University of Natural Resources and Life Sciences, Vienna
Department of Sustainable Agricultural Systems
Division of Livestock Sciences

INTENSIVELY KEPT AND STILL HIGH WELFARE?

EVALUATION OF A NEW AUSTRIAN PIG WELFARE INITIATIVE

Master Thesis
by

Cäcilia Wimmler

Supervised by:
Univ.Prof. Dr.med.vet. Christoph Winckler
Ass.Prof. Dr.med.vet. Christine Leeb
Dipl.-Biol. Anke Gutmann

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1 ABSTRACT

In response to the increasing public debate about intensive husbandry conditions in conventional pig production, an animal welfare label for fattening pigs has been implemented by an Austrian slaughterhouse operator. The standards include increased space allowance, straw bedding, an outdoor run and the prohibition of tail docking. As such systems are not common in Austrian conventional pig farming, the aim of this study was to assess pig welfare of labelled farms (LAB) compared with non-labelled conventional farms (CON). Animal-based parameters for assessment on-farm and at slaughter were identified from the literature and further discussed in a workshop with farmers and experts. A total of 1784 pigs from 9 LAB- and 4 CON-farms were assessed during one-day farm visits. Additionally, 1561 pigs of 12 LAB- and 13 CON-farms were assessed at the slaughterhouse. LAB-pigs directed oral manipulation mainly towards straw and showed less tail biting behaviour than CON-pigs (median % of pens affected: LAB = 10, CON = 28). The prevalence of tail lesions was low in both farm categories (median % of pigs: LAB = 1.6, CON = 4.1). Increased amount of straw was associated with less swellings on the hind legs (r = -0.89). Furthermore, the lower proportion of LAB-pigs with meat pH < 6.0 indicates less pre-slaughter stress in LAB-pigs compared to CON (median % of pigs: LAB = 6.1, CON = 17.1). However, the high proportion of pigs with milk spots indicating endoparasites may represent a challenge especially in LAB-farms (median % of pigs: LAB = 44.8, CON = 26.3). The results show that the label standards acknowledge the pig's 'nature' and improve animal welfare. They emphasise the importance of straw as bedding and enrichment material and support the feasibility to keep pigs with intact tails. Still, concerns of animal health should be considered and need special attention in such new systems.

2 ZUSAMMENFASSUNG

Die intensiven Haltungsbedingungen in der Schweinemast werden in der Öffentlichkeit zunehmend kritisch diskutiert. Ein österreichischer Schlachtbetrieb gründete daher ein Label-Programm zur Verbesserung des Tierwohls von Mastschweinen in konventioneller Haltung. Die Tierwohl-Standards umfassen ein erhöhtes Platzangebot, Stroh-Einstreu, Auslauf und den Verzicht auf Schwanzkupieren. Ziel dieser Arbeit ist es, das Tierwohl von Mastschweinen auf Label-Betrieben (LAB) zu evaluieren und mit konventionellen Betrieben (CON) zu vergleichen. Zur Beurteilung wurden tierbezogene Parameter identifiziert und im Rahmen eines Workshops mit LandwirtInnen und ExpertInnen diskutiert. Die Datenerhebung auf 9 LAB- und 4 CON-Betrieben umfasste 1784 Mastschweine. Ergänzend wurden 1561 Schweine von 12 LAB- und 13 CON-Betrieben am Schlachthof beurteilt. LAB-Schweine richteten die orale Beschäftigung v.a. auf Stroh und zeigten weniger Schwanzbeißen als CON-Schweine (Median betroffene Buchten: LAB = 10 %, CON = 28 %). Schwanz-verletzungen kamen in beiden Betriebssystemen selten vor (Median betroffene Tiere: LAB = 1.6 %, CON = 4.1 %). Eine höhere Einstreumenge war mit weniger Schwellungen an den Hinterbeinen verbunden (r = -0.89). Weiters deutet ein geringerer Anteil LAB-Schweine mit pH-Werten < 6.0 auf ein geringeres Stress-Level vor der Schlachtung hin (Median betroffene Tiere: LAB = 6.1 %, CON = 17.1 %). Allerdings stellt der hohe Anteil an Schweinen mit Endoparasiten-Befall (Median betroffene Tiere: LAB = 44.8 %, CON = 26.3 %) insbesondere auf LAB-Betrieben eine Herausforderung dar. Die Ergebnisse zeigen, dass die Standards das ‚natürliche Wesen‘ der Schweine berücksichtigen und zu einer Verbesserung des Tierwohls führen. Sie unterstreichen die Bedeutung von Stroh und zeigen, dass es möglich ist, Schweine mit unkupierten Schwänzen zu halten. Dennoch sollte potentiellen Problembereichen der Tiergesundheit in diesen neuen Systemen besondere Aufmerksamkeit geschenkt werden.

3 INTRODUCTION

The Austrian pig population amounts to about 2.8 million animals (Eurostat 2017a). Pork production represents the highest share of Austrian meat production and the per capita consumption of pork is about 39 kg per year with a self-sufficiency rate of 103 % (BMLFUW 2017). Even if the share of organic pigs in Austria is with 2.3 % highest in the European Union (Eurostat 2017b), the large majority of pigs is kept under intensive conventional conditions. The predominating system for fattening pigs consists of indoor housing with stocking densities of 0.7 m^2 per pig up to 110 kg according to minimum legal requirements in Austria (1. Tierhaltungsverordnung, Anlage 5, 5.2.). Pigs are usually kept without straw bedding in pens with fully and partly slatted floors (BMLFUW 2013). While legislation accentuates the provision of appropriate enrichment material such as hay, straw, wood shavings or hemp ropes for pigs (1. Tierhaltungsverordnung, Anlage 5, 2.7.), these materials are rarely provided in practice.

Another issue in the European pig industry is the practice of routine tail docking, which affects close to 100 % of conventional pigs in most European countries, including Austria (Nannoni et al. 2014). This contrasts with legal requirements, where tail docking is only permitted if there is clear evidence that biting injuries have occurred previously (Council of the European Union 2008). Furthermore, reviews have repeatedly stated an impairment of the pig's welfare through surgical procedures such as tail docking (Nannoni et al. 2014). Thus, there is urgent need to omit routine tail docking.

Intensive husbandry conditions and related management practices affect a large number of animals and have raised the question of how well pigs fare in such conditions. Throughout Europe, consumers' interest in animal welfare has increased in recent years (European Commission 2016). To address these welfare concerns, farm assurance schemes have been developed in several European countries, providing standards to improve and monitor animal welfare in conventional systems (**Figure 1**). One example of such a farm assurance scheme is the UK welfare label *'RSPCA assured'* (previously *'Freedom Food'*), established by the Royal Society for the Prevention of Cruelty to Animals (RSPCA) in 1994 (RSPCA Assured 2018). The RSPCA developed welfare guidelines for different farm animal species such as laying hens, dairy cows, turkeys, salmon and pigs with the objective to improve animal welfare in conventional and organic farming systems. In participating farms, pigs need permanent access to rootable and chewable enrichment material as for example straw, peat or silage, while routine tail docking is prohibited (RSPCA 2016). The successful implementation of this assurance scheme is shown by a remarkable market share of the labelled products: about 90 % of eggs of non-caged laying hens, nearly 70 % of salmon and 27 % of pork in the UK are produced in accordance to the RSPCA welfare standards (RSPCA Assured 2017). Another label is *'Beter leven'*, a more recent and smaller initiative for farm animal welfare in the Netherlands, implemented in 2007 by the Dutch Society for the Protection of Animals (Dierenbescherming 2018). The scheme differentiates three levels of provisions to achieve welfare improvement. Products labelled with one star refer to an improvement of the most urgent animal welfare issues in intensive conventional conditions (e.g. increased space allowance and enrichment material for pigs). Further improvements in conventional husbandry (e.g. straw bedding, access to an outdoor run and omission of tail docking) are awarded with two stars, whereas three stars stand for organic husbandry conditions (Dierenbescherming 2018). A further example for an assurance scheme is the German welfare label *'Für mehr Tierschutz'* established in 2013 by the German animal welfare organisation Deutscher Tierschutzbund e.V. Similar to *'Beter leven'*, the German assurance scheme distinguishes two levels of welfare improvement, using one star as entry level (e.g. 1.1 m^2 space allowance per pig) and two stars for premium welfare standards (e.g. provision of straw and 1.5 m^2 space allowance per pig including an outdoor run). For both levels, the duration of transport is restricted to four hours and anaesthesia is mandatory for piglet castration (Deutscher Tierschutzbund e.V. 2018).

Figure 1 Examples for European farm animal welfare initiatives with respective labelling.

1) *'RSPCA Assured'*, UK (RSPCA Assured 2017)
2) *'Beter leven'*, Netherlands (Dierenbescherming 2018)
3) *'Für mehr Tierschutz'*, Germany (Deutscher Tierschutzbund e.V. 2018).

3.1 A new Austrian pig welfare initiative

Welfare assurance schemes for conventional pig production as outlined above did not exist in Austria until recently. The implementation of a welfare initiative for fattening pigs together with respective labelling in 2017 represents an important step towards increasing pig welfare in conventional farming systems. In contrast to the initiatives in the UK, the Netherlands and Germany, which have been established by animal welfare organisations, the Austrian farm assurance scheme has been developed by a slaughterhouse operator in collaboration with farmers. Similar to the other European schemes, the Austrian scheme sets resource-based standards aiming to improve animal welfare. The assurance scheme exclusively comprises pig fattening whereas other age categories (sows and piglets) are not included.

In detail, the specific welfare standards for fattening pigs are:

1) ***100 % more space*** – Farmers must provide twice as much space as the minimum legal requirements for conventional fattening pigs (e.g. 1.4 m^2 per pig up to 110 kg live weight instead of 0.7 m^2).

2) ***Outdoor run*** – Pigs must have permanent access to an outdoor run (100 % roofing possible) equivalent to at least 25 % of the total pen area.

3) ***Straw bedding*** – A straw bedded lying area of at least 25 % of the total pen area must be provided either outdoors or indoors. Straw must be of high quality and in a quantity to ensure a soft and dry lying area.

4) ***Organic enrichment material*** – In addition to the straw bedded area, organic enrichment material like hay in racks or wooden blocks on chains must be provided permanently.

5) ***Intact tails*** – Routine tail docking is prohibited for all pigs. Exemptions are only accepted if the procedure is necessary to ensure the pig’s welfare and health. In this case, the procedure must be performed by a veterinarian following anaesthesia and analgesia.

6) ***Transport specifications*** – Handling at loading and unloading of pigs must be performed in a careful manner. The use of electric prods is prohibited. Transport duration must not exceed two hours and pigs should be unloaded at the slaughterhouse as soon as possible but at least one hour after arrival.

In addition, the label includes some further requirements concerning regionality (participating farms within a radius of 50 km to the slaughterhouse, purchased piglets must be born and reared in Austria) and feeding (e.g. GMO-free feedstuff). However, these additional requirements will not be addressed in the present master thesis.

3.2 Aim of the Study

In order to establish a trustworthy farm assurance scheme, a scientific evaluation of the effectiveness of the introduced standards in terms of animal welfare improvement is paramount. Moreover, effects of measures such as the prohibition of routine tail docking need to be monitored to respond effectively and quickly in case of problems. Even when each of the implemented measures is known - mostly from experimental research - to improve welfare (e.g. Lyons et al. 1995, Scott et al. 2006, Jensen et al. 2010, Vermeer et al. 2014), little knowledge exists regarding the combined effect of those measures when introduced in commercial systems for fattening pigs. The welfare assessment of pigs fattened under the *'Freedom Food"* label with animal-based measures (Whay et al. 2007) showed a large variation of welfare issues across farms (e.g. leg disorders and body lesions). Furthermore, a direct comparison with conventional farms as carried out for cattle (Main et al. 2003) and broiler chickens (Kells et al. 2001) is missing at the moment.

Therefore, the overall aim of this master thesis was to provide a scientific evaluation of the welfare situation in farms adhering to the above-described new Austrian welfare label compared to non-labelled conventional farms. For this purpose, an assessment protocol consisting of animal-based measures was developed based on literature and additional discussions with farmers and experts during a workshop. Subsequently, these protocols were applied on-farm and at the slaughterhouse in labelled and non-labelled conventional farms. This approach would allow on the one hand to identify areas of high welfare, confirming the effectiveness of implemented measures to promote animal welfare in conventional pig farming. On the other hand, possible areas for improvement could be discovered, which would help to improve such labelling programs for example by proposing adaptation of their standards or implementation of mitigation measures.

4 LITERATURE REVIEW

The label aims to improve pig welfare by the implementation of resource based measures such as increased space allowance or the provision of straw. These measures may affect different areas of animal welfare in different ways. This literature review will elucidate the potential impacts of the label standards specifically on aspects of behaviour and health of pigs.

4.1 Animal-based welfare indicators

Talking about animal welfare necessarily raises the question how to define animal welfare. There are several approaches that should be seen as complementary perspectives for a holistic understanding of animal welfare. Broom (1996) defined animal welfare as an animal's '*state as regards its attempts to cope with its environment*' focusing on the biological functioning of animals. Whereas, Duncan (1996) emphasises that the welfare of animals depends primarily on their feelings and cannot be determined solely by indicators of biological functioning. Finally, considerations about naturalness complement the definition of animal welfare accentuating the importance to perform all the behaviours of animals' natural behavioural repertoire (Kiley-Worthington 1989).

Once animal welfare is defined, parameters are required to measure it. Parameters to assess animal welfare can either be based on environmental conditions and the provision of resources or directly on the animals. Even if all relevant resources are provided in sufficient quantity and quality, many other factors (e.g. quality of stockmanship) may influence the welfare of animals (Keeling 2005). Indeed, the effectiveness of the resource-based label standards, i.e. their actual impact on the pigs, can only be assessed by looking at the pigs themselves. Therefore, animal welfare research focuses on animal-based rather than resource-based measures (Webster 2003, Keeling 2005, Wemelsfelder & Mullan 2014). Animal-based measures are increasingly used in on-farm welfare assessments as part of research projects or farm certification, e.g. by applying the Welfare Quality® protocol (2009) (Temple et al. 2011, Munsterhjelm et al. 2015) and appear to be suitable to compare welfare between farms (Goossens et al. 2008).

Animal health in an integral part of welfare assessment with animal-based measure as disease and injuries may result in pain and suffering (Cockram & Hughes 2011). However, welfare assessment should also include parameters which indicate how clinically healthy animals feel in their specific environment, e.g. by observing animal behaviour (Duncan 1996, Wemelsfelder & Mullan 2014). Recent developments in animal welfare science emphasise on welfare indicators of positive emotion, as the absence of poor welfare does not necessarily imply good welfare. However, objective indicators of positive emotion which are scientifically validated and practically feasible are rare (Boissy et al. 2007).

The subsequent chapters outline quantitative and qualitative behavioural as well as health aspects of animal welfare identifying potential parameters of positive emotions (e.g. play and exploratory behaviour) and welfare impairment (e.g. abnormal behaviour, impaired health).

4.2 Behaviour

4.2.1 Play and exploration

Play behaviour is most pronounced in young piglets and can be categorised as locomotory and object play (O'Connor et al. 2010, Held & Spinka 2011). The questions, what exactly play is and why young animals play, is much debated (Held & Spinka 2011). It is agreed, that play comprises elements of 'functional' behaviour (e.g. flight, fight or sexual behaviour) which are performed in an exaggerated, recurring way without being linked to the actual consummatory act (Boissy et al. 2007). The biological function of play can refer to training and self-assessment of physical (e.g. movement patterns), cognitive (e.g. perceptual capacities) or social skills (e.g. fights) (Boissy et al. 2007). Animals are considered to play only when other motivational needs are met. Moreover, it is suggested that play is rewarding by itself and consequently associated with positive emotions. Therefore, play is a promising indicator of positive welfare as it may result from and cause good welfare (Boissy et al. 2007, Brown et al. 2015).

Exploration is a substantial part of normal behaviour in pigs of all ages. Pigs have a remarkable sense of smell and investigate their environment using their snout to obtain olfactory, taste- and tactile information (Hoy 2009). Stolba & Wood-Gush (1989) described in detail the behaviour of domestic pigs in a semi-natural environment and found, that foraging and investigation of the environment (31% grazing, 23% finding/nosing food, 21% rooting, 25% other) accounted for most of pigs' occupation during the daylight period, even when fed to satiety. This highlights that exploratory behaviour is an innate and important part of domestic pigs' behavioural repertoire. The motivational background of exploration can be found either in hunger (e.g. foraging for the particular purpose to find food) or in curiosity (e.g. searching for changes in the environment) (Studnitz et al. 2007).

As a consequence, there are specific qualities needed for material to be suitable: To ensure a nutritive and novelty value, enrichment material should be edible, odorous, chewable, changeable and destructible (Weerd et al. 2006, Studnitz et al. 2007, Zwicker et al. 2013). Still, the novelty value of an enrichment material will decline over time, as pigs become accustomed to it (Zwicker et al. 2013), therefore it needs to be provided frequently. Straw is suggested to be highly attractive for pigs and is considered as one of the most suitable enrichment materials (Studnitz et al. 2007, Zwicker et al. 2013), especially when provided as straw litter on the floor. However, straw quality and the way it is provided have to be taken into account. Weerd et al. (2006) reported that a full bed of straw is more attractive to pigs than point source enrichment (e.g. substrate dispenser). Jensen et al. (2010) suggest maize silage to be more attractive compared to chopped straw because it is more heterogenous and nutritious. Additionally, a positive effect of higher space allowance on exploratory behaviour was attested in the same study.

4.2.2 Abnormal behaviour

If the behavioural need to explore is not satisfied, pigs are at risk of developing abnormal behaviours such as stereotypies or redirection of exploratory behaviour towards other pigs (Studnitz et al. 2007). Stereotypies are highly repetitive, invariable and intensively performed behavioural patterns which may result from restricted husbandry environments, e.g. lack of enrichment material. Pigs perform primarily oral stereotypies such as vacuum chewing, tongue rolling or bar biting. However, sows are more affected than young pigs (Lawrence & Terlouw 1993, Hoy 2009). More frequently, fattening pigs redirect oral manipulation to pen mates when appropriate enrichment material is lacking (Studnitz et al. 2007, Jensen et al. 2010, Pedersen et al. 2014).

Tail biting is considered to be the most important abnormal behaviour in fattening pigs across husbandry systems and countries and causes major welfare concerns as it results in tail damage and pain. (EFSA 2007). According to EFSA (2007), tail biting results from the unsatisfied behavioural need to explore. Therefore, not only bitten pigs but also tail biting pigs are considered to experience impaired welfare. Even when a variety of nutritional, management and animal-based factors could be determined to influence tail biting (Beattie et al. 2005, Zonderland et al. 2010, Kallio et al. 2018), the lack of straw and appropriate enrichment combined with slatted floors and barren husbandry environment were identified as main risk factors (EFSA 2007, Taylor et al. 2010, Wallgren et al. 2016).

