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Development of a simplified on-farm animal health and welfare benchmarking tool for pig herds

Entwicklung eines vereinfachten Benchmarking tools zur Erfassung von Tierwohl und Tiergesundheit in Schweineherden

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Summary

Animal health and welfare have become topics of increasing public interest. Especially improvements in the health and welfare of food-producing animals are currently being intensively researched. To be able to routinely assess the quality of health and welfare of individual pig herds for benchmarking purposes in a simple and robust way, a short and easy to use measuring tool is needed.
Since the very elaborate assessment tools of the Welfare Quality® (WQ) project (FOOD-CT-2004-506508) are too time-consuming for an assessment during a regular veterinary herd visit, easy to record indicators were targetly selected and supplemented by new elements in order to combine a number of measurements in one indicator, using the theoretical concept of iceberg indicators, which are thought to trigger further scrutiny into the management of pig herds that reveal potential deficiencies.
The thus created simplified Herd Health and Welfare Index (HHWI) shows a theoretical range of 10 (very good) to a maximum of 30 (very bad) index points. It has been demonstrated that it can be used as an animal welfare measurement tool to compare herds within a group of pig herds that are measured by the same set of criteria. The HHWI has proven to be a rough, semi-quantitative, and a less elaborate tool than, for example, the complete protocol of the WQ-project. All in all, the HHWI has a broader range of application possibilities than the WQ-protocol due to its reduced number of criteria for the assessment of the health and welfare status of pig herds.

Keywords: animal health and welfare index (HHWI), on-farm assessment of animal welfare, benchmarking of the quality of life of pigs per herd, iceberg indicators for triggering further improvement actions

Zusammenfassung

Das Öffentliche Interesse an Tierwohl und Tiergesundheit wird immer größer. Besonders im Bereich der Nutztierhaltung wird ein immer stärkerer Fokus auf die Verbesserung von Tierwohl und Tiergesundheit gelegt. Um eine kontinuierliche Überwachung und somit die Möglichkeit der Verbesserung von Tierwohl und Tiergesundheit zu ermöglichen, bedarf es jedoch vereinfachter, robuster Erhebungsprotokolle.
Um dieses Ziel zu erreichen, wurden aus der Vielzahl von Kriterien des sehr umfänglichen Protokolls des Welfare Quality® Projektes (FOOD-CT-2004-506508) selektiv im Bestand zu erhebende Parameter ausgewählt und zusätzlich um weitere Parameter ergänzt. Hierbei wurde das Konzept der „iceberg indicators" angewendet, um – basierend auf den durch die Iceberg Indikatoren dargestellten Mängeln – gezielte und weiterführende Untersuchungen in Schweinebeständen durchführen zu können. Dabei können mit der Erhebung eines Parameters mehrere Aspekte der Tierhal-

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tung, Tiergesundheit und des Tierwohls abgeschätzt werden. Der so entwickelte HHWI-Index wurde als Benchmarking-Instrument in Schweinemastbetrieben eingesetzt, um die Situation von Tierwohl und Tiergesundheit sowie die Qualität der Tierbetreuung einzuschätzen und mit gleichermaßen beurteilten Schweinemastbetrieben zu vergleichen.
Der Herd Health and Welfare Index (HHWI) besitzt eine theoretische Spannweite von 10 (sehr gut) bis maximal 30 (sehr schlecht) Indexpunkten. Es konnte gezeigt werden, dass der HHWI für den Vergleich des Tierwohlstatus zwischen schweinehaltenden Betrieben innerhalb der Länder eines großen europäischen Forschunsgprojektes zur Untersuchung der Antibiotikaresistenz entlang der Lebensmittelkette erfolgreich angewendet werden kann. Der HHWI hat sich zwar als gröberes, semi-quantitatives Maß als das vollständige Protokoll des Welfare Quality® (WQ) Projektes herausgestellt, doch ist der Anwendungsbereich des HHWI durch seine vereinfachte Struktur deutlich größer.

Schlüsselwörter: Tiergesundheits- und Tierwohlindex, HHWI, Benchmarking zur Einschätzung der Lebensqualität, Eisbergindikatoren für die Verbesserung von Tierwohl

