MAIN PAPER

Harmonization of welfare standards for the protection of pigs with the EU rules: the case of Croatia

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ABSTRACT

Three quarters of Croatian pigs are produced in small production units (1-5 sows) and on family farms with mixed farming activities. Only few farms have specialized production units with up-to-date technologies and comply with EU standards. The future competitiveness of Croatian pig production is therefore questionable unless production systems are changing. Modernisation will most probably result in the expansion and intensification of larger farms and the termination of a great number of small farms. The aim of this study was to investigate how the welfare of pigs on Croatian farms would be affected by modernisation. Seventeen Croatian pig farmers were interviewed to describe the different pig production systems, while the welfare of pigs was assessed using resource-based and animal-based welfare indicators. Three production systems were distinguished: part-time family farms (PFF), full-time family farms (FFF) and farm enterprises (FE). Resources-based welfare indicators were investigated in 17 pens located on seven PFF, 25 pens distributed across six FFF and seven pens were visited at two FE. Animal-based welfare indicators were assessed on 21 pigs at PFF, 90 pigs at FFF and 18 pigs at FE. The study demonstrated that different production systems have different welfare problems. Based on resource-based indicators pig welfare was better ensured on FE, but based on animal-based indicators there was no clear difference in welfare between the three production systems. Based on these findings is it unlikely that the modernisation of current production systems in Croatia will significantly improve pig welfare. From a welfare point of view, neither the enlargement nor the termination of pig farms can be supported. However, the number of farms involved in this study was too small to allow for generalisation. The case-study does, however, point at the importance of further studies into the specific welfare problems of each of the production-systems and their different solutions. These studies should be of larger scale in order to get a representative picture of pig welfare in Croatia, and its assurance within the process of modernisation.

Key words: Pig welfare, EU directives, Croatia.

RIASSUNTO

ARMONIZZAZIONE CON GLI STANDARD DI BENESSERE ANIMALE DELL'UNIONE EUROPEA PER I SUINI: IL CASO STUDIO DELLA CROAZIA

Circa tre quarti dei suini prodotti in Croazia provengono da allevamenti di piccole dimensioni (1-5 scrofe) e da aziende agricole a conduzione familiare con molteplici indirizzi produttivi. Sono poche le aziende specializzate che dispongono di moderne tecnologie, conformi agli standard europei. La futura competitività della suinicoltura croata appare quindi in discussione, in assenza di sostanziali modifiche degli attuali sistemi produttivi. E' probabile che il processo di modernizzazione determinerà una espansione ed intensivizzazione delle aziende più grandi e la parallela scomparsa di un gran numero delle realtà produttive più piccole. Il presente caso studio ha voluto indagare in che modo il benessere dei suini allevati in Croazia sarebbe influenzato da questo processo di modernizzazione. Diciassette allevatori croati di suini sono stati intervistati per descrivere i diversi sistemi di produzione presenti nel Paese. Il benessere degli animali è stato invece valutato utilizzando indicatori di tipo ambientale/strutturale e di tipo animale. Sono stati individuati 3 sistemi produttivi: le aziende part-time a conduzione familiare (PFF); le aziende full-time a conduzione familiare (FFF) e le aziende di tipo imprenditoriale (FE). Parametri di benessere relativi alle strutture di allevamento sono stati misurati in 17 box multipli di 7 aziende PFF, in 25 box distribuiti tra 6 aziende FFF e in 7 box di 2 aziende FE. Indicatori di benessere derivanti dall'osservazione degli animali sono stati valutati su 21 suini allevati in aziende PFF, 90 suini FFF e 18 suini FE. La ricerca ha evidenziato come i 3 sistemi produttivi presentino diversi problemi di benessere. Sulla base degli indicatori ambientali/strutturali, erano le aziende di tipo imprenditoriale (FE) a garantire un migliore livello di benessere ai suini, mentre non è emersa una chiara distinzione tra i 3 sistemi produttivi analizzando gli indicatori di benessere di origine animale. Questi risultati rendono poco probabile prevedere che l'attuale processo di modernizzazione della suinicoltura in Croazia giochi a favore di un significativo miglioramento del benessere degli animali. Sempre dal punto di vista del benessere dei suini, non appare auspicabile né promuovere l'ampliamento delle aziende più grandi, né l'uscita dal mercato di quelle più piccole. Va comunque rilevato che il numero di aziende coinvolte in questa sperimentazione non può essere considerato adeguato e sufficiente per trarre delle conclusioni definitive. E' emersa comunque l'importanza di promuovere nuove ricerche per identificare gli specifici fattori di rischio per il benessere dei suini e le loro possibili soluzioni in ciascuno dei sistemi produttivi esistenti. Tali studi dovrebbero abbracciare un numero più ampio di aziende per fornire informazioni più complete e rappresentative della suinicoltura croata nell'attuale processo di modernizzazione.

Parole chiave: Benessere dei suini, Regolamenti Comunitari, Croazia.