The most common practice to prevent tail biting is tail docking. However, tail docking is associated with acute pain and stress and, moreover, might have negative long-term consequences for the welfare of pigs (Nannoni et al. 2014). Consequently, the omission of tail docking can improve welfare by preventing pigs from unnecessary pain and stress. In addition, considering naturalness and animals' integrity as part of animal welfare (Kiley-Worthington 1989), it could be argued, that keeping pigs with intact tails represents per se a welfare improvement. Yet, it can only be considered as welfare improvement, if pain and injury caused by tail biting are minimised at the same time, which can be challenging in practice. Findings by Di Martino et al. (2015) indicate that un-docked pigs have more tail lesions than docked pigs kept under the same intensive husbandry conditions. However, Paoli et al. (2016) did not find considerable behavioural differences in docked and un-docked pigs kept on a commercial farm (pens with partly slatted floor and two handfuls straw provided per day). Docked pigs showed neither reduced investigation of tails nor increased avoidance behaviour compared to un-docked pigs. Nonetheless, docked pigs had less tail lesions than un-docked. The authors suggest, that the effect of tail docking to mitigate tail lesions is not based on behavioural differences but rather on tail length as long tails seem to be more easily bitten with the cheek teeth resulting in more severe tail damage. Hence, tail docking does not resolve the underlying behavioural problem.

4.2.3 Agonistic behaviour

In contrast to abnormal behaviours, agonistic behaviour (e.g. fighting) is part of pigs' normal behaviour but may still impair animal welfare as it can result in considerable skin damage and injuries. Apart from the more direct method of behaviour observation, the accumulation of skin lesions is a feasible indicator of aggressive behaviour in pigs (Turner et al. 2006). In fattening pigs, agonistic behaviour occurs primarily in the context of mixing unfamiliar pigs and competition for limited resources such as food (Spoolder et al. 1999, Turner et al. 2006, Hoy 2009). Therefore, increased space allowance and appropriate animal-per-feeder ratios play a major role in reducing aggressive behaviour and skin lesions (Spoolder et al. 1999, Picker 2014, Vermeer et al. 2014).

4.2.4 Elimination behaviour and thermoregulation

Regarding excretory behaviour, it must be stressed that pigs are extremely clean animals, which usually separate dunging from their lying area. Pigs prefer cool, light and humid places for defecation. Consequently, spatial and structural aspects of the pen design are key factors to stimulate this behaviour (Hoy 2009, Vermeer et al. 2014). Previous studies reported cleaner pigs and less pen fouling in systems with higher space allowance (Vermeer et al. 2014), drinker position in an outdoor run (Ocepek et al. 2017) or access to a rooting yard (Olsson et al. 2016). However, cleanliness of pigs is also associated with thermoregulation. Above certain temperatures (about 18 – 20°C), pigs seek for cool and humid lying areas (if available mud or, in indoor situations, slatted or soiled parts of the pen) which may result in more pigs with manure on the body (Aarnink et al. 2006, Hoy 2009).

4.2.5 Qualitative Behaviour Assessment

Qualitative behaviour assessment (QBA) represents a method to assess animals' positive and negative behavioural expression (Wemelsfelder et al. 2000) and associated affective states (Rutherford et al. 2012a). QBA is a 'whole animal' approach which integrates the qualitative behavioural expressions (i.e. **how** an animal behaves) using descriptive terms such as 'calm', 'confident' or 'tense' (Wemelsfelder et al. 2000). The application of QBA may not only reveal how animals experience their environment but could also help to interpret results of quantitative behaviour observation (Wemelsfelder & Lawrence 2001).

4.3 Health

4.3.1 Leg disorders

Lameness in fattening pigs can be caused – amongst other reasons such as genetic and nutritional deficiencies – by arthritis (non / infectious joint inflammation). This can also be linked to excessive tail biting as lesions represent a potential entrance for pathogens (Jensen & Toft 2009). Physical injuries and leg disorders may result from inappropriate husbandry conditions such as slippery floors or hard lying surface. Swellings (bursitis) on the hind limbs are most common in conventional fattening pigs as a result of (prolonged) lying on hard floors. Although swellings rarely cause pain, a strong association with foot lesions and lameness is reported (Jensen & Toft 2009, Harley et al. 2014). Straw bedded systems could reduce swellings, which has been previously shown by Lyons et al. (1995) and Kongsted & Sørensen (2017). Consequently, swellings may also indicate poor comfort around resting (Welfare Quality® 2009).

Whereas lameness can reliably be assessed on-farm by observing the pigs, the clinical inspection of leg disorders seems to be challenging (Geverink et al. 2009). Therefore, carcass inspection at the slaughterhouse as performed by Harley et al. (2014) and Kongsted & Sørensen (2017) is more promising for the assessment of swellings.

4.3.2 Endoparasites

Endoparasites play a minor role in intensive conventional systems but seem to be challenging in organic pig farming providing straw bedding and outdoor access (Carstensen et al. 2002, Baumgartner et al. 2003, Lindgren et al. 2014). The parasitic nematode *Ascaris suum* (large roundworm in pigs) is the most widespread endoparasite in pigs and only few herds are free from infection (Dold & Holland 2011). Parasite migration through the pig's liver results in inflammatory reactions visible as white liver spots, so-called 'milk spots' (Dold & Holland 2011). Milk spots are widely used to assess endoparasite infection at meat inspection (e.g. Dalmau et al. 2016, Kongsted & Sørensen 2017). But this parameter does only reflect infection with *Ascaris suum* while other nematodes are neglected. Alternatively, faecal samples can be used to obtain broader information about parasite species and actual degree of infection (Carstensen et al. 2002, Baumgartner et al. 2003).

The importance of endoparasites on pig welfare is not very clear. The negative effect of endoparasites on performance traits such as weight gain, feed conversion and slaughter weight has previously been confirmed (Dold & Holland 2011, Knecht et al. 2012, Martínez-Pérez et al. 2017). Though, this does not imply that pigs necessarily experience pain or suffering. A definition of animal welfare on the basis of 'biological functioning' (Broom 1996) would consider endoparasite infection as welfare impairment because of its biological and pathological relevance. But the situation may be different when animal welfare is solely defined in terms of feelings (Duncan 1996), as pigs may not necessarily suffer pain from endoparasite infection. However, endoparasites do affect biological functioning (Broom 1996) and, moreover, do matter for the farmers' economy. Therefore, parameters of endoparasite infection should be considered in the welfare assessment of pigs.

4.3.3 Respiratory health

Respiratory problems are a major concern in most pig fattening units (Kongsted & Sørensen 2017). Next to health management (e.g. vaccination strategy), husbandry conditions can affect respiratory health in different ways. Access to fresh air and natural climate (sunshine, weather conditions) through an outdoor run may be beneficial (Guy et al. 2002, Lindgren et al. 2014), while higher dust emissions caused by straw in littered systems could result in more respiratory problems (Scott et al., 2006; Edwards, 2011).

The treatment frequency against respiratory diseases as well as pathological aberrations assessed by viscera inspection at the slaughterhouse (e.g. signs of pneumonia, pleuritis and pericarditis) can provide information about respiratory health (e.g. Cagienard et al. 2005, Dalmau et al. 2016, Kongsted & Sørensen 2017). In addition, ocular discharge and conjunctivitis can be used as indicators for on-farm assessment (Whay et al. 2007, Schodl 2017). Ocular discharge has also been described as stress indicator in pigs. Deboer et al. (2015) investigated whether clinically healthy pigs differ in ocular discharge with respect to potentially stressful treatments (isolation and enrichment deprivation). The results indicate that ocular discharge, specifically when stained with brown colour secreted from Harderschen Glands, has a potential as non-invasive welfare indicator. This is further supported by Telkänranta et al. (2015), who found considerable correlations between tear staining scores and welfare-related parameters such as tail lesions. In addition, laterality of ocular discharge (right eye vs. left eye) might play a role, as left eye staining seems to be a sensitive indicator of poor welfare.

4.4 Stress prior to slaughter

Animal welfare does not end at the farm gate. During transport, unloading, lairage, stunning an lastly killing, pigs are exposed to a variety of stressors such as unknown environments, challenging new situations and unfamiliar animals and humans (Brandt & Aaslyng 2015). In addition to resource-based criteria (e.g. quality of transport and unloading facilities), welfare assessment protocols recently focus on animal-based parameters such as behaviour at unloading and meat pH (Welfare Quality® 2009, Brandt & Aaslyng 2015).

The behavioural parameters of the Welfare Quality® protocol for pigs assessed at unloading encompass reluctance to move, turning back, slipping and falling. Slipping and falling and are considered to indicate 'ease of movement' (Welfare Quality® 2009) as these parameters refer primarily to technical properties of the unloading facilities (e.g. ramp angle and material) which may provoke painful injuries (Brandt & Aaslyng 2015, Dalmau et al. 2016). In contrast, reluctance to move and turning around are associated with negative emotions such as fear (Welfare Quality® 2009, Brandt & Aaslyng 2015, Dalmau et al. 2016). However, behavioural indicators of 'fear' must be interpreted in the context of the respective situation.

For example, gentle handling can result in slower movement and more turning around because pigs have more opportunities to perform those behaviours (Brandt & Aaslyng 2015). Vocalisation is considered to reflect animals' emotional state and, therefore, seems to be an important welfare indicator (Boissy et al. 2007). High pitched vocalisation has previously been used as indicator for inappropriate handling and impaired human-animal-relationship at slaughter (Brandt & Aaslyng 2015, Munsterhjelm et al. 2015, Dalmau et al. 2016).

The pH-value of meat is an important parameter of meat quality and routinely assessed as part of meat inspection in Austrian slaughterhouses (Österreichische Fleischkontrolle - ÖFK 2016). Pale, soft and exudative meat (PSE) can be a quality defect in pork due to rapid post-mortem pH decline. The excessive decline results from an accelerated rate of glycolysis, for example as a consequence of pre-slaughter stress (Solomon et al. 1997, Hemsworth et al. 2002, Vermeulen et al. 2015) in combination with genetic loading. Therefore, meat pH can indicate aspects of pig welfare before slaughter (Hemsworth et al. 2002, Van de Perre et al. 2010, Brandt & Aaslyng 2015, Vermeulen et al. 2015). Meat pH less than 6.0 measured 30 minutes after sticking was used to indicate pre-slaughter stress in studies by Van de Perre et al. (2010) and Vermeulen et al. (2015), whereas lower thresholds are reported by Hemsworth et al. (2002) and Mota-Rojas et al. (2006) (5.6 and 5.7, respectively).

In addition to aspects of transport and slaughter (transport duration, handling, lairage) improved husbandry conditions might positively affect animal behaviour and stress in new challenging situations (Edwards 2011, Foury et al. 2011), as increased access to environmental stimuli in enriched husbandry conditions may be beneficial for pigs' adaptability in novel environments (Morrison et al. 2007).

5 HYPOTHESES

Based on the above-described impacts of the husbandry system on different aspects of pig welfare, the following hypotheses – whether and how the label standards could affect the health and behaviour of pigs – were formulated:

1) The label standards regarding provision of straw and higher space allowance are expected to increase exploration of enrichment material and reduce exploration of other pigs.

2) The omission of tail docking could increase the risk of tail lesions but the provision of straw as enrichment material may be an effective measure to ensure low levels of tail biting.

3) Increased space allowance and access to an outdoor run may provide more opportunities to avoid aggression, resulting in a decrease of skin lesions.

4) Enlarged space allowance and access to an outdoor run on label-farms are supposed to enable separation of dunging from lying and could provide opportunities to perform thermoregulatory behaviour by seeking cooler areas resulting in overall higher cleanliness of pigs.

5) A soft, straw bedded lying area may reduce the risk of bursitis, other leg disorders and lameness.

6) Regarding experiences from organic pig production, outdoor access in combination with straw bedding might result in increased endoparasite infection in labelled farms.

7) The label standards could affect respiratory health in two ways: First, pigs may profit from outdoor access resulting in better respiratory health. Second, straw dust emissions could evoke respiratory problems. Hence, no overall change is expected.

8) The transport specifications of the label program (short transport duration, careful handling, prohibition of electric prods) may reduce stress in pigs before slaughter. In addition, improved husbandry conditions could positively affect animal behaviour and stress in new challenging situations. Therefore, it is suggested, that the proportion of label-pigs showing stress-related behaviour at unloading and meat pH less than 6.0 is reduced.

6 ANIMALS, MATERIAL AND METHODS

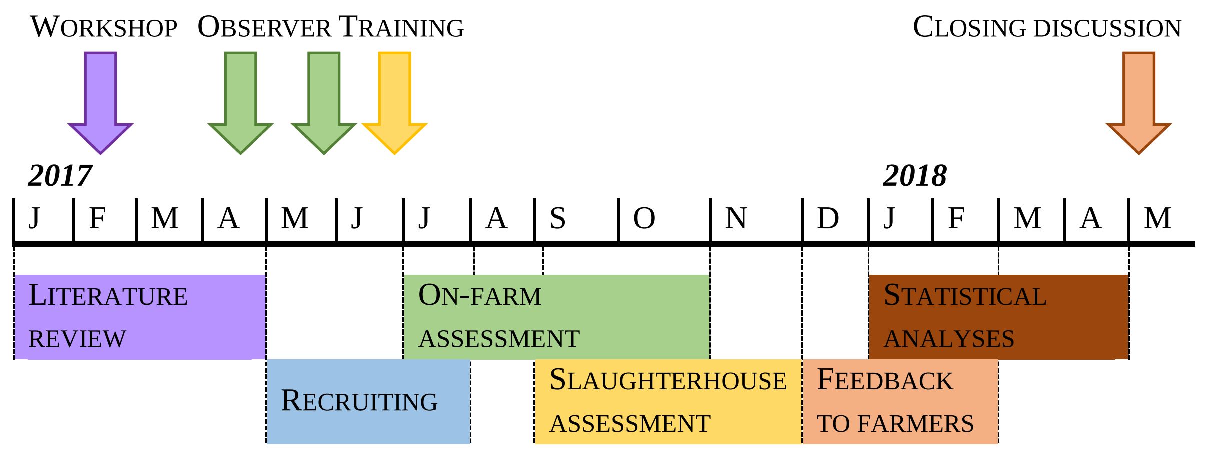
The present master thesis project was carried out in Upper Austria (Austria) in cooperation with the slaughterhouse operator of the welfare label and with conventional farmers of labelled (LAB) and non-labelled (CON) farms delivering pigs to this slaughterhouse.

As a first step, animal-based parameters of health and welfare derived from literature were discussed in a workshop with farmers and experts to combine scientific knowledge with practical experience. Three farmers (one male and one female LAB-farmer and one male CON-farmer) as well as three experts (the male veterinarian of the label project, one female supervisor and the female author of the thesis) participated at the half-day workshop. After an introduction to concepts of animal welfare and animal-based parameters, the potential effects of the label standards on pigs were discussed and respective parameters to assess those were identified (APPENDIX, **Table 13**). The list of parameters identified in the workshop was subsequently complemented and refined on the basis of scientific literature. In this way, a protocol of animal-based parameters was generated.

All assessments took place between July and November 2017 (**Figure 2**). They were accomplished by the same person (the author). Observer training took place prior to data collection through pilot assessments on three farms and at the slaughterhouse with experienced members of the Division of Livestock Sciences (BOKU). In addition, video recordings of a previous study (Schodl 2017) were used for intensive training of behaviour observation. Furthermore, the assessor was already familiar with QBA. However, due to practical limitations, observer-blinding for the farm category (LAB / CON) was not possible.

Descriptive results were fed back to the farmers and, after statistical analyses had been finished, a final presentation and discussion of the results with the participants completed the project (**Figure 2**). The following sections will describe in detail the participating farms and the study design as well as assessment methods and statistical approaches.

Figure 2 Timeline of the project.



6.1 Study design

To evaluate the welfare of pigs, assessments were carried out on conventional farms participating in the label project (LAB-farms) as well as non-labelled conventional farms delivering pigs to the same slaughterhouse (CON-farms). On-farm assessment consisted of a one-day farm visit, including an interview with the farmer and a comprehensive assessment of the pig fattening units. The pigs present on a given farm were assigned to three weight classes based on visual estimation (small pigs up to 50 kg, medium pigs from 50 to 80 kg, heavy pigs over 80 kg). Each pen was categorised according to the weight class of the pigs and three pens of each weight class were randomly selected. On farms with less than 9 pens, all pens were assessed, whereas in case of groups with more than 35 pigs, only 2 pens per weight class were selected. The farmers were recruited on a voluntary basis, given conventional production or label production for at least 6 months prior to the visit. 38 farmers (12 LAB, 26 CON) were contacted by an invitation letter and additional telephone calls, resulting in a total of 13 participating farms (9 LAB, 4 CON). The majority of the 12 LAB-farms producing under label conditions for the required time was willing to engage in the study, whereas only 4 CON-farms were interested to participate.

Due to the imbalanced number of LAB- and CON-farms for on-farm assessment (sample **A**), the sample for assessments at the slaughterhouse was extended to 25 farms (12 LAB, 13 CON; sample **B**), including the 13 farms comprised in the on-farm assessments. For each farm, 1 - 4 batches of pigs were assessed based on their availability at the slaughterhouse on assessment days. Data collection at the slaughterhouse took place on in total 13 days between August and November 2017.

In addition, farm records (medical treatments, performance data) as well as slaughter reports (meat inspection data, performance data) completed the data collection. Whereas assessments on-farm and at the slaughterhouse illustrate the current situation of the farms, data from records provide information about the long-term welfare situation (year / half year preceding the visit).

Consequently, the study consists of two different samples, **A** and **B,** differing in number of farms, assessment site and parameters assessed. Sample **A** represents a more comprehensive assessment of the 13 farms (assessment on-farm and at the slaughterhouse, including records for the previous 6-12 months) whereas **B** refers to a larger sample of 25 farms (only assessed at the slaughterhouse, including meat inspection data). In this way, a broad range of parameters assessed for a long period but for a relatively small and imbalanced number of farms (Sample **A**) is supplemented with less comprehensive information for selected batches of pigs only but of a larger and better-balanced sample (Sample **B**).

6.2 Farms and slaughterhouse

For sample **A**, a total of 1784 pigs was assessed on-farm (1417 LAB, 367 CON). Characteristics of farms and animals are presented in **Table 1**.

Table 1 Sample-size and characteristics of farms and animals for sample **A**, presented in numbers of farms and medians [range], respectively.

