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Relationships between pig welfare, productivity and farmer disposition

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Abstract

The aim of this study was, firstly, to investigate the connection between on-farm assessed welfare scores and production parameters for sows, and secondly, to examine how farmers perceive the connection between their disposition, animal welfare and productivity. We assessed environmental and management preconditions on animal welfare and interviewed farmers on 30 Finnish farms. We studied the relationship between welfare and production using correlation and regression analyses. The theory of planned behaviour served as an articulation of farmer disposition when studying farmer perceptions. Concerning the production data, better welfare scores from the 'health and stockmanship' category during lactation were correlated with shorter reproduction cycle and fewer stillborn piglets and it also explained some of the variation in the number of piglets per year and the length of the farrowing interval. The farmers agreed that the productivity parameters and the principles of assessing welfare used in this study were relevant. A majority of farmers considered that animal welfare affects productivity and that there are associations between farmer attitudes, animal welfare and productivity. There were no statistical relationships between farmer perceptions and animal welfare; yet on the farms of farmers with positive perceptions of attitudes to animal welfare and productivity there were slightly lower piglet mortality rates and lower stillbirth rates than on the farms with farmers holding less positive views. We conclude that actions to improve animal welfare also have an economic impact as they enhance sow production. Good stockmanship and healthier animals result in more piglets born and a shorter reproduction cycle.

Keywords: *animal welfare, attitude, farmer, pig, production, theory of planned behaviour*

Introduction

Animal welfare is multidimensional and can be defined in different ways. A common approach to the concept of welfare includes the Five Freedoms defined by the Farm Animal Welfare Council (1992). We share the interpretation of Appleby (1996), who represents animal welfare as a state of well-being brought about by meeting the physical, environmental, nutritional, behavioural and social needs of the animals under the care or influence of people. Husbandry and disease control that we consider to be suitable and meet the needs of an animal may satisfy physical, environmental and nutritional needs, but they do not necessarily guarantee that behavioural and social needs are met. Thus, special attention should be paid to these factors in intensive farming.

Welfare assessment can be carried out based on the animal or its environment. Environment-based measurements include space allowance, animal density and microclimate in the animal unit. Measurements of environmental parameters are based on previously collected information about the effects that the environment is known to have on the animal, but they can only identify conditions which could relate to animal welfare and should not be used to predict animal welfare *per se* (Keeling 2005). Though environmental measurements cannot provide direct information on welfare of an individual animal, they are widely used in on-farm welfare assessment systems because the measurements can be performed quickly and inter- and intra-observer repeatability is good (Napolitano *et al* 2009).

Animal-based measurements provide more detailed information on the welfare state of the animal. Human-animal interaction, abnormal behaviour, body condition score, skin condition, lameness and injuries are all animal-based measures used for on-farm welfare assessments. The main aim in the use of animal-based measurement with on-farm assessment is to establish measures that have proven validity and reliability and can be taken on a large number of animals in a reasonable time (Sevi 2009). When animal-based parameters are used they can be evaluated in different ways: i) as a percentage of all animals in the same production phase (eg A-index, [Munsterhjelm *et al* 2006]); or ii) detailed measures carried out on randomly selected animals from the production phase of interest (Welfare Quality® 2009), as evaluating all the individual animals on a given farm would be impossible.

It is argued that there is a connection between stress and welfare, and that stress can result from compromised welfare (Veissier & Boissy 2007). Stress is a situation whereby an animal is unable to adapt to stimuli and incidents in its surroundings, such as challenges concerning social environment, housing conditions and feeding (Einarsson *et al* 1996; Arey & Edwards 1998), without major hormonal or behavioural adjustments (Moberg 2000). Long-term stress has an impact on reproductive hormones and their function, especially during ovulation, heat and early pregnancy (Lang *et al* 2003; Turner *et al* 2005). Reduced piglet survival can result from behavioural and hormonal changes during parturition and early lactation, periods that are sensitive to stressors, as reviewed by von Borell *et al* (2007).

According to previous empirical studies, farmer attitudes are reflected in their behaviour toward animals and thus influence animal welfare and even productivity (eg Hemsworth *et al* 1994; Hanna *et al* 2009). The theory of planned behaviour (TPB) by Ajzen (1991) has often been used in studies concerning (farmer) attitudes towards animal welfare and productivity (eg Waiblinger *et al* 2002). It is demonstrated to be reasonably successful in predicting and explaining behaviour (eg Armitage & Conner 2001; de Lauwere *et al* 2012).

