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Application of the Welfare Quality® protocol at pig slaughterhouses

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Abstract

The objective of the present study was to assess the sensitivity and feasibility of the Welfare Quality® (WQ) protocol for finishing pigs in 10 Spanish slaughterhouses. Sensitivity refers to the ability of the WQ assessment system to discriminate between slaughter conditions whilst feasibility denotes that the protocol is concise and easy to implement. On arrival at the plant, the incidence of dead, sick and panting animals was assessed in 1,002 (± 93) pigs per abattoir. During unloading, the percentage of pigs that slipped, fell, showed reluctance to move or turned back and were lame was also assessed. In the lairage pens, the stocking density and the percentage of pigs that were panting, shivering, and huddling was assessed in a total of 346 (± 81.0) pigs per abattoir. Stunning effectiveness, slaughter checks and skin lesions were also assessed in 60 animals per abattoir. For the majority of measures, any differences between slaughterhouses were found to be attributable to the installation itself and the management of the slaughterhouse, such as generalised fear, slipping and falling or stunning effectiveness, as opposed to measures taken to assess transport conditions or farm origin, such as lameness or sick and dead animals. The study protocol took 5.5 h for one observer to complete, in a slaughterhouse killing more than 550,000 pigs a year, although this time could increase dramatically in smaller abattoirs due to delays in the arrival of lorries. The protocol provides a general overview of the state of welfare of animals at the slaughterhouse and can readily identify specific problems in certain areas, such as stunning of animals.

Keywords: *animal welfare, assessment protocol, pig, slaughterhouse,* Sus scrofa, *Welfare Quality®*

Introduction

European citizens regard the welfare status of farm animals as an important aspect of overall food quality. In support of these social concerns, the European Commission adopted their Action Plan (2006–2010) on the protection and welfare of animals to upgrade minimum standards for animal welfare and to introduce standardised animal welfare indicators during the whole life of the animal, as two of the main objectives. Welfare Quality® (WQ) is an EU-funded project designed to integrate farm animal welfare into the food chain by addressing such social expectations and market demands, and developing reliable on-farm welfare assessment systems. After an agreement between consumers, representatives of key stakeholder groups, policy-makers and scientists, Welfare Quality® defines four animal welfare principles: i) good feeding; ii) good housing; iii) good health and iv) appropriate behaviour. Within these principles, the project highlighted twelve distinct but complementary animal welfare criteria (Botreau *et al* 2007) and for each one of these criteria different indicators/parameters were validated (Table 1). Wherever possible, these protocols look at the animal rather than the environment in which it is kept, and by so doing, place less reliance on resource- and management-based measures and more emphasis on the effects of the housing and farming system on the animal itself.

Different points in the slaughterhouse must be considered in a full monitoring system to assess pig welfare, such as the unloading area, lairage, stunning area, etc. As transportation is considered a major stressor for farm animals, especially for pigs, and might have detrimental effects on the health, well-being, performance and meat quality (Stephens & Perry 1990), the unloading area is an important point to consider several welfare problems. Pigs are often stressed during loading, transport and unloading. This stress and excitement, associated with handling and transport, can lead to serious health problems and even death.

During unloading, animals face a novel environment and handling that may cause fear. In fact, fear is an emotional state induced by the perception of a threatening or a potentially threatening situation (Boissy 1995) and it involves physiological and behavioural changes that prepare the animal for coping with the danger (Forkman *et al* 2007). These behavioural changes, such as animals showing reluctance to move or trying to reverse, can be used to assess fear during unloading (Dalmau *et al* 2009). Ease of movement during unloading is another important criterion for the welfare of the animal (Grandin 2003).

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Table 1 Welfare Quality® protocol to assess pig welfare (based on Velarde *et al* 2007).

Category	Welfare criteria	Measures
Good feeding	2 Absence of prolonged thirst	Water supply (number of drinking points, state)
	3 Comfort around resting	Density and flooring of lorries, density of lairage pens
Good housing	4 Thermal comfort	Percentage of animals shivering or panting, degree of social thermoregulation/huddling
	5 Ease of movement	Percentage of animals that slip and/or fall during unloading
Good health	6 Absence of injuries	Skin lesions, lameness score
	7 Absence of disease	Percentage of sick and dead animals on arrival and in lairage pens, slaughter checks (pneumonia, pleurisy, pericarditis, white spots in the liver)
	8 Absence of pain induced by management procedures	Stunning effectiveness (presence of corneal reflex, righting reflex, rhythmic breathing, vocalisations)
Appropriate behaviour	11 Good human-animal relationship	High-pitched vocalisations when driven to stunning area
	12 Absence of general fear	Reluctance to move and turning back during unloading