Introduction

The human-animal relationship has drastically changed in industrialised countries worldwide, leading to the increasing requests to improve the quality of life of animals under human care (Hobbs et al. 2002, Broom 2010). Consumers demand measures to meet certain health and welfare criteria for the animals from and with which food is produced (Broom 2010). The measurement of animal welfare makes its way into legislation, as mentioned e.g. in recites of the animal health law (Regulation (EU) 2016/429) or the European Community Action Plan on the Protection and Welfare of Animals (COM (2006) 13) (Commission of the European Communities 2006, European Commission 2016). After several years of mainly using recourse-based indicators of the welfare status of food animals (space per animal, flooring systems etc.), the realization of the fact that focusing only on the husbandry systems did not lead to comprehensive animal welfare improvements, triggered the focus on animal-based indicators, such as body condition scores, tail and/or ear biting (EFSA 2012), and the number of heavily dirty animals, since they allow for more direct assessement of the real animals' welfare status. Therefore, the European Food Safety Authority (EFSA) recommends the protocols of the Welfare Quality® project (WQ-project) (FOOD-CT-2004-506508) as the most elaborated standardised measures to assess animal welfare (EFSA 2012). Due to the multidimensional determinants of animal welfare, the holistic approach of the WQ-protocol can define the level of animal welfare in detail. At the same time, the process of the WQ-data collection is time-consuming and therefore it can be a limitation for its routine use (Czycholl et al. 2015).

To ensure a continuous measurement of animal welfare, as asked for e.g. in some national legislations, measurement tools need to be quick and easy to use, in order to be readily implemented in the daily working routine of pig farms. The same requirements had to be met when planning the assessment of the level of animal health, welfare and animal care in the EFFORT project. The reason for this was: project's main focus was to investigate antimicrobial resistance, hence although the assessment of animal welfare was important, it was not the highest priority of the farm visiting teams of the EFFORT project. Therefore, an easy to use and time-efficient welfare assessment tool had to be developed to meet the needs of EFFORT.

As other indices before, the Herd Health and Welfare Index (HHWI) developed for the EFFORT project relies on animal-based indicators (Dickhaus et al. 2009, Pandolfi et al. 2017). To shorten the protocols of the WQ-project, the indicators used for the HHWI were to function as iceberg indicators to assess animal welfare. Iceberg indicators are described, as "the protruding tip of an iceberg that signals its submerged bulk beneath the water's surface" (FAWC 1992) indicating primary evidence for potential welfare challenges. Therefore, these indicators are used to get a first impression of the welfare status of food animal herds or flocks.

However, unlike most recently developed welfare indices, this specific "EFFORT"-HHWI could not be based on slaughter check findings, because expert consultations within EFFORT revealed that slaughter check findings are not provided in a standardised way in the countries that contributed to the project. Even at national levels, slaughter check findings are not always standardised between abattoirs and are therefore difficult to be used as benchmarking criteria. Hence, the new developed index is the attempt to assess animal welfare at herd level without using slaughter check findings.

This manuscript presents the development and first results of the HHWI used to assess the quality of health and welfare of pig herds in nine European countries. Each country was seen as a group of pig herds with comparable data recording possibilities and constrains. Therefore, this study is not attempting to compare the results between countries. In this manuscript the development of a simplified welfare benchmarking tool for pig herds with comparable data recording is presented, focusing on the continuous measurement and the process of continuous animal welfare improvements at herd level.

Material and Methods

Welfare data collection within the EFFORT project

Within the EFFORT project, 20 conventional farrow-to-finisher pig farms were assessed in each of the nine anonymized European countries in the period May 2014

TABLE 1: *Data on interobserver comparison in the pilot-study. For each measurement, the average frequency of each score for each indicator is shown for the three observers (A-C).*

Measurement	Score	Average of observer A	Average of observer B	Average of observer C
manure_weaner	1	86,89	76,10	84,23
manure_weaner	2	9,23	11,80	9,56
manure_weaner	3	3,89	7,06	6,21
manure_fattener	1	60,56	55,44	61,17
manure_fattener	2	31,63	27,3	28,19
manure_fattener	3	7,81	12,26	10,66
Bursa alteration weaner	1	99,27	93,07	96,18
Bursa alteration weaner	2	0,73	1,80	1,22
Bursa alteration weaner	3	0	0,13	2,60
Bursa alteration fattener	1	96,91	85,35	88,33
Bursa alteration fattener	2	3,09	9,54	11,41
Bursa alteration fattener	3	0	0,11	0,25
lameness_weaner	1	99,75	88,79	100
lameness_weaner	2	0,25	0,89	0
lameness_weaner	3	0	0,35	0
lameness_fattener	1	97,32	89,42	98,49
lameness_fattener	2	2,68	4,88	1,43
lameness_fattener	3	0	0,51	0,08
biting_weaner	1	95,68	77,69	98,43
biting_fattener	1	89,78	68,96	95,58
Runted_weaner	1	100	94,85	99,72
Runted_fattener	1	100	95	100

to December 2015. The 180 pig herds involved needed to have an average of at least 150 sows and 600 fatteners present on the farm at the time of the farm visit. However, not all participating farms could provide the required number of sows and some had to introduce piglets from different farms as previously described by Munk et al. (2018). The average number of fattening pigs varied between 160 and 1100. The farms were not allowed to have any animal trading contact with one another, and only one farm per owner was accepted for the study. The selection criteria and characteristics of the study farms are described in detail by Munk et al. (2018).