According to the TPB, an individual's intention to behave in a certain way is assumed to be a precondition for the implementation of the behaviour in question. This intention, in turn, is determined by self-evaluation of the behaviour (attitude toward the behaviour), belief that the behaviour can be realised (perceived behavioural control), and the supposed opinions of other people who are important to the individual (subjective norm). Two features are especially noteworthy in the theory. First, the studied attitude is toward behaviour, which makes the conceptual link between the attitude and overt behaviour direct and specific, and thus favourable to empirical testing. Secondly, not only the evaluation of the attitude as such but also other perceptions (perceived behavioural control, subjective norm) closely connected with it are considered relevant to the intention. These other perceptions (or beliefs) associate conceptually with attitude because they include at least indirect evaluation of the behaviour in question.

In the current study we used the TPB as a loose, theoretical framework when inquiring about farmers' perceptions concerning the impact of their own disposition. With disposition we refer to farmer attitudes, beliefs, perceived behavioural control, intentions and subjective norms. Sources of subjective norms in this study included consumers, trade, slaughterhouses, veterinarians, agricultural advisers, researchers and other specialists, and peer farmers. We were interested in how the farmers themselves visualise the linkage chain between their dispositions, welfare and productivity; ie how well their views comply with the theoretical framework provided by the TPB.

Firstly, our aim was to investigate connections between on-farm assessed animal welfare and production parameters of sows and discuss the reasons behind the possible connections. Secondly, we aimed to examine how farmers themselves perceived the connections between their own disposition, animal welfare and productivity.

Materials and methods

Animal welfare assessment system (A-index)

We used the A-index (described in Munsterhjelm *et al* 2006) for dry sow units and farrowing units to assess environmental and management preconditions for welfare on-farm. (The word 'unit' is used in this experiment for a building or part of a building where the majority of the animals in a certain production phase are housed). The A-index is a Finnish modification of the ANI-35L-model (Bartussek 1999). Modifications are made mainly on outdoor rearing parameters because pigs are not housed outdoors in Finland due to the harsh winter climate. Within the A-index, we divided some of the parameters (for details, see Tables 1 and 2 in the supplementary material to papers published in *Animal Welfare* section at the UFAW website, www.ufaw.org.uk) to create more specific measurements (suggested by C Munsterhjelm, personal communication 2006). In the A-index, there are a couple of animal-based measures for welfare but most measures deal with environmental and management preconditions for welfare. However, for the sake of clarity, we will later use the term 'welfare' also when referring to these environmental and management preconditions for welfare.

The A-index for both units has six categories: 'locomotion opportunities', 'social interaction', 'floor quality', 'stable climate', 'feeding' and 'health and stockmanship'. Each category comprises 3–10 parameters and the parameters differ between farrowing and dry sow (breeding and gestation) units (Tables 1 and 2; see the supplementary material to papers published in *Animal Welfare* section at the UFAW website, www.ufaw.org.uk.). Maximum score depends on how important this category or parameter is considered to be for the welfare of the animal. The maximum score for both units is 100.

Production data

We received the production parameters, extracted from the Finnish herd surveillance system database, from the Finnish Animal Breeding Association (FABA). The herd surveillance data, which include farm and production parameters, are collected by the farmers. All parameters are presented as actual values per litter or per year. We received data from 29 farms from the year preceding the farm visit. Parameters of interest were herd size, breed of the litter born, percentage of first litters, litters per sow per year (LSY), piglets per sow per year (PSY), weaned piglets per sow per year (WPSY), stillbirth rate (SB%), mortality of piglets from birth to weaning (MBW%), total piglet mortality (TM%), farrowing interval (FI) and weaning to gestation interval (WGI).

Farmer interviews

We carried out semi-structured, in-depth interviews during farm visits. One researcher interviewed the farmer (or the farmer couple) while the other assessed animal welfare in the barn. We designed the interviews to establish whether the farmers perceive the dispositions described in the TPB as factors affecting animal welfare and productivity. We piloted the interview protocol before the farm visits on two farms.