Introduction

Croatia is preparing for accession into the European Union (EU). As part of this process, Croatian legislation has to be aligned with the common European directives and regulations. In this course, also the EU pig welfare directives need to be implemented (EC, 1991; EC, 2001; EU, 2007). Croatia has a long tradition in pork production. The total number of swine reared in Croatia, including all categories of swine and pigs and excluding pigs from the time of farrowing until the time of weaning, is currently estimated to 1.1 million (CBSRC, 2009). The share of pork production amounts up to 14.5% of the total Croatian agricultural output and up to 33% of Croatian total livestock production output (MAFWM, 2005; MAFWM, 2006). In contrast to other European countries, however, pork production is mostly organized in small production units. For example, 75% of the farming activities on small, mixed family farms (1-5 sows) are related to pork production. On farms with up to ten sows, the share of pork production is even larger, accounting for 85% of the farming activities. In Croatia pig production systems are thus much smaller than in the old EU member states, where 67% of

all family farms own between 100 and 200 breeding sows (Antunovic *et al*., 2004b). So far, the majority of Croatian pig production systems do not comply with EU production standards concerning among others environmental protection, food safety and animal welfare. They are also described as economically and ecologically unsustainable (Juric *et al*., 2000; Misir, 2003; EC, 2006; EC, 2007). It is true that many farms are not specialized and not equipped with up-to-date technologies. Pigs, for instance, are often kept in small, improvised, buildings with hardly any technological devices. Pig production in Croatia will therefore not be able to comply with minimum EU production standards and also its competitiveness is questionable unless production systems undergo considerable changes.

The EU member states as well as accessing states should cooperate in farm preservation and environmental protection (Antunović et al, 2004a; EU, 2007). For this reason, the Croatian Government prepared the Pig Production Development Programme (MAFWM, 2005), that should support the modernisation of the existing pig production systems. According to this programme, most of the small producing units present in Croatia today will have to choose between modernizing their production according to the EU rules and terminating their farming businesses. In the old EU member states, the intensification of pig production has led to ethical concerns regarding the welfare of pigs on farms (Veissier *et al*., 2008). In Croatia, few studies have been conducted to assess other pig welfare aspects than health and the effects of diseases on production yields (e.g. Akos and Bilkei, 2004; Jemersic *et al*., 2004; Mauch and Bilkei, 2004). Reflecting on the current developments in Croatia, it is important to investigate how the described modernisation process could affect the welfare of pigs on Croatian farms.

There are several assessment methods to measure farm animal welfare. Most of these methods focus on resources such as housing (Smulders *et al*., 2006; Geers, 2007). Recently, it has been argued that the welfare of animal should be assessed through direct observation of the animal (e.g. Dawkins, 2006; Kirkden and Pajor, 2006; Yeates and Main, 2008). In the present study, both resource-based and animal-based indicators will be used. Arguably, resource-based welfare indicators can be used to analyse current compliance of different Croatian pig production systems with the EU pig welfare directives. Animal-based welfare indicators can be used to discuss how modernisation of Croatian pig production systems could affect the welfare of pigs in the future.

Based on the background information provided, the aim of this study was to investigate what consequences (in the light of modernising Croatian pig production systems) the implementation and enforcement of the EU pig welfare directives could have on the welfare of pigs on farms in Croatia. To address this problem, the following research questions were considered:

What characterises Croatian pig production systems?

Do the different case study farms representing different pig production systems differ in terms of pig welfare, either when assessed by resource-based indicators (as required by EU regulations) or when assessed by animal-based indicators?

Material and methods

From the total number of 31.845 swine farms in Croatia (MAFWM, 2005), seventeen farms were chosen as case studies, with a total number of 49 pens analyzed as farms' production units. Farms were chosen according to accessibility and possibilities to visit them as the authors depended on

arrangements made through contacts in Croatia. As it follows, the method of sampling was called "convenience sampling". On the one hand, this method allowed the researchers to visit a range of different farms, random from the point of view of the author; but on the other hand, a bias may have occurred according to the choice of farms by the Croatian contact persons. Additional selection criteria included the following: location in one of five counties with the largest pig production (Koprivničko-križevačka županija, Međimurska županija, Osječko-baranjska županija, Varaždinska županija and Zagrebačka županija, all located in the North and East of Croatia); being part of one of the three typical pig production systems in Croatia: traditional agricultural households (producing primarily for own consumption), business-oriented agricultural households and large pig production sites run by business companies. The sample consisted of approximately equal numbers of farms from each pig production system.

Information on pig production systems and production performances were collected using semi-structured interviews and descriptively analysed in the SAS/STAT 9.2 software (SAS, 2008). Interviews were conducted with the help of translators; this was unavoidable and may have confounded the results due to information lost in translation. The welfare of pigs was assessed on farm using resource-based and animal-based indicators. These two indicators were defined as follows:

a) Resource-based welfare indicators referred to the animals' pen, climate, conspecifics and stockpersons (Bracke, 2007a). The definition was applied in such manner that resource-based indicators were observed in the pigs' close environment or referred to interventions by a person and did not involve a direct observation of the pig.

b) Animal-based welfare indicators referred to behaviour, reproductive criteria, physiological and pathological measures (Bracke, 2007b). The definition was applied in such manner that animal-based indicators were directly observed on the pig and did not require a consideration of the pigs' environment.