Farms were mainly farrow-to-finish farms, with farm size slightly smaller and group size higher for LAB compared to CON. Austrian 'ÖHYB' crossbreed (Sow: Landrace x Large White, Boar: Piétrain) dominated on all farms and the median fattening period was 100 days (100 – 115, excluding one farm with 180 days). All CON-farms performed tail docking, whereas 8 of 9 LAB-farms kept pigs with intact tails. All LAB-farms provided an outdoor run and straw bedding either indoors, outdoors or in combination (6, 1 and 2 farms, respectively). One CON-farm supplied straw on the pen's floor. The majority of pigs were fed with liquid feed, either restrictively (3 LAB and 2 CON) or with sensor-controlled feeding systems where continuous provision of food depending on the amount consumed is ensured (5 LAB and 2 CON).

Table 1 Sample-size and characteristics of farms and animals for sample **A**, presented in numbers of farms and medians [range], respectively.

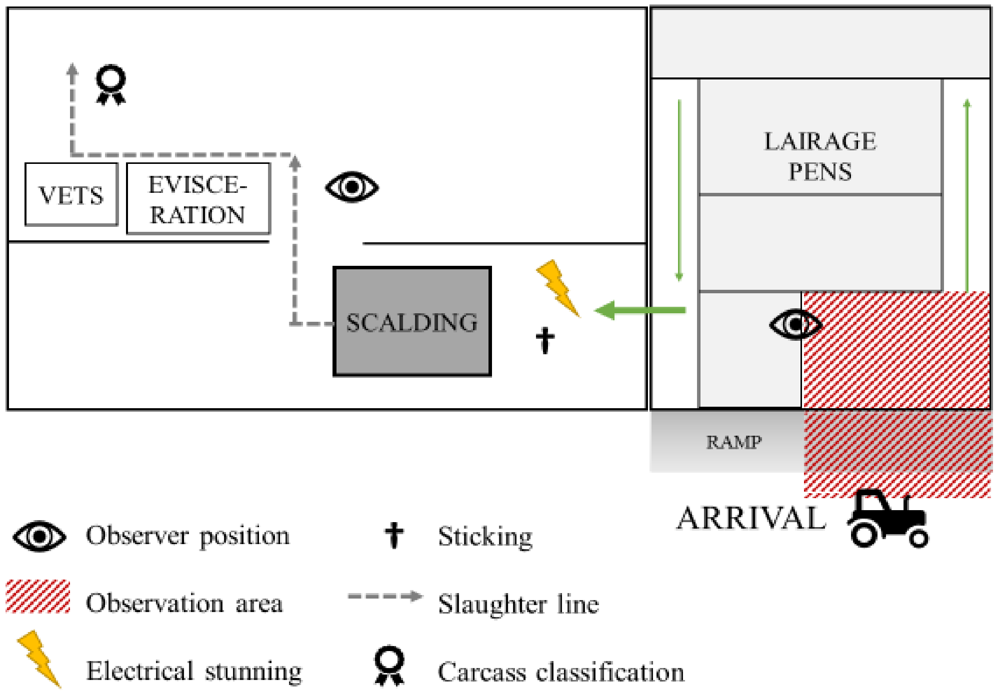
		LAB	**CON**
Number of farms assessed		9	4
Pigs slaughtered per year		717 [60 – 1209]	964 [248 – 1965]
Number of pigs assessed per farm		166 [29 – 273]	81 [51 – 155]
Percent of pigs assessed per farm (%)		69 [47 – 100]	39 [29 – 100]
Farm type	*Farrow-to-finish*	5	3
	Growing / finishing only	4	1
Housing	*Group size (pigs / pen)*	20 [15 – 59]	9 [6 – 16)]
	Straw bedding	9	1
	Straw use (g / pig / day)	111 [30 – 400]	66 [1 farm]
Feeding type	*Dry*	3	0
	Liquid	6	4
Availability of food	*Ad libitum*	1	0
	Sensor-controlled	5	2
	Restricted	3	2

Assessment at the slaughterhouse (sample **B**) included 1561 pigs (690 LAB, 871 CON). As farm characteristics in **Table 2** illustrate, LAB-farms mostly employed animal transport companies (hauliers) to deliver pigs to the slaughterhouse. As only one haulier transported most of LAB-pigs, unloading conditions were very similar for those pigs (ramps of non-slip synthetic material with low ramp angle under 10°, crossbars on the ramp to prevent slipping and side walls to border the ramp). In contrast, CON-farmers delivered their pigs exclusively by their own vehicles. Consequently, unloading facilities varied considerably. Ramps were made of wood or metal with ramp angles either even (0°) or steeply declining (up to 20°). Most of the ramps were equipped with sidewalls (11 LAB, 8 CON) and crossbars (11 LAB, 10 CON).

Table 2 Sample-size and characteristics of farms and animals for sample **B**, presented in numbers of farms and medians [range], respectively.

		LAB	**CON**
Number of farms assessed		12	13
Number of pigs assessed per farm		41 [11 – 146]	42 [11 – 162]
Farm distance to slaughterhouse (km)		13.2 [3.7 – 43.6]	6.8 [1.2 – 43.0]
Transport	*Haulier*	10	0
	Farmer	2	13
Ramp angle	*0°, even*	1	4
	< 10°, down	11	0
	Up to 20°, down	0	9
Ramp material	*Non-slip synthetic*	8	0
	Metal	3	6
	Wood	1	7

Figure 3 Simplified plan of the slaughterhouse indicating observer position and observation area.



According to the label standards, LAB-pigs were usually delivered and slaughtered in the morning prior to conventional non-labelled pigs. Unloading of the pigs was carried out by one responsible person of the slaughterhouse and the farmers or hauliers delivering the pigs. The pigs were driven to lairage pens with solid floor and water provided ad libitum. Groups of 4 to 5 pigs were then brought to the slaughter pen where electrical stunning occurred. Routine carcass inspection took place following evisceration by four alternating official veterinarians. Carcass classification including pH measurement was carried out about 30 minutes after sticking. For a better illustration, a simplified plan of the slaughter plant is provided in **Figure 3**.

6.3 Behaviour observations

Behaviour observations were carried out by direct observation on-farm and at unloading at the slaughterhouse. The detailed methods and ethograms are described in the following sections.

6.3.1 Quantitative behaviour observation on-farm

For on-farm assessment (sample **A**), predefined behaviours were assessed at group level with continuous, direct observations (**Table 3**). The observer was positioned outside the pen, switching between indoor and outdoor areas in case of farms with an outdoor run. After a two-minute acclimatisation period, the frequencies of behavioural events were noted on the protocol sheet. Behaviour was assessed twice for three minutes within a period of 12 minutes permitting a consecutive observation of two pens. Oral behaviours (except ear and tail biting) were only taken into account when they were performed for a minimum of 10 seconds. Resuming the behaviour after a period of at least 10 seconds was considered as a new event. At the start and end point of each three-minute period, the number of present pigs in the observed pen area was noted.

Furthermore, tail position was assessed by scan-sampling at the beginning of the first and at the end of the second observation period. The number of pigs with clearly visible tails was noted and the respective tail position assessed (**Table 4**). Examples for tail positions are given in **Figure 5**.

Table 3 Ethogram for continuous behavioural observation on-farm (**A**)

Behaviour	Definition
Exploration[1]	
Pen manipulation	Sniffing, licking, biting or chewing pen facilities (floor, bars, walls, except feeder and drinker) from an active position*.
Object manipulation	Sniffing, licking, biting or chewing enrichment objects (chains, plastic toys, wooden blocks) from an active position*.
Material manipulation	Sniffing, licking, chewing or rooting organic enrichment material (straw, hay in a rack, ropes) from an active position*.
Abnormal behaviour[1,2,3]	
Manipulation of other pigs	Licking, biting, chewing or massaging the body of pen-mates (except face, ears and tail) from an active position*.
Oral stereotypies	Highly repetitive, intensively performed behaviours without exploratory nature (vacuum chewing, bar biting, tongue rolling; examples are given in **Figure 4**).
Tail biting	Any oral manipulation of tails (including tail-in-mouth-behaviour) regardless of position and duration of the behaviour.
Ear biting	Any oral manipulation of ears like chewing or biting, regardless of position and duration of the behaviour.
Miscellaneous	
Locomotory play[4]	Jumping, turning, hopping and running around with playful elements, using a large area.

Parameters adapted from: [1] Zonderland et al. (2010); [2] Hoy (2009); [3] Zonderland et al. (2009); [4] Brown et al. (2015). * Active position = standing or sitting.

Table 4 Ethogram for scan sampling of tail position on-farm (A)

Behaviours	Definition[1]
Tail up	Upright position and curled (intact) tails with tail tip above tail base.
Tail hanging	Hanging tails with tail tip below tail base and not touching the body.
Tail between legs	Tails hanging down and squeezed between legs (only for intact tails).

[1]Adapted from: Schrøder-Petersen et al. (2003).

Figure 4 Examples for oral stereotypies

Oral stereotypies.
Left: Tongue rolling. Middle: Vacuum chewing. Right: Bar biting.

Figure 5 Examples for tail positions

Tail positions.
Outer left: Tail up (docked).
Middle left: Curly intact tail.
Outer right: Intact tails between legs (front) and hanging (rear).
Middle right: Tail hanging (docked).

6.3.2 Qualitative Behaviour Assessment

Qualitative Behaviour Assessment (QBA) has been found to be a valid and viable method to obtain information about the expressive behaviours of pigs through an integrated perception of the whole animal (Wemelsfelder et al. 2000, 2009), which may also yield information about the affective (emotional) state (Rutherford et al. 2012b). The original approach of QBA is to use a Free-Choice-Profiling (FCP) method to identify individual terms describing the quality of the observed behaviour (Wemelsfelder et al. 2001). For the inclusion of QBA in the Welfare Quality© protocol to be applied on-farm, a fixed list of terms has been prescribed (Welfare Quality® 2009). Comparing the two methodologies, Clarke et al. (2016) demonstrated significant agreement between FCP and fixed lists. Still, good quality training is crucial for both methods.

In this study, QBA was carried out on-farm (sample **A**) prior to the other assessments after a two-minutes acclimatisation period as suggested in the Welfare Quality© protocol (Welfare Quality® 2009). For each weight class, a maximum of three pens were observed consecutively for a total period of six minutes (e.g. 3 pens = 2 minutes per pen). Subsequent to the observation of one weight class, the behavioural expression of pigs of all observed pens was scored using 125-mm visual analogue scales (VAS) for a list of prescribed descriptors adapted from the Welfare Quality protocol (Welfare Quality® 2009). A detailed list of descriptors is provided in **Table 5**. In preparation for further statistical analyses, the distance from the minimum to the scoring mark (in mm) was measured and tabled for each descriptor using Microsoft Excel 2016.

Table 5 List of descriptor for Qualitative Behaviour Assessment, adapted from Welfare Quality® (2009)**.**

Active	Positively occupied	Relaxed	Indifferent
Fearful	Lively	Agitated	Irritable
Calm	Friendly	Content	Inquisitive
Enjoying	Tense	Frustrated	Listless
Sociable	Distressed	Bored	Apathetic
Playful			

6.3.3 Behaviour observation at unloading

In addition, the behaviour of pigs was assessed through direct continuous observation during unloading from the transport vehicle on arrival at the slaughterhouse during unloading from the transport vehicle (sample **B**). The observer was positioned at the unloading bay assessing the frequency of predefined behaviours as presented in **Table 6**. The starting point was determined as the moment the first pig entered the unloading ramp. Unloading was finished when the last pig had left the unloading bay (**Figure 3**). Moreover, the duration of unloading was measured and notes were taken concerning characteristics of transport, lorry and unloading ramp.

Table 6 Ethogram for direct continuous behavioural observation at unloading (**B**).

Parameters	Definition
Reluctance to move	The pig stops and remains motionless and without exploring for at least 2 seconds.
Turning back	The pig turns around 180°, facing now the lorry area.
Vocalisation	High pitched vocalisation like squealing, but not grunting.
Slipping	Loss of balance without the body touching the floor.
Falling	Loss of balance with the body touching the floor.

Adapted from: Welfare Quality® (2009)

6.4 Clinical inspection

The subsequent sections outline clinical inspection of the pigs on-farm (sample **A**) as well as carcass inspection at the slaughterhouse (sample **B**). In general, the range of clinical parameters was broader for on-farm assessment. Carcass inspection can be seen as additional or substitutional information. For example, tail lesions and tail length were comprehensively assessed on-farm as well as at the slaughterhouse in order to improve the quality and quantity of information. However, for feasibility reasons, some parameters as for example swellings were assessed exclusively at the slaughterhouse.

6.4.1 Clinical inspection on-farm

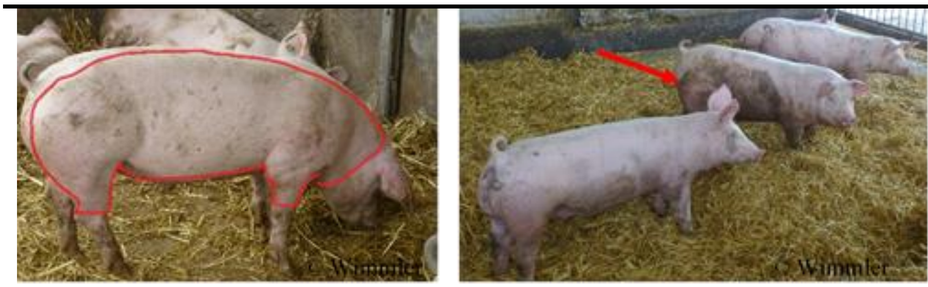
Clinical parameters were assessed at group level (number of affected pigs per pen) by close inspection of all pigs in the sample pens (**Table 7**). To prevent unnecessary disturbance and potential influence on pigs' behaviour by entering the pen, clinical inspection was the last part of on-farm assessment. For reasons of hygiene, pens were assessed according to the age of the pigs (weight class) in ascending order. Examples to illustrate the clinical parameters are given in **Figure 6**.

Table 7 Definition of clinical parameters of on-farm assessment (**A**).

Clinical parameter	**Definition**
Cleanliness[1]	Number of pigs soiled with manure on at least 20 % of the surface on one side of the body.
Ocular discharge[2]	Number of pigs with traces of incrusted or soiled eye secretion, distinguishing moderate (< 50 % of eye area) and severe discharge (≥ 50 % of eye area) and eyes affected (left, right or both).
Red eyes[3]	Number of pigs with red / inflamed conjunctiva.
Tail lesions[3]	Number of pigs with tail lesions, distinguishing mild (superficial wound on the tail tip), moderate (obvious lesion, signs of infection) and severe lesions (considerable tissue damage, obvious infection).
Tail length	Number of pigs with visually estimated tails shorter or longer than the pen average.
Body lesions[3]	Number of pigs with at least 3 superficial scratches (min. length 5 cm) or round wounds (> 1 cm Ø), distinguishing the two body regions shoulder / flank and hindquarter (ears and tail excluded).
Lameness[1]	Number of pens, where at least one pig is obviously lame (i.e. minimum or no weight-bearing on affected limb) or unable to walk.

Adapted from: [1] Welfare Quality® (2009); [2] Deboer et al. (2015); [3] Schodl (2017);

Figure 6 Examples for clinical parameters of on-farm assessment.



Cleanliness.
Left: Body region for the assessment of soiling.
Right: Pig in the middle with > 20% of the body surface soiled.

Ocular discharge.
Left: No discharge. Middle: Medium discharge. Right: Severe discharge with red eyes.

Tail lesion scores on-farm (from left to right):
Score **1** (mild), Score **2** (medium), Score **3** (severe)

Scratches on the body.
Left: Body regions for the assessment of scratches (red = hindquarter, green = shoulder/flank).
Right: Pig with more than 3 scratches longer than 5 cm on the shoulder/flank.

6.4.2 Carcass inspection

Carcass inspection was performed for sample **B** at a point of the slaughter line following scalding and prior to evisceration (**Figure 3**). For each parameter presented in in **Table 8**, the number of pigs affected was noted on a protocol sheet. Examples for the scoring of swellings and tail lesions are illustrated in **Figure 7** and **Figure 8**.

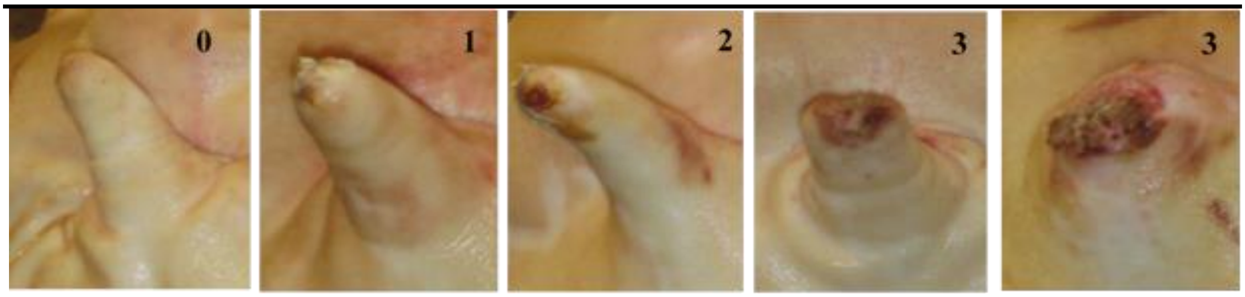
Table 8 Definition of clinical parameters for carcass inspection at the slaughterhouse (**B**).

Parameters	**Definition**
Moderate swellings[1]	Number of pigs with one large swelling (2-5 cm diameter) on one or both hind limbs.
Severe swellings[1]	Number of pigs with various large swellings (2-5cm diameter) on the same limb or one extreme swelling (> 5 cm diameter).
Tail lesions[2]	Number of pigs with tail lesions, distinguishing mild (superficial skin alteration on the tail tip), moderate (obvious tissue damage) and severe (considerable tissue damage, parts of the tail missing).
Tail length	Number of pigs with long (> 18 cm), short (≤ 18 cm) and extremely short tails (≤ 5 cm).

Adapted from: [1] Welfare Quality® (2009); [2] Harley et al. (2014)

Figure 7 Examples for swellings assessed at carcass inspection.

Figure 8 Examples for tail lesions assessed at carcass inspection.



Tail lesion scores at slaughter, adapted from Harley et al. (2014) (from left to right): Score **0** (no lesion), Score **1** (superficial skin alteration), Score **2** (obvious tissue damage), Score **3** (severe tissue damage)

6.5 Records

Records considered for sample **A** included medical treatments and slaughter reports of the previous 6 to 12 months, depending on the time when pigs were first housed under label conditions in case of LAB-farms. Slaughter reports consisted of performance data (e.g. carcass weight, lean meat content), meat quality (meat pH, measured 30 minutes after slaughter) and veterinary information from viscera inspection (e.g. milk spots on the liver and signs of respiratory disease). For sample **B**, only slaughter reports from the respective assessment day could be obtained.