The entire HHWI protocol, was carried out during each farm visit by a consistent visiting team, (2-3 observers), i.e. the same persons performed the assessment within each country.

During these assessments, the visiting team observed the same group of animals at the same time, to be able to compare the results of different observers in the end. Depending on the size of the pens, it was possible to observe two pens at each viewpoint (approximately 40-60 animals). First, the pigs in the pens under observation were chased up and then observed during the next five minutes. Second, the observer changed their position within the compartment and the procedure was repeated for different pens. In that way approximately 100 animals were observed per herd. For each age category the assessment time was approximately 50 minutes. The results were expressed as observations per indicator in percent of the total number of animals observed.

Within the EFFORT project pigs until 14 days before slaughter were considered suitable for sampling. One compartment out of all slaughter pigs present was considered as a representative sample and therefore as a sampling batch, independent of the size of the farm, as the size of more than 600 pigs was one of the inclusion criteria. For the EFFORT project the same procedure was performed for weaners. As all animals in a herd were looked after by the same persons, received comparable food and lived under the same housing conditions, the animal health and welfare status should be similar in all compartments and therefore could be assessed by selecting only one compartment, representative of the whole herd.

To achieve a standardized level of assessment skills, the observers have been trained before using a protocol including pictures of the different indicators and levels of severity. The deviation of assessment results between observers was tested in a pilot study within one of the participating countries of the EFFORT project. In 15 pig herds, that also participated in the EFFORT study, the protocol assessments were carried out by two observers: Observer A and B fulfilled five combined assessments (8004; 8006; 8008; 8032; 8036), while observer B and C examined ten farms together (8014; 8018; 8020; 8022; 8024; 8026; 8028; 8030; 8038; 8040). Observers A and B and observers B and C examined different pens within the same compartment, since welfare status within a compartment was considered homogeneous. The comparison of resulting scores for each batch between observers A and B and observers B and C were analysed using descriptive analysis. Due to results being very similar, the observations from different observers were aggregated in that country's scores reported to EFFORT (see Table 1) (unpublished results of Duarte ASR and Nielsen CL). The results of the pilot study of interobserver variation within a country indicated that the observations of different observers were comparable. Therefore, the observer bias within a country was neglected. However, we expect an inter-observer bias between different countries, therefore between-country comparisons were not considered.

Selection of Indicators

In the selection of indicators used for the new developed HHWI, the focus was put on two aspects: assessment time and feasibility for continuous, routine usage at herd level.

Continuous routine measuring of standardized parameters over time will reveal even minor changes in the health and welfare status of herds, realizing these changes will trigger improvements in the herd health and animal care management by either counteracting negative or reinforcing positive developments.

To ensure the feasibility of the HHWI, it was decided to use only data available at herd level. Based on expert recommendation, indicators were chosen representing the most common problems in pig fattening practice such as lung problems and diarrhea. Nevertheless, the indicators were always selected taking into account the characteristics "quickly and reliably detectable". As observations made by the visiting team were always available during a farm visit, they ensured a complete data set, which made the score robust against missing data. The set of indicators was limited to five per age category to ensure a short assessment time and therefore robust measurement tool. The indicators should be animal-based and, according to EFSA's recommendation, chosen from the set of indicators used in the protocols of WQproject. In order to shorten its assessement time, the HHWI does not consider the measurements for "Good Housing" and

"Appropriate Behaviour", due to their long assessment time (1.5h) (Welfare Quality® Consortium 2009).

Health and welfare are linked, as also mentioned in recital number seven of the animal health law (Regulation (EU) 2016/429) „better animal health promotes better animal welfare, and vice versa". This is also evident in the name of the Herd Health and Welfare Index.

For the term health, this paper will use the definition used by Smidt et al. (1996), who defined it as a "morphological intact status" or with "absence of clinical signs". All herds assessed within the EFFORT project were free of clinical signs. Nonetheless, the HHWI takes into account indicators influencing the animal health status, such as lameness or bursa alterations, to show the interdependence of health and welfare.

The new developed score aimed to capture the degree of animals being able to cope with its situation and the welfare level resulting from it, similar to the protocol of the WQ-project. The ability to cope with a situation is measured as a deviation from the normal, healthy status of animals (Wechsler 1995). In respect to the HHWI, it needs to be mentioned that it does also take into account the level of the care-taking quality of the farmer, which is for example represented by the number of animals with manure on their bodies or by the frequency of injuries.

To select the indicators, a mixed method of expert opinion and literature research has been used. Based on reviews of the past ten years and based on veterinary expert opinions suitable animalbased indicators for the HHWI were chosen (Broom 1986, Wechsler 1995, Veissier et al. 2013, Heath et al. 2014, Czycholl et al. 2017, Pandolfi, et al. 2017).

