Behaviour and performance of growing and finishing pigs depending on different housing conditions and sire breeds

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To the pigs

TABLE OF CONTENTS

General Introduction

Although aggressive interactions between newly regrouped pigs are studied since the 1970s (Ewbank and Bryant, 1972; Peden et al., 2018) and tail-biting was even already mentioned in the 1940s (Schrøder-Petersen and Simonsen, 2001), both problematic issues are still persistent in conventional pig husbandry, challenging farmers and putting the pigs at a welfare risk. Weaning is probably the most stressful event in a piglet's life (Weary et al., 2008). Under conventional housing conditions, piglets are usually weaned abruptly within one day at the age of three to four weeks (Council Directive 2008/120/EC) although it is known that weaning under (semi-)natural conditions happens gradually within four months (Jensen, 1986). The separation from the dam, the relocation and regrouping induce a stress reaction accompanied by an increased synthesis of the stress hormone cortisol (Moberg, 2000; Cornale et al., 2015). The mixing of unfamiliar pigs leads to aggressive rank fights in order to establish a social hierarchy, which result in skin lesions (Hessel et al., 2006; Kanaan et al., 2008; Stukenborg et al., 2011), an impaired immune response and declined performance (Ekkel et al., 1995). Studies showed that pigs compensate stressful events individually different and that this coping strategies might lead to oral manipulation and biting of pen mates (Benus et al., 1991; Rushen, 1993). Therefore, the optimisation of the management at weaning and an adjustment in the housing conditions might be a way to reduce both, aggressive interactions at weaning and tail-biting at long-term (Schrøder-Petersen and Simonsen, 2001; Moinard et al., 2003; D'Eath, 2005; Bohnenkamp et al., 2013; Gentz et al., 2020). Since 2021, the permanent confinement of (gestating and) lactating sows is forbidden and studies reported that loose-housed sows were able to perform maternal behaviour which influenced the piglets towards better coping with stress at weaning (Andersen et al., 2005; Oostindjer et al., 2011; Singh et al., 2017; Andersen and Ocepek, 2022). Additionally, beneficial effects of early, pre-weaning socialisation of different litters on post-weaning behaviour and performance were published (D'Eath, 2005; Hessel et al., 2006; Bohnenkamp et al., 2013) and a reduction of regrouping events seemed to decrease but not inhibit the incidence of tail lesions and tail losses (Gentz et al., 2020). Beside other multifactorial causes, the genetic background might induce tail-biting as differences have been found between pig breeds for exploratory and aggressive behaviour (Schrøder-Petersen and Simonsen, 2001; Sonoda et al., 2013) and within breeds for performance and phenotype as lean and fast growing pigs were more likely to develop tail-biting than their opposites (Breuer et al., 2005; Ursinus et al., 2014).

The aim of the present dissertation was to study the effects of different housing systems during suckling, rearing and finishing period and of different sire breeds on the behaviour and performance of docked and undocked growing and finishing pigs. The housing during suckling (farrowing crate, free-farrowing pen, group housing) differed in the possibilities of free movement of the sow and thus interactions between sows and litters. The housing after weaning and at rearing period (conventional, wean-to-finish, rearing in the farrowing pen) varied in the management at weaning, in terms of regrouping and relocation, but also in space allowance. The offspring of modern hybrid sows (Landrace x Large White) and either traditional, slow-growing sire breeds (Bentheim Black Pied pig, Swabian-Hall swine) or modern, lean Piétrain sires were compared.

Research article one reports differences in the perception of post-weaning stress for docked and undocked piglets from three different housing systems during suckling period that were weaned into different rearing environments (conventional, wean-to-finish). Therefore, piglets were assessed for skin lesions and their fighting behaviour was observed one day after weaning. Also, one week before and one day after weaning, the individual difference in serum cortisol of the piglets was analysed.

Research article two studied the long-term effects of three different housing systems during suckling period and two rearing systems (conventional, rearing in the farrowing pen). The study reports differences in the incidences of skin lesions, tail lesions and tail losses and performance of docked and undocked pigs.

Research article three estimated the effects of the genetic background in terms of the sire breed on docked and undocked piglets. Skin lesions after weaning, tail lesions and tail losses as well as the average daily gain during rearing period were assessed for the piglets from the three different sire breeds. Also, the activity score for focus pens with different mean tail lesion scores was analysed and reported.

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Welfare and Challenges in Pig Production – Literature Review

In 1965, a committee was established in Great Britain to outline the "Report of the Technical Committee to Enquire into the Welfare of Animals kept under Intensive Livestock Husbandry Systems". This report, named after the chairman F. W. Rogers Brambell ("Brambell Report"), deals with the protection of livestock animals in intensive production systems and demands several minimum standards for husbandry considering the animals' biology and behavioural needs (Brambell, 1965; Sambraus, 1997). The Brambell Report inspired partly the evolution of a new animal protection law in Germany in 1972 (Sambraus, 1997) which then again engendered a meeting of the International Society for Livestock Husbandry in 1981, and gave rise to several frameworks like the "Five Freedoms" by the Farm Animal Welfare Council in 1992 (FAWC; renamed to Animal Welfare Committee in 2019) (FAWC, 2009), the "five domains" by Mellor and Reid in 1994 or the three conceptions of animal welfare by Fraser in 2008 – all trying to define, assess and outline rules for the protection of (farm) animal welfare. The Five Freedoms were then considered and elaborated by the Welfare Quality® project which developed the Welfare Quality® protocols to assess animal welfare objectively, validly, reliably and feasibly (Welfare Quality®, 2009). Since 1972, the first paragraph of the German animal protection law or German Animal Welfare Act (German: Tierschutzgesetz; TierSchG) states that "the aim of this Act is to protect the lives and well-being of animals, based on the responsibility of human beings for their fellow creatures. No one may cause an animal pain, suffering or harm without good reason." (TierSchG). The German Animal Welfare Act is complemented by the "Animal Welfare Livestock Husbandry Ordinance" (German: Tierschutz-Nutztierhaltungsverordnung; TierSchNutztV) since 2001 which regulates husbandry and management standards for animals held for commercial purposes, i.e. calves, laying hens, broiler chicken, pigs and rabbits. In fact, for pigs all production stages are outlined briefly in contrast to the other named livestock species, where only certain production stages are defined, or to other livestock animals that are not named at all, like dairy cows, fattening bulls, sheep, goats or other poultry than chicken, e.g. geese or turkeys. In 2019, the "Competence Network for Livestock Husbandry" (German: Kompetenznetzwerk Nutztierhaltung) was established to support and advise the Federal Ministry of Food and Agriculture (German: Bundesministerium für Ernährung und Landwirtschaft) on its way to restructure German livestock husbandry towards more animal welfare and environmental protection (Federal Office for Agriculture and Food, 2020). This network, commonly known as "Borchert commission", named after its chair J. Borchert, aims to implement voluntary and federal animal welfare labels, achieving an overall improved animal welfare by 2040. In brief, the minimum standards for pig husbandry in Germany are defined by law, but still many decisions and options around pig keeping, like breeding or management practices, are left to the farmer. This does not only challenge German pig farmers but mostly the pig's welfare which depends on the decisions taken by its keeper. The current challenges for pigs under intensive husbandry are synoptically described in the following.