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Data collection

We collected welfare and attitude data on 30 commercial piglet, gilt-producing (breeding animals) and integrated (piglet and meat production) farms. In our previous study (Kauppinen *et al* 2010) we sent a questionnaire to all farmers that were members of the Finnish herd surveillance system and asked if the farmer wished to participate in a further on-farm welfare assessment study. Among the 44 volunteer farmers, we chose 30 farms that were geographically convenient to access. Farms were located in southern and western Finland, the main pig production areas of the country. We visited all the farms once during March 2007; the maximum being two farms per day. Each farm visit included a welfare assessment, a farmer interview and a discussion about the results of the welfare assessment. One trained person did the welfare scoring on all the visited farms.

We performed welfare scoring separately in the farrowing, breeding and gestation sow units. Because of the small number of independent breeding units (n = 7), we combined the unit scores (breeding and gestation) for dry sows and used the averages for statistical analyses. If a farm had multiple units for the same production phase that differed from each other (new vs old), we scored both the units and used the average as an A-index score for the unit (n = 2 for farrowing unit). If scores for one parameter were missing, we scaled other points in the category so that the impact of a missing parameter was accounted for. Scores were missing from the ventilation efficiency of dry sow units (n = 6) because of measurement difficulties, and from the boar pen size (n = 2) because one of the farms had no boar and the other always kept the boar in a group pen with sows.

We assessed body condition of sows in the 'feeding' category using a five-point scale (1 = thin, 5 = fat). We considered animals to be in good condition when a body condition score of 3 or 4 was given for at least 95% of the animals. When assessing the 'stable climate' category we used appropriate devices for the measurement of temperature, humidity, light intensity, noise and air draught. Effective temperature calculation followed Straw and Wilson (1985), with the addition of the impact of floor heating (+5°C). To calculate the efficiency of ventilation (m^3 per sow per h), we used the following formula:

[(total area of ventilation openings × air draught × 3,600 s per h)/number of animals]

In the interviews, we presented three sheets of paper one-by-one to the interviewees. The sheets illustrated: i) the contents of the animal welfare index (see Figure 1 in the supplementary material to papers published in *Animal Welfare* section at the UFAW website, www.ufaw.org.uk), ii) animal productivity in terms of piglet production parameters (piglets born, stillborn piglets, and piglet mortality from birth to weaning) (see Figure 2 in the supplementary material at the UFAW website, www.ufaw.org.uk), and iii) the dispositions proposed in the TPB with elaborations based on our previous studies (attitudes towards different welfare-improving measures: providing the animals with a favourable environment, taking care of animal health, treating the animals humanely, and taking care of farmer well-being; perceived ease of implementing these measures; subjective norm sources important for farmers; intentions to improve animal welfare; and abstract value dimensions termed 'reward-seeking farmers' with productivity and profitability as salient values, or 'empathic farmers' with animal welfare as an intrinsic value (Kauppinen *et al* 2010, 2011) (see Figure 3 in the supplementary material at the UFAW website, www.ufaw.org.uk). We also introduced the sheets verbally and requested that interviewees commented freely in their own words on the illustrations on separate sheets, and on the relationships between illustrations on different sheets. Tape-recorded conversations stimulated by the illustrations lasted from 30 min to almost 2 h. We transcribed the tape recordings *verbatim* and analysed farmer comments and standpoints individually across the interviews.

For statistical analyses, we quantified farmer perceptions into three categories (1 = agree, 2 = partly agree, 3 = do not agree) depending on whether farmers thought that: i) animal welfare affects productivity of the animals; ii) farmer attitudes affect animal welfare; or iii) farmer attitudes affect animal productivity.

Statistical analysis

We removed outliers and normalised the data with logarithmic transformations ('locomotion opportunities' and 'floor quality' in farrowing unit and 'WGI' in production data) and square-root transformations ('stable climate' in farrowing unit and 'locomotion opportunities' in dry sow unit). It was not possible to normalise the farrowing unit 'social interaction' or the dry sow unit 'floor quality' categories and consequently non-parametric Spearman rank correlation coefficients were calculated in those analyses.

When relationships between A-index scores and production parameters of interest were examined, the impact of herd size, breed of the litter born and percentage of first litters had to be managed by including them in the model. We used logarithmic conversion to normalise 'herd size' and divided 'breed' into two categories: mainly purebred (n = 4) and mainly crossbred (n = 25) litters on the farm. Piglet mortality from birth to weaning was assigned points in the welfare assessment of the farrowing unit. We removed points for piglet mortality from the 'health and stockmanship' category and total scores when relationships with production data WPSY, MBW% and TM% were assessed. In the same way farrowing rate was assigned points in dry sow units and we removed points from it when assessing relationships with LSY, PSY, and WPSY.