For the selection process of veterinary experts in the field, the snowball effect was applied, as described by Gustafson et al. (2013). Consequently, we contacted veterinary and farmer's assosications to recruit experts, aiming at having a total of ten experts. However, the majority of experts were involved in the EFFORT project, which represents a certain bias, although we have tried to maximize acquisition opportunities. Due to similarities within their CV's, the distribution of age and gender of the experts is very homogeneous. To obtain the information we conducted a phone interview with all experts individually, asking standardised questions.

Due to the tight schedule within the EFFORT-project, and the daily animal care routine in pig herds, time-consuming indicators had to be excluded. Possible indicators and their feasibility as iceberg indicators were discussed with the experts, taking into account indicators that represent typical problems influencing the welfare status of pig herds.

Within the group of experts, it was decided to use the HHWI index points as malus points, describing limiting factors for good health or welfare as an increase in index points representing the animal's health and welfare impairments due to those factors. In this context, the indicator "manure on body" is used to measure the hygienic status, including also elements of the management system. Animals with manure on them, are not just a sign of wet faeces, or diarrhoea, but they can also indicate an attempt of the animals to cool themselves down, as a sign of dysfunctional thermoregulation. The occurrence of runts is an indicator of how thoroughly the farmer or herd manager monitors the animals. Firstly, the occurrence of runts usually does not differ much between herds, but differences can be used as a sign of non-intense monitoring. Secondly, the occurrence of runts reflects the herd health situation, as a result, for example, of chronic infection. To identify stress factors triggered by non-ideal housing conditions influencing the health status, the two indicators "bursa alterations" and "lameness" were observed. The indicator "tail, ear and flank biting" in the herd was mainly chosen to represent the level of stress present. Even if it limits the explanatory power of a multifactorial indicator, like "tail, ear or flank biting" or "runts", they are assessed in a qualitative way, using "only" as an indication of inadequate welfare. In addition, it was difficult to clearly define the boundaries between the individual scores. Therefore, only two degrees of severity were given. For the three indicators measuring lameness, bursa alteration and manure on the body, distinct degrees of severity could be identified.

Step-wise calculation for the HHWI

The HHWI was created as a malus point system, one index point describing the best possible and three index points the worst health and welfare status of a single welfare indicator.

TABLE 2: *Definition of the Herd Health and Welfare Index (HHWI) measures for pigs*

Measurement[sa]	Degree of severitya	Measured as frequency (%)	Duration of assessement
Bursa alterations[1]	1	% of pigs in the observed group without any swelling of the bursae	2 x 5 minutes (10 minutes in total)
	2	% of pigs in the observed group with several small swollen bursae	
	3	% of pigs in the observed group with at least one large swollen bursa	
Lameness[1]	1	% of pigs in the observed group without any signs of lameness	2 x 5 minutes (10 minutes in total)
	2	% of pigs in the observed group putting less weight on at least one leg	
	3	% of pigs in the observed group putting no weight on at least one leg	
Manure on body[1]	1	% of pigs in the observed group with ≤ 20% of the body covered with dirt	2 x 5 minutes (10 minutes in total)
	2	% of pigs in the observed group with 20-50% of the body covered with dirt	
	3	% of pigs in the observed group with > 50% of the body covered with dirt	
Runts[1]	1	% of pigs in the observed group that are not runts	2 x 5 minutes (10 minutes in total)
	2	% of smaller/lighter pigs with little subcutaneous fat on hips/ ribs/backbone, most with prolonged hair (runts) in the observed group	
Tail, ear and flank biting[1]	1	% of pigs in the observed group without any deviations	2 x 5 minutes (10 minutes in total)
	2	% of pigs with fresh blood or crusts, as well as swelling as a sign of biting	

1 For the visiting team, a picture protocol including all assessed indicators was provided.
a Each pig in the selected sample was classified into one of the degrees of severity of each measurement

TABLE 3: *The lower (Q25) and upper quartile (Q75) and median (Ø) of frequencies of Scores 2 and 3 for the semi-quantitative assessed indicators (manure on body, lameness, bursa alterations) and the occurrence of tail, ear and flank biting, and occurrence of runt pigs. Results presented individually for each indicator, each age category and each country.*