Breeding in pig livestock

Even before they are born, challenging decisions have been made which shape the pigs' future development. The first decision of the farmer is choosing the dam and sire breeds and by this, even choosing the dams and sires of those, deciding whether the offspring will be pure bred or hybrids of several breeds. The latter is the usual choice for conventional pig production in Europe (Martino et al., 2014; Weißmann, 2014). In the conventional pork production, sows are usually Landrace and Large White hybrids, paired with a terminal sire line to produce hybrid offspring with higher weight gain and a better feed conversion rate, improved lean meat content and an enhanced proportion of valuable cuts (Wähner, 2012; Weißmann, 2014). However, Martino et al. (2014) described hybrids to have a low capacity to cope with different environmental conditions, a lower immune-competence and a higher vulnerability to stress. So-called traditional and/or local pig breeds lost their competitiveness around the 1950s when the demand for lean meat protein rose and fat pigs were associated with poor growth and feed conversion rates. Consequently, traditional pig breeds, like the Swabian-Hall swine or Bentheim Black Pied pig, became rare or even endangered breeds (Biermann et al., 2014; Weißmann, 2014; Petig et al., 2019; Federal Office for Agriculture and Food, 2021). Modern hybrids are based on only few lines of genotypes (Weißmann, 2014). The choice of the breeds does not only affect performance matters (Čandek-Potokar et al., 2019) but also behaviour. Studies reported that different breeds, purebred or crossbred, showed different behaviour patterns. Already in 1996, Bergeron et al. investigated behavioural differences of Yorkshire and Meishan pigs and reported that Yorkshire pigs manipulated chains and drinker significantly more often than the Chinese breed. Breuer et al. (2003) studied Large White, Landrace and Duroc pigs and found significant differences between the breeds in the expression of harmful social behaviour like ear biting and belly nosing. Chu et al. (2017) reported that Chinese Mi pigs showed a significantly milder reaction to the stress of being restrained in a backtest compared to crossbred Landrace x Large White pigs. In 2013, Brunberg et al. concluded that the selection on production traits by breeding companies resulted in pig-directed abnormal behaviour like tail-biting. However, the choice of which pig breeds the farmer uses is not regulated in the EU in contrast to the housing systems these pigs are kept in.

Housing during suckling period

The first housing system a newly born piglet gets to know is the system it is born in. In the EU, the vast majority of lactating sows and their litters are currently housed in single-housing farrowing crates for the whole lactation period (Marchant-Forde, 2009; Ko et al., 2022). While the crate inhibits the sow in her natural nest-building behaviour and overall in her ability to move, the main reasons given by piglet producers to maintain the confinement are the reduced piglet mortality, ease of sow and litter management and lowered labour costs (EFSA, 2007a; Marchant-Forde, 2009). Still, initiatives like "End the Cage Age" (www.endthecageage.eu) with over 1.6 million signatures showed that the public opinion is against (farrowing) crates. Some countries like Sweden, Switzerland and Norway already banned the confined housing of lactating sows (Vandresen and Hötzel, 2021). In July 2020, the German Federal Council (German: Bundesrat) passed the amendment of the TierSchNutztV and at the beginning of 2021, the new regulation for the housing of lactating sows entered into force in Germany which prohibits the routine confinement of sows in the farrowing unit for more than 5 consecutive days with a transitional period of 15 years for already existing farrowing accommodations (TierSchNutztV). Alternatives to the single-housing of sows in crates for the whole lactation period are single-housing with temporary crating (Lambertz et al., 2015; Lohmeier et al., 2020; Ko et al., 2022), single-housing free-farrowing pens (Oostindjer et al., 2011; Lohmeier et al., 2019; Nicolaisen et al., 2019b), group housing of lactating sows (Kutzer et al., 2009; Bohnenkamp et al., 2013; Grimberg-Henrici et al., 2018), outdoor farrowing systems (Johnson and Marchant-Forde, 2009) and hybrid forms. The farrowing system does not only affect the sow but also has an impact on the piglets. On one hand, piglets are affected indirectly by having a sow that can (or cannot) express its maternal behaviour depending on the extent of confinement. Sows in loose-housing systems, like free-farrowing pens, group housing or (semi-natural) outdoor farrowing systems, are able to interact with their piglets and showed nose-to-nose contacts, presumably shaping the piglets' social behaviours (Gundlach, 1968; Andersen et al., 2005; Singh et al., 2017). Oostindjer et al. (2011) reported that piglets from loose-housed sows showed higher levels of exploration and play behaviour after weaning into a new enriched environment. They further state that having a loose-housed sow during suckling period seems to build up the piglets' resilience to weaning stress. On the other hand, piglets are directly affected by the farrowing system in terms of socialisation. Several studies showed that early contacts between non-littermate piglets had a positive impact on the social behaviour and performance, especially after weaning. In farrowing systems where two or more litters could directly interact with each other, the early socialisation improved later on the formation of the hierarchy in the group and decreased the intensity of aggressions and consequently the incidence of skin lesions after moving to the rearing pens (D'Eath, 2005; Hessel et al., 2006; Kutzer et al., 2009; Bohnenkamp et al., 2013). A great concern against group housing of sows and litters is cross-suckling and thus impaired weight gain of the piglets (EFSA, 2007a), but studies by Hessel et al. (2006), Kutzer et al. (2009), Morgan et al. (2014) and Nicolaisen et al. (2019) could not confirm this negative impact of group housing on the weight gain. Higher piglet losses due to crushing were reported in loose farrowing environments like free-farrowing pens, group housing (Nicolaisen et al., 2019a; Lohmeier et al., 2020) and even in free-farrowing pens with short-time fixation (Lohmeier et al., 2020) compared to farrowing crates, but authors affirm the importance of the pen design and the duration of a temporary fixation as a measure to reduce piglet mortality but also increase the freedom of movement for the sow.

