performance in the remaining indicators in this WQ® criterion. In turn, these results can be attributed to the higher quality of the lying areas on the organic farms based on the European regulation of organic production (EC 2008; EU 2018), which prescribes bedding areas with litter. Rushen et al. (2007) described that cows prefer clean, dry and soft surfaces for lying down and resting and Tucker et al. (2003) showed that cows preferred deep-bedded lying areas to thin, sparsely littered geotextile mattresses. On the other hand, the deep littered free lying areas, which were more prevalent in our study on the organic farms (Table 2), also had an impact on this positive result, e.g. regarding the lying-down behavior. It can be assumed that this percentage of farms with deep littered free lying area in our study (54%) is higher than would be expected in German organic dairy farming in general, and this is substantiated in other studies. Despite an absence of recent data, a survey by Hörning et al. (2003) reported that out of 226 considered loose-housed herds, only 23% had straw yards, equating to15% in total of all 345 farms (including tie-stalls). In a European study of 192 organic dairy farms across four countries, Blanco-Penedo et al. (2019) conducted a cluster analysis based on the farm structure and milk recording data. They identified three clusters. The cluster with the highest percentage of deep litter systems (which included 54 of the 60 German dairy farms), still only had 28% straw yards, compared to 71% of cubicle housing for the lactating cows. But there is also a negative effect of these free lying areas, which concerns the cleanliness of the cows. Fregonesi and Leaver (2001) described that cows kept in barns with straw yards were significantly less clean than cows kept in barns with cubicles. Weary et al. (2009) examined the effects of different neck rail positions on the cleanliness of cows in cubicle systems and found a higher contamination level and dirtier udders in stalls with less restrictive positioned neck rails. As described above, our study also showed that the percentage of clean animals was lower in organic farms, where – compared to conventional farms – there were more free lying areas with deep bedding.

Welfare Quality® Principle "Good health"

Welfare Quality® Criterion "Absence of injuries"

The difference between the farming systems for this WQ® criterion was probably due to the better quality of the lying areas, which in turn can be justified to a certain degree by the requirements of the European regulation of organic production (EC, 2008) as mentioned above. Coignard et al. (2013) found a significantly better overall WQ®-health score in French dairy cattle herds which had straw yards, compared to the herds that were housed in cubicles. In our study, the high prevalence of straw yards probably also contributed to the better rating of organic farms regarding the WQ® principle "Good Health", but also has an effect on the WQ® criterion "Absence of injuries", which in turn influences this WQ® principle (lower prevalence of moderate lameness $P < 0.05$, Table 6). This difference between the farming systems is consistent with other studies (Dippel et al., 2009; Rutherford et al., 2009; Brenninkmeyer et al., 2013). Also, more lame cows were found in cubicle loose housing than in housing systems with a free, deeply bedded lying area (Somers et al., 2003; Brinkmann and March, 2010). The occurrence of joint damage and lameness were partly caused by the same risk factors in this multifactorial process: the design and quality of the lying surface had a decisive influence (Cook, 2003; Bernardi et al., 2009; Brenninkmeyer et al., 2013). Additionally, access to pasture, which was more common in the investigated organic farms, could reduce lameness (Hernandez-Mendo et al., 2007; Rutherford et al., 2009; Burow et al., 2013a; Sjöström et al., 2018).

Welfare Quality® Criterion "Absence of pain induced by management procedures"

Differences between the two types of farming were found with regard to dehorning and disbudding of calves. In our study, 20 organic farms (43.5%) kept horned cows but only one conventional farm did the same (Table 6). This difference between organic and conventional dairy farms in Germany seems to be in line with findings of Hörning et al. (2003) and Irrgang (2012), but differs from the situation in other European countries, where the percentage of organic farms keeping horned cows is higher: Cozzi et al. (2009) reported 43% of European organic farms practice disbudding/dehorning, and in European conventional farms this is 74%. In our study we did not consider any tie-stalls which – according to the available studies – have a higher proportion of horned cows, so we probably overrepresented the horned herds. Nevertheless there is a structural difference in disbudding routines between organic and conventional farms: the European regulation of organic production states that "operations such as dehorning may not be done routinely", but "the competent authority may allow them for reasons of health or security, case by case" (EC, 2008). In Germany it is mandatory for organic farmers to use anesthesia when disbudding calves (for example in Lower Saxony, www.laves.niedersachsen.de/download/112166). Therefore, all 26 organic farms in our study that kept dehorned dairy cows stated that they disbud the calves under anesthesia; in conventional farms, however, 31 of the 68 farms administered anesthesia when disbudding. The relatively large proportion of conventional farms using anaesthesia could be explained by the fact that (a) the (conventional) farms participating in the voluntary animal welfare program and were therefore presumably more sensitive to this issue, (b) dehorning methods were being intensively discussed in Germany at the time of the survey, as legal requirements were being developed or (c) some participants misunderstood the question which lead to over declaration of the use of anesthesia. The administration of additional painkillers during/after disbudding was also more common on organic farms: all but three organic farms provided this additional care option, whereas in half of the conventional farms no analgesic was administered for disbudding (37 vs. 31 farms). These differences were probably due to the legal standards and the animal friendly management measures prevalent in organic farming systems.