Measurements[a]		Bursa alterations[1]						Lameness[1]						Manure on body[1]						Runts[1]			Tail, ear and flank biting[1]		
		Score 2			Score 3			Score 2			Score 3			Score 2			Score 3			Score 2			Score 2		
Country		Q25	Q75	Ø	Q25	Q75	Ø	Q25	Q75	Ø	Q25	Q75	Ø	Q25	Q25	Ø	Q25	Q25	Ø	Q25	Q75	Ø	Q25	Q75	Ø
A	frequencies weaners (%)	0	1	0.5	0	0	0	0	0.8	0.9	0	0	0.2	0	7.5	7.0	0	2.5	2.4	0	2.5	1.7	0	1	1.7
	frequencies fatteners (%)	0	3.5	2.5	0	1	0.1	0	3.5	1.7	0	1	0.1	0	40	22.2	0	5.8	6.6	0	1.3	0.9	0	1.6	1.1
B	frequencies weaners (%)	0	3	4.1	0	0	0.3	0	3.2	1.8	0	0	0	0	4.8	6.3	0	0	1	0	0	0	0	20	2
	frequencies fatteners (%)	0	11.3	7.4	0	1	0.4	1.1	9.0	4.7	0	1.2	0.8	0	8.5	9.9	0	5.3	2.5	0.6	1.8	1.2	1.7	5.3	5.3
C	frequencies weaners (%)	0	0.9	0.9	0	0	0.9	0	0.7	0.5	0	0	0.1	1	3.3	10.5	0	1.5	5.6	0	0.4	0.5	3.9	14.5	9.9
	frequencies fatteners (%)	1.5	12.2	8.4	0	0.1	0.5	1.5	5.1	4.3	0	0.1	0.2	23.2	43.9	32.8	4.7	16.4	12.4	0	0	0	15.3	19.7	16.8
D	frequencies weaners (%)	1.8	8	5.4	0	0	0	1.7	3	2.5	0	0.3	0.2	0	0.5	5.3	0	0	0.1	2	4	3.8	0.8	3.3	2.9
	frequencies fatteners (%)	3	8.5	8.9	0	0	0	1.8	3	4.7	0	0	0.1	0	15	9.9	0	1.5	13	0.5	1	1	0	0.6	0.4
E	frequencies weaners (%)	0	1.5	0.8	0	0	0.3	0	1	0.7	0	0	0.2	0	10	9.6	0	0	1.1	0	5	0.8	0	0.4	5.8
	frequencies fatteners (%)	0	1.6	1.4	0	0	0	0	0.1	0.2	0	0	0.3	0	0.8	4.3	0	0	2	0	0	0.2	0	0.9	5.7
F	frequencies weaners (%)	2.3	5	5.5	0	0	0.1	0.1	1	1.3	0	0	0.1	2.7	20	13.3	0	0	0.5	0	1	0.5	3.6	23	19.6
	frequencies fatteners (%)	5	10.5	7.9	0	0	0.1	1	5	3	0	0	0.3	12.5	46.7	31.6	0.5	10	12.2	0	0	0.3	2.3	7.2	13.6
G	frequencies weaners (%)	0	1	1.2	0	0	0.2	0	1	0.9	0	0	0.2	0	11.3	11.3	0	0	2	0	3.3	2.2	0	2	5.6
	frequencies fatteners (%)	0	2	1.2	0	0	0.6	0	1.3	1.3	0	0	0.1	0	20	16	0	0	4.5	0	1.3	0.7	0	2	1.25
H	frequencies weaners (%)	0	10	4.2	0	0	0.1	0.8	10	4.2	0	0	0.1	0	5	2.4	0	10	0.8	8.8	60	32.4	0	0	0.2
	frequencies fatteners (%)	1.8	10	7.2	0	1	1.5	2.8	10	8.1	0	1.3	1.9	5	40	24.7	0	10	9.9	5	77.8	38.5	0	6.3	8.8
I	frequencies weaners (%)	1	5	3.6	0	0	0	1	5	4.1	0	0	0	10	14.3	14.3	0	2.3	2	1	3	3	2	5	3.9
	frequencies fatteners (%)	5	10	6.2	0	0	0.3	5	10	7.4	0	0	0.3	10	18.5	16.4	0	3.5	2.6	0	1.3	1.5	1	3	7

1 Expressed as frequency (%) of each indicator in the observed group
a Each pig of the selected samples was classified into one of the several degrees of severity of each measurement

The HHWI assessment protocol consists of five different indicators, composed of two qualitative and three categorial-qualitative animal-based indicators that allow for the semi-quantitative assessment of the health and welfare of pig herds.

The set of five indicators assessed in two age categories (fattener and weaner) results in a total of ten indicators for each herd. The categorial-qualitative indicators were scored using a threepoint scale ("healthy and well developed" (Score 1); "moderate signs of a deficiency" (Score 2); "severe signs of a deficiency" (Score 3)), and the quantitative indicators using a twopoint scale (1 = "absence of defects", 2 = "defects present"). The complete list of indicators and their definitions are presented in Table 2.

The HHWI was assessed on-farm in the nine participating countries by the visiting teams using the set of indicators to which all persons involved in the nine countries in the HHWI assessment had been introduced by text and pictures illustrating the criteria. The scores were assessed as frequencies (% of the total number of animals in the group) of animals showing clinical signs or a reduced welfare status in different degrees of severity. It was mandatory to assess all animals of a sampling batch and to assign one Score per indicator for each animal.