6.6 Statistical Analyses

Data processing and descriptive results were generated with Microsoft Excel 2016. The frequency of behaviours observed on-farm in the two three-minute periods were averaged at pen level and adjusted to the number of events per 10 pigs per 10 minutes. Behaviour at unloading was calculated as events per 100 pigs. Clinical parameters were expressed as percentage of pigs affected per pen (on-farm) or per batch (slaughterhouse). Some parameters showed a very low prevalence and, therefore, were transformed to binary variables, i.e. whether a pen or batch of pigs was affected or not. If, however, the prevalence was too low and further analyses were unreasonable, no statistical tests were carried out (for details see section **7** RESULTS).

Raw scores of the Qualitative Behaviour Assessment per descriptor and subject, i.e. weight class and farm, were analysed using a Principal Component Analysis (PCA) in SPSS 24. This method is used to reduce partly correlated data into a set of linearly uncorrelated variables, further referred to as ‘dimensions’, and calculates corresponding scores for each subject. PCA was computed once on the complete data set (34 cases from 1 to 3 weight classes from 13 farms, 9 LAB- and 4 CON-farms) based on correlation matrices. The initial solution (unrotated components) was used and the first two factors with Eigenvalues greater than one were further considered. Terms with loadings ≥ 0.65 were considered to describe the meaning of the dimensions. Subject scores on the dimensions are presented graphically in relation to farm category (LAB / CON).

The statistical comparison of LAB- and CON-farms as well as analyses within LAB-farms were carried out using SAS 9.4. According to the levels of data collection, analyses were performed at farm level (data derived from records), pen level (parameters assessed on-farm) or batch level (parameters assessed at the slaughterhouse). The main effects were farm category (comparison of LAB- and CON-farms) and the ‘amount of straw’ (analyses within LAB-farms), respectively. Moreover, weight class was expected to affect lesions and behaviour in the pen and was thus included as fixed effect in the respective models. To account for non-independent data, random effects ‘farmID’ and ‘weight class’ (when not used as fixed effect) were included into analyses at pen level, as well as ‘assessment day’ for data collected at the slaughterhouse. At farm level, a one-way analysis of variance (ANOVA) was carried out for normally distributed variables using the Procedure GLM, otherwise a non-parametric test (Wilcoxon Two-Sample Test) using the Procedure NPAR1WAY. Given normal distribution at pen or batch level, a linear mixed model considering fixed and random effects was carried out with the procedure MIXED. Data following binary distribution were analysed with a generalised linear mixed model using the procedure GLIMMIX, a model that considers fixed and random effects in non-normally distributed data. If data at pen or batch level were not normally distributed and a transformation to binary variables was not reasonable, data were aggregated on farm level and analysed with ANOVA.

For all statistical analyses, a p-value < 0.05 was determined as level of significance.

A detailed list of all parameters and respective statistical analyses is provided in the APPENDIX (**Table 14** to **Table 18**).

7 RESULTS

In sample **A**, the median number of pigs assessed per farm was 155 (29 – 273) representing between 29 % and 100 % of the current fattening stock. However, behaviour observation included less pigs (median 87, range 17 – 140 pigs / farm) because not all the pigs of a pen were necessarily present or visible in the observed area. Moreover, manipulation of enrichment (objects and material) depended on its availability. So, the median number of observed pigs per farm was even lower for those parameters (manipulation object: 65 pigs / farm [15 – 140]; manipulation material: 48 pigs / farm [17 – 88]). Records of the previous months covered a median period of 12 months (7 – 16.5) for medical treatments and 9.5 months (4.5 – 19.5) for slaughter reports, respectively.

Sample **B** resulted in a total number of 44 batches of pigs assessed at the slaughterhouse (21 LAB, 23 CON). The median number of assessed pigs per farm was 42, ranging from 11 to 162. For organisational reasons, not all parameters could be assessed for all pigs (e.g. due to overlapping of events, when behaviour observation at unloading and carcass inspection happened simultaneously).

To give a comprehensive overview of the results, the range of parameters assessed on-farm, at the slaughterhouse and derived from records is organised in different welfare areas concerning the behaviour of the pigs, lesions and leg disorders, cleanliness, endoparasites, respiratory health and stress prior to slaughter.

The descriptive results were fed back to the farmers by individualised documents, providing information about the overall welfare situation of the assessed farms as well as results for the own farm (APPENDIX, **Figure 16**).

A summary of results as well as respective sample size and statistical methods is provided in the APPENDIX (**Table 14** to **Table 18**).

7.1 Behaviour on-farm

The following section reports results of behaviour observation on-farm (sample **A**), distinguishing behaviours which are commonly seen as more positive or neutral (oral manipulation of inanimate objects and play) and undesirable abnormal behaviours as tail biting and manipulation of other pigs. Finally, results for QBA complete the behavioural part of on-farm assessments.

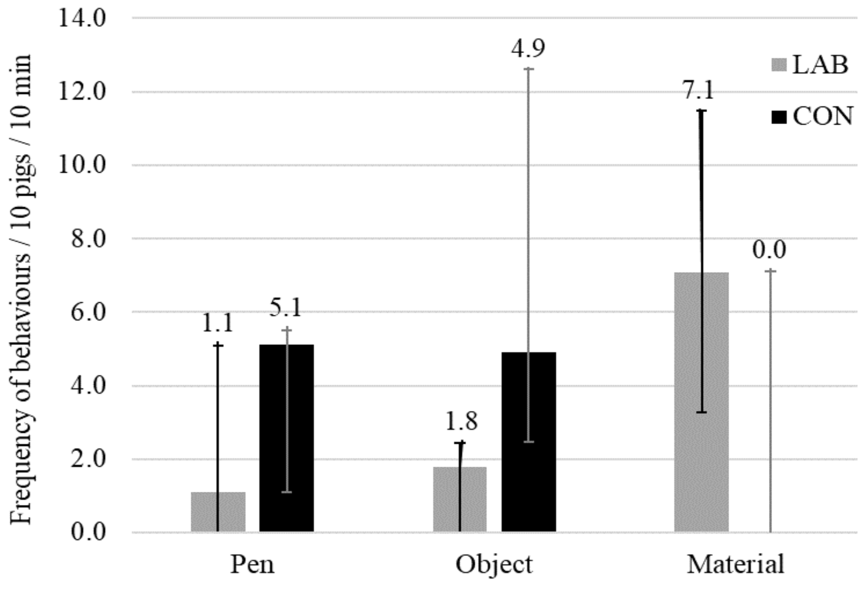
7.1.1 Locomotory play and oral manipulation of inanimate objects

Regarding play behaviour, playing events occurred only sporadically. Therefore, results are presented as a simple numerical description. During behaviour observation, play occurred only on LAB-farms and was never observed on CON-farms. In total, pigs in 9 pens on 4 LAB-farms showed locomotory play (4 pens on farm 21, 3 pens on farm 10 and one each on farm 6 and 22). The number of playing events per pen observation period was between 1 and 3.

Oral manipulation of inanimate objects included the manipulation of the pen, enrichment objects and enrichment material (generally straw) as defined in section **6.3.1**, **Table 3**. The three behaviours were assessed separately depending on the respective provision of enrichment. Consequently, manipulation of objects and material could not be assessed constantly for all farms (e.g. no enrichment material provided in CON-farms) or all pens of a farm (e.g. no enrichment object provided in the straw-bedded outdoor run).

The descriptive result for oral manipulation of the pen, enrichment objects and material (**Figure 9**) reveal, that LAB-pigs directed manipulation mainly towards enrichment material and to a lesser extent towards enrichment objects or pen facilities. CON-pigs manipulated both, pen and objects with nearly the same frequency. However, it must be considered, that only one CON-farm provided enrichment material.

Figure 9 Oral manipulation of inanimate objects



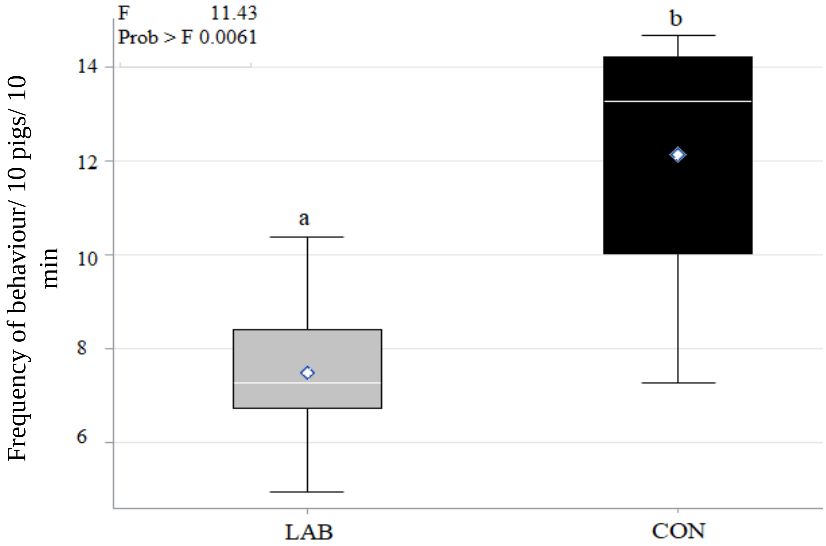
Medians (range) for labelled and conventional farms (**A**, LAB = 9, CON = 4)

Due to the different provision of enrichment, statistical comparison between LAB and CON seemed not appropriate for each individual behaviour separately, so that they were summed up as total manipulation (of inanimate objects). As shown in **Figure 10**, LAB-pigs performed less total manipulation than CON-pigs (median frequency / 10 pigs / 10 minutes [range]; LAB

= 7.3 [4.9 – 10.4], CON = 13.3 [7.3 – 14.7]). The estimates of statistical analysis at farm level indicate a significant difference (ANOVA: F = 11.4, p = 0,006) with LAB-pigs showing half the frequency than CON.

Furthermore, analyses were carried out among the 9 LAB-farms (**A**) to investigate whether the amount of straw affects oral manipulation of enrichment material. However, no significant correlation was found (r = 0.22, p = 0.573).

Figure 10 Total manipulation of inanimate objects



Results of ANOVA for labelled and conventional farms (**A**, LAB = 9, CON = 4). [a,b] Different subscriptors indicate significant difference (p < 0.05).

7.1.2 Abnormal behaviour

In this study, abnormal behaviour included manipulation of other pigs, tail and ear biting behaviour as well as oral stereotypies such as vacuum chewing, bar biting or tongue rolling.

In general, only few pigs performed abnormal behaviour in both LAB- and CON-farms. Manipulation of another pig's body (except tail and ears) occurred rarely in general and less frequently on LAB-farms (median frequency / 10 pigs / 10 minutes [range]; LAB = 0.8 [0.0 – 2.1], CON = 1.5 [0.7 – 2.8]). For statistical analyses, the parameter was therefore transformed to a binary variable expressing whether the behaviour occurred in a pen or not. Results indicate, that the probability for a manipulation event is lower in LAB- than in CON-farms (GLIMMIX: Probability for LAB = 0.41, CON = 0.57, F = 1.4, p = 0.248). However, the difference is not significant and numerically negligible. Weight class was considered in the model but did not have any effect (F = 0.3, p = 0.746).

As tail and ear biting occurred even less frequently, results are given for the proportion of pens affected. Tail biting occurred in a median of 10 % (0 – 22 %) of the observed LAB-pens which is equivalent to 0 – 2 pens of a farm. In CON-farms, the percentage of pens affected was higher with a median of 28 % (17 – 36 %) representing 1 – 4 pens per farm. The difference was statistically significant (ANOVA: F = 16.6, p = 0.002).

Concerning the scan sampling of tail positions, only a small proportion of pigs could be assessed, as visibility of the tail was not given in many cases (e.g. pigs were lying). Moreover, pigs with hanging tails and tails between the legs were rarely observed and therefore the two parameters were combined. The results show a lower proportion of LAB-pigs with tails hanging or between legs (median % pigs affected [range]; LAB = 3.1 [0.0 – 16.3], CON = 8.2 [0.7 – 13.2]). However, no statistical analysis was carried out due to the low number of pigs with visible tails for scan-sampling.

Ear biting occurred more frequently than tail biting, but there was a large variation within LAB-farms and no significant difference (median percentage of pens affected [range]; LAB = 22 % [0 – 67 %], CON = 39 % [27 – 44 %], ANOVA: F = 1.4, p = 0.258).

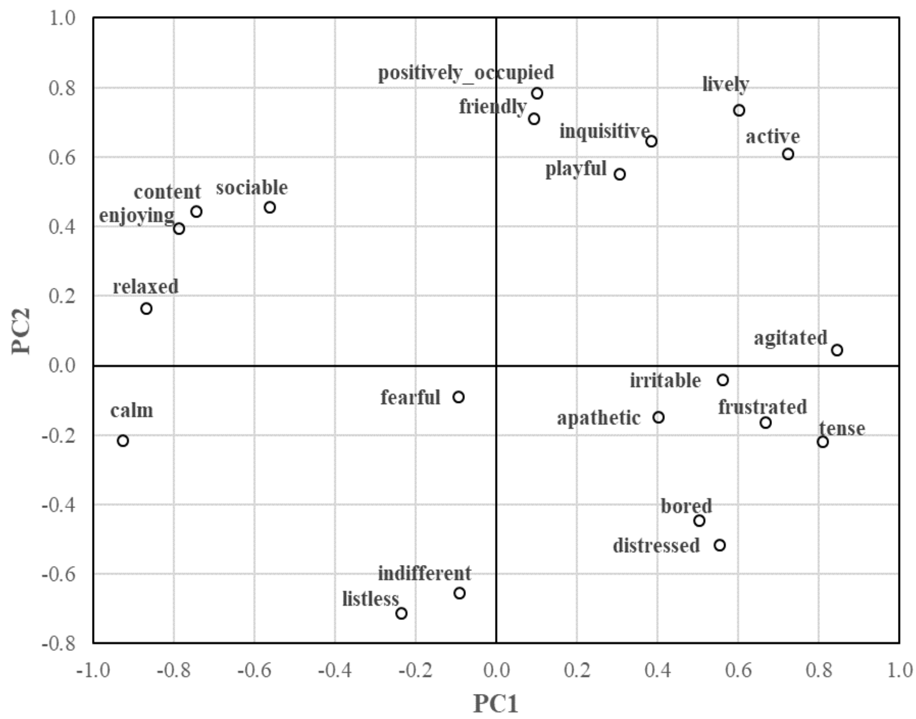
The frequency of oral stereotypies was extremely low. The behaviour occurred only in 5 pens of 4 LAB-farms and 6 pens of 3 CON-farms and was therefore not further tested.

7.1.3 Qualitative Behaviour Assessment

QBA raw data were suitable for PCA (Kaiser-Mayer-Olkin 0.719). PCA revealed two main dimensions explaining 57.5 % of the variance (PC1 = 34.2 %, PC2 = 23.3 %). As shown in the PCA word chart (**Figure 11**), PC1 is characterised by the terms ‘agitated’ (0.85), ‘tense’ (0.81), ‘active’ (0.72) and ‘frustrated’ (0.67) on the one hand and ‘calm’ (-0.93), ‘relaxed’ (-0.87), ‘enjoying’ (-0.79) and ‘content’ (-0.74) on the other. PC2 is described by ‘positively occupied’ (0.78), ‘lively’ (0.74), ‘friendly’ (0.71) and ‘inquisitive’ (0.65) as well as ‘listless’ (-0.72) and ‘indifferent’ (-0.65).

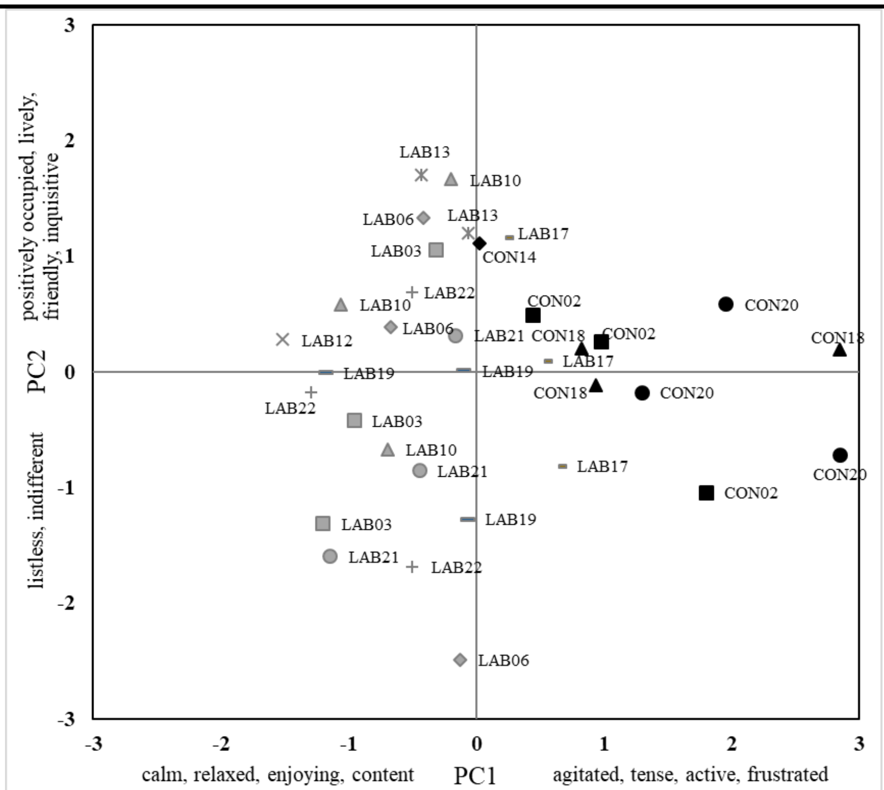
The position of each weight class for each farm as defined by the factor scores for PC1 and PC2 is plotted in **Figure 12**. LAB-farms vary considerably along the PC2-axis from ‘positively occupied – lively – friendly – inquisitive’ to ‘listless – indifferent’. Most of the farms show slightly negative scores for PC1 indicating that pigs were assessed as more calm, relaxed, enjoying and content. In contrast, CON-farms are mainly distributed along the PC1-axis and show only positive scores. This reflects that CON-pigs were assessed as more agitated, active, tense and frustrated.

Figure 11 PCA word chart



Word chart of QBA descriptors (**A**, LAB = 9, CON = 4).

Figure 12 Factor scores of PC1 and PC2



Factor scores of label (grey) and conventional (black) farms (**A**, LAB = 9, CON = 4). For each farm, 1 – 3 QBAs were carried out according to the weight classes small, medium and heavy. Different marking points indicate different farms.

7.2 Lesions and leg disorders

Lesions of different parts of the pigs' body and indicators of leg disorders were assessed on-farm (sample **A**) and at the slaughterhouse (**B**). The assessment of swellings was carried out exclusively at the slaughterhouse due to better visibility of the pigs' hind limbs at carcass inspection. Tail lesions were scored for live animals on-farm (**A**) and at carcass inspection (**B**) whereas other body lesions were only assessed on-farm (**A**).