Indicators were chosen from the book "On Farm Monitoring of Pig Welfare", edited by Verlade and Geers (2007), which discusses the reliability, validity and repeatability of different resource-based and animal-based welfare indicators. Furthermore, the feasibility of the indicators was assessed using the following questions:

- Is the indicator quick to use?
- Is the indicator independent of the pig production system visited?
- Can the indicator be used to compare the different pig production systems?
- Is the indicator easy to observe?
- Is the indicator applicable to sows and fattening pigs alike?

The chosen resource-based indicators are presented in table 1 and the chosen animal-based indicators are presented in table 2. Resource-based indicators were logically categorised according to the five freedoms (FAWC, 2007).

A trial assessment was carried out in the first pig barn visited in Croatia. The welfare assessment was carried out using a welfare check sheet and digital pictures were taken of each sampled pig pen. At each visited pig farm, at least one but a maximum of three pens were sampled. These pens were selected according to convenience, i.e. pens in front of the barn were prioritised because reaching the pens did not require a crossing of the barn which would have alerted the pigs and obstructed their behaviour. Three production systems were distinguished: part-time family farms (PFF), full-time family farms (FFF) and farm enterprises (FE). Resources-based welfare indicators were investigat-

Table 1. Resource-based welfare assessment indicators.

Freedom	EU equivalent Indicator	Indicator definition	Measuring Technique	Unit of Measurement
Freedom from hunger and thirst	Water supply	The quantity and way of providing water to one or more pigs in a pen.*	The farmer was asked for the type of watering technique. It was distinguished between ad libitum or watering times.*	Counts
	Feed supply	The quantity and composition of feed delivered to any type of pen.*	The farmer was asked about feeding mode and feed composition.*	Counts
	Individual feeding space	A feeding space for an individual animal separated from feeding spaces of another animal.*	The pen was scanned for the presence or absence of individual feeding spaces.*	Counts
Freedom from discomfort	Floor type	Refers to the type of floor construction (Hörning, 2007c).	The type of floor was noted as concrete, slatted or both present.*	Counts
Freedom from pain an injury	Castration	Surgical removal of the piglets' testicles.*	The farmer was asked if and when castration was performed.*	Closed-ended question
	Tail docking	Tail docking refers to the surgical amputation of the whole or parts of the tail (EC, 2001)	The farmer was asked if and when tail docking was performed.*	Closed-ended question
	Teeth clipping	Teeth clipping refers to a reduction of the pigs' corner teeth using grinding or clipping (EC, 2001)	The farmer was asked if and when teeth clipping was performed.*	Closed-ended question
Freedom to express natural behaviour	Manipulative material	Organic substrate that animals can manipulate (Hörning, 2007b)	Presence and type of bedding was denoted.*	Counts
	Individual Space	Space allowance per pig (Hörning, 2007a)	Size of pen and number of pigs counted.*	Square metres
	Pen Type	Pen is an enclosure in which one or more animals are kept.*	Pens were matched to initially defined types: Group pen, single stall or farrowing unit.*	Counts
	Toys	A manipulative device that provides recreation for the pig and does not consist of bedding material (Bracke, 2007b).	Presence and type of recreational device was noted.*	Counts
Freedom from fear and distress	Weaning age	The time at which a piglet is taken away from its mother. *	The farmer was asked when piglets were weaned.*	Closed-ended question

**Defined by the authors.*

Table 2. Animal-based welfare assessment indicators.

Indicator	Indicator definition	Observation Technique	Unit of Measurement
Cleanliness	The proportion of animal that is covered with urine, faeces or dirt (Courboulay, 2007).	A group scan in each pen was performed to note the number of pig which showed any signs of soiling. Soiling was scored if the pig showed dirt spots on its body that derived from other sources than dust. For illustration, pictures were taken.*	Counts
Skin Lesions	Lesions are wounds on the rump, shoulder, back, head, legs or ears (Velarde, 2007).	A group scan in each pen was performed and the number of animals with lesions was counted. Lesions were defined as all scratches and wounds visible with the pure eye. Additional pictures were taken.*	Counts
Tail bites	Tail wounds caused by biting the tails of pen mates (Bracke, 2007b).	A group scan in each pen was performed to count the number of pigs with bitten tails. In addition, pictures of bitten tails were taken in each sampled pen. *	Counts
Ear bites	Ear wounds caused by the biting of pen mates (Bracke, 2007b).	A group scan in each pen was performed to count the number of pigs with bitten ears. Ear bites were defined as wounds on the ears that were caused by other means than bacterial infections. In addition, pictures of bitten ears were taken in each sampled pen.*	Counts
Fear of humans	Fear of humans can be expressed as an active avoiding of the human hand or passivity, i.e. not approaching (Spoolder, 2007).	Hands in stall: The farmer was asked to place his hand in the stall and time was counted until one pig approached (on the basis of Spoolder, 2007). If the farmer was not available, the researcher put his hand in the stall.*	Time (Seconds)
Lying behaviour	The pig is lying on the side of his rump or belly.*	It was noted whether animals were laying cigar like (normal), huddled (cold), apart (too warm) (Geers, 2007).	Counts

**Defined by the authors.*

ed in 17 pens located on seven PFF, 25 pens distributed across six FFF and seven pens visited at two FE. For the animal-based welfare assessment, 129 group housed pigs were sampled using digital photographs. Animal-based welfare indicators were assessed on 21 pigs at PFF, 90 pigs on FFF and 18 pigs at FE. The obtained data were

coded and entered into SAS/STAT 9.2 software (SAS, 2008). Separate spread sheets were created for animal- and resource-based indicators for producing graphical presentations. Animal-based and resource-based welfare assessment results were analysed to determine differences in pig welfare between different pig production systems. To deal with on-farm variations, the results from separate pens at a farm were averaged for each indicator.