To take into consideration that even few animals with the Score 3 represent a much higher degree of health and welfare impairments than several animals with Score 2, the Score 3 was weighed twice of the weight of Score 2, which led to a "theoretical" frequency of animal health and welfare impairments in the group that was observed. Therefore, the HHWI was calculated using the equation below, which in terms of estimating semi-quantitatively the level of pain and distress of the animals, is more realistic than an unweighted addition of Score 2 and Score 3:

- "theoretical" frequency = Score 2 + (Score 3 x 2)

This "theoretical" frequency was then used as threshold value to allocate the HHWI points. Threshold values were calculated as upper (Q75) and lower quartile (Q25), which are shown in Table 3. The primary focus of the HHWI was put on the simple, but functional threshold values of the lower and upper quartile to allocate the HHWI points for each indicator. Values below Q25 were

TABLE 4: *Example for allocation of index points. Showing the related values (frequencies (%); theoretical percentage; index point) of one farm in country D, as an example of allocation. First, the outcomes of weaners and second of fatteners are shown for each farm within one row. These rows are split into three to demonstrate the different levels when allocating the index points. For each of the five indicators, the observed frequency for each severity score, the theoretical percentage calculated from these scores and the resulting index points are shown. The last row shows the sum of index points.*

Measurements[a] frequencies (%)		Weane			Fattener		
		frequencies (%)	theoretical frequencies	HHWI point	frequencies (%)	theoretical percentage	HHWI point
Bursa alterations1	Score 1	98	NA		96.5	NA	
	Score 2	1	1	1	2	5	2
	Score 3	1			1.5		
Lameness1	Score 1	98	NA		99.5	NA	
	Score 2	2	2	3	0.5	0.5	2
	Score 3	0			0		
Manure on body1	Score 1	80	NA		50	NA	
	Score 2	15	25	3	20	80	3
	Score 3	5			30		
Runts1	Score 1	93	NA		98	NA	
	Score 2	7	7	3	2	2	3
Tail, ear/ flank biting1	Score 1	95	NA		95	NA	
	Score 2	5	5	3	5	5	3
Sum of Index points		13			13		
Sum of Index points/farm		26					

1 Expressed as frequency (%) of each indicator in the observed group
a Each pig in the selected sample was classified into one of the degrees of severity of each measurement

treated as the best 25% of observations and 1 HHWI point was allocated. Values above Q75 were treated as the worst 25% of observations and 3 HHWI points were allocated. For the moderate values of observations between Q25 and Q75 2 HHWI points were allocated. This procedure was carried out for each individual indicator.

Based on these results, HHWI points were allocated as follows:

- 1 HHWI point: all frequencies < Q25
- 2 HHWI points: all frequencies between Q25 and Q75
- 3 HHWI points: all frequencies > Q75

An example for the calculation of the HHWI is shown in Table 4.

The last step was to add up the HHWI points for each indicator of the ten indicators to ascertain the overall sum of HHWI points per herd.

Due to the fact that we only had data of one visit per herd, it proved impossible to comment on the duration of the status.

Statistics

The index points were ranked by herd and the within-country between-herd differences were assessed using the Kruskal Wallis test. All statistical analyses were performed using SASÒ 9.4 (SAS Inst. Inc., Cary, NC).

Results

The feasibility of the HHWI was tested within the context of the European EFFORT project, which gave the opportunity to assess 20 pig herds in nine European countries (countries A to I; n=180). Table 3 presents the overall occurrence of each indicator in the nine EFFORT-countries, represented by the within-country upper and lower quartile and median frequencies (%) of different scores. The frequency of Scores 2 and 3 for the categorialqualitative assessed indicators (manure on body, lameness, bursa alterations) and the occurrence of tail, ear and flank biting, and occurrence of runts are shown (see Table 3). This descriptive analysis of the indicators revealed some variation in frequencies between the assessed groups, indicating a great variation between countries.

Based on the frequencies (%), the theoretical frequencies were calculated and used for allocating one to three index points to each indicator, which is representatively shown for one herd in Table 4. The outcomes of weaners and of fatteners are shown for each farm. Each row is split into three to demonstrate the different levels in the process of allocating the index points.

As an additional step, the resulting sum of index points was used to classify herds according to their health and welfare status, i.e., to identify herds with good or poor health status. The benchmarks used for classification were calculated using the procedure previously described for the index points and are shown in Table 5.