7.2.1 Tail lesions

The results for tail lesions including tail length are presented in **Table 9**. Regarding the results of on-farm assessment (**A**), mild tail lesions accounted for the majority of total tail lesions. In total, only 5 pigs with moderate and 1 pig with a severe lesion were found on LAB-farms whereby 5 farms showed no moderate or severe tail lesion at all. However, more pigs were affected on CON-farms (2 pigs with moderate and 4 pigs with severe tail lesions). One of the four CON-farm had no pigs with moderate or severe tail lesions. Due to the low prevalence, moderate and severe tail lesions were summed up as presented in **Table 9**. Subsequent statistical analysis with procedure GLIMMIX based on binary variables indicating whether tail lesions occurred in the pen or not. No statistically significant difference was found, neither for total ($F = 0.68$, $p = 0.412$) nor for moderate or severe tail lesions ($F = 0.25$, $p = 0.618$) although CON-pigs showed numerically more lesions. Moreover, no obvious difference could be seen in tail length (tails shorter than pen average). Yet, there was considerable variation within LAB-farms.

Additionally, statistical analyses were carried out within the group of LAB-farms (**A)** to investigate whether the amount of straw provided per pig and day affects the proportion of pigs with tail lesions. A negative correlation ($r = -0.63$, $p = 0.072$) indicated that the proportion of pigs with tail lesions decreased by 0.9 % per 100 g additional straw.

Compared to on-farm results, assessment of tail lesion at the slaughterhouse (**B**) revealed a generally higher proportion of pigs affected. As for sample **A**, lesions were mainly mild and the proportion of pigs with moderate or severe lesions was low. LAB-pigs showed slightly more tail lesions than CON but the difference was not statistically significant (MIXED, $F = 1.3$, $p = 0.282$). Moderate and severe lesions were again analysed as binary variables with procedure GLIMMIX. However, the difference was not significant ($F = 0.26$, $p = 0.619$) and numerically negligible. A relatively high proportion of LAB-pigs had short tails under 18 cm at carcass inspection (17 %) despite the omission of tail docking. The number of pigs with extremely bitten tails (length < 5 cm) was very low, while slightly higher for CON- than for LAB-farms (15 and 3 pigs, respectively). Moreover, it should be noted, that the median proportion of CON-pigs with short tails (< 18 cm) was about 92 %, which is indicating, that some CON-farms do not perform tail docking.

Table 9 Tail lesions and length as obtained from clinical inspection on-farm (**A**) and carcass inspection (**B**), given in median [range] percentage of pigs affected.

Parameters	LAB	CON	p-value
A	*(n = 9)*	*(n = 4)*	
Mild tail lesions (%)	1.2 [0.0 – 5.1]	1.6 [0.0 – 2.4]	n.t.
Moderate / severe tail lesions (%)	0.0 [0.0 – 1.4]	2.3 [0.0 – 5.6]	0.618[1]
Total tail lesions (%)	1.6 [0.0 – 6.5]	4.1 [0.0 – 7.4]	0.412[1]
Tail shorter than pen-average (%)	4.0 [0.0 – 25.9]	4.6 [0.0 – 7.0]	n.t.
B	*(n = 12)*	*(n = 13)*	
Mild tail lesions (%)	9.2 [0.0 – 20.0]	8.0 [0.0 – 13.3]	n.t.
Moderate / severe tail lesions (%)	1.8 [0.0 – 10.0]	1.4 [0.0 – 8.3]	0.619[1]
Total tail lesions (%)	11.4 [0.0 – 20.0]	9.1 [0.0 – 15.9]	0.282[2]
Short tails < 18 cm (%)	17.0 [0.0 – 100]	92.1 [0.0 – 100]	n.t.

[1] analysed as binary variable at pen / batch level (GLIMMIX); [2] analysed as % pigs affected at batch level (MIXED); n.t. = not tested.

7.2.2 Body lesions

Scratches assessed on-farm (**A**) were generally most prevalent on the body region 'shoulder and flank' with a high variability between farms. A median of 9.9 % of pigs (0.0 – 21.2 %) were affected on LAB-farms. Similar results were found on CON-farms with 8.3 % (7.6 – 24.0 %). Statistical comparison at farm level showed no significant difference (ANOVA, F = 0.28, p = 0.608).

Scratches on the hindquarter occurred considerably less and did not seem to differ (median percentage [range]; LAB = 1.6 [0.0 – 4.8], CON = 2.0 [0.0 – 16.7]). However, no statistical analysis was carried out due to the low prevalence. In LAB- and CON-farms, a total of 3 pigs showed round superficial wound but their number was too low for any further calculation.

7.2.3 Lameness and swellings

Data concerning leg disorders were derived from three different sources: on-farm observation of obviously lame pigs (**A**), farm records of medical treatments against lameness or joint inflammation (**A**) and carcass inspection for swellings on the hind limbs (**B**). The incidence of medical treatments was very low for both LAB- and CON-farms. The median treatment incidence per 100 fattening pigs per year was 0.2 (0.0 – 2.0) for LAB- and 0.1 (0.0 – 2.1) for CON-farms. Likewise, obvious lameness was seldom observed and occurred only on 4 LAB-farms with a total of 7 pigs affected and 2 CON-farms with 4 pigs affected. Because of these low values, further statistical analyses were not carried out, neither for observed lameness nor for lameness treatments.

However, carcass inspection revealed a considerable proportion of pigs with swellings on the hind limbs (median of 34.3% in LAB- and 40.3% in CON-farms). As shown in **Table 10**, the median proportion of affected pigs was about 6 % lower for LAB- than for CON-farms. Even when this difference was not significant (MIXED, F = 2.9, p = 0.107), a relatively low p-value mark a trend towards less swellings in LAB-pigs. However, there was a high variation between farms especially when labelled (LAB). Conversely, severe swellings were slightly more prevalent in LAB-pigs. Though, only a few pigs were affected (13 pig of 7 LAB- and 11 pigs of 5 CON-farms) and the difference seemed not to be consistent. Hence, no further analysis was carried out for severe swellings.

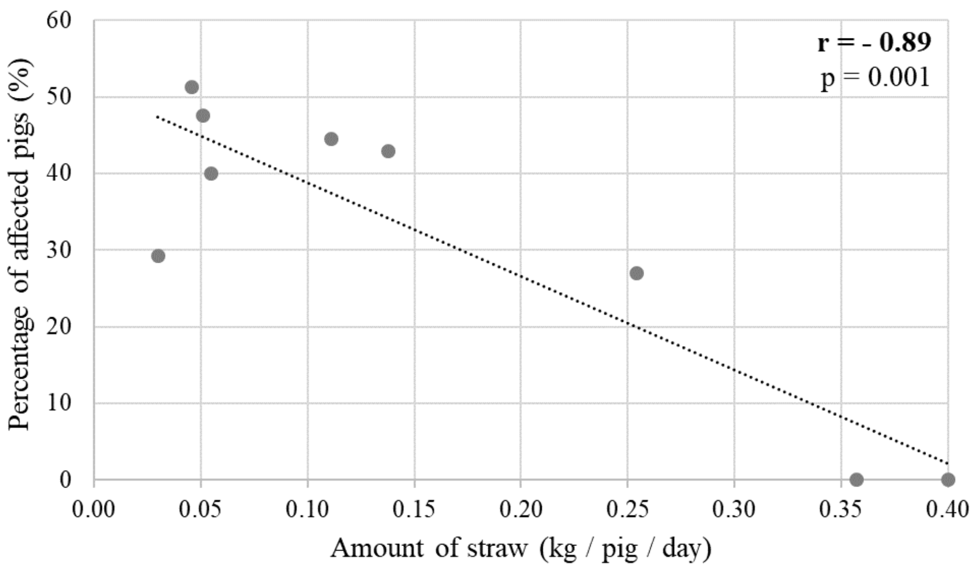
Further analysis of the effect of straw on total swellings among LAB-farms at farm level (n = 9) supports the results of the comparison between LAB and CON (**Figure 13**). A strong, negative correlation was found between the amount of straw provided per pig and day and the proportion of pigs with swellings at carcass inspection (r = -0.89, p = 0.001). Estimates indicate a decrease of 12.2 % per 100 g additional straw.

Table 10 Total and severe swellings as obtained from carcass inspection (**B**), given in median [range] percentage of pigs affected.

Parameters	**LAB** (n = 12)	**CON** (n = 13)	**p-value**
Total swellings (%)	34.3 [0.0 – 51.3]	40.3 [26.1 – 56.0]	0.107[1]
Severe swellings (%)	1.5 [0.0 – 8.5]	0.0 [0.0 – 8.0]	n.t.

[1] analysed at batch level (MIXED); n.t. = not tested.

Figure 13 Association between amount of straw and total swellings.



Correlation of the amount of straw provided on LAB-farms (n = 9) and the proportion of pigs with swellings as obtained from carcass inspection.(**A**, n= 9).

7.3 Cleanliness

The proportion of pigs with manure on the body assessed on-farm (**A**, LAB n = 9, CON n= 4) was more than twice as high in CON- than in LAB-farms. The median percentage of soiled pigs on LAB-farms was 7.0 % with a relatively broad range from 0.0 to 29.2 %. In contrast, CON-farms showed a median of 18.5 % ranging from 11.3 to 33.0 %. This is reflected in the results of statistical analysis at farm level (ANOVA: F = 2.5, p = 0.141) indicating a lower percentage of soiled LAB-pigs (- 9,3 %, intercept 20.3 %). Although, the difference is not significant, the p-value is relatively low and the numeric differences considerable. However, temperature could not be considered because of its association with the ‘label’ parameter (generally higher temperature on CON-farms).

The comparison between LAB-farms providing different amounts of straw at farm level showed a slight decrease of soiled pigs by 3.3 % per 100 g additional straw (intercept 16.3 %). However, cleanliness was hardly correlated with the amount of straw (r = -0.47) and the effect was not significant (ANOVA: F = 2.0, p = 0.204). A potential influence of different temperatures has been tested in the initial model but showed no effect and was therefore excluded.

7.4 Endoparasites

The evaluation of endoparasites based on the one hand on farm records of medical treatments (deworming) and on veterinary information of slaughter reports on the other. The latter were available for a longer period (median 12 month) for sample **A** as well as for the specific assessment days at the slaughterhouse for sample **B**.

The treatment frequency against endoparasites in fattening pigs was generally very low. None of the 9 LAB-farms applied deworming in fattening pigs whereas occasional treatments of fattening pigs occurred on 2 of the 4 CON-farms. Yet, regular deworming of weaner piglets seems to be a common practice as most LAB-farmers (6 out of 9) and 2 of the 4 CON-farmers stated, that deworming is performed in an earlier age of the pigs (weaning).

Apart from this, veterinary information revealed a relatively high proportion of pigs with milk spots on the liver indicating *Ascaris suum* (**Table 12**, page 41). In both samples (**A** and **B**), this proportion was considerably higher in LAB- than in CON-farms but the differences were found to be not significant (**A**: ANOVA, F = 1.7, p = 0.230; **B**: MIXED: F = 0.9, p = 0.367). Besides, there was a high variation between farms (**A**: 10 – 70 %, **B**: 0 – 100 %).

As LAB-pigs were strongly affected by *Ascaris suum*, the association of amount of straw and proportion of pigs with milk spots was analysed at farm level. The estimates indicate an increase of 9.3 % per 100 g additional straw (intercept 26.9) with a correlation coefficient of 0.51. However, these results were not significant (p = 0.238).

7.5 Respiratory health

A variety of parameters indicating respiratory problems has been evaluated either directly (signs of ocular discharge and red eyes) or by the use of farm records (treatment incidence) and slaughter reports (viscera inspection). As already mentioned in section **7.4**, the latter were available for a longer period (**A**) as well as for the specific assessment days (**B**).

On-farm assessment (**A**) of red eyes and ocular discharge showed only few differences between LAB- and CON (**Table 11**). Regardless the low prevalence of red eyes, results of statistical analysis with procedure GLIMMIX tend towards a higher probability of LAB-pens housing at least one pig with red eyes (Probability for LAB = 0.40, CON = 0.13, F = 3.3, p = 0.075). Ocular discharge affected a relatively high proportion of pigs, both in LAB- and in CON-farms. Besides, there was a high variation between farms (farm average ranging from about 20 % up to over 60 %). The statistical estimate calculated at pen level suggests 7.7 % less LAB-pigs affected but the difference is not significant (MIXED: F = 0.7, p = 0.414). However, the numeric difference is notable. The prevalence of severe ocular discharge was generally low and therefore analysis was carried out with procedure GLIMMIX on the basis of binary variables (pen affected or not) showing no difference between LAB and CON (F = 0.9, p = 0.343). The detailed evaluation of laterality revealed, that most pigs were affected equally in both eyes. Although the prevalence of ocular discharge predominating on the left eye was rather low, analysis at farm level resulted in a significant difference between LAB- and CON-farms (ANOVA: F = 7.1, p = 0.022). Similar effects were not found for ocular discharge in both eyes or predominant in the right eye.

Medication was most frequently applied to treat respiratory disease (**A**). Fattening pigs were treated less often on LAB- as compared to CON-farms but the variation between LAB-farms was considerable (median frequency per 100 fattening pigs per year [range]; LAB = 1.0 [0.0 – 53.1], CON = 3.3 [0.0 – 7.1]). Yet, the general low level of treatments should be noted.

Table 11 Red eyes and ocular discharge as obtained from on-farm assessment (**A**), given in median [range] percentage of pigs affected.

Parameters	**LAB** (n = 9)	**CON** (n = 4)	**p-value**
Red eyes (%)	3.4 [0.0 – 5.9]	2.6 [0.0 – 7.4]	0.075[1]
Total ocular discharge (%)	42.4 [23.6 – 60.6]	52.7 [18.2 – 66.9]	0.414[2]
Severe ocular discharge (%)	3.2 [0.0 – 9.6]	4.1 [1.2 – 12.3]	0.343[1]
Both eyes affected (%)	32.1 [14.4 – 53.3]	38.2 [8.4 – 53.8]	0.663[3]
Predominant on left eye (%)	2.8 [0.0 – 4.8]	5.3 [3.9 – 16.2]	**0.022**[3]
Predominant on right eye (%)	4.6 [0.0 – 9.8]	4.6 [2.4 – 9.5]	0.953[3]

[1] analysed as binary variably at pen level (GLIMMIX). [2] analysed at pen level (MIXED).
[3] analysed with ANOVA at farm level.

Veterinary information obtained from viscera inspection at slaughter is presented in **Table 12** (page 41) for sample **A** and **B**. In both samples, LAB-pigs seemed to be more affected by pneumonia than CON-pigs, although no significant differences were found. Besides, these differences appear to be ambiguous regarding the contrasting results for total viscera alterations (TVA) which were more prevalent in LAB-pigs for sample **A** but less prevalent in sample **B**. In addition, the high variability between farms must be taken into account.

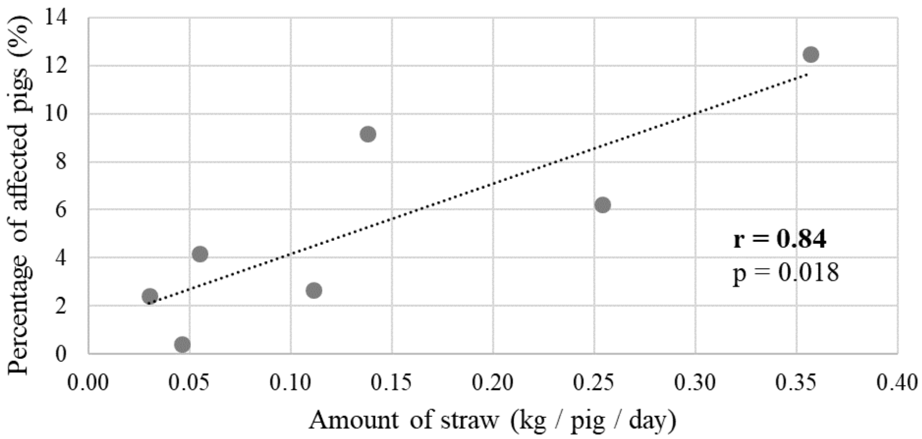
Table 12 Results of viscera inspection and pH measures as obtained from slaughter reports for sample **A** and **B**, given in median [range] percentage of pigs affected.

Parameters	LAB	CON	p-value
A	*(n = 7) **	*(n = 4)*	
Milk spots (%)	44.8 [9.7 – 71.3]	26.3 [8.3 – 36.0]	0.230[1]
Pneumonia (%)	4.2 [0.4 – 12.5]	2.5 [1.5 – 4.5]	0.271[1]
Total TVA** (%)	6.3 [2.6 – 14.8]	5.9 [3.2 – 7.4]	0.410[1]
Meat pH < 6.00 (%)	6.1 [2.5 – 17.1]	17.0 [9.2 – 22.9]	**0.023**[1]
B	*(n = 12)*	*(n = 13)*	
Milk spots (%)	55.0 [0.0 – 100]	45.5 [0.0 – 95.7]	0.367[2]
Pneumonia (%)	6.3 [0.0 – 63.5]	4.0 [0.0 – 52.0]	0.403[3]
Total TVA[1] (%)	6.6 [0.0 – 63.5]	15.0 [0.0 – 56.0]	0.808[3]
Meat pH < 6.00 (%)	7.5 [0.0 – 72.7]	13.2 [1.0 – 50.0]	0.301[3]

* Information only available for 7 LAB-farms. ** TVA = Thoracic viscera alterations, including pneumonia, pleuritis and pericarditis. [1] analysed at farm level (ANOVA). [2] analysed at batch level (MIXED). [3] analysed at farm level with non-parametric tests.

Finally, LAB-farms were analysed regarding amount of straw in relation to total ocular discharge and pneumonia (**A**, on-farm assessment and slaughter reports). Analysis of ocular discharge at pen level showed a rather low decrease of 2.1 % per 100 g additional straw (intercept 41.9 %) which was not significant (MIXED: $F = 0.3$, $p = 0.565$). In contrast, there was a substantial association between straw and the percentage of pigs showing pneumonia at slaughter (**Figure 14**). Estimates calculated at farm level indicate a significant increase of 2.9 % per 100 g additional straw with an intercept of 1.2 % ($F = 12.8$, $p = 0.018$). The parameters were highly correlated ($r = 0.84$) but it has to be considered, that data were only available for 7 farms, therefore, no other effect could be considered in the model.

Figure 14 Association between amount of straw and pneumonia.



Correlation of the amount of straw provided on LAB-farms and the proportion of pigs with pneumonia as obtained from veterinary information of slaughter reports. (**A**, n = 7).

7.6 Stress prior to slaughter

Two different parameters were assessed in order to evaluate welfare aspects before slaughter. The proportion of pigs with meat pH lower than 6.00 measured 30 minutes after sticking was calculated using data from slaughter reports of sample **A** (longer period) and **B** (more farms). In addition, behavioural indicators of stress and impaired welfare as well as the duration of unloading were observed directly on arrival at the slaughterhouse.

