The Old School, Brewhouse Hill, Wheathampstead,
Hertfordshire AL4 8AN, UK
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Assessing the welfare level of intensive fattening pig farms in Germany with the Welfare Quality® protocol: does farm size matter?

SEK Meyer-Hamme†, C Lambertz*‡ and M Gauly‡

† Department of Animal Sciences, Georg-August-University, Albrecht-Thaer-Weg 3, 37075 Göttingen, Germany
‡ Faculty of Science and Technology, Free University of Bozen-Bolzano, Universitätsplatz 5, 39100 Bolzano, Italy
* Contact for correspondence and requests for reprints: Christian.Lambertz@unibz.it

Abstract

*The housing condition of pig (*Sus scrofa*) fattening farms are increasingly receiving criticism, because they are associated with impaired animal welfare. Consumers view the increase in farm sizes critically, even though scientifically based knowledge on the relationship between farm size and welfare is still limited. Therefore, the aim of this study was to assess the welfare level of conventional fattening pig farms in Germany and to evaluate the relationship between farm size and animal welfare level. In total, the Welfare Quality® protocol (WQ) for pigs was applied on 60 farms. Farms were classified according to their size into small (< 1,500 pigs per farm), medium (1,500–3,000 pigs per farm) and large (> 3,000 pigs per farm). Independent of the farm size, the overall WQ classifications 'excellent' and 'not classified' were not recorded in any of the farms, while 'enhanced' and 'acceptable' was achieved by 80 and 20% of the farms, respectively. Farm sizes had no effect on any of the four principles 'good feeding', 'good housing', 'good health' or 'appropriate behaviour'. Overall, moderate bursitis (35%) was found to be the most prevalent indicator of welfare-related problems. However, it did not differ between farm sizes. Another highly prevalent indicator, moderately soiled body, increased from 11.1% in small- to 20.8% in large-sized farms. In conclusion, our findings show that none of the farm sizes were superior in terms of animal welfare. Overall, acceptable or enhanced scores were achieved for many of the criteria, however the need for improvement in other criteria such as 'expression of other behaviour' and 'positive emotional state', was clear.*

Keywords: *animal-based indicators, animal welfare, farm size, fattening pigs, housing systems, Welfare Quality® assessment protocol*

Introduction

Modern pig fattening facilities are designed to optimise management and increase efficiency, and are generally large production units in terms of the number of animals kept on a single farm (Turner *et al* 2003; Farm Animal Welfare Committee [FAWC] 2012). Recently, Kayser *et al* (2012) demonstrated that German consumers associate the term 'intensive farming' with a farm size of more than 1,000 pigs per farm. In Germany, the average farm size is 1,037 fattening pigs per farm, whereas 74% of all pigs are kept in farms with more than 1,000 and even 18% with more than 5,000 animals per farm (Statistisches Bundesamt 2014). The proportion of farms in the latter category, in particular, is continually growing (FAWC 2012). These production conditions are subject to increasing criticism from society and from politicians since they are believed to impair the welfare of the animals (Kayser *et al* 2012; Velarde *et al* 2015). Public discussions are hindered by the fact that no definition of intensive or industrial farming exists. Previous studies have mainly focused on the effects of farm sizes on health parameters and reported contradictory results. On the one hand, the risk of pathogens being imported through purchased animals and then transmitted by a high number of potentially susceptible animals is higher in larger units. On the other, large farms commonly implement improved hygiene measures (Gardner *et al* 2002). Carstensen and Christensen (1998) reported a higher incidence of salmonellosis with increasing farm size but Van der Wolf (2001) found the opposite. In contrast, farm size did not affect salmonellosis in the studies of Zheng *et al* (2007) and Baptista *et al* (2010). Farm size was also shown not to affect respiratory diseases, such as enzootic pneumonia and influenza in studies by Maes *et al* (2008) and Grøntvedt *et al* (2013).

Studies investigating the effect of farm size on animal welfare are rare and have only focused on a very limited number of welfare indicators (Winckler & Leeb 2010). Knage-Rasmussen *et al* (2013), for example, did not find any relationship between farm size (120 to 7,825 pigs per farm) and behaviour or health parameters. Also, the occurrence of tail-biting, one of the major welfare problem in pig fattening, did not differ between farm sizes (500 to 7,500 pigs per farm) in the study of Moinard *et al* (2003). Comparisons between studies are difficult due to variations in study designs, country-specific production and environmental conditions, and varying welfare indicators.

Studies on the effect of dairy farm size and animal welfare found that large farms benefit from professional management which, in turn, reduces welfare risks and improves the lives of the animals (Robbins *et al* 2016). As proposed by Robbins *et al* (2015), cases of animal neglect and mistreatment are perhaps more likely to occur on smaller farms, because specialisation might result in superior farmers' expertise on larger ones.

Since animal welfare is multifactorial and needs a combination of various parameters for its evaluation (Blokhuis *et al* 2003), the Welfare Quality® assessment protocol (WQ; Welfare Quality® 2009) was developed as an on-farm assessment tool. In the protocol, animal welfare is defined as a multidimensional concept consisting of the absence of thirst, hunger, discomfort, disease, pain and injuries and stress and the expression of normal behaviour (Veissier 2007). WQ is widely accepted by stakeholders and researchers (Blokhuis *et al* 2013), although there is still a considerable number of challenges regarding the reliability, validity, feasibility and costs of assessments (Knierim & Winckler 2009). Recently, it has been used to assess the welfare status of growing pigs raised under intensive production systems (Temple *et al* 2011b, 2012). However, effects of varying herd sizes on the well-being of fattening pigs has yet to be studied. The impact of group size (small: < 15 pigs per pen; medium: 15 to 30 pigs per pen; and large: > 30 pigs per pen) on welfare indicators in fattening pigs was evaluated by Meyer-Hamme *et al* (2016), where none of the studied group sizes proved to be superior. Munsterhjelm *et al* (2015) also did not observe an effect of group size on welfare problems. The most important environmental determinants of pig welfare were found to be space allowance and the use of bedding.