Assessment results are presented as HHWI points as shown in Table 5. The full range of HHWI points (10-30) was not attained by any of the participating countries. Between countries, the minimum and maximum HHWI points ranged from ten to 16 and from 23 to 30 HHWI points, respectively. The median number of HHWI points was between 16 and 20, representing the focal point of the HHWI. The box plots in Figure 1 illustrate the variations within and between countries, showing that the health and welfare status of the farms in each country varied considerably. The resulting range of the HHWI points of the selected and assessed pig herds indicated considerable differences between farms within one country (see Table 5). The Kruskal Wallis test was used to assess the between-farm differences in the range of HHWI points within countries (Chi-Quadrat = 20.6377, p = 0.0082). Further analyses need to be carried out to identify the structural differences and risk factors influencing the health and welfare status.

Discussion

The aim of this study was to develop a robust and, compared to the Welfare Quality (WQ) protocol, simplified index to assess the health and welfare of pig herds in the context of the EFFORT project and to explore whether the herd health and welfare index (HHWI), originally developed for EFFORT, can be used for routine assessments of the herd health and welfare quality of pig herds as a benchmarking tool to promote continuous improvement programmes in the pig industry. The short assessment time for the HHWI increases the chance that the index is used on a regular basis as e.g. a continuous self-assessment tool of pig health and welfare by farmers or as a consulting tool by veterinarians for e.g. verifying the outcome of veterinary advice.

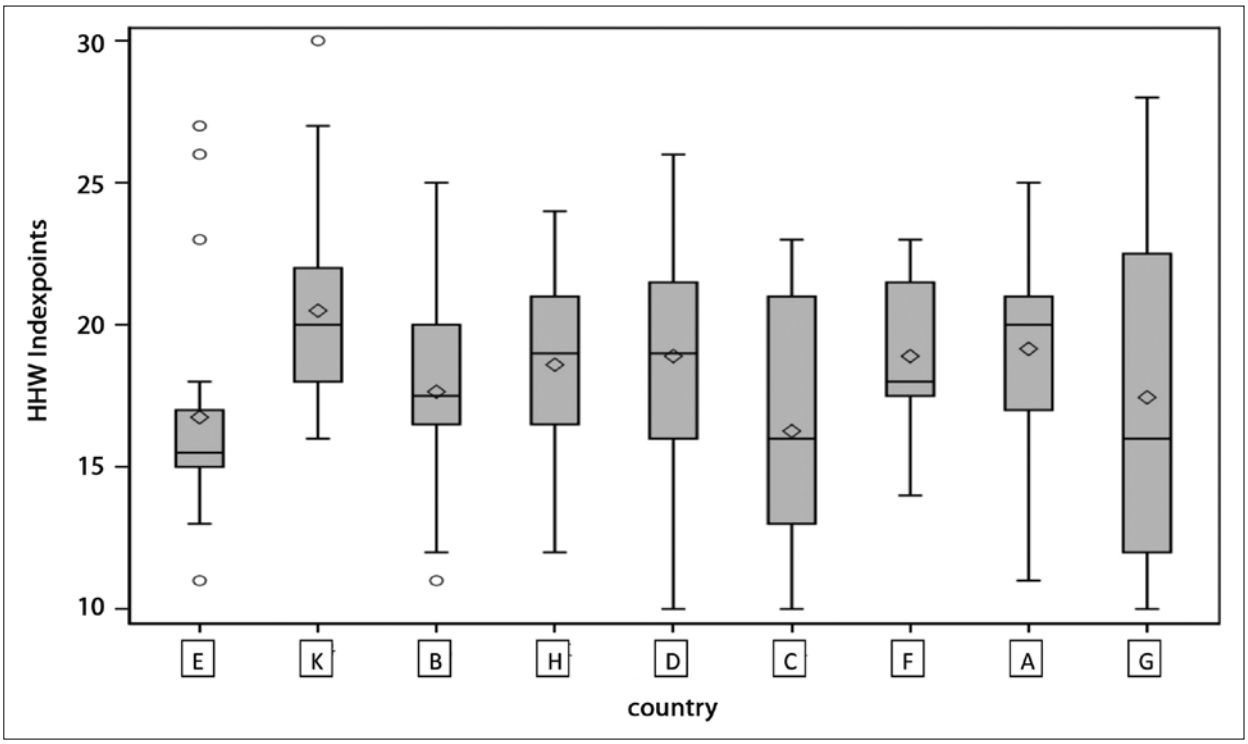

FIGURE 1: *Boxplot illustrating the variations in the HHWI per country in countries A to I. A box represents the 25th (Q1) to 75th (Q3) percentile; the centreline depicts the median (Q2).*

Data from nine European countries was obtained using the HHWI. Even though individual thresholds at national level are being used, all herds are assessed using harmonized indicators. Therefore, the benchmarks of the HHWI refer to an EFFORT database of 180 pig herds. Hardly any comparable databases of this scale can be found neither at the national nor at the European level, due to the lack of a common animal welfare monitoring database.

Using the HHWI as an assessment tool, the health and welfare status could be assessed without the availability of slaughter check findings by replacing them by on-farm animal-based indicators. In addition, the level of the care-taking quality of the farmers could be indirectly assessed.