7.6.1 Meat pH

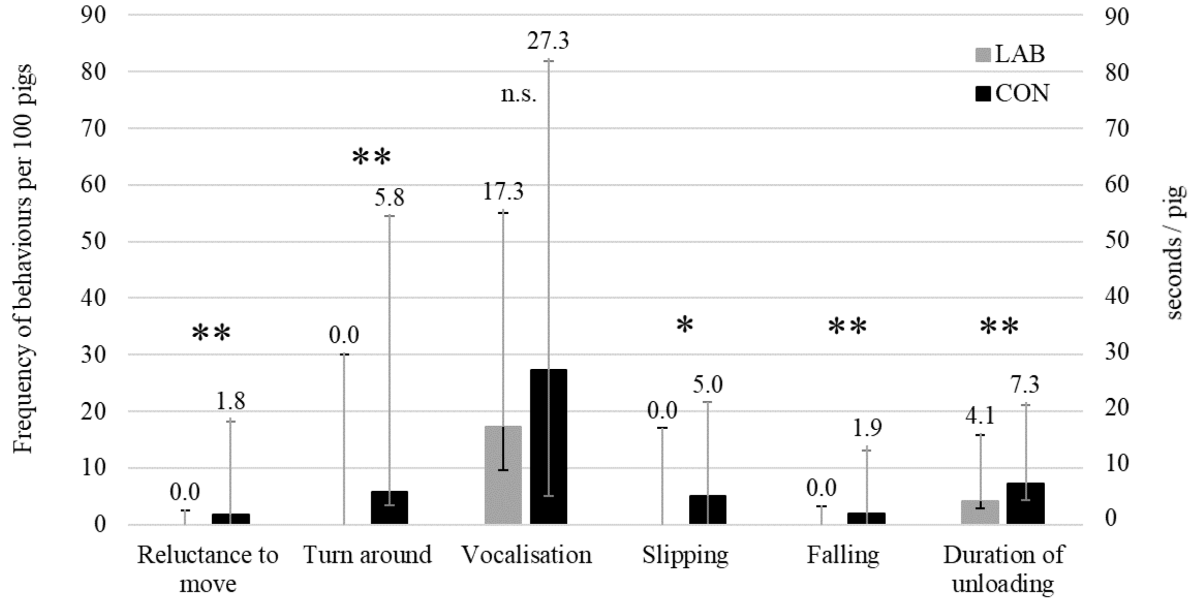
The farm average of pigs with a pH lower than 6.00 at meat inspection differed considerably between LAB- and CON-farms (**Table 12**, page 41). The evaluation of reports covering a median period of 9.5 month (**A**) resulted in an almost three times higher percentage of affected pigs in CON compared to LAB farms (median [range]; LAB = 6.1 [2.5 – 14.1], CON = 17.1 [9.2 – 22.9]). Statistical analysis at farm level attest a significant difference (ANOVA: F = 7.0, p = 0.023). In line with this, results from sample **B** display a nearly doubling median percentage of affected CON-pigs compared to LAB (median [range]; LAB = 7.5 [0.0 – 72-7], CON = 13.2 [1.0 – 50.0]). However, the range was considerably broader and statistical analysis with non-parametric Wilcoxon Two-Sample Test was not significant (p = 0.301).

7.6.2 Behaviour at unloading

All the behavioural parameters observed at unloading were not normally distributed and therefore analysed with non-parametric Wilcoxon Two-Sample Test. As shown in **Figure 15**, considerable differences occurred between LAB- and CON-farms. LAB- pigs performed significantly less reluctance to move (p = 0.013), turning around (p = 0.002) and falling (p =

0.037) and tended to slip less (p = 0.069). However, the frequency of these behaviours was rather low. Vocalisation showed the highest frequency but did not differ significantly (p = 0.149), although being lower in LAB-farms. Finally, the duration of unloading was significantly shorter in LAB-farms (p = 0.014).

Figure 15 Duration and behaviour at unloading.



Medians (range) for labelled and conventional farms (**B**, LAB = 12, CON = 13). Data from direct observation at unloading. Non-parametric analysis (Wilcoxon Two-Sample Test) at farm level.
** p < 0.05, * p < 0.1, n.s. = not significant.

8 DISCUSSION

The aim of this master thesis project was to evaluate welfare of fattening pigs housed under improved husbandry conditions as part of a new Austrian welfare label. The evaluation was based on on-farm assessments complemented by assessments at the slaughterhouse and data from records. However, before going into details of the actual welfare outcomes, some limitations and challenges regarding the on-farm application of animal-based parameters which have been revealed in this study will be discussed.

8.1 Methodological aspects

On-farm assessment of animal welfare raises some methodological challenges. In the present study, it was not possible to recruit a sufficient number of CON-farmers to ensure a balanced sample for on-farm assessment (**A**). In addition, the 4 CON-farms interested to participate in a welfare study maintained a relatively high welfare standard and are probably not representative for Austrian conventional pig producers. To compensate this imbalance, assessments at the slaughterhouse were carried out with an enlarged sample (**B**). Although the slaughterhouse assessment covered less and rather indirect parameters, these are reflecting important outcomes of the situation of farms and husbandry systems, as e.g. Kongsted & Sørensen (2017) demonstrated that parameters of routine meat inspection are associated with the production system. However, assessments at the slaughterhouse only reflect the situation of pigs at the end of the fattening period. The welfare situation in an earlier age of the pigs is not covered. Moreover, the parameters refer primarily to animal health (e.g. respiratory disease, milk spots), while little information is provided regarding animal behaviour. Finally, the results of sample **A** and **B** point into the same direction regarding the welfare outcomes for LAB- and CON-farms and support the reliability of the results.

Furthermore, it needs to be discussed if the chosen sampling size on farms (number of pens, number of animals) is suitable. Mullan et al. (2009) investigated the effect of sample size on the accuracy of prevalence estimates, where it was found, that the lower the prevalence of a parameter, the higher the proportion of pens required to achieve accurate estimates. For example, in their study, the proportion of pens required for accurate assessment of dirtiness, which showed a high prevalence across farms, was less than 10 %. In contrast, the percentage for accurate assessment of the parameter lameness with a very low prevalence was highly variable and reached up to 80 % depending on the specific farm. In the present study, a maximum number of 9 pens was determined for on-farm assessment, resulting in a median of 56 % (26 – 100 %) of pens assessed per farm. Overall, this should have been appropriate for most parameters assessed. Yet, it might have been too little for some parameters with low prevalence (e.g. lameness or play behaviour), especially on CON-farms with larger herds kept in smaller groups and thus the results for these parameters should be interpreted with caution. However, for the assessment of the given parameters by one person within one day, a larger sample would not have been feasible.

Another limitation in this study was, that observer blinding for the farm category (LAB / CON) was not possible. Therefore, a potential observer bias, previously reported in other studies (e.g. Tuyttens et al. 2014), cannot be excluded. All assessments were carried out by the same person avoiding inter-observer differences as described by Mullan et al. (2011). In addition, data from farm records and slaughter reports, that are more objective as recorded by either the farmers themselves or at the slaughterhouse, complemented the parameters and corresponded with results of direct assessments on-farm and at the slaughterhouse. The association between on-farm welfare indicators and parameters assessed at the slaughterhouse is also supported by other studies, e.g. Alpigiani et al. (2016).

Statistical limitations refer to the limited consideration of potentially influencing factors such as breed, feeding system (e.g. ad libitum vs. restricted feeding, animal-per-feeder ratio), specific housing characteristics (e.g. straw provided indoor vs. outdoor), transport conditions (e.g. duration, unloading facilities) or temperature on assessment days. Although information on those factors was partially available, the quality of this information was often poor (e.g. rough estimation of transport duration) or the variability too low (e.g. only one farm providing ad libitum feeding). Moreover, due to the rather low sample size especially at farm level the number of parameters included in the statistical models had to be limited.

8.2 Behavioural measures of welfare

8.2.1 Play and exploratory behaviour

Play behaviour is one of the few indicators for positive welfare (Held & Spinka 2011). On the one hand, it is considered a rewarding activity by itself. On the other hand, play is assumed to occur when other motivational needs are satisfied and therefore reflects overall good welfare (Boissy et al. 2007). Lyons et al. (1995) reported more locomotory play in pigs kept in systems with straw compared to conventional systems. However, locomotory play tends to occur spontaneously (Brown et al. 2015). As the observation periods in this study were rather short, it could only be observed occasionally and might therefore not be representative of the actual situation. Still, locomotory play occurred solely on LAB-farms, whereas none of the pigs kept on CON-farms displayed the behaviour. This could also be influenced by the higher space allowance in LAB-farms providing more opportunities to play (Jensen & Kyhn 2000, Chaloupková et al. 2007).

The most unexpected result was the considerably higher level of oral manipulation of inanimate objects (pen facilities, enrichment objects and material) in CON-pigs. This result contrasts with several other studies, which found that pigs kept in barren environments showed less activity and exploration compared to systems providing straw (Lyons et al. 1995, Scott et al. 2006, Morrison et al. 2007). One explanation could be the presence of an unknown person during the direct observation influencing the pigs' behaviour. Cimer (2011) found higher levels of straw manipulation when an observer was present compared to video observations and concluded, that the presence of the observer has a substantial impact on pig behaviour. Cimer (2011) argues, inter alia, that increased manipulation of straw might help pigs to cope with stressful situations as shown by De Jong et al. (1998). Even if the CON-pigs of this study did not have the opportunity to manipulate straw, increased manipulation of pen and objects could have been a response to stress caused by the presence of an observer. Still, this would imply that CON-pigs were more sensitive to an observer influence, since LAB-pigs were equally confronted but showed lower levels of oral manipulation. One explanation could be that LAB-pigs had the possibility to actively avoid observation because the observer was only positioned either indoors or outdoors during the observation of one pen. Hence, they probably could cope better with the presence of an unfamiliar observer.

Another explanation for the increased levels of exploration in CON pigs could be that pigs kept in barren environments may not satisfy their behavioural needs to explore and therefore their motivation is maintained (De Jong et al. 1998, Studnitz et al. 2007). To satisfy the need to explore, appropriate enrichment material which is easily changeable, chewable and destructible is required (Studnitz et al. 2007). Most of the CON-pigs had no access to enrichment with those properties and therefore might not have been able to satisfy their behavioural needs resulting in a maintained motivation. This is supported by De Jong et al. (1998) who argued that increased exploration of a novel object and manipulation of pen mates in pigs kept in barren environments results from unsatisfied motivation to explore.

This leads to another question, namely the interpretation of the explorative quality of oral manipulation. Apart from hunger, Studnitz et al. (2007) determine curiosity as major motivation of a pig to explore its environment by rooting, chewing and sniffing. Thus, novelty plays an important role. Enrichment material that is changeable, destructible and even edible (e.g. straw) has such novelty value, when applied regularly and is highly attractive to pigs (Studnitz et al. 2007). Whereas LAB-pigs did have access to enrichment with those qualities, this was not the case for CON-pigs. This could also explain, that CON-pigs manipulated pen facilities and enrichment objects – which show a similar low novelty value – nearly in the same frequency. Consequently, it can be questioned, whether oral manipulation of inanimate objects (i.e. pen facilities and enrichment objects) should be considered as explorative behaviour. The manipulation of pen facilities or chains can be performed in a rather repetitive and invariable way – terms that are commonly used to describe stereotypic behaviour, e.g. by Lawrence & Terlouw (1993) who related intensive manipulation of pen facilities such as chains to stereotypic behaviour in pregnant sows. So, the evaluation of exploratory behaviour in pigs is not only a question of quantity but also of the quality – the exploratory character – of the observed behaviour. In the end, quantitative behaviour observation in this study was not able to differentiate, whether a pig manipulated an object or material in an explorative way or a stereotypic one. Therefore, the comparison between LAB and CON should be carefully interpreted.

Anyway, the descriptive illustration of oral behaviour shows, that LAB-pigs directed their manipulation mainly towards straw and to a far lesser extent towards enrichment objects or pen facilities. Analysis within LAB-farms revealed no effect of the amount of straw on straw manipulation. In contrast to this findings, Pedersen et al. (2014) reported more activity with gradually increasing amounts of straw (10 – 500 g / pig / day). The authors suggested an amount of about 400 g of straw per pig and day to satisfy pigs' behavioural needs, which is more than most of the LAB-farms in the present study provided. In the cited study, pens were cleaned and fresh straw was provided daily and did not accumulate. However, daily cleaning and provision of fresh straw was not common practice on LAB-farms. The parameter 'amount of straw per pig and day' used in the present study is based on the estimated use of straw as reported by the farmers (mostly in kg straw per week / month / year). Therefore, the estimated amount of straw per pig and day did not represent the absolute amount of straw available in a pen, which was probably higher. It is suggested, that the absolute amount of straw in the pens was sufficient to allow appropriate exploratory behaviour.

It can be carefully concluded, that the provision of straw favours appropriate manipulative behaviour. From this perspective, the results of the study tend to support the enriching effect of straw for pig welfare as already shown by several other studies (Lyons et al. 1995, Scott et al. 2006, Weerd et al. 2006, Morrison et al. 2007, Zwicker et al. 2013, Picker 2014).

8.2.2 Abnormal behaviour

Even when abnormal oral behaviours were generally low in this study, LAB-pigs tended to perform less manipulation of other pigs. Moreover, the proportion of pens, where tail biting occurred, was significantly lower in LAB-farms. The results suggest, that LAB-pigs could satisfy their behavioural need to explore and support the effectiveness of straw to prevent abnormal behaviour. In addition to actual tail biting behaviour, tail position was assessed as early indicator of the presences of tail biting in a pen (Zonderland et al. 2009). The proportion of pigs with tails hanging down or squeezed between legs was lower in LAB- than in CON-farms but this could not be statistically confirmed due to the low prevalence. However, the results may support a lower level of tail biting in LAB-pigs.

Picker (2014) demonstrated that pigs kept with lower stocking density and straw provided in a rack performed less manipulation of pen mates as well as less tail and ear biting. In addition, the prevalence of abnormal behaviour was comparably low. Decreasing manipulation of pen mates in housing systems with straw compared to systems without straw has also been previously shown by Lyons et al. (1995) and Scott et al. (2006). However, Weerd et al. (2006) did not find any difference in manipulation of other pigs due to improved quality and provision of enrichment material but a reduction of tail biting.

In a study investigating the amount of straw necessary to satisfy pigs' behavioural needs, Pedersen et al. (2014) confirmed a reduction of manipulation of pen mates by successively increasing the amounts of straw from 10 g to 500 g per pig and day. The provision of straw in the LAB-farms of this study displays a comparable range from 30 g to 400 g per pig and day. However, effects of the amount of straw on abnormal behaviour was not tested due to the low prevalence of these behavioural parameters but only for the manipulation of enrichment material. Yet, there is no indication of an association between manipulative behaviour and the amount of straw. It is suggested, that other factors such as straw quality (freshness, length) and frequency of provision influence the manipulation of straw (Jensen et al. 2010, Zwicker et al. 2013).

It can be concluded that the low prevalence of abnormal behaviour in both LAB- and CON-farms reflects an acceptable level of welfare in both systems regarding the opportunity to perform species-specific behaviour. Moreover, abnormal behaviour tended to be reduced in LAB-farms, which supports the effectiveness of straw to allow natural behaviour and to prevent abnormal behaviour.

8.2.3 Qualitative Behaviour Assessment

QBA has been confirmed as valid method to assess animal welfare: Rutherford et al. (2012) validated the method by showing that QBA is sensitive to detect pharmacologically induced changes of emotionality. With regard to reliability, Wemelsfelder et al. (2012) investigated the influence of observer groups with different professional background and attitude resulting in a high level of agreement. In addition, Phythian et al. (2013) reported high levels of inter-observer agreement using fixed QBA terms in sheep. Even more important for the present study comparing housing systems, Wemelsfelder et al. (2009) explored, whether and how QBA of pigs is influenced by environmental background such as indoor or outdoor housing. The results of their study indicate a slight shift of observer ratings but the overall characterisation of the pigs' behavioural expression was not changed.

In this study, PCA resulted in two main dimensions. PC1 is characterised by the terms 'agitated – tense – active – frustrated' versus 'calm – relaxed – enjoying – content'. This dimension can be interpreted as a combination of activity and emotional state ranging from a negatively connoted high level of activity ('agitated – tense – active') to a positively connoted low level of activity ('calm-relaxed-enjoying'). This seems to be an uncommon characterisation compared to other QBA studies which mostly found two separate dimensions for activity and valence (positive and negative emotional states) (Wemelsfelder et al. 2000, Temple et al. 2011, Rutherford et al. 2012a). The terms describing PC2 were 'positively occupied – lively – friendly – inquisitive' versus 'listless – indifferent'. These terms seem to reflect the level of occupation and interest in the environment. Therefore, PC2 may indicate the quality of the relationship with the environment.

Interestingly, LAB-pigs varied mainly within the PC2 ('occupation and interest') which suggests, that they were primarily characterised according to their relation to the environment. The differentiation within PC1 ('activity and emotional state') was less pronounced. However, most scores for LAB-pigs on PC1 were closer to 'calm – relaxed – enjoying' than to 'agitated – tense – active'. In contrast, CON-pigs showed only little variation within PC2 and were primarily distinguished according to PC1 ('activity and emotional state'). It is noticeable, that CON-pigs were mainly positioned close to the high level of activity associated with negative emotions. This may help to interpret the results of quantitative behaviour observation indicating increased manipulation of inanimate objects in CON-pigs. Whereas it was not possible to capture the explorative character of manipulation in the quantitative assessment, the results of QBA may better describe the situation on CON-farms. The fact, that CON-pigs were scored as more active but also more tense and less content and enjoying could support the hypothesis of increased manipulation due to the unsatisfied behavioural need to explore (see **8.2.1**).

Specific studies investigating behavioural differences in relation to the husbandry conditions in pigs are rare. Temple et al. (2011) performed, inter alia, QBA in order to evaluate the welfare of Iberian pigs kept under extensive and semi-intensive conditions. Even though the breed as well as the housing systems are not comparable with the current study, the use of QBA to provide a more complex picture of pigs' affective state can be supported. In the referred study, semi-intensively kept pigs obtained lower scores on the dimension described as 'mood' indicating a more negative emotional state. Similarly, CON-pigs showed higher scores on the first dimension which was characterised by mostly negative connoted terms. However, LAB-pigs were scored as more 'neutral' within the dimension described as 'activity and emotional state' which contrasts with the results of extensively kept Iberian pigs showing a more positive 'mood'.

In conclusion, QBA illustrated a high variability between LAB-farms. However, a comparison between the two farm categories (LAB / CON) is difficult as LAB-farms were mainly characterised by PC2 and CON-farms by PC1. Regarding the unexpected results of quantitative behaviour observation, the information provided by QBA seems to be particularly important for the evaluation and interpretation of animals' emotional welfare.