We studied relationships between A-index scores and production data with correlation and regression analyses performed with PASW Statistics 18 (SPSS Inc, Chicago, Illinois, USA). We studied connections between A-index scores and herd surveillance data using partial correlation methods to control the impact of number of animals, breed of the litter born and percentage of first litters, and calculated Pearson Correlation Coefficients for production data. If dependent variables (total unit points or category points) showed more than two correlations ($P < 0.05$) with a

Table 1 Total welfare and A-index category scores from farms included in the experiment.

Category	Mean (± SEM)	Min–Max
Farrowing unit, total score (max 100)	50.9 (± 1.23)	37.5–64.0
Locomotion opportunities (max 11)	3.5 (± 0.54)	0.5–10.5
Floor quality (max 8)	6.4 (± 0.26)	3.0–8.0
Social interaction (max 9)	4.0 (± 0.15)	2.0–5.5
Stable climate (max 28)	11.8 (± 0.61)	7.0–18.0
Feeding (max 21)	12.8 (± 0.63)	6.5–19.0
Health and stockmanship (max 23)	12.4 (± 0.37)	9.0–16.0
Dry sow unit, total score (max 100)	63.1 (± 2.01)	40.0–83.5
Locomotion opportunities (max 21)	8.2 (± 0.93)	1.5–17.5
Floor quality (max 12)	8.7 (± 0.46)	4.5–12.0
Social interaction (max 16)	9.8 (± 0.39)	5.0–13.0
Stable climate (max 16)	7.5 (± 0.45)	4.0–14.3
Feeding (max 16)	12.3 (± 0.50)	7.0–16.0
Health and stockmanship (max 19)	15.3 (± 0.24)	12.5–17.5
Total farm score (max 200)	**113 (± 2.84)**	**77.5–140**

The categories 'locomotion opportunities', 'floor quality', 'social interaction', 'stable climate', 'feeding' and 'health and stockmanship' form total welfare score for unit. Total farm score is the sum of farms' farrowing unit and dry sow unit scores.

Table 2 Descriptions and reproduction data from farms included in the experiment (n = 29) and averages from Finnish Production Recording Scheme 2006 (n = 379 farms) (FPRS06).

Category	Mean (± SEM)	Min–Max	FPRS06
Sows per herd	79.7 (± 5.50)	46.8–164.2	71.4
Parity number	3.5 (± 0.15)	1.4–4.9	3.5
Litters per sow per year	2.1 (± 0.04)	1.4–2.4	2.1
Piglets per sow per year	26.6 (± 0.65)	16.4–31.9	24.8
Piglets weaned per sow per year	21.0 (± 0.63)	12.4–25.7	19.7
Stillbirth rate (%)	8.7 (± 0.41)	2.8–12.8	9.0
Piglet mortality birth-weaning (%)	13.6 (± 0.78)	6.1–24.9	12.9
Total piglet mortality (%)	21.2 (± 0.85)	13.8–31.9	20.7
Farrowing rate (%)	71.1 (± 2.79)	35.8–88.8	72.2
Farrowing interval (days)	164.6 (± 1.45)	152.0–186.0	170.0

production parameter we performed further analyses with linear regression by entering herd size, breed of the litter and percentage of first litters into the model. To prevent the negative impact of multi-collinearity, we analysed the collinearity of predictors with correlation analysis; we report only results from models with normally distributed residuals. Missing values were excluded pair-wise.

Results

Pig welfare assessment

Four of the farms had free farrowing for all the sows. A majority of the farms kept gestating sows loose-housed, either in deep litter (n = 11) or without bedding (n = 5). Fourteen farms kept the sows in crates for breeding and four retained them in crates for the whole gestation period.

Table 1 presents the combined A-index points. Dry sow units had better total welfare scores than farrowing units and the variation was greater in dry sow unit scores. There was a positive correlation between dry sow and farrowing unit total scores ($r = 0.474$, $P = 0.008$), and also between 'locomotion opportunities' categories of the units ($r = 0.404$, $P = 0.027$).

Pig production parameters

Production parameters from 2006 show that farms participating in this study represented the average Finnish farm (Table 2).