The aim of this study was to evaluate the welfare level of conventional fattening pig farms in Germany and to assess its relationship to farm size.

Materials and methods

Farms and animals

Sixty conventional pig farms, located in Northern Germany, with sizes ranging from 250 to 11,000 pigs per farm were assessed using WQ. Eighty percent of the farms raised only fattened pigs, while 20% had a closed system raising sows, piglets and fattening pigs.

Farm acquisition was organised with the help of the Association of Pig Farmers in Germany (ISN eV). Only conventional full-time farms with indoor barns, equipped with fully or partly slatted concrete floors, forced ventilation system, automatic feeding systems and 'all-in-all-out' management were included. Participation was voluntary, with all farms being members of the aforementioned association.

One single assessor, who had received intensive training on the correct application of WQ, performed data collection between September 2013 and June 2014. The assessor was trained in the theory and practice of WQ by two persons who participated in a training session held by experienced trainers of the Welfare Quality® Network group. Assessment on all farms began in the morning.

Farm size was defined as the number of pigs raised at the same location (Report of the Agricultural Policy Advisory Council 2015). Three farm size categories were defined as: i) small: < 1,500 pigs per farm; ii) medium: 1,500 to 3,000 pigs per farm; and iii) large: > 3,000 pigs per farm. Each category consisted of 20 farms. Categories were defined considering the development of farm sizes in pig production in Germany in recent years according to the federal statistical office (Statistisches Bundesamt 2014) and in accordance with the classification of pig farms by the German Federal Pollution Protection Act (Bundes-Immissionsschutzgesetz 2013).

The age of the barns was independent of farm size and ranged from 10 to more than 25 years. All barns were insulated but had different mechanical ventilation systems (ie doorway ventilation, channel ventilation, underfloor extraction, perforated steel plates or wood wool cement boards). Pigs were kept on fully (92% of the farms) or partly slatted (8%) concrete floors. Either automatic or sensor-controlled liquid feeders (62%) or dry- or pulp-feeding automats (38%) were used. All of the observed pens were equipped with enrichment material (chain with a ball or piece of wood).

Pigs entered the fattening farms with a mean (± SEM) bodyweight of 29.9 (± 2.8) kg and were slaughtered at 120.8 (± 3.5) kg. The age classes of the pigs being assessed varied between farms but did not differ between herd size classes. Tail-docking was performed in all pigs at an age of approximately four days. The working time per fattening place, as estimated by farmers, ranged from 0.13 to 1.42 h.

Assessment using the Welfare Quality® protocol

The Welfare Quality® assessment protocol for pigs (Welfare Quality® 2009) was carried out during the farm visit. Briefly, farm-related data (feeding and hygiene management, prevention of diseases, mortality rate, castration and tail-docking practices) were gathered by interviewing each farmer at the beginning of the assessment. Data on the prevalence of pneumonia, pleurisy, white spots on liver and pericarditis were collected from slaughterhouse records. Average values for the preceding year were used in the calculations. After the assessor had obtained an overview of the design of the stable, barns and the whole farm, ten pens for the animal-based assessment and the observation points for the behavioural observations were selected following the WQ instructions. In each of these pens up to 15 individuals were selected for observation. Both pens and pigs were chosen randomly. Hospital pens were not considered.

Measures were scored on a three- (0 = absent, 1 = light affection, 2 = strong affection) or two-point scale (0 = absent, 2 = present). Pigs were individually scored from inside the pen for body condition, bursitis, manure on the body, wounds, tail-biting, lameness, laboured breathing, twisted snouts, rectal prolapse, skin condition and hernias. Wounds, pig dirtiness (manure on the body), skin condition and bursitis were observed only on one side of the pig, because differences between body sides can be neglected

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for these measures (Courboulay & Foubert 2007). Furthermore, for feasibility reasons, WQ recommends that the assessor should choose the side with the optimal view for observation. Shivering, panting, and huddling were scored prior to the assessor entering the pen. Huddling was recorded only in resting animals.

The principle 'appropriate behaviour' was assessed by means of social and exploratory behaviour, qualitative behaviour assessment (QBA) and human-animal relationship test. In all farms, QBA was carried out as the first observation and at four randomly chosen points. At each point, animals were observed for 5 min after which point they were rated on a visual analogue scale (0–125 mm with 0 = absent and 125 mm = dominant) with respect to the following 20 adjectives: active, relaxed, fearful, agitated, calm, content, tense, enjoying, frustrated, bored, playful, positively occupied, listless, lively, indifferent, irritable, aimless, happy, distressed and sociable. The values obtained on each farm for the 20 terms of the QBA were then transformed into an index based on a weighted sum. This index was then converted into a score using an I-spline function (Welfare Quality® 2009). QBA data were expressed at farm level.

Following QBA, social and exploratory behaviour were assessed using scan samples at three randomly chosen observation points of the farm, which differed from the QBA observation points. For the assessment of the social and exploratory behaviour, all the pigs in the pens were forced to stand up. If necessary, hands were clapped before starting with the observation 5 min later. During this time, coughing and sneezing was counted and scouring assessed. Afterwards, 40–60 animals were scan-sampled with 2-min intervals for a total of 10 min at each observation point. During scan-sampling, positive social, negative social, pen investigation, use of enrichment material, other active behaviour (ie eating, drinking) and resting were differentiated. Another three observation points were chosen for additional assessment of coughing and sneezing. In total, 20–40 animals at each of the six observation points were analysed. The exact number of observed animals depended on the group size.

The human-animal relationship test was carried out after entering the pen and walking around in one direction. Then, the observer waited in the middle of the pen for 30 s, before walking around the pen in the other direction. Ratings were: 0) no panic present; and 2) more than 60% of the pigs showing panicking behaviour. For the human-animal relationship test, the number of pens with a panic response from the total observed pens per farm expressed as a percentage was used for further analysis.