8.3 Clinical measures of welfare

8.3.1 Tail lesions

In the present study, no significant differences were found between pigs with intact tails and docked pigs regarding tail lesions assessed on-farm (**A**). Besides, the prevalence of tail lesions – particularly of moderate and severe ones – was low, in both LAB- and CON-farms. This is in accordance with the low level of tail biting observed in the pens (see **8.2.2**). Similar low levels of tail lesions in un-docked pigs have been reported by Whay et al. (2007) and Schodl (2017). The proportion of affected pigs was slightly lower in LAB- than in CON-farms, especially regarding moderate and severe tail lesions. This is in accordance with other studies showing less tail lesions in systems providing straw (e.g. Cagienard et al., 2005; Scott et al., 2006; Schodl, 2017). Moreover, tail lesions tended (p-value of 0.072) to decrease with increasing amount of straw. Consequently, increasing the provision of straw may be effective as preventive measure or when tail biting occurs. Previous studies support this assumption while additionally showing a decrease of abnormal behaviour with increasing amounts of straw (Pedersen et al. 2014, Kallio et al. 2018).

Similar to the on-farm assessment, carcass inspection (**B**) revealed no significant or numerically relevant difference between LAB- and CON-farms. However, the prevalence of tail lesions was generally considerably higher compared to on-farm assessments. This could be explained by the potential influence of the slaughter process, as tails were scored following scalding, which might have caused skin alterations. In addition, scoring of mild tail lesions included any detectable change, whereas only clearly visible lesions were assessed on-farm. Keeling et al. (2012) reported about 7% of un-docked pigs with injured or shortened tails assessed at the slaughterhouse, which corresponds to the results of the present study with a median of 11.4 and 9.1 % for LAB- and CON-farms, respectively. In contrast, findings by Kongsted and Sørensen (2017) indicate, that un-docked pigs kept under improved welfare conditions are more frequently affected by tail lesions than docked pigs kept in conventional indoor systems.

Apart from lesions with high impact on the current welfare situation of pigs, the assessment of tail length can reveal previous tail biting incidences with major tail damage resulting in shorter tails with healed lesions. Yet, the actual cause of reduced tail length (tail docking, necrosis of suckling piglets or tail biting) can hardly be determined. Therefore, a deviation of tail length within the pen rather than absolute length was used in this study to indicate previous tail biting problems. The proportion of pigs with shorter tails than the pen average (**A**) was similar for LAB- and for CON-farms. Though, the broad range of deviations in LAB-farms of up to 25 % suggests, that individual farms had some tail biting problems (additionally to a likely occurrence of tail necrosis of suckling piglets) previously. This was mostly confirmed when farmers were asked. Tail length assessed at carcass inspection differentiated long tails (> 18 cm), short tails (< 18 cm) and extremely short tails (< 5 cm). Only the latter were considered to indicate tail biting because it is unlikely that tails have been docked that short. However, it was not possible to distinguish whether tails with less than 18 cm length had been docked or bitten. Even if the pigs of one LAB-farm were tail docked, the median of 17 % of LAB-pigs with short tails suggests that individual farms or groups of pigs at the piglet producer or in the finishing farm had problems with previous tail biting. In any case, it was not possible for all participating LAB-farms in the current study to maintain 100 % of pigs with intact tails until slaughter.

The omission of tail docking can be considered as welfare improvement as pigs are prevented from unnecessary pain and stress caused by the surgical procedure (Nannoni et al. 2014). Moreover, keeping pigs with intact tails acknowledges pigs' integrity and naturalness (Kiley-Worthington 1989). However, the results of the present study point out that the omission of tail docking can be challenging for individual farms, where tail biting is observed. Though, it was also shown, that it is possible to keep pigs with intact tails without increasing the risk of tail lesions when improved husbandry condition are provided. It should be considered that the successful omission of tail docking requires not only changes in the entire husbandry system (including rearing conditions) but also increased knowledge and experience of farmers as discussed by Zonderland & Zonderland-Thomassen (2016).

8.3.2 Body lesions and leg disorders

Scratches on shoulder and flank indicating aggressive behaviour (Turner et al. 2006) were the most prevalent types of body lesions and showed a high variation between farms. There was no statistically significant or even numerically relevant difference between LAB- and CON-farms. Scratches on the hindquarter, indicating displacement (e.g. at feeder / drinkers) were less frequent and round superficial wounds due to manipulation by other pigs occurred only occasionally. Similarly, Schodl (2017) did not find any difference in skin lesions of pigs kept under improved welfare conditions either. Vermeer et al. (2014) reported less skin lesions on the hindquarter in pigs with increased space allowance. This has also previously been shown by Spoolder et al. (1999) who, additionally, reported an effect of increased feeder space allowance on a reduction of agonistic interactions at the food trough. Turner et al. (2006) described an accumulation of skin lesions due to post-mixing aggression, which however would primarily affect young pigs recently moved to the fattening units. Some of those potential risk factors for lesions (e.g. feeder space allowance, mixing) could not be considered in the present study. Whereas information about recent mixing of pigs was not available at all, animal-per-feeder ratio was, although available, not included in the model to avoid over-parametrisation. It can be suggested, that scratches on the body were rather influenced by management measures such as mixing or feeding system, while the different housing conditions of LAB- and CON-farms had little effects. This could also explain the large variation between farms.

Obvious lameness assessed on-farm as well as medical treatments of leg disorders were very rare throughout all farms, keeping in mind, that only severe lameness could be detected due to the difficulty of observing pigs' gait within the tight space conditions of the pens. Similar results have been reported by Cagienard et al. (2005), who found a generally low prevalence of lameness and considered lameness scoring as difficult for on-farm assessment at group level. Mullan et al. (2009) confirmed the challenge to assess lameness in groups of fattening pigs due to the low prevalence and the unfavourable space conditions, as already discussed in section Fehler! Verweisquelle konnte nicht gefunden werden..

Swellings on the hind limbs are considered to indicate impaired comfort around resting (Welfare Quality® 2009). Besides, there is a relation between swellings and leg lesions causing lameness and pain (Jensen & Toft 2009). Resting on a hard underground – as it is typical in conventional pig husbandry systems with fully slatted floors – favours the development of swellings. In contrast, a soft straw bedded lying area has been shown to prevent swellings (Leeb et al. 2001). Previous studies reported lower levels of swellings when straw bedding is provided (Scott et al. 2006, KilBride et al. 2009). Lyons et al. (1995) found a lower proportion of pigs with swellings in systems with straw compared to systems without straw. Though, the general level of swellings was higher with 41.2 % in straw systems and even 91.1 % in systems without straw. Kongsted & Sørensen (2017) report a similar decrease of swellings in conventional free-range compared to conventional indoor systems, however on a lower level (15.8 and 30.9 %, respectively). Harley et al. (2014), in turn, found comparably high levels in conventional pigs (44 %) but did not investigate different husbandry systems.

A decrease of swellings in LAB-pigs compared to CON – even when not very distinct (34 % and 40 %, respectively) was also found in this study. However, contrary to the hypothesis, the difference between LAB and CON was not statistically significant. Though, the numerical difference of about 6 % as well as the low p-value (0.107) indicate a tendency of less swellings in LAB-pigs. The relatively high proportion of pigs with swellings in both, LAB- and CON-farms demonstrates, that comfort at resting is a welfare concern in conventional pig husbandry. Interestingly, results revealed a significant decrease of swellings with increasing amount of straw, which supports the importance of straw regarding comfort at resting.

Therefore, a decrease of swellings in LAB-pigs due to the provision of straw bedding was expected in this study. The results revealed about 34 % of LAB- and 40 % of CON-pigs with swellings on the hindlimbs and showed considerable variation between individual farms. The relatively high proportion of pigs with swellings in both LAB- and CON-farms demonstrates, that comfort at resting is a welfare concern in conventional pig husbandry. Contrary to the hypothesis, the difference between LAB and CON was not statistically significant. However, the numerical difference of about 6 % as well as the low p-value (0.107) indicate a tendency of less swellings in LAB-pigs. In order to investigate, whether the amount of straw influences the development of swellings, additional analyses were carried out within LAB-farms. Results revealed a significant decrease of swellings with increasing amount of straw.

So, there is considerable variation not only between the farms of this study but also throughout other studies. Possible explanations are firstly, that the results of the cited studies are either based on experiments (Lyons et al. 1995, Scott et al. 2006), on-farm assessments (KilBride et al. 2009) or carcass inspection at the slaughterhouse (Harley et al. 2014, Kongsted & Sørensen 2017). Therefore, care has to be taken when comparing results, as e.g. on-farm assessment may not confirm significant results of experimental studies as a variety of potentially confounding factors cannot be considered on-farm. Furthermore, definitions of swellings are probably inconsistent in different assessment strategies (e.g. on-farm vs. carcass inspection) or studies. The differing outcomes of the studies may also result from different quantities of straw bedding as only few studies provide information about the amount of straw provided in littered systems.

To conclude, straw bedding seems to reduce swellings and increases comfort at resting by the provision of a soft lying surface. However, the quantity of straw needs also to be considered. It can be suggested, that the numerically lower level of swellings in LAB-pigs, which is in accordance with scientific knowledge, combined with the correlation with amount of straw indicate a welfare improvement through comfortable resting and better leg health in systems providing a soft lying area.

8.3.3 Cleanliness and endoparasites

Results of the present study show a numerically lower proportion of pigs with manure on the body in LAB-farms than in CON-farms with high variation between farms. Moreover, temperature was generally higher in CON-farms and therefore not considered for the statistical comparison. Analysis within LAB-farms showed no correlation between the amount of straw and cleanliness. Regarding a potential influence of temperature, it should be noted, that all assessments were conducted in the summer period with ambient temperatures that were comparably high across LAB-farms. Our results are comparable to e.g. Vermeer et al. (2014), who reported higher cleanliness in systems with increased space allowance, where pigs have the possibility to separate the dunging from the lying area. Moreover, as Scott et al. (2006) demonstrated improved cleanliness in straw bedded compared to fully slatted husbandry systems. It can be concluded, that the combination of provision of straw, increased space allowance and access to an outdoor run does not result in a higher proportion of soiled pigs but, in contrast, tends to improve cleanliness.

With regard to endoparasites, LAB-farms displayed an increased proportion of pigs with milk spots (44.8 and 55.0 % for sample **A** and **B**) compared to CON-farms (26.3 and 45.5 % for sample **A** and **B**). This was not unexpected as comparable levels of endoparasites are already known from organic pig production providing straw bedding and outdoor run (Lindgren et al. 2014). Baumgartner et al. (2003) found a similar high proportion of pigs with milk spots in organic systems (50 %) In contrast, Kongsted & Sørensen (2017) reported a much lower level of milk spots in conventional free-range systems (12.2 %), which was still more than in conventional indoor systems (4.6 %). Even if there was no significant difference between LAB- and CON-farms, the high number of pigs affected on LAB-farms raises concerns. However, it should be noted, that even CON-farms of the current study showed a considerably higher proportion of pigs with milk spots than results from other studies suggest for conventional pigs (e.g. 14.5 % reported by Dalmau et al. (2016)).

Moreover, the variability between farms was considerable, indicating that individual farms had major problems with endoparasites while others apparently managed this challenge quite well. In addition, viscera inspection by the official veterinarians was possibly not consistent as no clear guideline for the assessment of milk spots did exist and even low levels (e.g. one white spot) were included. It is suggested, that other factors than the husbandry system account for the higher levels of endoparasites in welfare improved and organic systems, e.g. manure management, hygiene or deworming strategies. Whereas no information concerning hygiene (manure management, cleaning, disinfection) were collected in this study, deworming was mainly applied in weaner piglets but rather uncommon in fattening pigs on CON-farms and even completely absent in fattening pigs on LAB-farms. Hence, the increased level of milk spots might be connected to a low level of knowledge and awareness of (some) farmers concerning the challenge of endoparasites in such new systems. Baumgartner et al. (2003) emphasise the importance of hygiene procedures as well as health management and monitoring (e.g. through faecal samples) for organic pig production. In particular, they point out the need for a reliable feedback system of slaughterhouses.

To conclude, endoparasites seem to be challenging, not only but particularly for LAB-farms. Improvements regarding management (e.g. 'all-in-all-out' production), hygiene (e.g. cleaning and disinfection of pens) as well as strategic deworming in combination with monitoring (e.g. through regular analysis of faecal samples) might be necessary. Moreover, reliable and consistent feedback from the slaughterhouse may help farmers to manage this challenge (Sanchez-Vazquez et al. 2010).

8.3.4 Respiratory health

The evaluation of medical treatments and data from viscera inspection (slaughter reports) confirmed, that airway infections represent one of the most frequently observed health issues in fattening pigs. Correspondingly, Kongsted & Sørensen (2017) identified respiratory diseases as the most prevalent disease complex with an average herd prevalence of about 20 % across different production systems; an effect of the production system (conventional indoor, conventional free-range, organic free-range) was not found. In line with this, the current study did not find any significant differences between LAB- and CON-farms in lung lesions. Though, the generally low level should be noted (medians of under 5 % for pneumonia and about 6 % for TVA in sample **A**). Goossens et al. (2008) reported similar levels for conventional pigs (medians of 3.9 % for pneumonia, 3.7 % for pleuritis and 2.9 % for pericarditis). Findings by Guy et al. (2002) demonstrated a significant decrease in lung damage for pigs kept in littered systems with outdoor access. This is in contrast with the results of the present study, as LAB-farms reached slightly higher proportions of pigs with pneumonia in sample **A** and **B**. Moreover, analysis within LAB-farms revealed a positive correlation between the amount of straw and signs of respiratory diseases at viscera inspection indicating an increase of pneumonia with higher amounts of straw. This outcome must be interpreted carefully as only 7 LAB-farms were considered. Moreover, the amount of straw was also related to characteristics of the barns such as the location of the straw bedded area (indoors / outdoors) and the year of construction, i.e. low amounts of straw were mainly provided indoors in new constructed barns. So, the described effect may also rest on other aspects of housing (e.g. design of outdoor runs, ventilation system) and management (e.g. vaccination strategies).

Apart from pathological signs assessed through viscera inspection, ocular discharge and eye inflammation (conjunctivitis, 'red eyes') can be used as early indicators to evaluate respiratory health and air quality on-farm (e.g. Whay et al. 2007, Schodl 2017). The current study resulted in a relatively high proportion of pigs with ocular discharge (42.4 % and 52.7 % for LAB and CON, respectively) with no differences. Eye inflammation occurred far less frequently and did not differ between LAB and CON either. Likewise, Schodl (2017) investigated the effect of higher space allowance and hay provided in a rack and did not find any difference between control and improved pens, neither for ocular discharge nor for eye inflammation. While the level of eye inflammation was comparable, ocular discharge was far less prevalent in the cited study, probably because only dark-coloured secretion was considered. Contrastingly, Whay et al. (2007) reported a higher but still comparable prevalence of total ocular discharge (62.2 %) for pigs kept under improved husbandry conditions.

In addition to its relevance for respiratory health, ocular discharge, specifically when stained with brown colour resulting from Harderschen Glands (so-called ‘tear staining’) has recently been studied for its use as non-invasive stress indicator (Deboer et al. 2015). More in detail, Telkänranta et al. (2015) suggested, that left ocular discharge is a more sensitive indicator of stress than right ocular discharge. Against this background, the current study distinguished ocular discharge predominating in the left or right eye and found a significant difference with a higher proportion of CON-pigs affected on the left eye only. However, most pigs were equally affected on both eyes and the proportion of left ocular discharge was very low. Furthermore, clinical health could not be considered in the analysis and may confound the results. As the validity of ‘tear staining’ has not yet been sufficiently confirmed, the meaning of these results should not be overvalued.

In the end, the lack of difference between LAB and CON as well as the large variability between farms suggests that respiratory health does not primarily depend on the production system. Individual farm characteristics and management practices that where not studied here (e.g. vaccination, mixing of pigs from different farms) might have more influence. Though, straw as litter could be additionally challenging with respect to respiratory health due to higher dust emissions. Therefore, particular attention should be payed to straw quality. Moreover, the effect of providing straw either indoors or outdoors requires further evaluation.

8.4 Stress prior to slaughter

Considerable differences emerged regarding the behaviour at unloading: LAB-pig showed significantly less reluctance to move, turning around and falling and tended to perform less slipping and vocalisation. Additionally, the duration of unloading was significantly shorter for LAB-pigs. While the behaviours slipping and falling relate to deficient unloading facilities or handling which potentially compromise welfare, reluctance to move and turning back may actually reflect fear (Dalmau et al. 2010). Both types of behaviour were rarely seen in LAB-pigs and more frequently in CON. One explanation – apart from different husbandry conditions – could be found in the characteristics of transport and unloading procedures. LAB-pigs were mostly transported by one haulier providing a well-equipped transport vehicle (non-slip unloading ramp of low angle with side walls and crossbars). This could also explain the significantly shorter unloading duration in LAB-pigs, as appropriate equipment favours undisturbed and even unloading of animals (Wiberg 2012). In contrast, most CON-farmers delivered pigs with their own vehicles, resulting in a large diversity of transport and unloading conditions. Moreover, LAB-pigs were usually delivered and slaughtered in the morning prior to other pigs. At this time of the day, the lairage area was still calm and not yet crowded and – as slaughter started about 2 - 3 hours after the first pigs arrived – the sound level was low. A negative effect of high sound levels on meat pH (indicating pre-slaughter stress) has previously been reported (e.g. Dalmau et al. 2010, Vermeulen et al. 2015). Presumably, a less stressful environment at unloading and lairage accounted for the lower percentage of LAB-pigs with meat pH < 6.00. However, it was not possible to dissociate the farm category (CON vs. LAB) from transport, unloading and lairage conditions.

Furthermore, data from meat inspection (slaughter reports) showed a considerably lower proportion of pigs with pH < 6.00 in LAB-farms. This could be a result of pre-slaughter handling and transport for pig welfare as shown by Van de Perre et al. (2010), Wiberg (2012), Vermeulen et al. (2015) and Dalmau et al. (2016). Moreover, Foury et al. (2011) demonstrated an positive effect of husbandry system providing straw bedding and outdoor access on indicators of stress and meat quality at slaughter. Morrison et al. (2007) concluded that pigs kept under improved husbandry conditions are easier to handle and can adapt better to novel environments due to increased access to environmental stimuli. Therefore, the difference between LAB- and CON-farms may indicate a better adaptability to novel environments and potentially stressful situations of pigs kept under improved husbandry conditions. Hence, a clear statement whether the husbandry system or other factors such as transport characteristics accounted for the difference in LAB- and CON-farms cannot be made.

To sum up, the comparison of behaviour observed at unloading combined with the lower number of pigs with meat pH < 6.00 indicate, that labelled pigs experienced less stress before slaughter. The underlying causes cannot be clearly determined. However, label standards included not only provisions at farm level but also transport and slaughter specifications. Considering the implementation of those standards as a whole, it can be concluded, that this affects the welfare of LAB-pigs positively.