Pig welfare and production

LSY increased with better scores from farrowing units' 'health and stockmanship' category (Table 3). PSY was positively correlated with the farrowing units' 'health and stockmanship' category. In addition, points in the 'locomotion opportunities' categories in both units were negatively correlated with the number of weaned piglets per sow per year. The percentage of stillbirths decreased if the farrowing units' 'health and stockmanship' points increased. Farrowing intervals shortened with farrowing units' increasing points in 'stable climate' and 'health and stockmanship'.

Parameters PSY, WPSY and FI had multiple significant correlations with index categories and we performed further analyses on them with linear regression (Table 4). PSY increased with increasing 'health and stockmanship' score; a one-point rise in scores resulted in 0.637 piglets more per sow per year. The percentage of first litters and 'locomotion opportunities' score in dry sow units lowered WPSY; a one-point rise in 'locomotion opportunities' score resulted in 1.213 fewer weaned piglets per sow per year. Farrowing interval shortened by 1.354 days if 'health and stockmanship' score rose by one point.

Farmer perceptions of the connections between their own disposition, pig welfare, and productivity

All the farmers were comfortable with the welfare measures (Supplementary Figure 1; www.ufaw.org.uk), the productivity figures (Supplementary Figure 2; www.ufaw.org.uk) and the farmer dispositions (Supplementary Figure 3; www.ufaw.org.uk) introduced in the interview sheets. Some farmers mentioned other parameters that they considered relevant to the subject, such as the option for species-specific behaviour and meat quality as measures of animal welfare, and sow longevity and fitness of piglets after weaning as measures of productivity.

> Nothing occurs to be missing here… For me, these all appear true and objective. I've been thinking about these myself, and yes, these all affect animal welfare.

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Table 3 Results from correlation analysis on production parameters and total welfare and category scores.

Category	LSY	PSY	WPSY	SB%	MBW	TM%	FI	WGI
Farrowing unit								
Total score							–0.391†	
Locomotion opportunity		–0.347†	–0.426*					
Stable climate							–0.486*	
Health and stockmanship	0.561**	0.528**		–0.491*			–0.449*	–0.463*
Dry sow unit								
Locomotion opportunity	–0.383†	–0.403*	–0.451*		0.367†	0.347†		
Feeding								–0.385†

** $P < 0.01$; * $P < 0.05$; † $P < 0.1$; LSY: litters per sow per year; PSY: piglets per sow per year; WPSY: weaned piglets per sow per year; SB%: stillbirth rate; MBW%: mortality birth-weaning; TM%: total mortality; FI: farrowing interval; WGI: weaning to gestation interval. Categories forming part of the total welfare score for unit were 'locomotion opportunities', 'stable climate', 'feeding' and 'health and stockmanship'.

Table 4 Results of regression analyses on production parameters with multiple correlations to total welfare and category scores.

	PSY		WPSY		FI	
	$R^2 = 0.702$, $p(F) < 0.001$		$R^2 = 0.572$, $p(F) < 0.001$		$R^2 = 0.665$, $p(F) = 0.001$	
Parameter	**b**	**SEM**	**b**	**SEM**	**b**	**SEM**
Constant	25.12**	8.056	29.24***	7.249	202.78***	18.992
Number of sows	–1.88, ns	3.041	1.34, ns	3.195	–2.39, ns	7.234
Breed of litter	3.18, ns	2.038	–0.21, ns	1.796	–7.52, ns	4.297
Percentage of first litters	–0.14, ns	0.096	–0.31*	0.085	0.37, ns	0.221
Farrowing unit						
Total score					–0.13, ns	0.229
Locomotion opportunity	–1.26, ns	1.580				
Stable climate					–3.75, ns	3.197
Health and stockmanship	0.64*	0.269			–1.35*	0.622
Dry sow unit						
Locomotion opportunity	–0.70, ns	0.510	–1.21*	0.505		

*** $P < 0.001$; ** $P < 0.01$; * $P < 0.05$; ns: non-significant. PSY: piglets per sow per year; WPSY: weaned piglets per sow per year; FI: farrowing interval. Categories forming part of the total welfare score for unit were 'locomotion', 'stable climate' and 'health and stockmanship.'

Farmer perception: welfare and productivity

Most of the farmers were convinced of the positive effect of welfare on productivity. They highlighted several welfare-related factors that improve production:

> When you treat the animals well, take good care of them, give them good food, treat illnesses, if you come to the piggery every day to look after them and watch the farrowings and everything, I think it also affects productivity.