Furthermore, resource-based parameters, such as the number, functioning and cleanliness of the drinkers, were recorded. In order to determine space allowance, pen size was measured and the average weight of the animals calculated using the weight at the start of the fattening period, the length of the fattening period at the assessment and assuming an average weight gain of 800 g per day.

The assessed measures were aggregated to 12 criteria, four principles and an overall assessment using the algorithms of WQ. On the given scale for principles and criteria, score 0 represents the worst and 100 the best welfare state. The overall assessment of a farm was rated as 'excellent', 'enhanced', 'acceptable' or 'not classified'. 'Excellent' suggests that the welfare of the animals is on the highest level, 'enhanced' that it is good and 'acceptable' that it is above or meets animal requirements. Farms are 'not classified' when the welfare of the animals is low and has to be considered as unacceptable. In fact, the individual criteria within a particular principle do not compensate for each other, thus a high score in one does not compensate for a low score in another. A farm is considered to be 'excellent' if it scores more than 55 in all principles and more than 80 in two of them, 'enhanced' if it scores more than 20 in all principles and more than 55 in two of them, 'acceptable' if it scores more than ten in all principles and more than 20 in three of them. A farm is 'not classified' if this minimum standard is not reached.

Statistical analysis

The SAS statistical package version 9.3 (SAS Institute Inc, Cary, NC, USA 2010) was used. Generalized Linear Mixed Models using the GLIMMIX procedure were performed separately for the animal-based measures, criteria (absence of prolonged hunger, absence of prolonged thirst, comfort around resting, thermal comfort, ease of movement, absence of injures, absence of diseases, absence of pain, expression of social behaviour, expression of other behaviours, good human-animal relationship, positive emotional state), principles (good feeding, good housing, good health, appropriate behaviour) and the overall assessment. The individual animal-based measures were expressed as the proportion of pigs in the pen with a score of 1 or 2 indicating poor welfare evaluated in each pen. After visual assessment of the residuals and performance of the Chi-squared goodness-of-fit test, a Poisson distribution and a logarithmic-link function were assumed. As fixed effect, the farm category (small, medium and large) was included. The farm served as random effect to account for the possible dependence between observations of pens from the same farm. Differences between farm categories were assessed by applying the Tukey-Kramer test. Scores are presented as Least Square Means (LSM) and standard error. Significance was established at $P < 0.05$.

Additionally, a Principle Component Analysis (PCA) applying the FACTOR procedure without rotation was performed for the QBA, in order to highlight the relationship among the single adjectives. This was done at the level of the 20 different attributes. Single PCAs were calculated for the three herd size categories. To verify that PCA assumptions were met, the Bartlett's test ($P < 0.0001$) and Kaiser-Meyer-Olkin Measure of Sampling Adequacy (0.77) were performed. The factor loadings quantified the weight each adjective had on the two main axes (Rencher 2002). Factor loadings greater than or equal to 0.40 were interpreted as highly positive and factor loadings less than or equal to –0.40 as highly negative (O'Rourke & Hatcher 2013). The first two principle components (factor 1 and factor 2) with an eigenvector of greater than 1.0 were retrieved. The values were plotted in a two-dimensional interpretative word chart.

Table 1 Distribution (in % of farms) of space allowance (legally justified and not legally justified), floor type (fully and partly slatted), feeding system (dry or liquid), group sizes (small, medium and large), number of pigs per drinker, vaccination rate and deworming rate, separated by farm size (small: < 1,500 pigs per farm [n = 20 farms], medium: 1,500 to 3,000 pigs per farm [n = 20 farms] and large: > 3,000 pigs per farm [n = 20 farms]).

Farm size	Space allowance†		Floor type		Feeding system	
	Not according to the legal regulations	Acccording to the legal regulations	Fully slatted	Partly slatted	Dry	Liquid
Small	16.2	16.0	30.0	3.3	22.7	9.7
Medium	15.8	18.2	31.2	2.2	10.3	23
Large	8.7	25	31	2.3	4.7	28.7
Total	40.7	59.3	92.2	7.8	38.7	61.3

	Group size			Pigs per drinker		Vaccination‡	Deworming
	< 15 pigs per pen	15 to 30 pigs per pen	> 30 pigs per pen	< 10 pigs per drinker	> 10 pigs per drinker		
Small	9.8	17.7	5.8	26	7.3	95.0	35.0
Medium	12.7	11.7	9.0	26.7	6.7	100.0	60.0
Large	12	13.5	7.8	26	7.3	85.0	40.0
Total	34.5	42.8	22.7	78.7	21.3		

† Space allowance: According to the legal regulations = 30 to 50 kg = > 0.5 m^2 per pig; 51 to 110 kg = > 0.75 m^2 per pig; > 111 kg = > 1 m^2 per pig; Not according to the legal regulations = space allowance below the thresholds of the regulations.
‡ Vaccination against *Mycoplasma* spp and porcine circovirus type 2 during the fattening period.

Results

The majority of the farms fattened castrates and females. Boars and females were kept on 15% of the farms, while two farms fattened boars, castrates and females. In the majority of the studied pens (60%), females and castrates were kept in mixed groups, while boars mixed with females (6%) and boars alone (4%) were only found in exceptional cases. In the other pens, males and females were raised separately. The distribution of sexes was similar between farm size classes. Pen sizes ranged between ten and 350 animals.

In Table 1, farm-related data are shown for the three different farm size categories. On average, 1.3 m^2 were available per 100 kg bodyweight (range 0.5 to 5.4 m^2). The mean space allowance was 0.83 m^2 per pig ranging from 0.3 to 2.5 m^2. The space allowance in more than 40% of the pens was below the German Farm Animal Welfare Regulations (Tierschutz-Nutztierhaltungsverordnung 2006) and overcrowded pens (pens below the German Farm Animal Welfare Regulations) were found on 92% of the farms. The proportion of overcrowded pens was lowest on large farms. Partly slatted floors were similarly distributed among farm size categories, whereas the proportion of liquid-fed pigs was highest in large farms. Group sizes with less than 15 or more than 30 pigs per pen were equally distributed between farm sizes (Table 1).