9 CONCLUSION

The output of this thesis can support the effectiveness of the specific measures such as the provision of straw of the label program to improve animal welfare. The results highlight the importance of appropriate enrichment material to fulfil the need of pigs to explore and to reduce abnormal behaviour such as tail biting. In particular, tail lesions were not increased in pigs with intact tails confirming the possibility to omit routine tail docking. Moreover, the positive effect of – especially large amounts of – straw bedding on swellings can be supported. In addition, cleanliness and health parameters, such as respiratory health, seem not to be impaired through the provision of straw or access to an outdoor run. Nonetheless, some health issues like endoparasites seem to be challenging: Management measures such as strategic deworming and increased emphasis on pen hygiene to optimise the new system seem necessary. Finally, the comparison of behaviour observed at unloading combined with the lower number of pigs with meat $pH < 6.00$ indicate, that labelled pigs experience less stress before slaughter. The results of this study could be used in discussions with farmers and stakeholders and may contribute to further developments of the new system. Moreover, results could also provide helpful information to improve pig welfare of non-labelled farms, e.g. by the use of appropriate transport and unloading facilities. In the end, this work encourages the implementation of this new label standards and shows that it is indeed feasible to keep pigs with intact tails, provided increased space, outdoor access and appropriate enrichment such as straw. We conclude that such improved husbandry conditions acknowledge the pig’s ‘nature’ and account for considerable welfare benefits by the omission of tail docking and the opportunity to perform natural behaviour. Still, concerns of animal health should be taken into account and need special attention in such new systems.

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13 APPENDIX

Table 13 Results from the workshop with farmers and experts: Label standards, their potential effects on pigs and respective indicators.

Potential effects on pigs	Indicators
Label standard 1 & 2: Space allowance and outdoor run	
Separation of dunging area	Cleanliness
Limb lesions due to slippery floors	Lameness, medical treatments
Avoiding agonistic interactions	Skin lesions
Higher endoparasite burden	Deworming, Milkspots (VI*)
Less respiratory problems due to better air quality	Coughing, ocular discharge/red eyes, medical treatments, VI*
Stress resistance	Behaviour at unloading, meat pH
Label standard 3 & 4: Straw bedding and organic enrichment material	
More respiratory diseases due to dust emissions	Coughing, ocular discharge / red eyes, medical treatments, VI*
Better lying comfort	Bursitis / swellings on the hind limbs
Higher endoparasite burden	Deworming, Milkspots (VI*)
More exploratory and less abnormal behaviour	Behavioural observation
Label standard 5: Intact tails	
More tail biting and more tail lesions	Behavioural observation, tail position, tail lesions
Label standard 6: Transport specifications	
Lower stress level at slaughter	Behaviour at unloading, meat pH

* VI = Viscera inspection at the slaughterhouse

Figure 16 Example for feedback to the farmers including descriptive results of overall assessed farms as well as results for the own farm.

Source
Data from recordings, behavioural observation, clinical inspection etc.

Category A
The best 25% of farms treated **0.0 – 0.2%** of fatteners for respiratory disease.

Category D
The worst 25% of farms treated **>5.9 – 64.1%** of fatteners for respiratory diseases.

The own farm treated **0.6%** of fatteners for respiratory disease.
(n = number of assessed animals)

RESPIRATORY HEALTH						
INDICATOR		**A**	**B**	**C**	**D**	**Own farm**
Treatments – Respiratory diseases *(%)*	*MR*	0.0 – 0.2	>0.2 – 1.4	>1.4 – 5.9	>5.9 – 64.1	**0.6** (n=720)
Pneumonia *(%)*	*SR*	0.4 – 2.0	>2.0 – 3.4	>3.4 – 5.4	>5.4 – 12.5	**4.2** (n=440)
Moderate ocular discharge *(%)*	*C*	13.5 – 24.1	>24.1–37.3	>37.3–44.4	>44.4–54.9	**31.2** (n=160)
Severe ocular discharge *(%)*	*C*	0.0 – 1.1	>1.1 – 2.9	>2.9 – 6.0	>6.0 –11.8	**0.8** (n=160)

Indicators
Treatments → Data from medical recordings (*MR*)
Pneumonia → Data from slaughter reports, including viscera inspection (*SR*)
Ocular discharge → Data from clinical inspection on-farm (*C*)

Colours from blue to red indicate more positive or more problematic results.

Table 14 Summary of statistical methods and results for behaviour, leg disorders, cleanliness and endoparasites.

Animal Welfare Area	Parameters	Original data level	n	Unit	Descriptive Results - Median (min-max) at farm level		Statistical procedure	Level of analysis	n	Unit of analysis	Distribution	Effects considered (f=fixed, r=random)	Significant Difference LAB vs CON (p-
					LAB	CON							
Behaviour	Manipulation Pen	Pen	101	frequency/ 10 pigs/ 10 min	**1.1 (0.0-5.1)**	**5.1 (1.1-5.5)**	None				not normal		n.t.
	Manipulation Object	Pen	60	frequency/ 10 pigs/ 10 min	**1.8 (0.0-2.5)**	**4.9 (2.5-12.6)**	None				not normal		n.t.
	Manipulation Material	Pen	44	frequency/ 10 pigs/ 10 min	**7.1 (3.3-11.5)**	**7.1**	None				not normal		n.t.
	Total Manipulation	Pen	100	frequency/ 10 pigs/ 10 min	**7.3 (4.9-10.4)**	**13.3 (7.3-14.7)**	GLM	Farm	13	average frequency/ 10	normal	label	0.006
	Locomotory Play	Pen	100	number of pens affected	**0 (0-4)**	**0**	None				not normal		n.t.
	Manipulation Pig	Pen	100	frequency/ 10 pigs/ 10 min	**0.8 (0.0-2.1)**	**1.5 (0.7-2.8)**	GLIMMIX	Pen	100	pen affected (0/1)	binary	label (f), weight class (f), farm (r)	0.248
	Stereotypes	Pen	100	number of pens affected	**0 (0-2)**	**2 (0-2)**	None				not normal		n.t.
	Tailbiting	Pen	100	number of pens affected	**1 (0-2)**	**2.5 (1-4)**	GLM	Farm	13	proportion of pens affected	normal	label	0.002
	Earbiting	Pen	100	number of pens affected	**2 (0-4)**	**3.5 (2-4)**	GLM	Farm	13	proportion of pens affected	normal	label	0.258
Leg Disorders	Lameness Treatments	Farm	13	treatments/ 100 pigs/ year	**0.2 (0.0-2.0)**	**0.1 (0.0-2.1)**	None				not normal		n.t.
	Obviously Lame Pigs	Pen	101	number of pens affected	**0.0 (0-2)**	**1.0 (0-2)**	None				not normal		n.t.
	Total Swellings	Batch	40	percentage of pigs affected	**34.3 (0.0-51.3)**	**40.3 (26.1-56.0)**	MIXED	Batch	40	percentage of pigs affected	normal	label (f), farm (r)	0.107
	Severe Swellings	Batch	40	percentage of pigs affected	**1.5 (0.0-8.5)**	**0.0 (0.0-8.0)**	None				not normal		n.t.
Cleanli-ness	Soiling	Pen	101	percentage of pigs affected	**7.0 (0.0-29.1)**	**18.5 (11.3-33.0)**	GLM	Farm	13	percentage of pigs affected	normal	label	0.141
Endoparasites	Deworming Treatments	Farm	13	treatments/ 100 fatteners/ year	**0.0 (0.0-0.0)**	**1.9 (0.0-39.8)**	None				not normal		n.t.
	Milkspots (on-farm/year)	Farm	11	percentage of pigs affected	**44.8 (9.7-71.3)**	**26.3 (8.3-36.0)**	GLM	Farm	11	percentage of pigs affected	normal	label	0.230
	Milkspots (slaughter)	Batch	44	percentage of pigs affected	**55.0 (0.0-100)**	**45.5 (0.0-95.7)**	MIXED	Batch	44	percentage of pigs affected	normal	label (f), farm (r), assessment day	0.367

LAB = Labelled farms. CON = Conventional farms. GLM = Analysis of variance, NP = non-parametric tests. n.t. = not tested.

Table 15 Summary of statistical methods and results for tail position, tail lesions and body lesions.

Animal Welfare Area	Parameters	Original data level	n	Unit	Descriptive Results - Median (min-max) at farm level		Statistical procedure	Level of analysis	n	Unit of analysis	Distribution	Effects considered (f=fixed, r=random)	Significant Difference LAB vs CON (p-value)
					LAB	CON							
Tails	Tail Position hangign/between legs	Pen	100	percentage of pigs affected	**3.1 (0.0-16.3)**	**8.2 (0.7-13.2)**	None				not normal		n.t.
	Total Tail Lesions (on-farm)	Pen	101	percentage of pigs affected	**1.6 (0.0-6.5)**	**4.1 (0.0-7.4)**	GLIMMIX	Pen	101	pen affected (0/1)	binary	label (f), weight class (f), farm (r)	0.412
	Mild Tail Lesions (on-farm)	Pen	101	percentage of pigs affected	**1.2 (0.0-5.1)**	**1.6 (0.0-2.4)**	GLM	Farm	13	percentage of pigs affected	normal	label	0.745
	Medium+Severe Tail Lesions (on-farm)	Pen	101	percentage of pigs affected	**0.0 (0.0-1.4)**	**2.3 (0.0-5.6)**	GLIMMIX	Pen	101	pen affected (0/1)	binary	label (f), weight class (f), farm (r)	0.618
	Total Tail Lesions (slaughter)	Batch	37	percentage of pigs affected	**11.4 (0.0-20.0)**	**9.1 (0.0-15.9)**	MIXED	Batch	37	percentage of pigs affected	normal	label (f), farm (r)	0.282
	Mild Tail Lesions (slaughter)	Batch	37	percentage of pigs affected	**9.2 (0.0-20.0)**	**8.0 (0.0-13.3)**	GLM	Farm	25	percentage of pigs affected	normal	label	0.144
	Medium+Severe Tail Lesions (slaughter)	Batch	37	percentage of pigs affected	**1.8 (0.0-10.0)**	**1.4 (0.0-8.3)**	GLIMMIX	Batch	37	pen affected (0/1)	binary	label (f), farm (r)	0.619
	Short Tails < 18 cm (slaughter)	Batch	37	percentage of pigs affected	**17.00 (0.0-100)**	**92.1 (0.0-100)**	None				not normal		n.t.
	Short Tails < 5 cm (slaughter)	Batch	37	number of pigs affected	**0 (0-1)**	**0 (0-9)**	None				not normal		n.t.
	Tails shorter than pen average (on-farm)	Pen	101	percentage of pigs affected	**4.0 (0.0-25.9)**	**4.6 (0.0-7.0)**	None				not normal		n.t.
Body Lesions	Scratches Shoulder	Pen	101	percentage of pigs affected	**9.9 (0.0-21.2)**	**8.3 (7.6-24.0)**	GLM	Farm	13	percentage of pigs affected	normal	label	0.608
	Scratches Hindquarter	Pen	101	percentage of pigs affected	**1.6 (0.0-4.8)**	**2.0 (0.0-16.7)**	None				not normal		n.t.
	Round Wounds	Pen	101	number of pens affected	**1 (0-2)**	**1 (0-2)**	None				binary		n.t.

LAB = Labelled farms. CON = Conventional farms. GLM = Analysis of variance, NP = non-parametric tests. n.t. = not tested.

Table 16 Summary of statistical methods and results for respiratory health.

Animal Welfare Area	Parameters	Original data level	n	Unit	Descriptive Results - Median (min-max) at farm level		Statistical procedure	Level of analysis	n	Unit of analysis	Distribution	Effects considered (f=fixed, r=random)	Significant Difference LAB vs CON (p-value)
					LAB	**CON**							
Respiratory Health	Respiratory Treatments	Farm	13	treatments/ 100 pigs/ year	**1.0 (0.0-53.1)**	**3.3 (0.0-7.1)**	None				not normal		n.t.
	Pneumonia (on-farm/year)	Farm	13	percentage of pigs affected	**4.2 (0.4-12.5)**	**2.5 (1.5-4.5)**	GLM	Farm	11	percentage of pigs affected	normal	label	0.271
	Pneumonia (slaughter)	Batch	44	percentage of pigs affected	**6.3 (0.0-63.5)**	**4.0 (0.0-52.0)**	NP	Farm	25	percentage of pigs affected	not normal	label	0.403
	Thoracic Viscera Alteration (on-farm/year)	Farm	13	percentage of pigs affected	**6.3 (2.6-14.8)**	**5.9 (3.2-7.4)**	GLM	Farm	13	percentage of pigs affected	normal	label	0.410
	Thoracic Viscera Alteration (slaughter)	Batch	44	percentage of pigs affected	**6.6 (0.0-63.5)**	**15.0 (0.0-56.0)**	NP	Farm	25	percentage of pigs affected	not normal	label	0.808
	Red Eyes	Pen	101	percentage of pigs affected	**3.4 (0.0-5.9)**	**2.6 (0.0-7.4I**	GLIMMIX	Pen	101	pen affected (0/1)	binary	label (f), farm (r), weight class (r)	0.075
	Total Ocular Discharge	Pen	101	percentage of pigs affected	**42.4 (23.6-60.6)**	**52.7 (18.2-66.9)**	MIXED	Pen	101	percentage of pigs affected	normal	label (f), farm (r), weight class (r)	0.414
	Severe Ocular Discharge	Pen	101	percentage of pigs affected	**3.2 (0.0-9.6)**	**4.1 (1.2-12.3)**	GLIMMIX	Pen	101	pen affected (0/1)	binary	label (f), farm (r), weight class (r)	0.343
	Ocular Discharge Both Eyes	Pen	101	percentage of pigs affected	**32.1 (14.4-53.3)**	**38.2 (8.4-53.8)**	GLM	Farm	13	percentage of pigs affected	normal	label	0.663
	Ocular Discharge Left Eye	Pen	101	percentage of pigs affected	**2.8 (0.0-4.8)**	**5.3 (3.9-16.2)**	GLM	Farm	13	percentage of pigs affected	normal residues	label	0.022
	Ocular Discharge Right Eye	Pen	101	percentage of pigs affected	**4.6 (0.0-9.8)**	**4.6 (2.4-9.5)**	GLM	Farm	13	percentage of pigs affected	normal	label	0.953

LAB = Labelled farms. CON = Conventional farms. GLM = Analysis of variance, NP = non-parametric tests. n.t. = not tested.

Table 17 Summary of statistical methods and results for parameters indicating stress before slaughter.

Animal Welfare Area	Parameters	Original data level	n	Unit	Descriptive Results - Median (min-max) at farm level		Statistical procedure	Level of analysis	n	Unit of analysis	Distribution	Effects considered (f=fixed, r=random)	Significant Difference LAB vs CON (p-value)
					LAB	CON							
Stress at Slaughter	Meat pH < 6.00 (on-farm/year)	Farm	13	percentage of pigs affected	**6.1 (2.5-17.1)**	**17.1 (9.2-22.9)**	GLM	Farm	13	percentage of pigs affected	normal	label	0.023
	Meat pH < 6.00 (slaughter)	Batch	44	percentage of pigs affected	**7.5 (0.0-72.7)**	**13.2 (1.0-50.0)**	NP	Farm	25	percentage of pigs affected	not normal	label	0.301
	Reluctance to Move	Batch	37	frequency/ 100 pigs	**0.0 (0.0-2.6)**	**0.0 (1.8-18.2)**	NP	Farm	25	percentage of pigs affected	not normal	label	0.013
	Turning Around	Batch	37	frequency/ 100 pigs	**0.0 (0.0-30.0)**	**5.6 (3.4-54.6)**	NP	Farm	25	percentage of pigs affected	not normal	label	0.002
	Vocalisation	Batch	37	frequency/ 100 pigs	**17.4 (9.7-55.0)**	**27.3 (5.0-81.8)**	NP	Farm	25	percentage of pigs affected	not normal	label	0.149
	Slipping	Batch	37	frequency/ 100 pigs	**0.0 (0.0-17.1)**	**5.4 (0.0-22.3)**	NP	Farm	25	percentage of pigs affected	not normal	label	0.069
	Falling	Batch	37	frequency/ 100 pigs	**0.0 (0.0-3.2)**	**1.4 (0.0-13.0)**	NP	Farm	25	percentage of pigs affected	not normal	label	0.037
	Duration of Unloading	Batch	37	sec/pig	**4.1 (2.8-15.8)**	**7.3 (4.4-21.1)**	NP	Farm	25	duration in sec/ pig	not normal	label	0.014

LAB = Labelled farms. CON = Conventional farms. GLM = Analysis of variance, NP = non-parametric tests. n.t. = not tested.

Table 18 Summary of statistical methods and results for evaluation within LAB farms depending on the amount of straw provided per pig and day.

Animal Welfare Area	Parameters	Original data level	n	Unit	Descriptive Results - Median (min-max) at farm level	Statistical procedure	Level of analysis	n	Unit of analysis	Distribution	Effects considered (f=fixed, r=random)	Significant effect STRAW (p-value)	Coefficient of Correlation
					LAB								
Leg Disorders	Total Swellings	Batch	16	percentage of pigs affected	**34.5 (0.0-52.6)**	GLM	Farm	9	percentage of pigs affected	normal	litter kg	0.001	-0.89
Respiratory Health	Pneumonia (on-farm/year)	Farm	7	percentage of pigs affected	**4.2 (0.4-12.5)**	GLM	Farm	7	percentage of pigs affected	normal	litter kg	0.018	0.84
	Total Ocular Discharge	Pen	66	percentage of pigs affected	**42.4 (23.6-60.6)**	MIXED	Pen	66	percentage of pigs affected	normal	litter kg (f), farm (r), weight class (r)	0.565	n.t.
Cleanliness	Soiling	Pen	66	percentage of pigs affected	**7.0 (0.0-29.1)**	GLM	Farm	9	percentage of pigs affected	normal	litter kg	0.204	-0.47
Endo-parasites	Milkspots (on-farm/year)	Farm	7	percentage of pigs affected	**44.8 (9.7-71.3)**	GLM	Farm	7	percentage of pigs affected	normal	litter kg	0.238	0.51
Behaviour	Manipulation Material	Pen	65	frequency/ 10 pigs/ 10 min	**7.1 (3.3-11.5)**	GLM	Farm	9	frequency/ 10 pigs/ 10 min	normal	litter kg	0.573	0.22
Tails	Total Tail Lesions (on-farm)	Pen	66	percentage of pigs affected	**1.6 (0.0-6.5)**	GLM	Farm	9	percentage of pigs affected	normal	litter kg	0.072	-0.630

LAB = Labelled farms. Litter_kg = amount of straw per pig and day. GLM = Analysis of variance. n.t. = not tested.