A few farmers brought up the ambiguity of the relationship between animal welfare and productivity. They thought welfare improves production at least in part, but a productive animal may not yet feel well:

> Well, it's a bit contradictory. I've been wondering how they can get such high production figures in those big piggeries. And I don't think animal welfare is quite all right there. […] I'd be glad to think a productive animal would feel well and have everything fine, to a T. Yet it's not always like that, however.

> The animal with the best welfare is not necessarily the most economic.

Table 5 Farmer perceptions of the animal welfare and farmer disposition influence on productivity; quantification based on the interview data.

Farmer perception	Yes	Partly	No
Welfare affects productivity	29	1	
Disposition affects welfare	25	5	
Disposition affects productivity	20	7	1

Farmer perception: disposition and welfare

Almost all the farmers thought their attitudes affected animal welfare; only five out of 30 farmers doubted this (Table 5). Perceived importance and ease of good stockmanship and own well-being were the most often mentioned features that affect animal welfare in the farmer responses. The farmers emphasised that their own well-being is also a precondition for the welfare of their animals:

> Stockmanship impacts everything, every section [of animal welfare]. I think the stockmanship is the most important, it's the key for everything.

> Human well-being seals the well-being of the animals.

Other important features that the farmers believed could affect animal welfare were the perceived importance and ease of humane and individual treatment of the animals, keeping an eye on the behaviour and health of the animals, and a farmer's own motivation.

Roughly one-third of the farmers thought intentions to improve animal welfare have a positive effect on animal welfare *per se* (Table 5). The remainder said sheer intention is not enough to make the difference, although intentions improve motivation and are a good starting point:

> I think it goes indirectly, so that when you have an intention you believe in yourself a little more again and the motivation grows and you keep your eyes open all the time, you're not going around half-asleep.

All the farmers said that listening to veterinarians greatly influences the welfare of their animals. Most of them also mentioned the abattoir as being influential, but in the sense that there is no choice but to listen to the slaughterhouse staff as they are the main purchasers and co-operators. Farmers perceived that taking into account researchers and other farmers also had a positive effect on the welfare of their animals.

The majority of the farmers felt that the values they held had a positive impact on animal welfare, irrespective of whichever values they emphasised (Table 5). Interestingly, some of the farmers that thought values affected animal welfare and productivity said that improving animal welfare as an intrinsic value makes a difference while some thought it was the instrumental value that improves the output:

> If you appreciate animals as animals, you surely take better care of them than if you keep them only for money.

> If I consider an animal as an instrument then I keep a sharper eye on its feeding, environment, medication etc. and particularly keep up my own professional skills.

Farmer perception: disposition and productivity

The majority of the farmers thought that their attitudes affected productivity (Table 5). They perceived the linkage between these two as the farmer's affection for his/her animals, or as the farmer's way of thinking about and managing the whole farm, which results in the desired positive outcome:

> Of course, if you really like your animals and take care of them accordingly, it affects productivity, you get more piglets.

> The productivity [of the farm] culminates in me. If I have positive thoughts and intentions, I take my animals into account better and also get more profit.

Yet, some of the farmers were undecided about the linkage between disposition and productivity. One of them, for example, protested against overemphasis on farmer attitudes and claimed that the sows produce offspring regardless of farmer opinion on their welfare:

> Efficiency always conflicts with welfare. […] The caretaker doesn't necessarily need to be of the opinion that animals should feel well, and yet the animal can produce well.

No statistical connections were established between farmer perceptions and welfare scores. We did not conduct correlation analysis for the perception 'welfare affects productivity' and production parameters because the farmers agreed with the statement. The animals of farmers who thought that there was a connection between their own attitudes and pig welfare had a lower stillbirth rate than animals of farmers that were in doubt. The pigs of farmers with positive perceptions of the influence of attitudes on productivity had lower stillbirth and total mortality rates than pigs of other farmers. (Table 6).

Discussion

We found significant, although moderate, correlations between pig welfare and productivity. On-farm, assessed welfare was correlated with reproduction parameters. Better animal health and stockmanship during the lactation period shortened the reproductive cycle. However, better locomotion opportunities were negatively correlated with the annual number of piglets produced and weaned. Overall, better quality of stockmanship and animal health seemed to enhance piglet production. Farmer interviews reaffirmed the relevance of welfare and production measures used.

Welfare and production data

Several different categories of the A-index were connected to the reproductive parameters of sows. Farms participating in this experiment had similar A-index total scores to those in the study of Munsterhjelm *et al* (2006).