In lairage, it is extremely important to take space allowance into account. Animals must have enough space to lie comfortably or be able to move to drinking points or perform specific exploratory behaviours. When temperatures become too high, animals can show panting and when it is too low they shiver to increase the body temperature (Huynh *et al* 2005). In the case of low temperatures, pigs can also develop social thermoregulation behaviour, such as huddling, in which pigs are lying with over 50% of their body in contact with other pigs in order to maintain their body temperature. Therefore, densities, drinking points and behavioural signs of thermoregulatory problems are valid indicators of poor animal welfare in lairage. Another important stage at which welfare can be compromised is during the movement to the lairage pen or stunning area. Most of the time, animals are forced to move quickly during the last metres prior to stunning to maintain the chain speed. It has been stated that in challenging situations, the frequency and intensity of vocalisations (squeals/screams) can be a measure of the animal's inner state and, thus, serve as an indicator of poor welfare (Weary *et al* 1997; Grandin 2001). In the case of slaughterhouses, the presence of vocalisations during handling could be used to assess the relationship between humans and animals.

Stunning before slaughter is a statutory requirement in Europe (EC 1993) and is performed to induce unconsciousness and insensibility in animals so that the slaughter can be performed without causing any avoidable anxiety, pain, suffering or distress to the animals. The effectiveness of the stunning includes immediate loss of consciousness, and prolongation of this state until animal death due to bleeding. Ineffective stunning can be recognised by the presence of physiological signs, such as corneal reflex, rhythm of breathing, righting reflex and vocalisations (Velarde *et al* 2000).

Skin lesions can be assessed in carcases after slaughter. The number of skin lesions reflects the quality of the animal's physical and social environment (Gloor 1986) and, in fact, could provide valuable information regarding the management of animals in the farm of origin, transport or in the lairage pens. Furthermore, the health status of the animals in the farm of origin could also be assessed after slaughter through inspection of lungs, heart and liver.

The objectives of the present study were to assess the sensitivity and feasibility of the WQ protocol for finishing pigs in 10 Spanish slaughterhouses. Sensitivity refers to the ability of the WQ assessment system to discriminate between slaughter conditions. Feasibility means that the protocol is concise and easy to implement.

Materials and methods

The WQ protocol was assessed in 10 Spanish pig slaughterhouses during spring (April and May) and summer (August and September) 2007. The plants assessed slaughtered between 230,000 and 2,000,000 pigs per year with a chain speed of between 90 and 640 pigs per hour. To maintain the plants in an anonymous state, a number was applied to each one randomly from one to ten and no information that could be used for identification is provided. The estimated time to carry out the full monitoring procedure is 5.5 h (Table 2). However, this time was measured in all the slaughterhouses in different areas to define exactly the real time consumed.

Unloading area

The welfare assessment started in the unloading area, where general fear, behaviour associated with thermoregulation, slipping and falling, lameness, sickness and mortality were measured. The unloading area in the slaughterhouse consisted of: i) the truck ramp and unloading bay and, ii) when the slaughterhouse did not have ramp, the unloading

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Table 2 Measure, sample size, place of assessment and estimated time to take the measure, for all the measures assessed in the WQ protocol for pigs in the slaughterhouse.

Measure	Sample size	Place	Estimated time
Slipping	2 lorries	Unloading	1.0 h
Falling			
Reluctance to move	2 lorries	Unloading	1.0 h
Turning back			
Dead animals	6 lorries	Unloading/from unloading to lairage	
Sick animals			
Thermal comfort			
Comfort around resting			
Lameness	2 lorries	From unloading to lairage	1.0 h
Pen facilities	8 pens	Lairage	0.75 h
Huddling			
Shivering			
Panting			
High-pitched vocalisations	12 min	From lairage to stunning	0.25 h
Corneal reflex	60 pigs	Stunning area	0.5 h
Rhythm of breathing			
Righting reflex			
Vocalisations			
Fresh skin lesions	60 pigs	After slaughter	1.0 h
Pneumonia			
Pleuropneumonia			
Pericarditis			
White spots in liver			

area was considered to stretch from the beginning of the truck ramp to the end of the floor slope. If the truck had a tail-gate lift, the assessment began when the lift was on the floor with the doors open. In each abattoir, the animals unloaded from six lorries were assessed. In the first two unloaded, the percentage of animals that slipped and fell was recorded. The definition of slipping was of a loss of balance without the body touching the floor, while falling consisted of a loss of balance in which a part of the body other than the legs was in contact with the floor.