Resource-based welfare assessment results were analysed along the five freedoms (FAWC, 2007). As table 3 shows, most sampled pens housed fattening pigs (n=21), followed by pens with non-lactating sows (n=12), weaners (n=8) and lactating sows (n=7). Resources provided at different production systems were checked for compliance and divergence from the EU recommended resources. Each indicator at each pig production systems that, on average, conformed to the EU recommended resources received a (+) to determine an overall resource-based welfare score.

To discuss the effect of modernising farms on pigs, their welfare was further assessed using animal-based welfare indicators. The feasibility of the chosen animal-based indicators was sometimes reduced because of methodological problems. For instance, the use of instantaneous group scans was not appropriate for assessing the number of animals with lesions or bites, amongst others due to overcrowding, dirty pigs, rapid movement of the pigs and distraction by other persons in the barn. Alternatively, it was decided to take pictures of the pigs in each sampled pen with the intention to analyse tail bites, ear bites and skin lesions digitally. Using this method, 30 to 100% of pigs in each pig pen were sampled. To investigate the pictures systematically and to avoid repeated assessment of the same pig, one picture of each pen was chosen. To analyse skin lesions on pictures, the number of pigs of which the back, rump and hind quarters were visible, was denoted. Out of these, the number of pigs showing lesions was counted and the percentage of pigs with lesions calculated. For ear bites, the number of ears that were fully visible from the front or back were denoted, the number of ears with bites counted and the percentage calculated. The farm average was used for comparison between the different production systems. For tail bites, assessment from pictures was not possible, as it was impossible to distinguish dirty tails and tail bites. Also lying behaviour was not taken into consideration because in most barns pigs stood up upon entry of the researcher and remained standing for the duration of the visit. Consequently, the animal-based welfare analysis was limited to the following indicators: cleanliness, skin lesions, ear bites and fear of humans. Finally, animal-based welfare assessment results were compared between the different production systems.

Table 3. Number of pig pens (N) sampled at the different pig production systems for the purposes of resource-based welfare assessment.

	Part-time family farms (PFF, N=7)	Full-time family farms (FFF, N=6)	Farm enterprises (FE, N=2)
Pens with non-suckling sows (N)	5	5	2
Pens with farrowing sows (N)	1	4	2
Pens with fatteners (N)	8	10	3
Pens with weaners (N)	3	5	0

Results were statistically analysed using SAS/STAT 9.2 software (SAS, 2008). Non-parametric tests of associations were chosen (denoted as χ^2) for analysing differences in counts between different production systems, (Hawkins, 2006). Non-parametric Kruskall-Wallis tests of differences (denoted as H) were used for analysing differences in space allowance for pigs serving different production functions at different production systems (Hawkins, 2006). The non-parametric Mann-Whitney U test (denoted as U) was used for comparing the differences in space allowance between two types of production systems (Hawkins, 2006).

Results and discussion

The results of this investigation indicated that different production systems in Croatia have different pig welfare problems in terms of resource based and animal based welfare indicators, as well as EU welfare standards. However, the number of farms in this study is small; moreover, health related indicators were not checked because veterinary skills were not available for this study. It is also important to take into account that the farms participating in this study differed in terms of age composition of the herd, and that the assessed samples of animals were at different production stage. As a result, it is not legitimate to make generalised statements about different types of production systems on the basis of this study. This study should be seen as an exploratory case-study. As such it does however, deliver important and relevant results. It appoints the need for further studies into the specific welfare problems of each of the production-systems and their different solutions. These studies should be of larger scale in order to get a representative picture of pig welfare in Croatia, and its assurance within the process of modernisation.

1. Pig production systems in Croatia

The visited pig farms in Croatia represented three different pig production systems. Traditional agricultural households which produced primarily for their own consumption were referred to as part-time family farms (PFF). Business-oriented agricultural households were referred to as full-time family farms (FFF). Large pig production sites which were run by business companies were referred to as farm enterprises (FE).

1.1. Part-time family farms (PFF)

In total, seven PFF were visited. Five out of seven PFF considered pig keeping a "family tradition". Pigs were usually taken care of by wives or grandparents, while the men engaged in off-farm work. Their main off-farm income sources included factory work and military pensions. Six out of seven PFF owned small areas of land, ranging from one to three hectares. An exception was a farm which owned 16 ha for crop production. Feedstuff was produced on farm but supplemented with purchased feedstuff; pigs were obtained from neighbours or relatives. Although all PFF kept pigs primarily for own consumption, table 4 shows, that 71% of all PFF also traded their pigs. These farmers often sold piglets to middlemen and regarded piglet trade an important addition to their off-farm income. All trading farmers agreed that they depended on this extra income to sustain their livelihoods.