A negative connection between locomotion opportunities for the sow and WPSY in the farrowing unit could be explained by the free movement of sows and crushing of piglets (Marchant *et al* 2000). Weber *et al* (2007) observed that free sows did crush more piglets, but piglets from the sows in crates died for other reasons, resulting in equal total piglet mortality values. In our experiment, crushing of the piglets could not be the reason behind the lower number of

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Table 6 Relationships between farmer perceptions and production parameters (n = 29).

Farmer perception	LSY	PSY	WPSY	SB%	MBW%	TM%	FI	WGI
Disposition affects welfare				0.320*				
Disposition affects productivity				0.460*		0.314*		

Note that positive correlations indicate positive direction of association (lower mortality). Controlled for: number of sows, percentage of first litters, breed. * $P < 0.05$; LSY: litters per sow per year; PSY: piglets per sow per year; WPSY: weaned piglets per sow per year; SB%: stillbirth rate; MBW%: mortality birth-weaning; TM%: total mortality; FI: farrowing interval; WGI: weaning to gestation interval.

weaned piglets because there was no connection between 'locomotion opportunities' scores and the piglet mortality parameters MBW% and TM%.

The 'health and stockmanship' category was the only significant factor influencing the number of piglets born per sow per year. The increase in category scores was associated with a greater number of litters born per year and a lower stillbirth rate. High scores result from a clean working environment and healthy animals. Munsterhjelm *et al* (2006) also reported the connection between 'health and stockmanship' and a greater number of LSY, although the connection was observed with gestation unit's health and stockmanship category. Low quality of stockmanship has also been previously associated with decreased production (reviewed by Hemsworth *et al* 2009).

'Health and stockmanship' in a farrowing unit was connected to the length of the reproductive cycle and to the number of litters per year. The shorter FI and WGI can be achieved through better sow health at weaning time. Farrowing supervision is assigned points in 'health and stockmanship' in the farrowing unit, and this is probably from where the connection with a lowered stillbirth rate derives, as also observed by Holyoake *et al* (1995).

'Stable climate' in the farrowing unit was correlated with FI even though a connection was not established in the regression analysis. In 'stable climate' good points are achieved when conditions, including ventilation and lighting, are ideal for piglets and at the same time the sow is not stressed by excessive warmth. A longer lighting period has a positive impact on sows' appetites during lactation (Prunier *et al* 1994). This might shorten the weaning to oestrus interval, but the direct impacts of a long light period and various light intensities on weaning to oestrus interval are contradictory (reviewed by Prunier *et al* 1996). High ambient temperatures lower sow milk production, body reserve mobilisation and appetite-reducing feed intake, which in turn delays oestrus after weaning (Prunier *et al* 1997) thereby lengthening the farrowing interval.

The negative association between 'locomotion opportunities' scores in the dry sow unit and piglets born and weaned per year could be related to group-housing solutions. The results of Kongsted (2006) suggest that the most important factor reducing reproduction in group-housed sows is unwanted variation in feed intake. The A-index considers feed intake and probability of satiety using six parameters, but they are located in three different categories ('locomotion opportunities', 'social interaction' and 'feeding'). As a consequence, it is not possible to assess the connection between the reduced piglet production and the success of the dry sow feeding on the farms. Even though the 'feeding' category does not include all parameters connected with successful feeding, it does highlight the importance of feeding in a dry sow unit, as also observed by Munsterhjelm *et al* (2006).

As a tool to evaluate welfare, the A-index is problematic in a few ways. Firstly, the results are compounded with the weighted sum method. Measured parameters (pen areas, the % of animals) are assigned points on a scale. These points are weighted so that they reflect the parameters' impact on animal welfare (see variation in point scales in supplementary Tables 1 and 2; www.ufaw.org.uk). Though the weighted sum method is widely used in animal welfare assessment problems exist as sums allow compensation between scores (Botreau *et al* 2007) which conflicts with the multi-dimensional nature of welfare. Secondly, there is a problem with the fact that farms meeting the demand for zero points do not differ from the farms that would score below zero if such a score were possible. Ideally, this should not be a problem as a below zero score would mean that the terms of animal protection legislation are not met. However, only five out of the 30 farms studied met all the terms. This may have an impact on results as the lack of negative scores makes it impossible to see the true difference between the farms at the lower end of the point scale. Excluding the farms with deficiencies was impossible due to the small number of farms participating in this study. Lack of knowledge on animal protection legislation is unfortunate but, as far as our observations were concerned, not meeting the environment-based legislation terms did not seem to directly impact the welfare of the animals or the welfare score the farms received. This, in turn, tells us that welfare should be observed from the animals not environment.