Regarding hygiene management, all farms practiced an 'all-in-all-out' system applying standard hygiene measures. After depopulation, barns were soaked with water for a few days, cleaned with high-pressure cleaners and disinfected.

Overall assessment

While none of the farms was classified as 'excellent' or 'not classified', 17 (85%), 16 (80%) and 15 (75%) of the small, medium and large farms, respectively, achieved the overall WQ assessment 'enhanced'. The remaining farms were classified as 'acceptable'. The scores for the different criteria and principles for the farm size categories are presented in Table 2.

Principle 'Good feeding'

Farm size did not affect the principle 'good feeding' ($P > 0.05$) (Table 2), which scored the highest of all four principles. This was mainly due to the fact that only a very limited number of pigs had a poor body condition (Table 3). The criterion 'absence of prolonged thirst' was scored, on average, below 90 points in all farm size classes, mainly because of an insufficient number and poor functionality of the drinkers. The number of animals per drinker ranged from 2 to 43. The only type of drinkers found on the farms were nipple drinkers. As shown in Table 1, on 21% of the farms more than ten pigs had to share one drinker. Furthermore, in 6.7% of pens, only one drinker per pen was available, which seven to 22 pigs shared. On 38% of the farms, at least one drinker did not function correctly. There were farms with a liquid feeding system (n = 3 farms), which had either no additional drinkers or turned them off at a certain point in the fattening period. These deficits were observed in each farm size category.

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Table 2 Results of the Welfare Quality® assessment at the level of principles (italics) and criteria (least square means [LSM], [± SEM], range), separated by farm size (small: < 1,500 pigs per farm [n = 20 farms], medium: 1,500 to 3,000 pigs per farm [n = 20 farms] and large: > 3,000 pigs per farm [n = 20 farms]).

Principle/Criteria	Farm size						*P*-value[†]
	Small		Medium		Large		
	LSM (± SEM)	Range	LSM (± SEM)	Range	LSM (± SEM)	Range	
Good feeding	86.9 (± 4.8)	41.4–100.0	86.7 (± 4.8)	57.0–100.0	86.6 (± 4.8)	38.3–100.0	ns
Absence of prolonged hunger	99.7 (± 0.2)	95.2–100.0	99.8 (± 0.2)	98.4–100.0	99.8 (± 0.2)	98.5–100.0	ns
Absence of prolonged thirst	86.5 (± 5.1)	40.0–100.0	87.0 (± 5.1)	55.0–100.0	87.0 (± 5.1)	35.0–100.0	ns
Good housing	71.7 (± 1.6)	56.9–81.5	71.3 (± 1.6)	61.2–82.4	70.5 (± 1.6)	54.0–84.3	ns
Comfort around resting	69.2 (± 2.2)	48.7–82.9	69.6 (± 2.2)	55.2–80.9	66.4 (± 2.2)	43.3–87.6	ns
Thermal comfort	100.0 (± 1.2)	100.0–100.0	98.0 (± 1.2)	59.0–100.0	100.0 (± 1.2)	100.0–100.0	ns
Ease of movement	73.0 (± 1.7)	59.7–88.6	71.0 (± 1.7)	56.8–86.6	75.7 (± 1.7)	60.3–87.4	ns
Good health	29.8 (± 1.9)	20.1–38.4	28.2 (± 1.9)	16.8–48.9	29.4 (± 1.9)	18.3–48.8	ns
Absence of injuries	84.3 (± 2.3)	65.5–98.4	87.6 (± 2.3)	59.6–99.7	89.9 (± 2.3)	66.8–99.2	ns
Absence of diseases	71.4 (± 4.7)	29.0–100.0	56.3 (± 4.7)	29.0–100.0	64.2 (± 4.7)	34.1–100.0	0.08
Absence of pain	11.0 (± 2.4)	8.0–38.0	14.0 (± 2.4)	8.0–38.0	12.5 (± 2.4)	8.0–38.0	ns
Appropriate behaviour	30.9 (± 1.2)	21.9–39.9	33.1 (± 1.2)	25.1–46.7	33.7 (± 1.2)	24.9–45.6	ns
Expression of social behaviour	52.8 (± 3.4)	29.3–74.6	57.1 (± 3.4)	34.4–85.1	61.6 (± 3.4)	30.7–93.3	ns
Expression of other behaviours[‡]	23.7 (± 1.6)	15.2–38.4	26.8 (± 1.6)	16.4–41.7	26.9 (± 1.6)	13.0–38.7	ns
Good-human-animal relationship	65.5 (± 6.4)	15.5–100.0	69.0 (± 6.4)	15.5–100.0	75.3 (± 6.4)	30.2–100.0	ns
Positive emotional state[§]	37.9 (± 2.4)	15.4–60.1	36.4 (± 2.4)	15.1–53.0	37.0 (± 2.4)	17.0–63.5	ns

[†] *P*-value of the general linear mixed model effect of herd size category; ns = not significant ($P > 0.05$).
[‡] The criterion 'other behaviour' is based on the indicator exploratory behaviour. Exploratory behaviour includes behaviours such as pen investigation, use of enrichment material, other active behaviour (eg eating, drinking) and resting.
[§] The criterion 'positive emotional state' is assessed using QBA.

Principle 'Good housing'

For the principle 'good housing', differences between the farm sizes were not found ($P > 0.05$) (Table 2). Among all animal-based measures, moderate bursitis (35%) showed the highest prevalence, independent of the farm size ($P > 0.05$) (Table 3). This was followed by moderately soiled body (16%), where medium- and large-sized farms had a higher occurrence than small ones ($P = 0.005$).