1.2. Full-time family farms (FFF)

An agricultural household that engaged in business-orientated pig production was referred to as a full-time family farm (FFF). In total, six FFF were visited. In contrast to PFF, only two farmers kept pigs out of tradition. All other farmers started pig keeping out of economical interests and more men

Table 4. Characteristics of different pig production systems.

	Part-time family farms (PFF) N =7	Full-time family farms (FFF) N=6	Farm enterprises (FE) N=4
Number of pigs on farm (range excluding piglets)	1 to 8	12 to 590	100 to 12.000
Number of fattening pigs on farm	1.6 ± 1.5	450.0 ± 70.7	350 and 12.000
Number of breeding sows on farm	2.0 ± 1.7	43.2 ± 32.1	100 and 1350
Farm size (ha)	4.3 ± 5.2	42.2 ± 44.3	- *
History of pig farming (years)	8 to 30	10 to 30	10 to 15
Labour units (FTE)	3.0 ± 2.2	3.0 ± 0.8	7.0 ± 5.5
Off-farm income (%)	100	33	50
Home consumption (%)	100	83	0
Sources for pigs (%):			
Own farm	57	83	100
Neighbour	29	17	0
Family	14	0	0
Farms trading pigs (%)	71	100	100
Feed origin (%)			
On-farm	14	83	50
On-farm /purchased	71	17	25
Unknown	15	0	25

**The production sites did not include agricultural land that needed to be taken care of by the employees of the visited production site.*

engaged in the care of pigs than on PFF. As table 4 shows, five of six FFF owned between 10 and 117 hectares of land and farmers partially produced their own pig feed. Their main income was generated through pig trading and only two farmers stated to have additional off-farm income sources. Despite the economic focus, five out of six farmers produced pigs also for their own consumption. Pig supply was ensured through own production except for one farmer who purchased his pigs from a piglet supplier. Pigs were sold to slaughterhouses, fattening farms and middlemen.

1.3. Farm enterprises (FE)

Large pig production sites which were run by business companies were referred to as farm enterprises (FE). In total, four production sites of three different FE were visited. Two sites were company-owned production units, while two further production sites belonged to contracted family farmers. The visited farm enterprises were founded 10 to 15 years ago. FE were managed by agronomists. On company-owned production sites, pigs were taken care of by trained workers and veterinary assistants; on contracted farms the farming family took care of the pigs. The workers who took care of the pigs at company-owned production sites, had no additional income source whereas the contracted family farmers generally earned an additional income through crop production and off-farm work (see table 4). FE owned large areas of lands which were often partly rented and partly owned. The employees managing the arable lands were not engaged in the care for the pigs. All production sites were supplied with feedstuff by the FE. Feed was mostly produced at the FE and only additives were purchased. Pig supply was ensured through company-owned nucleus farms and fatteners were brought to company-owned slaughterhouses.

2. Pig production parameters

As table 4 shows, most farmers on PFF, housed between one and four pigs, whereby the number of sows was higher than the number of fattening pigs. As FFF, the numbers of sows varied greatly, i.e. from 11 to 90 whereas both fattening pig producers owned between 400 and 500 fattening pigs. With increasing farm size, farmers appeared to specialise in either fattening pig or piglet production. Amongst the PFF, no farmer was specialised in pig production; they owned poultry, rabbits or cows, as well. FFF were specialised in pig production but three farmers also kept poultry for own consumption. Three FFF further specialised in piglet production, one farmer specialised in fattening pig production and two farmers engaged in piglet and fattening pig production. Farm enterprises owned separate production sites for breeding sows, piglets and fattening pigs. Two of the visited production sites were specialised in piglet production and two visited production sites were specialised in fattening pig production. The number of pigs varied between contracted farmers and company-owned production sites. For example, the visited contracted farmer housed 350 fattening pigs while the company-owned production site housed 12.000 fattening pigs. Similarly, one contracted farmer owned 100 breeding sows while the company-owned production unit housed 1.350 breeding sows.

Across all production systems, the same high performing pig breeds were used. All farmers owned hybrids, involving the following breeds (in descending order of frequency): German Landrace, Swedish Landrace, Pietran, Duroc, Yorkshire, Large White and Edelschwein.

As table 5 shows, fattening periods were longest at PFF and slaughter weights were correspondingly higher than on FFF and FE. A possible explanation for this difference can be derived from the purpose of the pigs. At PFF, pig meat was often processed into dry cured ham, which required a high fat content and correspondingly higher slaughter weights. Prices for piglets appeared to be stable across the different production systems.

3. Resource-based welfare assessment results

The resource-based welfare assessment results are presented along the five freedoms (FAWC, 2007):

3.1 Freedom from hunger and thirst

Freedom from hunger and thirst should be ensured by providing fresh water and species-specific diets (FAWC, 2007). The EU pig welfare directives recommend that all pigs must be fed at least once a day. Where pigs are fed in groups and not *ad libitum* or by an automatic system feeding the animals individually, each pig must have access to the food at the same time as the others in the group. All pigs over two weeks of age must have permanent access to a sufficient quantity of fresh water (EC, 2001).