Management procedures on postnatal piglets

A couple of days after birth, piglets in commercial production face the next challenges by undergoing certain management procedures (Marchant-Forde et al., 2009). During the first days of life, piglets are usually ear-tagged, their teeth might get clipped and male piglets might be castrated surgically. While the castration of piglets without anaesthesia is prohibited by law in Germany since the 1st of January 2021, ear-tagging and tooth clipping happens without anaesthesia and/or analgesia (TierSchG). In brief, male piglets are castrated for easier management, an improved carcass composition, to avoid the possible incidence of boar taint and a lower expression of aggressive and mounting behaviours (Jungbluth et al., 2017; von Borell et al., 2020; Lange et al., 2021). Although routine tail docking is prohibited in the EU (Council Directive 2008/120/EC), most of the conventionally housed piglets in Germany are being tail-docked within the first three days of life (European Commission, 2018) as it is seen as one of the most effective measures to reduce tail-biting in pigs (Hunter et al., 2001; Schrøder-Petersen and Simonsen, 2001; EFSA, 2007b). However, tail-docking also happens without anaesthesia and/or analgesia (TierSchG) and studies reported at least temporary stress reactions of the piglets to tail-docking (Marchant-Forde et al., 2009; Sutherland and Tucker, 2011) and even painful traumatic neuromas in the tail stumps of docked fattening pigs (Simonsen et al., 1991). Additionally, tail-docking alone does not prevent tail-biting completely. There is evidence that an improvement of management and housing can be an effective way to house undocked pigs without tail-biting and/or entire males without a higher risk for welfare impairment (Gentz et al., 2020; Lange et al., 2021). Also, studies reported that all named routine processing procedures affected the piglet welfare negatively and although piglets seem to overcome this stress, it remains ethically questionable (Marchant-Forde et al., 2009, 2014; von Borell et al., 2020).

Weaning and stress

Under (semi-)natural conditions, weaning happens gradually in a time span of around 17 weeks post-partum (Jensen, 1986) with a decreasing milk intake and growing independence of the piglets. In conventional pig husbandry it was undertaken already after eight weeks in the 1950s (Pluske et al., 2003) and is now usually carried out after three to four weeks after farrowing when piglets weigh at least 5 kg (Council Directive 2008/120/EC; TierSchNutztV). In just one day, weaning involves the separation from the dam, relocation to an unknown environment, a change in feed and the regrouping with unfamiliar piglets. Piglets, that were formerly nursed by a confined sow, showed a stable nursing frequency and little intake of solid food until the end of suckling period, are now forced to find (solid) food and water on their own (Weary et al., 2008). This change from digesting sow's fat milk to complex carbohydrates consequently alters the digestive tract of the piglet and can possibly lead to diarrhoea and a post-weaning growth lag (Williams, 2003). It is well studied that regrouping of unfamiliar (weaning) pigs leads to rank fights in order to form a social hierarchy in the group and that these fights lead to severe injuries, like skin lesions and lameness (Friend et al., 1983; D'Eath, 2005; Kutzer et al., 2009; Stukenborg et al., 2011; Bohnenkamp et al., 2013; Peden et al., 2018). Usually fights of pigs are defined as a series of several typical agonistic behaviours: biting, head-knocks and/or parallel/antiparallel pushing (e.g. D'Eath, 2005; Kutzer et al., 2009; Stukenborg et al., 2011; Bohnenkamp et al., 2013; Lange et al., 2021; Laves et al., 2021). Literature reports different findings about the duration of these fights in order to achieve a social hierarchy after mixing. Bohnenkamp et al. (2013) analysed the first 40 hours after weaning and found this time frame adequate. Friend et al. (1983) inspected the first 48 hours after regrouping, but stated that most of the fighting already ceased after three hours. Meese and Ewbank (1973) also studied the first 48 hours after regrouping, noted a peak in aggression at 4.5 hours and reported that fights were eliminated after 24 hours. On the other hand, Stukenborg et al. (2011) found their own observation period of 48 hours after regrouping too short as fights had not ceased and advised an observation period of up to four continuous days. However, there is agreement that the weaning process is the most stressful event in a pig's life (Weary et al., 2008; Campbell et al., 2013). Moberg (2000) and Palme (2012) defined stress as the physical response to a threat to the individual's homeostasis. A so-called stressor induces the release of the corticotropin-releasing hormone (CRH) from the hypothalamus, which itself stimulates the secretion of the adrenocorticotropic hormone (ACTH) from the pituitary gland. Then, ACTH provokes the release of glucocorticosteroids, like of the stress hormone cortisol (amongst others), from the adrenal cortex (Moberg, 2000). Cortisol acts as a transcription factor in the gluconeogenesis and therefore, induces the synthesis of glucose which itself is needed for a fight-or-flight-reaction. Prolonged stress can suppress the immune response, inhibit growing of growing animals and/or impair reproduction (Moberg, 2000). One way to measure stress in terms of cortisol levels is through blood sampling which usually requires the restraint of the animal and is therefore classified as invasive (Moberg, 2000; Palme, 2012; Cornale et al., 2015). Alternative methods to measure the stress response of an animal (or human) are through other samplings like of saliva, milk, urine, faeces or hair but also through the evaluation of the heart rate or in some animals by the assessment of tear staining (Palme, 2012; Parois et al., 2022). The interpretation of the measurement data must be done with caution because e.g. cortisol levels can differ individually as they can be influenced by specific characteristics like species, age, sex and/or health status (Palme, 2012). There is evidence that they can also be influenced by the housing system with regard to (weaning) piglets (Cornale et al., 2015; Parois et al., 2022).