During the unloading of the two lorries that followed, the number of animals that showed general fear was assessed by means of a reluctance to move and attempts to turn back. A pig showed reluctance to move when it stopped walking, without moving its head and body, and failed to explore for at least 2 s. Turning back occurred when the pig facing the unloading area, turned its body and faced the truck area. Animals which turned back on arrival at the end of the unloading area were not considered. In all cases, animals unable to move for themselves were not included in the fear and slipping or falling assessment.

The number of lame animals was assessed in the final two lorries to be unloaded when they were moved to the lairage pens. Gait was scored when walking between 3 and 10 m, according to a three-point scale: (0) normal gait; (1) difficulties walking, but still using all legs (lameness 1), and (2) severely lame, minimum weight-bearing on affected limb (lameness 2). Animals which were unable to move by themselves were considered to be infirm. Lameness was not assessed when the length of the corridor was less than 3 m.

Numbers of sick and dead animals, and individuals shivering or panting were measured in all six lorries assessed in the protocol. Shivering was defined as slow and irregular vibration of any body part or the body as a whole and panting as rapid breathing with short gasps. In addition,

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the length, width and height of the six lorries and the total number of animals in the lorries were also considered.

Lairage pens

In lairage, the length and width of eight pens were measured and the number of animals counted. The eight pens were selected according to the time of arrival of animals, the situation in the plant close to and far away from the stunning system and the loading area and the size. The number of drinking points in each pen was counted (in the case of drinking valves) or the total water surface area supplied (in the case of water troughs). Behavioural thermoregulation measures, such as huddling, shivering or panting were also scored by using a three-point scale: (0) no pigs in the pen showing shivering, panting or huddling; (1) up to 20% of pigs in the pen with the above behaviour and, (2) more than 20% of pigs in the pen with the above behaviour. Shivering and panting were defined in the same way as in the unloading area and huddling denoted a pig lying with more than 50% of its body in contact with another pig (ie virtually lying on top of another pig). Dead animals were also recorded in the eight pens.

From lairage to stunning

The human-animal relationship was assessed in terms of high-pitched vocalisations (HPV), defined as squealing or screaming, at group level when animals were moved from lairage to the stunning area. Any animals displaying HPV in the corridor from lairage to the stunning system were noted. Two types of measures were taken. The first, one-zero sampling, consisted of assessing whether any animal was showing any vocalisation during a 20 s period while the second, instantaneous sampling, assessed if any animal was vocalising at the end of each period of 20 s. If at this moment only one animal was vocalising it was considered as a 'single vocalisation' but if more than one animal was vocalising it was considered 'multi-vocalisation'. This process was repeated three times for four minutes each.

Stunning effectiveness

To assess the stunning effectiveness, the presence of corneal reflex (through physical stimulation of the cornea), rhythmic breathing (as indicated by movements of the flanks), righting reflex and vocalisations were assessed in 60 pigs per slaughterhouse divided into three batches of 20 pigs.

Post-stunning area

After slaughter, the presence of pleurisy and pneumonia in the lungs, pericarditis in the heart and white spots in the liver was inspected in 60 animals, divided into three batches of 20. Finally, skin lesions were also assessed in the carcases of 60 animals divided into three batches of 20 animals. The carcase was divided into five parts: i) ears; ii) front (from the head to the back of the shoulder); iii) middle (from the back of the shoulder to the hind-quarters); iv) hindquarters and v) legs (from the accessory digit upwards). Each part was scored as follows: 0) no visible skin damage, only one lesion greater than 2 cm or lesions smaller than 1 cm; 1) between two and 10 lesions greater than 2 cm and 2) any wound which penetrated the muscle tissue, or more than 10 lesions greater than 2 cm. The scoring of the five parts of the carcase was combined in one scoring: 0) all body parts with a score of zero; 1) at least one body part with a score of one; 2) a part with a score of two or more or, 3) more than one part with a score of two.

Statistical analyses

Analyses were carried out with the Statistical Analysis System (SAS software SAS Institute Inc, Cary, NC, USA; 1999–2001). Differences between slaughterhouses for the variables, reluctance to move, turning back, slipping, dead, sick and panting animals at the arrival, number of animals in lairage, densities in trucks and lairage, number of animals per drinking point, huddling and panting in lairage, one-zero, instant and single vocalisations, presence of corneal reflex, pneumonia and skin lesions were analysed with non-parametric models (PROC GENMOD). In all cases, a Poisson or negative binomial distribution was used (Cameron & Trivedi 1998). The residual maximum likelihood was used as a method of estimation and the least square means of fixed effects (LSMEANS) when analysis of variance indicated differences. On the other hand, differences between slaughterhouses for the variables falling, lameness, multiple high-pitched vocalisations, presence of rhythmic breathing, righting reflex, pleurisy, white spots in the liver, pericarditis and vocalisations after stunning were analysed with the PROC MIXED procedure. When the analysis of variance indicated significant differences ($P < 0.05$), the least square means of fixed effects (LSMEANS) was used to carry out the multiple comparison. Spearman correlations were also carried out to assess the relationship between different variables. In all cases, significance was fixed at $P < 0.05$.