All sampled pig pens received *ad libitum* water and where supplied with feed more than once a day. Group pens at FE and FFF that were not supplied with *ad libitum* feed were equipped with individual feeding spaces. At PFF, two out of six sampled group pens without provision of *ad libitum* feed did not provide individual feeding spaces. Pigs, nevertheless, had access to feeders at the same time as their pen mates.

3.2 Freedom from discomfort

Discomfort can be avoided by providing shelter, adequate environments and comfortable resting areas (FAWC, 2007). On this line, the EU pig welfare directives pro-

Table 5. Comparison of piglet production and market parameters

	Part-time family farms (PFF) (n=5)	Full-time family farms (FFF) (n=5)	Farm enterprises (FE) (n=2)
Litter size	11.3 ± 4.2	12.1 ± 7.5	12.5 ± 1.4
Litter/year	2.4 ± 0.5	2.0± 0.0	2.0 ± 0.0
Length of fattening period (weeks)	39.2 ± 13.7 (n=5)	13.0 ± 2.7 (n=3)	12.0 ± 0.0 (n=2)
Slaughter weight (Range) (Kg/Live weight)	100.0 to 200.0 (n=5)	100.0 to 120.0 (n=4)	110.0 (n=2)
Average price for piglet*	14.00 (n=2)	12.75 (n=4)	14.00 (n=1)
Average price for fattener*	10.50 (n=4)	13.75 (n=2)	7.50 (n=1)
Average price for sow*	5.50 (n=2)	?	?

**Market prices (Kuna(1)/Kg/Live weight) for pigs, 1Kuna~0.34Euro.*

pose that all pigs should have access to dry, clean and thermally comfortable areas (EC, 1991). Furthermore, the EU pig welfare directives indicate that dry comfort areas should be created by providing pigs with separate lying areas and defecating areas that are equipped with standardized drainage openings (EC, 1991).

Floor types found at the different pig production systems were categorised into concrete floors, fully slatted floors and partly slatted floor areas. Based on this distinction, floor types differed significantly between the different production systems (χ^2=29.96, df=2, P<0.001, n=3). At the company-owned production site, pen floors were partly slatted (n=4) while at the contracted pig production site pen floors were concrete (n=3). At FFF, most pen floors were also concrete (n=13 out of 25) and on PFF all pen floors were concrete (n=17). No difference was observed between pen floors provided for pigs with different functions (χ^2 test of association, in all cases P>0.05).

It is recommended that slats for fatteners must be 80mm wide and openings 20mm small (EC, 1991). On old FFF, however, slatted floors had larger openings (25mm) and smaller slats (65mm) than recommended by the EU welfare directives. When confronted with the differences in slat widths, one full-time farmer objected to the EU recommendation because it would increase cleaning labour.

3.3 Freedom from pain, injury and disease

Freedom from pain, injury and disease should be ensured by using preventive measures, rapid diagnosis and immediate treatments (FAWC, 2007). The EU pig welfare directives (EC 1991; EC, 2001) provide several recommendations on this line that relate to a) flooring and b) surgical interventions. Floors should not be slippery to prevent leg injury. Regarding surgical interventions, tail docking and teeth clipping may not be carried out routinely, castration

may not involve tearing of tissue and all interventions should be carried out by trained persons.

Flooring

In line with the EU pig welfare directives (EC, 1991; EC 2001), previous researches have shown that leg injuries appear to be influenced by floor conditions. For example, Edwards and Lightfoot (1986) showed that leg injuries were lowest in concrete but straw-bedded stalls and increased with the proportion of slatted floor areas. Furthermore, Anderson and Bøe (1999) showed that leg injuries were lower on straw-bedded, concrete floors than on barren, concrete floors or fully slatted floors. Based on these results, one can argue that leg injuries are more likely to occur on concrete, barren or fully-slatted floors than on straw-bedded, concrete floors.

The percentage of pens with straw bedding differed significantly between the different production systems (χ^2=23.88, df=2, P<0.001, n=3). While all sampled pens at PFF (7/7) were bedded with straw, none of the pens at FE were bedded with straw (0/2); FFF scored somewhere in between (3/6). Following Anderson and Bøe's (1999) research, leg injuries were most effectively prevented on PFF. In contrast, injury-promoting concrete and barren floors were found at three pens of the visited contracted family farm and at four pens of FFF. One can, therefore, argue that pigs in these pens were more at risk of leg injuries. At the company-owned production site, floors were fully slatted with the exception of concrete lying boxes (n=4). Since Edwards and Lightfoot (1986) showed that leg injuries are depending on the proportion of slatted floor area, one can argue that pigs in these pens were also at risk of obtaining leg injuries.

Surgical interventions

Regarding surgical interventions (tail docking, teeth clipping and castration), different production systems appeared to follow different practices. Regarding table 6, PFF stated to routinely clip the teeth of piglets at 1-2 days of age. Looking at FFF, both, teeth clipping and tail docking were carried out routinely. At FE, teeth were not clipped routinely but tails were docked at three days of age. Accordingly, all farms practised one or more routine interventions. Routine surgical interventions are all still common throughout the EU (Gallois *et al*., 2005). However, the EU recommends refraining from these practices (EC, 2001). To reduce surgical interventions, changes in management practises seem necessary.