Housing during rearing period

Pig husbandry, often referred to as pig or pork production, is highly intensified. To reduce costs of production, feed and management and therefore yield a cheap(er) product, and due to hygienic matters, pigs are commonly accommodated in separate buildings or farming sites for the suckling period, rearing period and as well for the fattening period (EFSA, 2007b; Jungbluth et al., 2017). After weaning, piglets are usually relocated from the farrowing environment and often regrouped with several litters to achieve pens filled with equally weighing piglets (EFSA, 2007b; Jungbluth et al., 2017). This so-called two-phased rearing predominates in Germany (Jungbluth et al., 2017). Single-phased rearing, where the piglets remain in their farrowing environment for the rearing period and only the sow is relocated after the suckling period, plays a minor part in German pig husbandry. Although this system reduces regrouping and the relocation of the piglets and therefore weaning stress at least for the weaning pigs, the higher investments due to the need of more farrowing pens are seen disadvantageous (Jungbluth et al., 2017). The majority of rearing pigs in Germany are housed under conventional conditions, indoors on fully slatted floors (EFSA, 2007b; Rohlmann et al., 2020; Statistisches Bundesamt, 2021). These prevalent housing conditions, i.e. the space allowance, slat width and tread area, number of drinkers and the feeder space ratio, air quality and illumination are under the impact of legal regulations giving minimum standards (TierSchNutztV), but are often described as barren where the pigs cannot carry out natural behaviours like rooting (Breuer et al., 2003; EFSA, 2007b; a; Weary et al., 2008; Sonoda et al., 2013; Prunier et al., 2020).

Tail-biting

These barren conditions (amongst others) are held responsible for harmful social behaviours like tail-biting, ear-biting or other injurious manipulation of pen mates (Hunter et al., 2001; Van De Weerd et al., 2005; Sonoda et al., 2013). Especially tail-biting is described as "one of the largest animal welfare problems" (Sonoda et al., 2013) which might lead to infections, health impairment of the piglets and economic loss for the farmer (Van De Weerd et al., 2005). Tail-biting is generally considered as an abnormal behaviour and described as the dental manipulation of one pig's tail by another pig (Schrøder-Petersen and Simonsen, 2001). Schrøder-Petersen and Simonsen (2001) further devide tail-biting into two stages: one stage before any lesions can be detected on the tail (pre-injury stage) and the following stage, where lesions and blood on the tails are present (injury stage). Taylor et al. (2010) picked this definition up and elaborated three types of tail-biting behaviours: (1) the two-stage biting, (2) sudden-forceful biting and (3) obsessive tail-biting which do not necessarily exclude each other but mean to have partly different motivational backgrounds. Injurious tail-biting incidences are usually first detected during the rearing period, typically starting in the first two weeks after weaning and increase with age (Schrøder-Petersen and Simonsen, 2001; Schrøder-Petersen et al., 2003; Abriel and Jais, 2013; Naya et al., 2018; Gentz et al., 2020). Besides by the housing system and, as mentioned above, by the genetic background, tail-biting is triggered by multifactorial causes, namely by internal and external factors (Schrøder-Petersen and Simonsen, 2001). Internal risk factors are characteristics of the pigs, like the sex (Zonderland et al., 2010, 2011; Brunberg et al., 2011) and breed (Breuer et al., 2005; Ursinus et al., 2014), but also early experiences like early socialisation (Gentz et al., 2020) or the health status (D'Eath et al., 2014; Valros et al., 2016). External risk factors for tail-biting are ascribed to the pig's environment, like the housing systems (including the manure management), (re)grouping, group size and space allowance (Moinard et al., 2003; EFSA, 2007b; Gentz et al., 2020), feed, feeding systems and feeder space ratio (Schrøder-Petersen and Simonsen, 2001; Moinard et al., 2003; D'Eath et al., 2014), climate in terms of room temperature, ventilation rate, air quality, season and light (Hunter et al., 2001; Schrøder-Petersen and Simonsen, 2001; Valros et al., 2016), and the management of manipulable material (Hunter et al., 2001; Moinard et al., 2003; Van De Weerd et al., 2005; EFSA, 2007a, 2014; Valros et al., 2016). The provision of organic manipulable material like straw, hay, saw dust or a mixture of those is legally required in Germany (TierSchNutztV). Hunter et al. (2001), Schrøder-Petersen and Simonsen (2001) and D'Eath et al. (2014) concluded that straw (in racks) are compatible with most slatted floor types and effective in reducing or even eliminating tail-biting in pigs.