Results

The time needed to assess the different measures in each slaughterhouse is shown in Table 3. The mean time to develop the full protocol ranged from 260 to 440 min, with a mean value of 328 (± 18.8) min.

Unloading area

Two lorries arrived at slaughterhouse 10, four at slaughterhouse 6 and five in slaughterhouse 7. Differences between slaughterhouses were found for reluctance to move, turning back, slipping, falling and panting (Table 4). No differences were observed for lameness 1 (difficulties walking, but still using all legs), lameness 2 (minimum weight-bearing on the affected limb), dead animals and sick animals at the arrival and densities in the lorry (Table 4).

Lairage pens

Differences were found between slaughterhouses in the mean number of pigs housed in each lairage pen, the density, the number of animals per drinking point and huddling score 2 (more than 20% of pigs in the pen showing

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Table 3 Time needed to assess the different measures in the 10 slaughterhouses, total time spent and mean times obtained in the study.

	Slaughterhouses										
Measures	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Mean (± SE)**
Measures during unloading (min)	195	165	180	165	240	155	255	180	225	300	206 (± 14.98)
Measures in lairage (min)	30	33	33	30	40	24	55	48	28	40	36.7 (± 2.97)
Vocalisations (min)	12	12	12	12	12	12	12	12	12	10	11.8 (± 0.20)
Stunning effectiveness (min)	20	20	25	38	23	20	23	20	20	25	23.2 (± 1.81)
Slaughter checks (min)	20	15	30	30	25	29	35	30	28	35	27.4 (± 2.12)
Skin lesions (min)	18	15	20	25	20	20	25	25	32	30	22.9 (± 1.73)
Full protocol (min)	295	260	300	300	360	260	405	315	345	440	328.0 (± 18.81)

Table 4 Differences between slaughterhouses for general fear (reluctance to move and turning back), slipping and falling, lameness (score 1 and 2), sick and dead animals on arrival, animals showing panting on arrival and mean densities in the truck.

					Slaughterhouses									
	Parameter	**Statistics**	**df**	***P*-value**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Fear	n				440	214	453	355	326	431	243	460	330	220
	Reluctance to move (%)	Chi-square = 31.51	9	0.0002	2.73 ± 1.818^{ab}	1.87 ± 0.379^{bc}	5.74 ± 4.426^{a}	0.00 ± 0.00^{d}	5.21 ± 2.068^{a}	1.39 ± 0.957^{bc}	3.70 ± 0.288^{ab}	6.09 ± 2.173^{a}	0.91 ± 0.037^{c}	7.27 ± 0.00^{a}
	Turning back (%)	Chi-square = 21.29	9	0.0114	4.32 ± 0.682^{bc}	0.47 ± 0.685^{d}	9.49 ± 5.537^{b}	2.25 ± 1.348^{c}	11.35 ± 5.536^{ab}	7.66 ± 1.798^{ab}	5.76 ± 2.292^{bc}	18.69 ± 0.870^{a}	3.03 ± 1.629^{c}	9.09 ± 0.00^{abc}
Slip/fall	n				460	237	464	363	270	213	383	445	344	220
	Slipping (%)	Chi-square = 31.45	9	0.0002	7.61 ± 0.549^{e}	30.80 ± 20.461^{ab}	31.03 ± 0.699^{ab}	7.44 ± 1.047^{de}	57.41 ± 5.467^{a}	17.40 ± 0.00^{bde}	18.80 ± 5.925^{bc}	53.71 ± 9.368^{a}	9.59 ± 4.918^{e}	14.09 ± 0.00^{bde}
	Falling (%)	*F* = 4.33	9/8	0.0254	0.43 ± 0.454^{c}	3.80 ± 3.982^{bc}	3.66 ± 1.046^{bc}	0.55 ± 0.099^{c}	12.96 ± 1.374^{a}	0.94 ± 0.00^{bc}	2.87 ± 0.731^{bc}	6.74 ± 2.171^{b}	1.74 ± 1.364^{bc}	0.45 ± 0.00^{c}
Lameness	n				435	262	385	492	441	220	168	260	371	0
	Lame-1 (%)	*F* = 0.20	8/7	0.9806	1.84 ± 0.481	1.91 ± 1.131	2.60 ± 0.047	3.25 ± 0.940	2.95 ± 0.687	1.82 ± 0.00	1.79 ± 0.00	0.77 ± 0.454	2.96 ± 0.659	–
	Lame-2 (%)	*F* = 1,63	8/7	0.2669	0.00 ± 0.00	0.38 ± 0.385	0.26 ± 0.311	0.20 ± 0.278	0.00 ± 0.00	0.00 ± 0.00	0.60 ± 0.00	0.00 ± 0.00	0.81 ± 0.035	–
Total	n				1,335	713	1,302	1,210	1,037	864	794	1,265	1,055	440
	Dead animals (%)	Chi-square = 9.18	9	0.4212	0.30 ± 0.184	0.14 ± 0.147	0.23 ± 0.151	0.00 ± 0.00	0.29 ± 0.143	0.23 ± 0.172	0.00 ± 0.00	0.16 ± 0.088	0.19 ± 0.124	0.68 ± 0.682
	Sick animals (%)	Chi-square = 8.88	9	0.4488	0.30 ± 0.224	0.14 ± 0.126	0.38 ± 0.204	0.41 ± 0.165	0.68 ± 0.314	0.46 ± 0.145	0.00 ± 0.00	0.24 ± 0.091	0.09 ± 0.118	0.00 ± 0.00
	Panting (%)	Chi-square = 32.91	9	0.0001	0.37 ± 0.217^{b}	0.00 ± 0.00^{c}	0.61 ± 0.342^{b}	0.08 ± 0.079^{b}	7.31± 2.502^{a}	0.23 ± 0.099^{b}	0.38 ± 0.173^{b}	0.00± 0.00^{c}	0.76 ± 0.813^{b}	0.00 ± 0.00^{c}
	Densities in trucks	Chi-square = 8.15	9	0.5189	0.45 ± 0.011	0.49 ± 0.031	0.47 ± 0.031	0.45 ± 0.019	0.495 ± 0.035	0.445 ± 0.002	0.42 ± 0.013	0.46 ± 0.032	0.48 ± 0.026	0.445 ± 0.005