Farmer perceptions and correlations with pig welfare and productivity

The positive effects of farmer disposition on both welfare and productivity were obvious in the farmers' views. Farmers perceived that their attitudes counted when it came to animal welfare and productivity, and that their intentions, subjective norms and values also had at least some effect on the welfare and productivity of their animals. However, statistically significant correlations occurred only between

farmer perceptions and production parameters. It is possible that with a larger sample size and more variation among farmer perceptions, other linkages between farmer perceptions and pig welfare might have been detected.

The farmers were unified with respect to welfare and production measures and also agreed when it came to farmer attitudes. Animal welfare can mean different things to different people (Hewson 2003), and thus it is crucial to make sure the interviewees are familiar with the terms and topics and that their definitions of animal welfare and productivity are at least approximately the same as the researchers'. All farmers in our study agreed with the relevance of the measures of welfare and productivity that were illustrated on the interview sheets. They were also comfortable with the attitudes/farmer characteristics presented in the interview. This reaffirms that the attitude components outlined in our previous studies are relevant to farmers (Kauppinen *et al* 2010, 2011).

There was no doubt among farmers that welfare of animals is strongly related to productivity. However, some of the farmers acknowledged that high productivity does not necessarily reflect good animal welfare, and that an animal living in a compromised environment or suffering from various behaviour-related problems can still produce well. Good productivity should not be taken as conclusive evidence of good welfare (Scientific Veterinary Committee 1997). To assimilate this requires a profound understanding of the behavioural needs of animals.

The majority of farmers perceived their own attitudes as being important contributors and highlighted the influence of stockmanship on the welfare and productivity of their animals. A similar result was reported by Hubbard and Scott (2011). Good stockmanship and motivation are proven to be significant factors in improving animal welfare and productivity (Hemsworth 2007).

Surprisingly, farmer perceptions were not linked statistically with the outcome of the welfare measures on-farm. Yet, there were significant correlations between piglet mortality and farmer perceptions: the more positive the perceptions, the lower the mortality figures. As there are numerous other factors that affect productivity, in addition to farmer attitudes, we would have anticipated that attitudes would be linked with welfare, but not to such an extent as with production. However, the findings from the farmer interviews were in accordance with our previous study (Kauppinen *et al* 2011) where we reported that pig farmers with positive attitudes towards the improvement of animal welfare gained around 0.5 piglets per litter more than average farmers.

The correlations between farmer perceptions and welfare and productivity figures are not very high. In addition to the factors we controlled, there are numerous other factors that affect animal welfare, and especially production. Therefore, the fact that attitudes explain any degree of variation in production is noteworthy (Hanna *et al* 2009).

The actual value of the qualitative interview data lies within the opportunity to understand how the farmers themselves outline the hypotheses built through the theoretical framework: the hypothesis that farmers' own attitudes and disposition affect animal welfare, and the hypothesis that animal welfare affects production. The data show that in farmers' views, these hypotheses, as well as the operationalisations used, are reasonable. Some of the farmers express certain reservations and specifications which, we think, adds to the credibility of our main point, that is, they generally accept our basic hypotheses. Thus, we conclude that the statistical linkages, although moderate or low, are noteworthy because even in the light of the farmers' own views, these types of correlations were expected.

Animal welfare implications and conclusion

Better health of the animals and higher quality of stockmanship have a positive impact on the piglet production parameters as well as on the length of the reproductive cycle. Not only did the farms with healthy animals and good stockmanship produce more litters and piglets per year, they also had lower stillbirth rates. Farmers perceived that their own attitudes and disposition affect animal welfare, and that animal welfare affects production. Thus, we conclude that the statistical linkages, although moderate or low, are noteworthy because even in the light of the farmers' own views, these kinds of correlations were expected. With a connection to the shorter reproduction cycle the efforts made on environmental and management preconditions on animal welfare do pay off economically. The influence that skilled and motivated farmers have on animal welfare cannot be underestimated and parameters evaluating those factors should be included into the assessment systems. Farmers' affirmative perceptions of the importance of their own attitudes to animal welfare and productivity represent an encouraging finding that should be further studied.

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