Principle 'Good health'

There was no farm size effect on the principle 'good health' ($P > 0.05$). Among all principles, 'good health' was scored lowest (Table 2). Without differences between farm sizes ($P > 0.05$), moderate wounds (11%) was the third most common indicator of poor welfare (Table 3). In this study, tail-biting, lameness, hernia, severe wounds, skin condition, coughing and sneezing were only observed at very low rates without any difference between farm sizes. Panting and shivering were not observed at all. The mortality rate averaged 2.5%, ranging between 0.9 and 5.2% ($P > 0.05$) (Table 3). The vast majority of the small and large farms and all medium-sized farms vaccinated against *Mycoplasma hyopneumoniae* and porcine circovirus type 2. In contrast, deworming was only practiced by 35 to 60% of the farms, depending on the farm size (Table 1).

Principle 'Appropriate behaviour'

Within the principle 'appropriate behaviour', low scores were recorded in all farm sizes, while differences between categories were found neither for the principle nor for any of the related criteria ($P > 0.05$; Table 2). Scores were above 50 for the criterion 'expression of social behaviour' and above 65 for 'good human-animal relationship' in all three categories. For the criteria 'positive emotional state' (assessed using QBA) values were below 38 and for 'expression of other behaviours' (including the behaviours pen investigation, use of enrichment material, other active behaviour [ie eating, drinking] and resting) below 27.

For the measure QBA, Figure 1 presents the factor loadings of each adjective on factor 1 and factor 2 separated by farm size. Ideally, a comparison between farm size categories is displayed for the three selected adjectives agitated, listless and bored. In small farms, factor 1 retained 39.4% and factor 2 another 21.0% of the total variance. In the PCA of the medium-sized farms, factor 1 explained 35.3% and factor 2 another 22.8% of the total variance. For large farms, values were 32.4% for factor 1 and 23.9% for factor 2. The adjectives content, happy, aimless are characterised by large distances

Table 3 Scores (least square means [LSM], [± SEM]) of selected indicators of the Welfare Quality® protocol, separated by farm size (small: < 1,500 pigs per farm [n = 20 farms], medium: 1,500 to 3,000 pigs per farm [n = 20 farms] and large: > 3,000 pigs per farm [n = 20 farms]).

Indicator	Farm size			*P*-value[†]
	Small	Medium	Large	
	LSM (± SEM)	LSM (± SEM)	LSM (± SEM)	
Pneumonia	4.2 (± 2.8)	11.6 (± 2.8)	10.7 (± 2.8)	0.081
Pleurisy	3.1 (± 1.5)	4.9 (± 1.5)	4.2 (± 1.5)	ns
Pericarditis	2.5 (± 0.7)	2.3 (± 0.7)	3.3 (± 0.7)	ns
Liver spots	7.9 (± 1.7)	8.9 (± 1.7)	4.0 (± 1.7)	ns
Body condition score	0.3 (± 0.2)	0.2 (± 0.2)	0.2 (± 0.2)	ns
Moderate bursitis	34.9 (± 2.0)	34.9 (± 2.0)	34.3 (± 2.1)	ns
Severe bursitis	2.8 (± 0.8)	2.5 (± 0.7)	2.9 (± 0.7)	ns
Moderately soiled body	11.1 (± 2.1)	14.7 (± 2.1)	20.8 (± 2.1)	0.005
Severely soiled body	4.7 (± 1.4)	5.6 (± 1.4)	8.4 (± 1.4)	ns
Moderate lameness	0.6 (± 0.2)	0.1 (± 0.1)	0.5 (± 0.1)	ns
Severe lameness	0.2 (± 0.1)	0.1 (± 0.1)	0.1 (± 0.1)	ns
Moderately wounded	11.8 (± 1.7)	9.8 (± 1.7)	9.7 (± 1.7)	ns
Severely wounded	1.6 (± 0.6)	1.9 (± 0.6)	1.0 (± 0.6)	ns
Tail-biting	2.6 (± 0.6)	1.8 (± 0.6)	1.1 (± 0.6)	ns
Moderate skin condition	0.4 (± 0.2)	0.8 (± 0.2)	0.6 (± 0.2)	ns
Severe skin condition	0.0 (± 0.0)	0.0 (± 0.0)	0.0 (± 0.0)	ns
Moderate hernia	0.5 (± 0.2)	0.7 (± 0.2)	0.6 (± 0.2)	ns
Severe hernia	0.0 (± 0.0)	0.0 (± 0.0)	0.0 (± 0.0)	ns
Panic response	19.0 (± 4.0)	14.0 (± 3.9)	10.5 (± 3.9)	0.095
Mortality	2.3 (± 0.2)	2.5 (± 0.2)	2.5 (± 0.2)	ns

[†] *P*-value of the general linear mixed model effect of herd size category; ns = not significant ($P > 0.05$).

between the three farm size categories. Factor 1 of the medium-sized farms corresponded to factor 2 of the other two categories and *vice versa*. For factor 1 of the small and large herds, highly positive values were found for adjectives describing active behaviour with a positive connotation (active, agitated, enjoying, playful, lively and sociable) and highly negative values for those describing inactivity (bored, calm and relaxed). Factor 1 of the medium herd size showed adjectives expressing negative behaviour (fearful, agitated, tense, frustrated and irritable) with highly positive loadings and descriptive terms for positive inactivity (relaxed, calm, content, enjoying, happy) with highly negative loadings. A similar observation was found for factor 2. In brief, highly positive loadings for terms related to frustration (irritable, aimless and listless) and highly negative loadings for terms of relaxation (relaxed, calm, happy and positively occupied) were observed for small and large farm sizes, while it was *vice versa* for medium-sized farms.

A wide agreement between farm size classes, expressed as short distances of the same adjective, was found for the adjectives agitated, tense, calm, irritable and relaxed. Adjectives such as sociable, content and aimless were equally distributed in the chart. For the adjectives listless, bored, interested, enjoying and frustrated distances were large between medium farms and the two other farm sizes, which were close to each other.