Superscripts denote significant differences, $P < 0.05$.

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Table 5 Differences between slaughterhouses for mean number of animals per lairage pen, densities in the lairage pen, mean number of animals per drinking points in the lairage pen and percentage of pens scored as huddling (score 1 and 2) and for panting (score 1).

				Slaughterhouses								
Parameter	**Statistics**	**df**	***P*-value**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mean animals per pen	Chi-square = 93.37	9	0.0001	46.0 ± 8.28^{bc}	32.8 ± 1.07^{cd}	32.6 ± 1.41^{cd}	21.9 ± 0.93^{f}	26.5 ± 1.17^{def}	23.9 ± 9.02^{def}	48.8 ± 18.43^{b}	128.8 ± 48.66^{a}	32.9 ± 12.43^{ce}	45.6 ± 17.24^{bc}
Densities (m^2 per pen)	Chi-square = 32.27	9	0.0002	0.71 ± 0.05^{a}	0.49 ± 0.02^{bc}	0.48 ± 0.03^{bc}	0.51 ± 0.01^{bc}	0.41 ± 0.02^{c}	0.47 ± 0.18^{bc}	0.52 ± 0.20^{b}	0.47 ± 0.22^{bc}	0.47 ± 0.18^{bc}	0.65 ± 0.25^{a}
Mean animals per drinking point	Chi-square = 58.28	9	< 0.0001	21.9 ± 2.21^{ab}	30.6 ± 2.07^{ab}	14.4 ± 1.07^{b}	20.3 ± 1.26	26.5 ± 1.17^{a}	23.9 ± 9.02^{ab}	48.8 ± 18.43[l]	25.1 ± 0.50^{ab}	32.9 ± 12.43^{a}	27.6 ± 10.44^{ab}
Total animals assessed for thermoregulation				368	262	261	175	212	167	390	1,030	263	365
Pens with more than 1% and less than 20% huddling (%)	Chi-square = 8.15	9	0.5189	37.5	50.0	50.0	12.5	12.5	25.0	37.5	25.0	0.0	37.5
Pens with more than 20% huddling (%)	Chi-square = 20.61	9	0.0145	37.5^{bc}	12.5^{b}	25.0^{bc}	50.0^{bc}	62.5^{bc}	12.5^{b}	25.0^{bc}	50.0^{bc}	75.0^{a}	0.0^{c}
Pens with more than 1% and less than 20% panting (%)	Chi-square = 13.83	9	0.1286	0.0	12.5	0.0	25.0	50.0	0.0	12.5	0.0	0.0	50.0

Superscripts denote significant differences, $P < 0.05$.
[l] Drinking points were not nipples but a long trough occupying the major part of one of the walls of the pen.