Welfare Quality® Criterion "Absence of disease"

Although there were no significant differences regarding the WQ® criterion "Absence of disease", at the more detailed level of

WQ® measures some differences between the farming systems were found. The lower "Percentage of coughing per cow per 15 min" in organic farms could possibly be traced back to the fact that animals were less exposed to the higher emissions of ammoniac, infiltration or dust in the barn. On the one hand this could be explained by access to the outdoor loafing and/or to pasture, which was provided more frequently and for longer periods for cows in organic farms than conventional farms (Table 7). For example, Richert et al. (2013) reported that, on grazing dairy farms, cases of pneumonia were four times lower than in non-grazing herds. On the other hand, the lower "Percentage of coughing cows per 15 min" could have been a result of the reduced ammonia load in organic farms due to fewer slatted floors (Zhang et al., 2005), more bedding (Gilhespya et al., 2009) and a lower stocking density of livestock (Charpiot et al., 2012). These points corresponded to by the requirements of organic farming.

The term 'mortality' includes all animals that have died as well as those that have been euthanized or emergency killed. It is of great importance from both a welfare and economic perspective and depends on individual farm management (Dechow et al., 2012). The mortality rate of cows in the project farms was 2.8%, which is lower than reported by Burow et al. (2011) for 391 Danish dairy farms (5.6%) and by Pannwitz (2015) for all German states (3.7–5.9%). Concerning differences between farming systems Thomsen et al. (2006) in Denmark and Alvåsen et al. (2012) in Sweden describe – in line with our results – a lower mortality rate in organic farms compared to conventional farms. They also found that herd size had an effect, namely that mortality was higher in larger herds. However, a recent study in Germany showed that herd size had no significant influence on mortality in cows (Gieseke et al., 2018).

Welfare Quality® Principle "Appropriate Behavior"

The differences in the WQ® criterion "Expression of other behavior" could be related back to the regulations regarding organic farming. The impact of grazing on animal welfare is described in current literature, e.g., Arnott et al. (2017) and Mee and Boyle (2020) presenting the advantages and disadvantages/risks, respectively. For example, pasture could be beneficial for animal health issues such as mastitis, lameness or metritis (Burow et al., 2013b; Armbrecht et al., 2019; Grimard et al., 2019). Furthermore, access to pasture could also allow dairy cattle to express their natural behavior, such as grazing and exploration, and improve the comfort around resting (Hemsworth et al., 1995; Wagner et al., 2018). Nonetheless there are some negative effects that can also be associated with grazing, for example in terms of parasite infestation, climatic stress or hunger (Höglund et al., 2010; Sorge et al., 2015, Polsky and von Keyserlingk, 2017; Mee and Boyle, 2020). For example, a higher parasite load was found in the fecal samples on organic farms compared to conventional farms. However, if the cows are given the choice between barn and pasture, they prefer the pasture, even if only at night (Legrand et al., 2009).

Concerning the WQ® criterion "Good human-animal relationship", the better human-animal relationship (HAR) on organic farms could be explained by the significantly smaller herds compared to conventional farms, accompanied by fewer employees. Previous studies found a correlation between herd size and HAR; the larger the herd size, the greater the avoidance distance and the lower the proportion of animals that could be touched (Waiblinger and Menke, 1999; Mattiello et al., 2009). Furthermore, Ebinghaus et al. (2018) determined an association between herd size and a higher percentage of cows that avoided the approaching human at ≥100 cm, and they found a relationship between a higher median avoidance distance and the percentage of dehorned cows. In fact, herd sizes were on average lower in our organic project farms and fewer dehorned cows were found in these organic herds (Table 6), which could explain the differences in the HAR.

Conclusion

In line with our hypothesis, we found significant differences between organic and conventional farming systems for all four WQ® principles. Despite the better performance of the organic farms, the animal welfare principle "Good Health" in particular showed potential for improvement. Indeed, all dairy farms investigated in this study had the potential to improve animal welfare. To achieve this, it is necessary to identify farm-specific opportunities and derive possible specific measures/interventions from them. The range of all values was very large in both farming systems, indicating that farm-specific management is of great importance. Even though the European regulations of organic production offer great potential for good animal welfare, they cannot provide a guarantee. These current regulations, which at present focuses only on action-oriented/-based demands, should therefore be supplemented by outcome-based assessments to consider and safeguard the health-related aspects of animal welfare.

Ethics approval

Not applicable. In this study, no invasive measurements were carried out on farms, i.e. no laboratory animals were used.

Data and model availability statement

None of the data were deposited in an official repository. The data that support the study findings are available upon request.

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Declaration of interest

None.

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