Housing during fattening period

The Council Directive for the protection of pigs (Council Directive 2008/120/EC) and the TierSchNutztV demand a specific floor space allowance based on the live weights of the housed animals. According to the Council Directive, pigs above 30 kg require 0.4 m^2, based on German regulations pigs above 30 kg need 0.5 m^2 of floor area per pig. As mentioned above, the majority of pigs in Germany is housed conventionally on fully slatted floors (Rohlmann et al., 2020). During fattening period, pigs are usually housed on concrete flooring which is also regulated by the TierSchNutztV (slat width: 18 mm, tread area: 80 mm). In order to obey the given regulations, it is common to relocate pigs at around 25 to 30 kg to specialised fattening units (Jungbluth et al., 2017). The housing of pigs in one pen consecutively from weaning to the end of the fattening period, the so-called wean-to-finish system, is rather impracticable in Germany due to the weight and floor specific regulations but it is common practice in The United States of America (Wolter et al., 2001, 2002; Gentz et al., 2020). Studies reported that wean-to-finish housing is particularly practised to reduce transport and regrouping, therefore cut labour and building costs (Wolter et al., 2001, 2002; DeDecker et al., 2005). However, it became a habit to double-stock pens at weaning to avoid underutilisation of the space allowance and then subsequently relocate some of the pigs which only postpones the regrouping (Wolter et al., 2002; Davis et al., 2006). Turner et al. (2006) reflected from their findings that the regrouping of heavy pigs led to a greater level of injury due to the greater strength and larger teeth of the opponents. The last challenge a commercial fattening pig experiences is the transport to and the handling at the abattoir which are the last stressful events in terms of elevated cortisol levels (Parrott and Misson, 1989; Bradshaw et al., 1996; Averos et al., 2007).

Objectives of the present dissertation

Although studies about confined, loose- and/or group housing of sows exist (Lambertz et al., 2015; Singh et al., 2017; Grimberg-Henrici et al., 2019; Lohmeier et al., 2020; Ko et al., 2022), only few examined the effects of these pre-weaning housing systems on growing (Hessel et al., 2006; Kutzer et al., 2009; Bohnenkamp et al., 2013) and even less on finishing pigs (Gentz et al., 2019, 2020). To the authors knowledge, there is no study that compared the effects of all three systems at once on one farming site, especially in combination with different alternative post-weaning (rearing) housing systems. Therefore, in a first study (Research Article One), this dissertation investigated the short-term effects of three different housing systems during suckling period (farrowing crate, free-farrowing and group housing of lactating sows) on post-weaning stress of piglets that were weaned into either conventional rearing pens or into wean-to-finish pens with a greater space allowance at weaning. In a second study (Research Article Two), the present dissertation studied the long-term effects of the named farrowing systems on growing and finishing pigs that were either weaned into conventional rearing pens or remained in their farrowing pens for the rearing period and then relocated and regrouped into conventional fattening pens. As rearing in the farrowing unit has not been investigated previously, the effects had to be tested, especially with regard to the housing of undocked pigs. After studying the impact of different housing systems during suckling, rearing and fattening period, the third study (Research Article Three) investigated the potential of certain sire breeds. So far there has been a lack of knowledge on the crossbreeding of different local, traditional sire breeds with "modern" hybrid sows on the behaviour and performance of conventionally housed undocked rearing pigs, therefore, the offspring of Swabian-Hall or Bentheim Black Pied boars and hybrid sows (Landrace x Large White) were monitored over the rearing period.

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Research Article One:

Effects of Different Farrowing and Rearing Systems on Post-Weaning Stress in Piglets

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Abstract

This study aimed to investigate how farrowing and rearing systems affect skin lesions, serum cortisol, and aggressive behaviour as indicators for weaning stress of piglets. Between May 2016 and March 2018, in total 3144 weaning piglets from three different farrowing systems were examined: farrowing crates (FC), single-housing free-farrowing pens (FF), and group housing of lactating sows and litters (GH). After weaning and regrouping, piglets were relocated to conventional rearing pens (conv; 5.7 m^2) or to wean-to-finish pens (w-f; 12.4 m^2). Skin lesions were scored 24 h. Blood samples were taken one week before and 24 h after weaning to analyse the individual difference in serum cortisol. Behaviour was observed for 24 h after relocation. Animals raised in FC and FF had significantly more skin lesions than that of GH animals. Piglets born in GH showed lower cortisol differences and fought less and for shorter periods compared to FC and FF piglets. Piglets weaned to w-f pens showed greater cortisol changes and fought significantly longer than piglets in conv pens. Group housing during the suckling period reduced weaning stress for piglets in terms of skin lesions, serum cortisol, and aggressive behaviour. Greater space allowance (w-f vs. conv) was not beneficial with regard to the investigated parameters.

Keywords: lactation housing; skin lesions; serum cortisol; early socialisation; regrouping; agonistic interactions