Table 6 Differences between slaughterhouses for vocalisations using the one-zero system and the instantaneous single or multi system.

				Slaughterhouses								
Parameter	**Statistics**	**df**	***P*-value**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
% of periods of 20 s in which at least one animal was vocalising	Chi-square = 26.81	9	0.0015	41.6 ± 4.81^{b}	52.8 ± 11.11^{b}	100.0 ± 0.00^{a}	44.4 ± 13.89^{b}	97.2 ± 2.78^{a}	100.0 ± 0.00^{a}	100 ± 0.00^{a}	97.2 ± 2.78^{a}	89.0 ± 8.33^{a}	89.0 ± 12.50^{a}
% of instantaneous sampling in which vocalisations were observed	Chi-square = 31.44	9	0.0002	11.1 ± 2.78^{b}	5.5 ± 2.78^{b}	39.3 ± 2.78^{a}	11.1 ± 7.35^{b}	39.3 ± 10.02^{a}	47.2 ± 11.11^{a}	42.3 ± 9.62^{a}	25.1 ± 8.33^{ab}	44.1 ± 22.22^{a}	22.3 ± 4.17^{ab}
Instantaneous sampling with a single vocalisation	Chi-square = 21.22	9	0.0117	11.1 ± 2.78^{bc}	5.5 ± 2.78^{c}	27.8 ± 5.56^{ab}	11.1 ± 7.35^{bc}	27.8 ± 7.35^{ab}	41.7 ± 8.33^{a}	33.3 ± 4.81^{ab}	19.4 ± 5.56^{ab}	30.5 ± 16.89^{ab}	13.9 ± 4.17^{ab}
Instantaneous sampling with more than one animal vocalising	$F = 0.83$	9/19	0.5964	0.0 ± 0.00	0.0 ± 0.00	11.1 ± 7.35	0.0 ± 0.00	11.1 ± 5.56	5.5 ± 2.78	8.3 ± 8.33	5.5 ± 2.78	13.9 ± 10.01	8.3 ± 8.33

Superscripts denote significant differences, $P < 0.05$.

behavioural thermoregulation; Table 5). No differences were found for huddling score 1 (up to 20% of pigs in the pen showing huddling behaviour) and panting (Table 5).

From lairage to stunning

In slaughterhouse 10, only two periods of 4 min were assessed. The high-pitched vocalisations differed significantly between slaughterhouses with both one-zero and instantaneous sampling (Table 6). In addition, differences between slaughterhouses were found when only one animal vocalised (Table 6).

Stunning effectiveness

Differences were observed between slaughterhouses for the presence of corneal reflex, rhythmic breathing, righting reflex and vocalisations (Table 7).

Post-stunning area

Differences were found between slaughterhouses for the presence of pneumonia, white spots in the liver, carcases with a score 1 and 2 for skin lesions (Table 7), but not score 3 for skin lesions, pleurisy and pericarditis (Table 7).

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Table 7 Differences between slaughterhouses for percentage of animals showing corneal reflex, rhythmic breathing, righting reflex, vocalisations after stunning, viscera with pneumonia, pleurisy, pericarditis, white spots in the liver and skin lesions in the carcase (scoring 1, 2 and 3).