With regard to individual measures of social and exploratory behaviour, positive (10%) was observed three times as often as negative social behaviour (3%) independent of the farm size (Table 4). In two out of the 60 farms, negative social behaviour was exceptionally high with 8 and 9%. Pen investigation was observed at a rate of more than 20% of the total active behaviour. Exploration of enrichment material, in contrast, was only performed at rates between 2 and 4% of total active behaviour. Overall, a panic response (assessed as human-animal relationship) was observed on 14% (n = 84) of all the 600 inspected pens.

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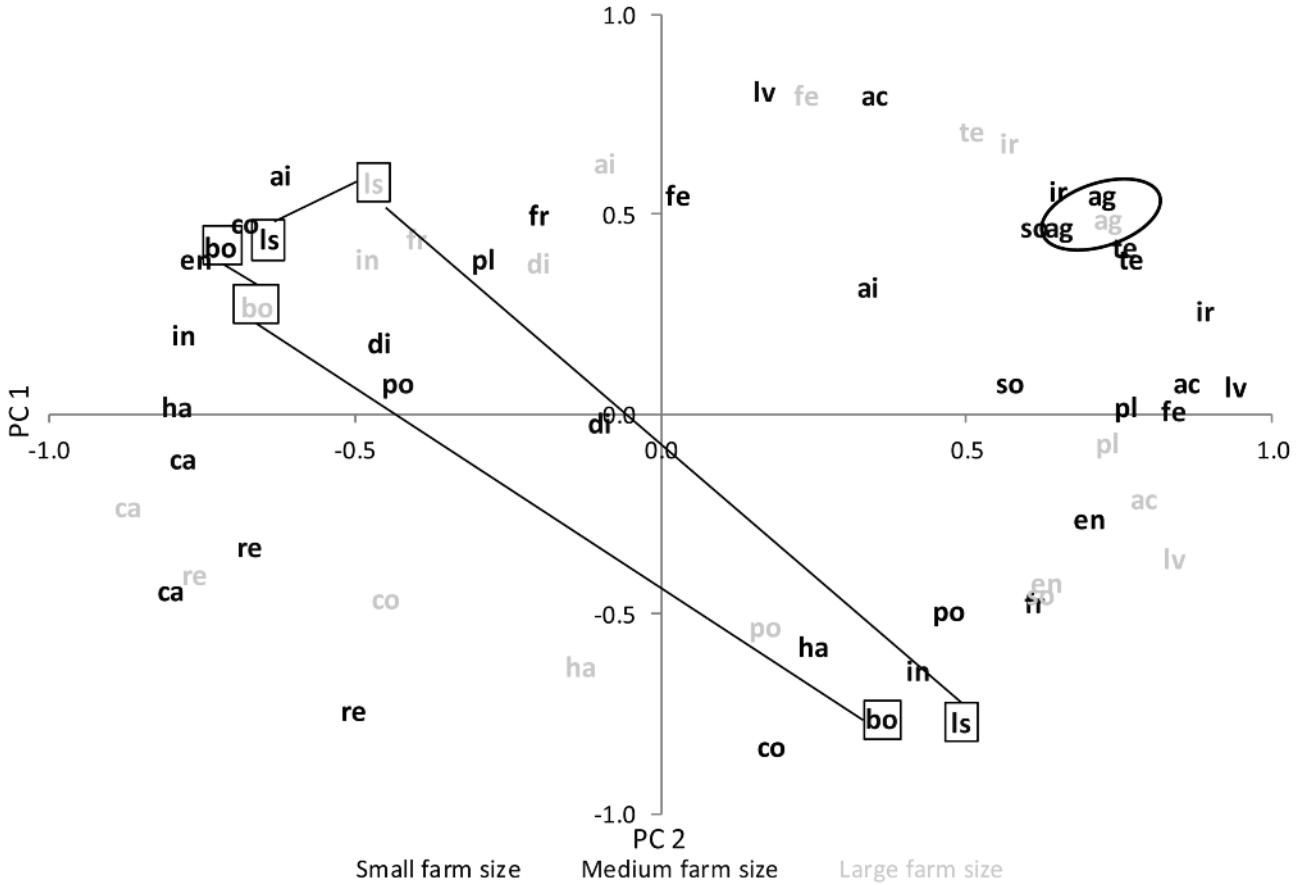
Figure 1



Results of the Principle Component Analysis of the Qualitative Behaviour Assessment (QBA) presenting loadings on principal component 1 and 2 for the 20 different adjectives for small (black; < 1,500 pigs per farm [n = 20 farms]), medium (dark grey; 1,500 to 3,000 pigs per farm [n = 20 farms]) and large (light grey; > 3,000 pigs per farm [n = 20 farms]) farms. For behaviours, (ac = active, re = relaxed, fe = fearful, ag = agitated, ca = calm, co = content, te = tense, en = enjoying, fr = frustrated, so = sociable, bo = bored, pl = playful, po = positively occupied, ls = listless, lv = lively, in = indifferent, ir = irritable, ai = aimless, ha = happy, di = distressed).

Discussion

Given the distribution of the different farm sizes and management systems in the present study, the farms can be considered as representative for conventional pig fattening farms in Germany, even though results might be biased by the fact that participating farms were members of the Association of German Pig Farmers and presumably received professional support regarding management issues. It still remains unknown whether management practices of farms from the Association of German Pig Farmers were superior to the average of all German farms, despite the fact that: i) none of the farms was classified as 'excellent'; ii) overcrowded pens were found on 92% of the farms (n = 55); iii) the water supply was insufficient on 16 farms; and iv) the high prevalence rates of bursitis, wounds and manure on the body. In addition, it has to be considered that 20% (n = 12) of the farms ran a closed system which, in general, requires a higher level of management practice and expertise because farmers have to manage the whole production cycle. This is not necessary for farmers who only raise pigs during the fattening stage. In order to avoid biased results, details on the level of education and experience of the farm workers should be considered in future welfare assessments of pig fattening farms. Usually at farm sizes of more than 2,000 pigs, farmers recruit external, generally less-experienced labour. The high variation of working time requirement per animal estimated by the farmers already depicts great variation in how farmers treat their animals. Here, not only does the working time per animal need to be considered, but also the quality of animal treatment. Of course, this is complicated to evaluate and might be based on the education of farmers and employees and their experience in swine farming.