1. Introduction

In many European countries, lactating sows are commonly kept in farrowing crates, altering the sow's welfare by inhibiting movement and natural nest building behaviour but preventing the crushing of piglets (EFSA, 2007). Since it became mandatory in 2013 to house gestating sows in groups (Council Directive 2008/120/EC), many studies investigated group housing of gestating sows (Brouns and Edwards, 1994; Marchant et al., 1997), and group housing of lactating sows (Hessel et al., 2006; Bohnenkamp et al., 2013), focusing on the welfare of the sow, and some reviewing the effects of these housing systems on the weaning piglets (Wattanakul et al., 1997; Hessel et al., 2006; Kutzer et al., 2009; Melotti et al., 2011; Bohnenkamp et al., 2013). Although studies on aggression in (weaning) pigs date back to the 1970s, mixing aggression is still a persistent problem in pig husbandry (Ewbank and Bryant, 1972; Peden et al., 2018). In modern pig husbandry, weaning still poses a critical welfare-altering factor for the piglets. While (semi-)natural weaning is a gradual process that takes up to 17 weeks (Jensen, 1986), weaning under conventional conditions is carried out earlier and abruptly. Usually, piglets are weaned at 21 to 28 days of age (Council Directive 2008/120/EC). They are separated from the sow, moved to a new environment with a change in feed, and regrouped with unknown conspecifics on the same day. The handling of the animal induces a stress reaction of the piglet by activating the hypothalamus–pituitary–adrenal axis, which leads to an increased synthesis and release of gluco-corticosteroids such as the stress hormone cortisol (Moberg, 2000; Cornale et al., 2015). Since weaning involves multiple stressors (Weary et al., 2008), the weaning process should be improved to better meet the biological needs of the piglets. Already by 1983, Friend et al. showed that mixing of litters did not affect the performance at rearing but greatly increased the incidence of fights in the first two days after weaning. The more a group was intermixed with unacquainted pigs, the more fights took place. Fights that occurred during establishment of a hierarchy resulted in a high skin-lesion score, especially in pigs that were regrouped during a fattening period (Stukenborg et al., 2011). Early socialisation of piglets with other litters prior to weaning was found to have long-term benefits for the later social behaviour (D'Eath, 2005; Hessel et al., 2006; Bohnenkamp et al., 2013; Peden et al., 2018). When these pigs were mixed, a new hierarchy was formed more quickly compared to unsocialized pigs. Besides these social and physical components, there are also non-social aspects that affect how piglets respond to weaning. For example, Ewbank and Bryant (1972) found that a greater space allowance at regrouping lowered the incidence of agonistic behaviour. Enrichment before weaning, as well as loose-housing of sows were found to affect how piglets reacted to their environment after weaning (Oostindjer et al., 2011).

The aim of this study was to investigate to what extent different farrowing and rearing systems affect weaning stress for piglets in regard to skin lesions, serum cortisol, and behaviour.

2. Materials and Methods

2.1. Animals and Housing

The study was conducted on the research farm Futterkamp of the Chamber of Agriculture of Schleswig-Holstein in Germany. In nine batches between May 2016 and March 2018, in total 3144 crossbred ([Landrace × Large White] × Piétrain) weaning pigs (26.45 ± 0.97 days of age) were included in a 3 × 2 × 2 factorial design study from three different farrowing systems: (1) conventional single-housing in farrowing crates (FC; n = 869), (2) single-housing in free-farrowing pens (FF; n = 1087), and (3) group housing of lactating sows (GH; n = 1188) (Figure 1).

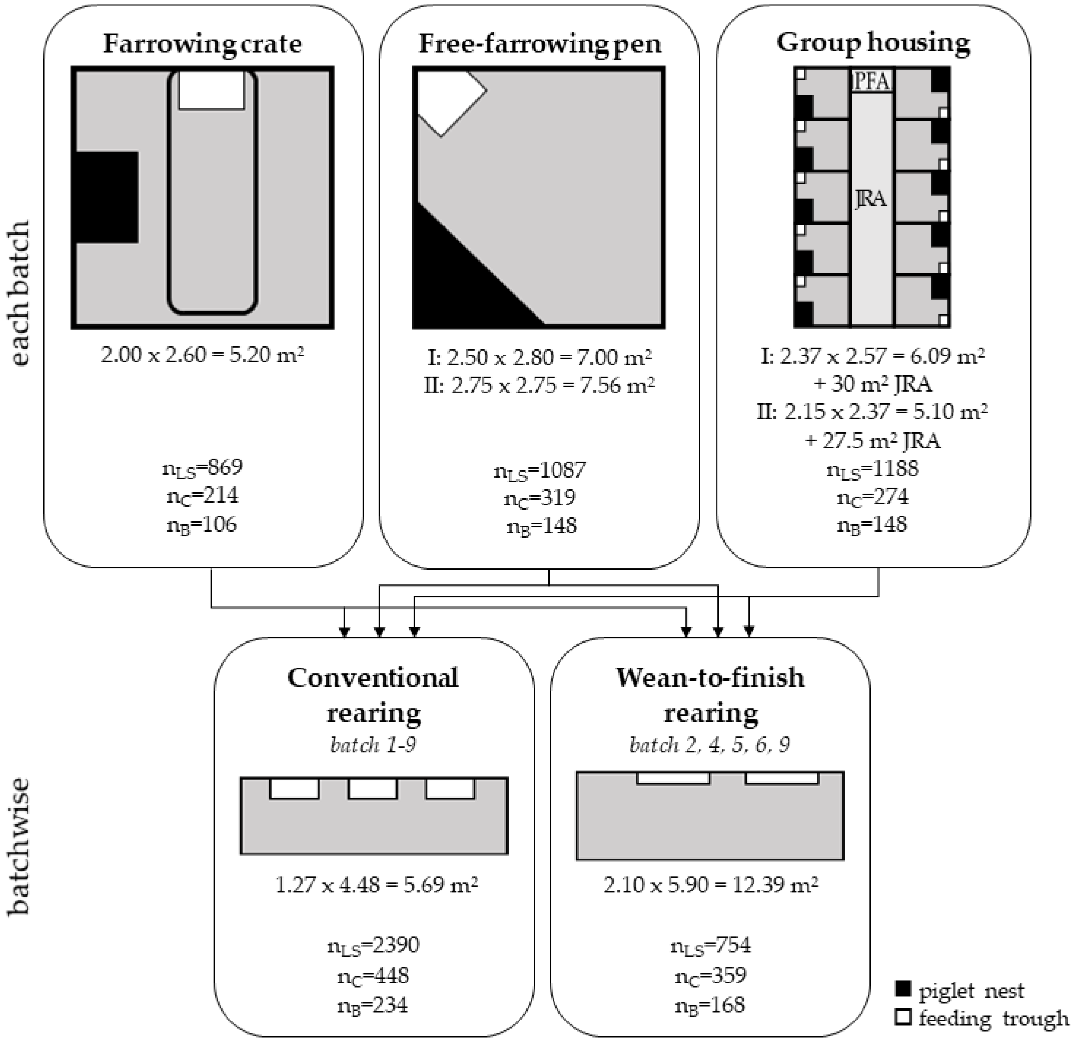

Figure 1. Schematic overview of the experimental design (nSL = number of animals scored for skin lesions; nC = number of animals sampled for serum cortisol; nB = number of animals observed for behaviour; I/II: different types of pen size; PFA = piglet feeding area; JRA = joint running area).