Compared with the results of previous studies obtained at national level, where, for example, the WQ animal welfare protocol was applied to a representative number of herds, it can be seen that for some parameters, such as manure on body or lameness in fatteners, these benchmarks are comparable to the presented benchmarks (Dalmau et al. 2010, Temple et al. 2011). For the indicator "bursa alterations", a lower overall average prevalence (5.64%) was recorded compared to that recorded in Germany for the WQ project (45.2%) (Czycholl, et al. 2017). The deviations between the welfare benchmarks resulting from national studies and the outcome of the HHWI may be due to differences in sample size or by considerable observer variations, especially in the case of young animals, in which differences are less pronounced and harder to recognise. This could suggest, that especially training for the observation of bursa alterations in young animals is needed.

Even though the number of animals in the assessed batch was consistent in all samplings, the size of the evaluated herds varied, which may have affected the results. Therefore, the sample size used for the assessment should be adapted to the total number of animals present at a farm, i.e. a standardized sample size should not be used.

The indicator "bursa alteration" and "tail, ear and flank biting" were mentioned in previous studies as iceberg indicators (Czycholl, et al. 2017). The remarkable differences in the prevalence of "tail, ear and flank biting" between the countries reflects, apart from observer differences, the multifactorial character of the risk factors for tail biting. While the indicator "tail, ear and flank biting", as iceberg indicator gives hardly direct hints to the causation of the bitings, the indicator "runts" hints more directly to a poor feeding and health management.

A future application could also be as a benchmarking tool, e.g. indicating to each herd owner or manager their ranking position compared to other assessed herds. However, the HHWI is not intended to identify the cause of the indicated deficiencies, but to trigger further explorations at the farms in question. The readiness of individual farmers to improve the status of the own herd can be spurred on when farmers are confronted with the fact that peer farmers in the benchmarking system are "better" farmers, which results in a continuous improvement process. Due to the large-scale design of the project within which the data were collected, the intra- and interobserver bias cannot be ignored. However, consistent with literature, the interobserver bias assessed in the pilot study within the EFFORT project showed no considerable varaition. (Main et al. 2000, Temple et al. 2012). Nevertheless, the interobserver bias was assessed only in one country, and based on e.g. inter cultural differences between countries, it is likely that those findings were not applicable to all participating countries.

Overall, the results indicate that the HHWI is a relatively rough, semi-quantitative, and less elaborate tool than, for example, the complete protocol of the Welfare Quality® project. Nevertheless, the assessment results within the EFFORT project have demonstrated that the HHWI can be used as an animal health and welfare assessment tool. Measuring the welfare of herds, for which only limited parameters are available (e.g. no slaughterhouse data) has enabled us to group herds according to their HHWI status. However, the HHWI was initially developed to be used at project level and therefore still lacks validation.

As seen in this study, the index can be used to compare herds within a country and show differences in their health and welfare status. Even though the HHWI was only used at a single sampling event for each farm participating in the project, a future application for the HHWI could be as a tool for a continuous benchmarking and, thus, for continuous improvements, e.g., as a self-assessment tool for herd managers.

Conclusion

This study demonstrates that the health and welfare status of pig herds can be assessed in a simplified way, using only animal-based on-farm measures. The HHWI has been proven feasible and sufficient for indicating animal health and welfare differences between farms within a country. In commercial farming, thorough and continuous animal welfare monitoring, e.g. following the Welfare Quality® protocol, is nearly impossible to implement due to the broad and time-consuming approach. However, the importance of introducing a common animal welfare monitoring is increasing due to the need to meet the expectations of society and consumers.

Our results suggest that the Herd Health and Welfare Index (HHWI) can be used as a suitable tool for continuously measuring the health and welfare status of pigs at herd level. Further studies are needed in order to validate HHWI.

Supplementary Material

Questionnaire on animal welfare and animal health as used in this study. Available on request from the corresponding author.

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Conflict of interest

The authors declare that they have no competing interests.

Ethical approval and consent to participate

This study was carried out in strict accordance with the European Guidelines for Accommodation and Care of Animals. Only observations of animals were carried out that did not cause any pain, suffering or injury to the animals (Animal Welfare Act §7). Thus, the use of the HHWI is in accordance with the German national legislation and does not require any application to be submitted for approval to the Animal Ethics Committee.

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Author contribution

TB, JAW, HS, DB and the EFFORT group designed the study. TB, KW and DM detailed the structure of the index. KW, ASRD, CLN and the EFFORT group carried out sampling. KW, TB and DM analysed the health and welfare data from 180 herds in nine countries. ASRD and

CLN carried out the pilot study of interobserver variation. KW created the figures and drafted the manuscript. All authors helped to review, edit and complete the manuscript and gave their consent to publication of the manuscript´s final version.

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