The low welfare level regarding the principles 'good health' and 'appropriate behaviour' is broadly in agreement with other recent studies using WQ in pigs (Temple *et al* 2011b; Otten *et al* 2013). Studying only three intensive fattening pig farms, Otten *et al* (2013) found comparable values with the highest scores for the principle 'good feeding'. Pigs under intensive production conditions, which are usually fed *ad libitum*, very rarely (< 1%) show a poor body condition (Temple *et al* 2012). An inadequate water supply was also

Table 4 Effect of farm size (small: < 1,500 pigs per farm [n = 20 farms], medium: 1,500 to 3,000 pigs per farm [n = 20 farms] and large: > 3,000 pigs per farm [n = 20 farms]) on the variables of social and exploratory behaviour (least square means [± SEM]).

Behavioural measure	Farm size			Minimum	Maximum	*P*-value[1]
	Small	Medium	Large			
Active	56.6 (± 2.3)[a]	58.6 (± 2.3)[ab]	64.6 (± 2.5)[b]	36.3	83.7	0.0545
Negative social	3.1 (± 0.4)	3.3 (± 0.4)	2.6 (± 0.5)	0.4	8.9	0.5424
Positive social	9.4 (± 0.7)	10.1 (± 0.7)	10.9 (± 0.8)	3.6	18.9	0.6113
Exploration of pen fittings	22.5 (± 1.7)	22.5 (± 1.6)	24.7 (± 1.8)	11.4	39.2	0.5978
Exploration of enrichment material	2.6 (± 0.6)	4.3 (± 0.5)	3.2 (± 0.6)	0.0	9.9	0.0973

[1] *P*-value of the general linear mixed model effect of herd size category.
[a,b] Different letters within rows indicate significant differences ($P < 0.05$; Tukey-Kramer test).

reported by Otten *et al* (2013) and the fulfilment of legal requirements regarding the supply of an adequate water supply requires more attention. Regarding the water supply, it should be noted that farms with a liquid feeding system (n = 3 farms), which had either no additional drinkers or turned them off at certain point in the fattening period fulfil the requirements according to the WQ, but not according to German legislation. The maximum number of pigs per drinker, which was 43 in the present study, exceeded by far the threshold of 12 pigs according to German legislation.

Regarding farm size effects, the present results confirm those of Knage-Rasmussen *et al* (2013), who did not find any relationship between the number of pigs per farm (120 to 7,825 pigs per farm) and a welfare index composed of behavioural measurements and clinical examinations. The low prevalence of the aforementioned animal-based measurements (lameness, hernias, wounds) is also related to health and may indicate that those farms had a good quality of handling and care skills. As pointed out by Pandolfi *et al* (2017), the low prevalence of lameness, hernia and wounds is influenced by the management of the hospital pens. Even though the assessment of hospital pens is not considered by WQ nor by modified welfare schemes (eg Pandolfi *et al* 2017), the actual prevalence of, for example, lameness and hernia is biased by its exclusion. Although on-farm assessments require more time, the observation of the animals in the hospital pens is warranted, in order to at least quantify the use of hospital pens by counting the number of animals present in them. Furthermore, recording the main reasons for moving animals to the hospital pens as well as the severity of the problem, can provide the assessor with an overall picture of the health status of the farms and on the care skills.

Moderate bursitis is a sensitive indicator to compare different production systems and differentiate farms, because of high between-farm and low within-farm variability (Temple *et al* 2012). In this study, the prevalence was not affected by farm size, which might be partly explained by the fact that animals were assessed at different stages of the fattening period. Since the prevalence increases throughout the fattening period (Meyer-Hamme *et al* 2016), farm size effects might become obvious when farms are assessed at the very end of the fattening period.

Almost all of the investigated farms had slatted floors. Consequently, the values for moderately soiled body are similar to those of fattening pig farms with concrete floors reported by Temple *et al* (2011b). The occurrence of soiled bodies is multifactorial, including mainly environmental factors (Velarde & Geers 2007). The type of floor is a predominant causal factor for dirty pigs in conventional housing systems (Temple *et al* 2011b). On partly slatted floors the risk is generally higher than on fully slatted floors (Temple *et al* 2012). As more than 90% of the animals in the present study were raised on fully slatted floors, this was not further examined. Regarding feeding system as another determining factor, liquid-fed pigs were reported to be dirtier than dry-fed (Hyun & Ellis 2001). Thus, the increasing use of liquid feeding systems with an increasing number of animals per farm may explain the greater occurrence of dirty pigs in large-sized farms. Unexpectedly, the number of dirty pigs was not higher in crowded pens.

The principle 'good health' was scored worst of all principles. The criterion 'absence of pain induced by management practice' had a determining effect. Given that all farms fattened tail-docked pigs, they could only reach a score of 38 for this criterion. Farms that conducted castration in addition received a maximum score of eight for this criterion, given that none of the farms used anaesthetics or analgesics. Proposed changes in EU regulations as regards tail-docking and castration of pigs will lead to higher scores for this criterion.