Sows were moved simultaneously to the farrowing system four days before the expected farrowing date. Sows in FC were confined permanently during farrowing and lactation. In two types of FF that differed in pen size (type I = 7.00 m^2, type II = 7.56 m^2), sows were housed individually but not confined permanently for the first eight batches, and confined for three days postpartum in the ninth batch to minimize the crushing of piglets. The FF pens were equipped with an open farrowing crate, so sows could be fixed temporarily. Therefore, FF sows could move freely and interact with their piglets for the whole (batch 1–8) or most (batch 9) of the lactation period of 27 days. In each of the two compartments of GH that differed in size, 10 sows were stalled in single-housing free-farrowing pens until day 5 postpartum, then, single-pens were opened and sows and their litters were able to interact freely in a joint running area (JRA) until weaning (compartment I = 6.09 m² pen + 30 m² JRA; compartment II = 5.10 m² pen + 27.5 m² JRA; for further details on lactation pens, see Grimberg-Henrici et al., 2018). In all three farrowing systems, weaning took place on day 27, and piglets were regrouped and relocated farrowing-system-wise to one of two different rearing systems: (1) conventional rearing (conv; n = 2390) or (2) wean-to-finish rearing (w-f; n = 754). In conventional rearing, 13 piglets per equally balanced mixed-sex group were housed on fully slatted plastic floors with a space allowance of 0.44 m² per pig. In w-f rearing, groups of 14 piglets were housed on fully slatted concrete floors. Since animals in the w-f group were not regrouped for finishing, groups were sorted by sex at weaning to house single-sex groups, and the space allowance was adjusted for the finishing period to give 0.89 m² per pig. Also, the floor was especially customized for the study to suit the rearing of growing and finishing pigs on one floor type (conv: slat width = 10 mm, tread area = 10 mm; w-f: slat width = 13 mm, tread area = 67 mm; ethical approval code number V242-226720/2015). In both rearing systems, the same commercial diet was fed ad libitum, and nipple drinkers and manipulable material like pieces of wood and ropes were provided. Half of the animals' tails were docked using a hot cautery iron on the first day after birth while the other half's tails were left intact (further details: Gentz et al., 2019, 2020). Tail-docked and undocked piglets were not grouped together, and so tail-docking was seen as the third factor in the study design. A climate computer regulated ventilation and heating in both rearing systems, starting with 28 °C on the first days after weaning. Teeth grinding on the first day after birth as well as the raising of intact males was part of the farm management practice. The animals received a vaccination against porcine circovirus and deworming 9 days prior to weaning.

2.2. Scoring of Skin Lesions

All weaning pigs (n = 3144) were assessed for skin lesions on the day after weaning, following the Welfare Quality® assessment protocol applied to growing and finishing pigs (Welfare Quality®, 2009). The assessment was carried out by three assessors who trained together, and for each assessment, at least two of the three persons were present; one being the assessor, the other one an active observer, always ready to justify the given score. The assessor scored the animal's right side from a distance of approximately 0.5 m, dividing the pig's body into five parts (ears, front, middle, hind, and legs) and scoring each part separately. A scratch longer than 2 cm or two parallel scratches within a distance of only 0.5 cm or a small wound with a diameter of maximum 2 cm was considered one lesion. A bleeding wound between 2 and 5 cm or a healed wound greater than 5 cm was considered as 5 lesions and a deep open wound greater than 5 cm was considered as 16 lesions. Lesions were then scored from 0 to 2: according to the number of lesions, the body part was scored 0 for no or up to 4 lesions (minor lesions), 1 for 5 to 10 lesions (moderate lesions), and 2 when more than 10 lesions were visible (severe lesions).

2.3. Blood Sampling and Serum Cortisol Analysis

In 7 batches (batch 3–9), blood samples of 807 animals were collected on average 6.5 ± 1.1 days before weaning (pre; 19.88 ± 1.83 days of age) and one day after weaning (post; 27.39 ± 1.12 days of age) to assess physiological stress via the stress hormone cortisol (ethical approval code number V244-26304/2016). All samples were collected in the morning. Pre- and post-weaning samples had a time-of-day difference of 41 min on average. Pre-collection took place in the farrowing unit. For each batch, the selection of piglets aimed to achieve an equal balance of dams, sexes, and tail-docked and not docked piglets. The sampled piglets weighed 8.03 ± 1.44 kg. On average, 5.8 ± 3.9 piglets per rearing pen were post sampled (FC = 5.4 ± 4.4, FF= 6.3 ± 3.8, GH = 5.5 ± 3.7). For blood sample collection, the piglets were caught and sampled one after the other as quickly and quietly as possible by two persons (one veterinarian). One person restrained the piglet by holding it in a supine position with its neck straightened out. The other person took the blood sample from the vena cava approximately 3 cm cranial to the sternum with 18 G needles (1.2 × 40 mm) plugged onto Serum-Monovettes® (S-Monovettes®, Sarstedt AG & Co. KG, Nümbrecht, Germany) that contained a clotting activator. If blood sampling was not successful within two minutes, the piglet was released and not used for further blood sampling. The blood samples were stored in a dark and cool (7 °C) location until centrifugation, which took place on the sampling day. After centrifugation at 1500×g for 10 min, the serum was aliquoted and stored at −20 °C. For the determination of serum cortisol, an enzyme immunoassay kit (Cortisol ELISA, IBL International, Hamburg, Germany) was used by the same laboratory technician for all samples. Since cortisol follows a circadian rhythm (Evans et al., 1988) and differs individually between the animals, the relative difference between pre- and post-weaning serum cortisol was calculated for each piglet and used for further analysis:

$$\text{Relative cortisol difference} = ((\text{post}-\text{pre})/\text{pre}) \times 100\% \quad (1)$$

When the value of the relative difference equals 100 %, it doubles in value. A rise in cortisol between the two samplings was interpreted as a rise in stress.