Furthermore, production systems differed in the age of piglets at castration. On PFF and FFF, castrations were performed at three weeks of age. At FE, castration was performed at three days, together with tail docking and vaccinations in order to reduce human interventions. Looking at the EU pig welfare directives, the

Table 6. Age (days) of piglets at surgical interventions.

	Part-time family farm (PFF)	Full-time family farm (FFF)	Farm enterprise (FE)
Number of farms	3	4	1
Age at teeth clipping	1-2	2	N/A1)
Age at castration	23	21	3
Age at tail docking	N/A1)	50%: 1 50%: 21	3

1)This parameter was not applicable at the visited pig production system.

maximum age for castrating piglets without anaesthetic is one week (EC, 2001). It has been argued that pigs feel less pain when castrated before 20 days of age (McGlone and Hellman, 1988). However, Taylor *et al.* (2001) found no difference in pain experience when castrating piglets as early as three days and as late as 17 days of age. No statement can therefore be made as to whether pigs on family farms or FE experienced more pain.

Arguably, the collected data on resources was not comprehensive enough to fully investigate the freedom from pain, injury and disease. Future studies should, for instance, investigate a) whether castration is performed by trained persons and b) whether castration methods differ between the different pig production systems. Also, no indicators were chosen to assess freedom from disease. Differences in medical treatments provided at the different pig production systems and prevention methods (such as all in-all out) should be addressed in future studies.

3.4 Freedom to express natural behaviour

The freedom to express natural behaviour can be ensured by providing pigs with sufficient space, companionship and proper facilities (FAWC, 2007). Following this line, the EU pig welfare directives (EC, 1991; EC, 2001) recommend a) to house all pigs (except lactating sows) in groups, b) to provide specific individual space allowances and c) to provide sufficient quantities of manipulative material.

Group housing facilities

The majority of sampled pens (30 out of 48 pens) were group pens and there was no significant difference in pen types across the different production systems (χ^2 test of association, P>0.05; n=3). Looking at group housing facilities for pigs with different functions, FE and FFF housed all fatteners and weaners in groups. Only at PFF fatteners were housed individually in two out of eight cases. At the company-owned production site one of the two sampled pens for non-lactating sows were group houses and one of the two individual pens in an insemination unit. It was, however, stated that these sows would be transferred to group housing facilities after successful insemination. At FFF, only one of the four sampled pens with non-lactating sows was in groups. All PFF had less than ten sows and were not required to provide group housing (EC, 2001). And indeed, all PFF housed their non-lactating sows in individual pens.

Individual space allowances

In order to analyse whether pigs were provided with sufficient space allowance, it is necessary to pay attention to the weight of the pigs from the different pig production systems. Reference values for space recommendations will therefore be defined on the stated slaughter or selling weights. For weaners, the EU recommended space allowance is 0.30m^2 (25kg), for fatteners at FE and FFF the EU recommended space allowance is 0.65m^2 (110kg) and for fatteners at PFF the EU recommended space allowance is 1m^2 (>110kg). For group-housed sows an individual space allowance of 1.30m^2 is recommended (EC, 1999).

As table 7 shows, except for sows, all visited farms provided on average more individual space for their pigs than recommended by the EU welfare directive. At one PFF, however, individual space for sows in a group pen was smaller (1.21m^2) than recommended by the EU (1.30m^2). Furthermore, fattening pigs at PFF were provided with significantly more individual space than on FE and FFF (H=11.75, df=2, P=0.003; n=3). Space allowance for weaners did not differ between the different production systems (P >0.05; n=3, Mann-Whitney U test).

Table 7. Individual space allowances in group pens at the different production systems (m^2).

Individual space allowance in group pens	EU recommended space allowance	Part-time family farm (PFF)	Full-time family farm (FFF)	Farm enterprise (FE)
Sows	1.30	1.2 (n=1)	2.3 (n=1)	3.1 (n=1)
Fatteners	0.65/1.00	2.0 ± 0.5[a] (n=9)	0.9 ± 0.2[b] (n=6)	1.1 ± 0.0[b] (n=3)
Weaners	0.30	1.0 ± 0.7 (n=3)	0.7 ± 0.8 (n=5)	N/A[1)]

The different subscripts (a, b) indicate significant differences at p<0.05.
1)The recommendation is not applicable for the pig production system.

Manipulative material

To encourage investigation behaviour, the EU pig welfare directives recommend providing pigs with manipulative material such as straw, hay or sawdust (EC, 1991). None of the visited FE and only 11 out of 25 of the sampled pens at FFF provided bedding material. At PFF, all pens provided bedding material, thus conforming to the recommendations of providing manipulative material for pigs. In addition, bedding can also enhance physical and thermal comfort for pigs (Tuytten, 2005) and decrease leg injuries (Edwards and Lightfoot, 1986; Andersen and Bøe, 1999). The EU pig welfare directives should therefore recommend the provision of manipulative material with more stringency. Few pens were also equipped with toys. Blackshaw *et al.* (1997) indicate that aggressive behaviours were significantly lower in group pens with toys than without toys. The visited company-owned production site provided group housed sows with iron chains and also a FFF provided iron chains for his pigs. He argued, however, to only use the chains when he observed behavioural problems amongst the pigs. The provision of toys should therefore be promoted by educating farmers about ways of providing pigs with safe toys and by advocating beneficial results from doing so.