Moderate wounds in this study were found more often than by Temple *et al* (2011b). In general, it remains questionable to what extent fights or an inappropriate environment were the predominating cause. In general, a higher prevalence of wounds is found in boars and castrates (Temple *et al* 2012), a dry feeding system (Botermans &

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Svendsen 2000), large group sizes (Velarde & Geers 2007), higher stocking density (Turner *et al* 2000) and in the beginning of the fattening period (Temple *et al* 2013). Mainly attributed to tail-docking (Sutherland *et al* 2008), the prevalence of tail-biting was as low as presented by Temple *et al* (2011b) under intensive fattening conditions. The average incidence of pneumonia, which was calculated from slaughterhouse data, in the small farms exceeded the warning threshold (2.7%), while the average of medium and large farms were above the alarm threshold (6.0%) (Welfare Quality® 2009). Because of the low repeatability and validity of slaughterhouse data due to unclear definitions and assessments (Schleicher *et al* 2013) and seasonal influences (Stärk *et al* 1998), results have to be considered cautiously and data should always be evaluated over at least one entire year.

According to Van de Weerd and Day (2009), intensive systems are often criticised with respect to the inability for the animals to perform species-specific behaviour. The low score for the principle 'appropriate behaviour' in the present study point out these deficits. The assessment of behaviour involves a greater degree of subjectivity in comparison to the three other principles (Temple *et al* 2011a), but both psychological and physiological parameters are indispensable when it comes to on-farm welfare assessments (Duncan & Petherick 1991).

QBA was considered as one of the main measures to assess behaviour in WQ. Its good reliability when used on-farm was recently shown by Czycholl *et al* (2017). The use of QBA in intensive pig fattening production systems, when used as implemented in the WQ, has already been reported on by Temple *et al* (2011a), and the influence of the mood of the observer on outcomes cannot be ruled out (Temple *et al* 2013; Tuyttens *et al* 2014). For further interpretation of QBA results the Principle Component Analysis (PCA) has been proposed (Temple *et al* 2011a).

When interpreting PCA results of the present study, it first has to be mentioned that the sample size was low. Second, the percentages of explained total variance of factor 1 and 2 did not differ largely within farm size categories, so that neither outweighed the other. Despite factor 1 of the medium-sized farms corresponding to factor 2 of the other two categories and *vice versa*, both factors have to be considered as important for all farm size classes. With regard to the single adjectives of the QBA, Otten *et al* (2013) observed a low proportion of pigs showing behavioural patterns, such as frustrated, indifferent and distressed. Here, as well as in the study of Temple *et al* (2011a), behaviours that are negatively connoted (tense, agitated, irritable) and therefore reflect a high level of disturbance in the animals, were found at high proportions.

In the study of Wemelsfelder and Millard (2009), factor 1 distinguished between positive and negative behaviours and factor 2 differentiated these behaviours in low and high levels of arousal. Comparison with the present findings underlines the complex physiological system involved with emotions (Temple *et al* 2011a). Although no predominating factor was found between classes of farm size classes in the present study, it has to be borne in mind that small farms tend to be run as family farms whereby the farm manager takes care of the pigs. On large farms, however, improved standard operating procedures are more likely to be implemented (Robbins *et al* 2015). Medium-sized farms might, on the one hand, be managed in such a way that would mean an optimal animal care was not provided by the available labour force on-farm. On the other hand, these farms generally do not implement improved management procedures. As already pointed out, the working time per animal and, even more importantly, the quality of the animals' treatment should be assessed in future studies to further elucidate farm size effects in fattening pigs.

The results for the social behaviour observed in the present study were similar to the findings of Temple *et al* (2011a), who reported values of 12.2% for positive and 5.4% for negative social behaviour. Negative social behaviour as an indicator of insufficient welfare, which correlates with a high number of stressful situations and competition for resources like feeding places, did not exceed the threshold (7%) for welfare problems proposed by Temple *et al* (2011a) in this study (3%). The proportion of investigation of the pen and exploration of enrichment material in this as well as previous studies (Temple *et al* 2011a) indicates that the behavioural needs are not fulfilled under intensive fattening conditions. Extensive housing conditions (eg space allowance, enrichment material, floor type) enhance exploratory behaviour (Temple *et al* 2011a). Although all of the observed pens in the present study were provided with enrichment material, the occurrence of exploration of enrichment material was low (around 3%) and the provided materials were probably insufficient to stimulate the pigs for manipulation. The enrichment material mainly consisted of simple toys, which are known to be inferior compared to materials such as straw, which can be manipulated. Referring to the results of Munsterhjelm *et al* (2015), space allowance and bedding were identified as the most important environmental determinants of pig welfare. Bearing in mind the proportion of overcrowded pens found here, improvements would seem necessary.

Proportions of panic responses found in our study correspond with values found by Temple *et al* (2011a). Overall, this can be considered as a good relationship between animal and farmer. Apart from an adequate interaction, there are other important factors influencing the human-animal relationship, such as genetics, growing stage, rearing system (Waiblinger *et al* 2006), feed supply (Hemsworth *et al* 1993) or group size (Meyer-Hamme *et al* 2016).

Animal welfare implications and conclusion

The findings in the present study demonstrated that none of the farm sizes (< 1,500 vs 1,500–3,000 vs > 3,000 pigs per farm) proved superior in terms of animal welfare. The fact that: i) none of the farms was classified as 'excellent'; ii) overcrowded pens were found on more than 90% (n = 55) of the farms; iii) the water supply was insufficient on 16 farms; and iv) the high prevalence rates of bursitis, wounds and manure on the body emphasise the necessity for optimisation of the production system to improve animal welfare on the farms. Further field studies should pay particular attention to factors, such as the management (eg number of employees, quality of animal care) and/or the housing conditions, ie the feeding system or the floor type, in combination with the farm size. The high prevalence of bursitis and soiled animals, which are known to be affected mainly by floor type and quality, underline the necessity of improving the quality of floors and climate management under practical fattening conditions. The fact that 40% of the farms had a space allowance below the German farm animal welfare regulations (Tierschutz-Nutztierhaltungsverordnung 2006) and water supply was insufficient on many farms, emphasises, that simple adjustments in the management can already improve the overall level of welfare. Besides, poor scores for a number of animal-based indicators (eg bursitis, wounds, soiled body, panic response, pneumonia) illustrate the expression of species-specific behaviour is limited in current production systems.

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