					Slaughterhouses									
	Parameter	**Statistics**	**df**	***P*-value**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Stunning effectiveness	Corneal reflex (%)	Chi-square = 119.13	9	< 0.0001	0.0 ± 0.00^{d}	6.7 ± 1.67^{bc}	3.3 ± 1.67^{c}	3.3 ± 1.67^{c}	16.7 ± 4.41^{b}	60.0 ± 2.89^{a}	5.0 ± 0.00^{bc}	20.0 ± 5.77^{b}	13.3 ± 6.01^{b}	51.7 ± 1.67^{a}
	Rhythmic breathing (%)	*F* = 5.13	9/20	0.0011	0.0 ± 0.00^{c}	1.7 ± 1.67^{c}	1.7 ± 1.67^{c}	0.0 ± 0.00^{c}	1.7 ± 1.67^{c}	21.7 ± 16.67^{b}	10.0 ± 2.89^{bc}	10.0 ± 5.00^{bc}	1.7 ± 1.67^{c}	45.0 ± 8.66^{a}
	Righting reflex (%)	*F* = 6.05	9/20	0.0004	0.0 ± 0.00^{b}	1.7 ± 1.67^{b}	0.0 ± 0.00^{b}	0.0 ± 0.00^{b}	0.0 ± 0.00^{b}	25.0 ± 10.41^{a}	0.0 ± 0.00^{b}	1.7 ± 1.67^{b}	0.0 ± 0.00^{b}	23.3 ± 7.26^{a}
	Vocalisations (%)	*F* = 2.67	9/20	0.0325	0.0 ± 0.00^{b}	1.7 ± 1.67^{b}	0.0 ± 0.00^{b}	0.0 ± 0.00^{b}	0.0 ± 0.00^{b}	1.7 ± 0.00^{b}	0.0 ± 0.00^{b}	0.0 ± 0.00^{b}	0.0 ± 0.00^{b}	6.7 ± 3.33^{a}
Viscera state	Pneumonia (%)	Chi-square = 24.34	9	0.0037	23.3 ± 4.41^{bc}	23.3 ± 4.41^{bc}	26.7 ± 9.28^{abc}	31.7 ± 11.67^{ab}	43.3 ± 13.64^{ab}	15.0 ± 2.89^{c}	33.3 ± 7.26^{ab}	41.7 ± 8.33^{ab}	45.0 ± 8.66^{a}	13.3 ± 7.26^{c}
	Pleurisy (%)	*F* = 1.02	9/20	0.4565	10.0 ± 5.77	0.0 ± 0.00	6.7 ± 6.67	6.7 ± 4.41	1.7 ± 1.67	8.3 ± 4.41	0.0 ± 0.00	8.3 ± 6.01	0.0 ± 0.00	1.7 ± 1.67
	Pericarditis (%)	*F* = 1.07	9/20	0.4221	3.3 ± 1.67	3.3 ± 1.67	1.7 ± 1.67	1.7 ± 2.89	3.3 ± 1.67	3.3 ± 1.67	5.0 ± 1.67	0.0 ± 0.00	5.0 ± 2.89	5.0 ± 0.00
	White spots in the liver(%)	*F* = 6.29	9/20	0.0003	3.3 ± 1.67^{c}	3.3 ± 3.33^{c}	6.7 ± 1.67^{bc}	40.0 ± 13.23^{a}	20.0 ± 2.89^{b}	10.0 ± 5.00^{bc}	5.0 ± 0.00^{c}	8.3 ± 1.67^{bc}	8.3 ± 1.67^{bc}	0.0 ± 0.00^{c}
Skin lesions	Skin lesions-1 (%)	Chi-square = 18.77	9	0.0272	78.3 ± 7.26^{ab}	85.0 ± 0.00^{a}	83.3 ± 1.67^{ab}	73.3 ± 10.14^{bcd}	73.3 ± 10.14^{bcd}	68.3 ± 4.41^{cd}	58.3 ± 10.92^{d}	81.7 ± 3.33^{a}	73.3 ± 7.26^{bcd}	76.7 ± 3.33^{abc}
	Skin lesions-2 (%)	Chi-square = 18.68	9	0.0281	11.7 ± 4.41^{bcd}	5.0 ± 2.89^{d}	11.7 ± 3.33^{bcd}	10.0 ± 5.77^{cd}	15.0 ± 7.64^{bcd}	25.0 ± 2.89^{ab}	30.0 ± 8.66^{a}	11.7 ± 3.33^{bcd}	20.0 ± 5.77^{abc}	11.7 ± 4.41^{bcd}
	Skin lesions-3 (%)	Chi-square = 6.54	9	0.6850	1.7 ± 1.67	3.3 ± 3.33	1.7 ± 1.67	1.7 ± 1.67	6.7 ± 6.67	3.3 ± 3.33	10.0 ± 5.77	3.3 ± 3.33	6.7 ± 1.67	1.7 ± 1.67

Superscripts denote significant differences, $P < 0.05$.

Correlation between variables

The highest correlation found between variables was for slipping and falling ($r = 0.86$, Table 8).

Discussion

Feasibility of the WQ protocol

The more concise and easily implemented the assessment system, the greater the feasibility of the protocol. The mean time to carry out the full protocol in the slaughterhouse was around 5 h 28 min. However, in two of the 10 slaughterhouses assessed (Table 3), this was 6 h 45 min and 7 h 20 min. In both cases, after 4 h in the unloading area, the number of lorries that arrived was less than six. These were, in actual fact, the slaughterhouses with the lowest number of animals slaughtered per year, ranging from 230,000 to 550,000. Therefore, in terms of time needed to carry out the assessment, we must consider that the smaller the slaughterhouse, the more severely the feasibility is reduced, basically due to the time required to wait for the arrival of lorries. On the other hand, if 5 h and 28 min is considered too long and the time to assess the full protocol needs to be reduced, there are two considerations that could be taken into account: i) some parameters, such as slaughter checks, give information about the welfare state of pigs on the farm of origin, but not at the slaughterhouse, so if the information about the farm is not necessary, the total time is reduced by 27.4 (± 2.12) min and ii) no differences were observed between slaughterhouses for lameness, therefore the sensitivity of this parameter is low. In addition, the time to assess this measure is approximately one hour. So, if the time to develop the full protocol must be reduced, lameness could be eliminated from the WQ protocol for pigs in the slaughterhouse. In this case, the assessment of the final protocol takes 4.5 h or 4 h if the viscera are not assessed.