3.5 Freedom from fear and distress

In order to prevent fear and distress, any conditions which may cause mental suffering should be avoided. This can be achieved by good housing conditions, good treatment and avoidance of mental suffering (FAWC, 2007). Arguably, the freedom of fear and distress seem to be the least covered by the EU pig welfare directives (EC 1991; EC, 2001), possibly because they can hardly be addressed by resource recommendations. One can, however, argue that recommendations regarding weaning age are associated with fear and distress. According to the EU pig welfare directives (EC, 1991; EC, 2001), piglets should not be weaned before 28 days or 21 days if the piglets will be kept in an all in-all out management system. All visited pig production systems complied with the EU welfare recommendation.

3.6 Compliance with and divergence from EU recommended resources

According to compliances with EU recommended resources, FE provided the best welfare for pigs, while FFF and PFF were less successful in ensuring the welfare of their pigs. Looking at the different freedoms, table 8 shows that FE did not ensure all five freedoms equally well and some freedoms were better ensured on PFF than on FE. For

Table 8. Resource-based welfare score for the different pig production systems.

	Part time family farms (PFF)	Full-time family farms (FFF)	Farm enterprises (FE)
Freedom from hunger and thirst (score/total)	2/3	3/3	3/3
Freedom from discomfort (score/total)	0/1	0/2	2/2
Freedom from pain, injury and disease (score/total)	2/3	0/3	1/3
Freedom to express natural behaviour (score/total)	5/8	5/8	4/6
Freedom from fear and distress (score/total)	1/1	1/1	1/1
Overall resource-based welfare score/total	10/16	9/17	11/15
Percentage of total compliance	(59%)	(56%)	(75%)

example, FE were more successful than family farms in ensuring freedom from discomfort. PFF were, however, superior in ensuring freedom from pain and injury.

In particular, FFF often lacked group housing facilities for sows, provided bigger slat widths than recommended by the EC (EC, 1991; EC, 2001) and provided no manipulative and bedding material. In order to facilitate the implementation of manipulative materials in intensive pig production systems, research has already been carried out regarding the ecological feasibility of different bedding substrates in modern, intensive production systems (e.g. Amon *et al*., 2007; Blanes-Vidal *et al*., 2008). Also, Tuytten (2005) has argued that pigs may prefer earth-like substrates to straw, which could also be more feasible with the modern slurry systems.

4. Animal-based welfare assessment results

As indicated in table 9, the percentage of pens with clean pigs differed significantly between the different pig production systems (H=7.70, df=2, P=0.02, n=3). The percentage of pens with clean pigs was highest on PFF and lowest at FE. The percentage of skin lesions and ear bites observed at the different pig production systems was not significantly different (all Kruskall-Wallis test, df=3, P>0.05, n=3). Additionally, there was no significant difference between the fear responses of pigs towards humans shown at the different farm types (Kruskall-Wallis test, df=3, P>0.05, n=3).

The scientific validity of the animal-based welfare assessment results was sometimes reduced by methodological problems. On the one hand, the number of samples was too small to make general statements about differences between the different pig production systems and hence they do not provide a basis for firm conclusions. Pictures were biased because they were taken according to the visibility of the pigs on the pictures. Furthermore, when comparing lesions no distinction was made between lesions on shoulders, rump and hind quarters. As Whay *et al.* (2007) report, skin lesions are more frequently observed on the flank than on head or neck regions. The comparison of different body parts may have biased the re-

Table 9. Animal-based welfare assessment results (n=total number of observed pens/animals).

	Part-time family farms (PFF)	Full-time family farms (FFF)	Farm enterprises (FE)
Percentage of pens with clean pigs	88.2 ± 20.8b (n= 7)	44.5 ± 39.0b (n=6)	0.0 ± 0.0a (n=2)
Percentage of skin lesions	8.0 ± 17.9 (n= 5)	3.7 ± 5.1 (n= 4)	33.3 ± 47.1 (n=2)
Percentage of ear bites	6.0 ± 13.4 (n= 5)	13.7 ± 9.7 (n= 4)	22.5 ± 31.8 (n= 2)
Fear of humans in seconds	2.4 ± 3.1 (n=7)	2.0 ± 3.1 (n=6)	2.2 ± 3.7 (n=2)

*)*The different subscripts indicate a significant difference at p<0.001.*

sults. Also, the cleanliness of the pigs could have influenced the assessment results for ear bits and skin lesions. When pigs were dirty, skin lesions and ear bites were difficult to observe. Future studies are therefore necessary to improve animal-based welfare assessment methods and to repeat the animal-based welfare assessment between the different pig production systems.

Conclusions

Different production systems revealed different welfare problems. From the perspective of resources, pig welfare was better ensured on farm enterprises but from the perspective of animal-based welfare indicators no difference was found between the three pig production systems. The presented case studies indicated that current modernisation of production systems is not likely to significantly improve pig welfare. Arguably, a number of outlined welfare problems are related to lacking knowledge and education which cannot be overcome by modernising farming premises. From a welfare point of view, neither the enlargement nor the termination of pig farms can be supported.

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