Variability between slaughterhouses

Most of the parameters showed differences between slaughterhouses. However, the measures of mortality, sick animals, lameness, pleurisy and pericarditis, parameters related to the transport or farm of origin, did not differ. This result could be due to the fact that the present work was

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Table 8 Spearman correlations between variables for the measures assessed in the 10 slaughterhouses.

Category	Measures	Spearman (*r*)	*P*-value
Slipperiness	Slipping/falling	0.86	< 0.0001
Fear	Reluctance to move/turning back	0.57	0.0103
Human-animal relationship	Vocalisations one-zero/vocalisations instant	0.78	< 0.0001
Stunning effectiveness	Righting reflex/vocalisations after stunning	0.71	< 0.0001
	Corneal reflex/righting reflex	0.65	< 0.0001
	Righting reflex/rhythmic breathing	0.62	0.0003
	Corneal reflex/rhythmic breathing	0.60	0.0004
	Rhythmic breathing/vocalisations after stunning	0.43	0.0184
Other	Reluctance to move/slipping	0.54	0.0218
	Turning back/lameness	–0.51	0.0459

defined to assess slaughterhouse differences, but not differences between origins. For the latter, more unloaded lorries would need to be assessed at the same slaughterhouse.

On the other hand, the protocol allows scoring the welfare of pigs in slaughterhouses from both a general viewpoint and through identifying specific problems in specific areas. For instance, slaughterhouse 1 scored well in comparison to the rest for most measures, but slaughterhouse 5 was the opposite (Tables 4, 5, 6 and 7). However, in other cases, it is easy to identify specific problems. For instance, slaughterhouse 4 only had a high incidence of animals with liver problems caused by the farm of origin, and slaughterhouse 6 had a good score for unloading and lairage but problems were observed in the driving of the animals to the stunning system (vocalisations) and in the stunning effectiveness (presence of physiological reflexes). In fact, when the results of the protocol were discussed with the managers of this slaughterhouse (6), they recognised they were slaughtering more animals than the actual capacity of the stunning system. Consequently, pigs were pushed with electric prods into the system (vocalisations) and spent less time than necessary for an effective stunning. After the welfare assessment, these problems were solved with the help of a new stunning system which had automatic doors to move the animals. Although a further visit is yet to be carried out to this slaughterhouse since the changes, an improvement in stunning effectiveness is expected, along with a reduction of vocalisations before stunning.

According to the one-zero vocalisation measurement, two groups of slaughterhouses were classified: three of them with a low percentage of periods with animals vocalising (plants 1, 2 and 4) and seven with a higher percentage of vocalisations. The first (plants 1, 2 and 4) disposed of automated doors to drive the animals and the rest of an alley, with pigs being moved via an electric prod.

Relationship between variables

If Spearman correlations between variables are analysed, it can be concluded that the highest values (those around 0.60 or higher) were found between one-zero and instantaneous vocalisations, slipping and falling, and corneal and righting reflexes. In the case of slipping and falling, the relationship encountered ($r = 0.86$) is high enough to consider using only one of the two measures to assess the welfare criteria of ease of movement during unloading in future. However, the values found for the rest of the variables are not high enough to consider the substitution of any measure by another one. Below $r = 0.60$, some expected correlations were found, such as reluctance to move with turning back, both assessing general fear, or rhythmic breathing with vocalisations after stunning, both being signs of ineffective stunning. That could be because different causes of fear are assessed in the first case (Dalmau *et al* 2009) and different states of lack of unconsciousness are assessed in the second. In fact, when an animal was recovering consciousness, the vocalisations were observed as being the last response to appear. In contrast, other relationships were observed between variables less related. For instance, as more animals were slipping (ease of movement), more animals showed reluctance to move (general fear). That means that the slope and the slipperiness of the unloading floor affected the reluctance of pigs to move. In contrast, the main cause of the turning back (also general fear) could be the behaviour of the personnel in charge of the stock.

Animal welfare implications

The Welfare Quality® protocol for assessing pig welfare is sensitive to the variety of handling and facilities between the different slaughterhouses. The mean time required to develop the full protocol for an observer is 5.5 h. The WQ protocol allows for determination of a general score for the slaughterhouse and the identification of problems in specific areas by means of the different measures.

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