2.4. Behavioural Observations

Immediately after weaning, when the piglets were relocated to the rearing unit, animals were marked individually on their backs. To enable an association of the behavioural observations with the other parameters taken 24 h after weaning, animals were filmed continuously for 24 h. Cameras (AXIS M3024-LVE, Axis Communications AB, Lund, Sweden) were placed above the pen, guaranteeing a full top view of the pen. Four observers were trained and passed an inter-rater reliability check in the definition and identification of fights and their duration, which were defined as physical contact of two animals lasting longer than five seconds featuring aggressive behavioural elements such as parallel/inverse parallel standing and/or pushing, biting, and head-knocks. If physical contact resulted in a fight, the duration was measured from first contact until the end of a fight, which was marked by an interruption of longer than three seconds. For each of the 402 observed animals in 30 pens (batches 4 and 5), fights and their duration were sampled continuously for the first 15 min of each hour using the Observer XT 14 (Noldus Information Technology BV, Wageningen, the Netherlands). The agonistic behaviour could be assessed individually during light hours (6 a.m. until 6 p.m.). During the night, markings were indistinguishable due to insufficient lighting. Therefore, each animal’s individual number of fights could only be counted for light hours, the duration of each occurring fight was measured, regardless of individual markings. In general, out of the 402 observed animals 233 individuals were involved in fights and for 355 fights, fighting duration could be detected.

2.5. Weaning Weight

The animals were weighed individually on weaning day prior to relocation and regrouping. For analysis, weaning weights were divided into three classes: light (≤7 kg), medium (>7 to ≤8.5 kg) and heavy (>8.5 kg).

2.6. Statistical Analysis

Skin lesions were primarily found on the ears, front, and middle part and to a negligible amount on hind-quarters and legs (score 1 = 31.92 %, 36.43 %, 29.18 %, 11.97 %, 3.99 %, respectively; score 2 = 16.46 %, 29.65 %, 4.24 %, 0 %, 0.75 %, respectively; frequencies calculated with the FREQ procedure in SAS® (SAS Institute Inc., Cary, NC, USA)). Only lesions for the first three body parts were included in the analysis, as it is a common method to examine skin lesions after fights for rank (D'Eath, 2005; Stukenborg et al., 2012). To analyse the frequency of the skin lesion scores, a general linear model assuming a multinomial distribution was applied using the statistical language R (R core team, 2016). Fixed effects were tested with vector generalized linear models within the VGAM package in R (Yee, 2015) and determined as batch (1–9), rearing system (conv, w-f), farrowing system (FC, FF, GH), weaning weight class (light, medium, heavy), and tail-docking (yes/no). An additional possible fixed effect (sex) and interaction (farrowing system × rearing system) were tested, but not included in further analysis because parameters showed no significant influence on the model ($p > 0.05$) and increased the AICC (Akaike's information criterion corrected, (Hurvich and Tsai, 1989)) and BIC (Bayesian information criterion, (Schwarz, 1978)). Afterwards, the glht (general linear hypothesis testing) function of the multcomp R-package (Hothorn et al., 2008) was used to allow a Tukey post-hoc comparison on all marginal models simultaneously. Fitted values of the glht function are presented in the results section.

The data on cortisol differences were analyzed using the MIXED procedure in SAS® 9.4 (SAS Institute Inc., Cary, NC, USA). The model included the fixed effects batch (3–9), rearing system (conventional, wean-to-finish), farrowing system (FC, FF, GH), weaning weight class (light, medium, heavy), and tail-docking (yes/no). Other effects like sex, sampling time, difference between sampling time pre- and post-weaning, and interactions were excluded if no significant effect could be found and the AICC and BIC were increased. Pen type was added as a random effect.

The behavioural data (number of fights, duration per fight) were normalized using the log transformation (Bohnenkamp et al., 2013; Prunier et al., 2013) and then analyzed with the MIXED procedure in SAS® 9.4 (SAS Institute Inc., Cary, NC, USA) including the fixed effects batch (4–5), rearing system (conventional, wean-to-finish), and farrowing system (FC, FF, GH). For the number of fights, sex was included as a fixed effect in the model. Other possible fixed effects and their interactions (sex, tail-docking, farrowing system × rearing system, weaning weight class,) were tested but not included in further analysis because parameters showed no significant influence on the model ($p > 0.05$) and increased the AICC and BIC.

For all three MIXED models, the significance of differences for multiple comparisons between the least square means was adjusted using the Bonferroni correction. Residuals fulfilled requirements to assume variance homogeneity as well as a normal distribution.

The results of the log-transformed behavioural data were back transformed by the rise of 10 to the power of the estimates.

3. Results

3.1. Skin Lesions

The batch, the farrowing system, and weaning weight class had a highly significant effect on all body parts 24 h after weaning ($p < 0.001$). The rearing system differed only for the body part ears significantly ($p < 0.01$), and the docking status did not affect the frequency of skin lesions at all ($p > 0.05$). On average, more than half of the animals had only minor lesions: 55 % of single-housed animals (FC and FF) vs. 85 % in GH piglets.

Animals raised in the single-housing systems (FC and FF) had a significantly higher incidence of skin lesions than animals raised in GH ($p < 0.05$; Figure 2). For all three body parts, GH piglets differed significantly from FC and FF piglets ($p < 0.05$).

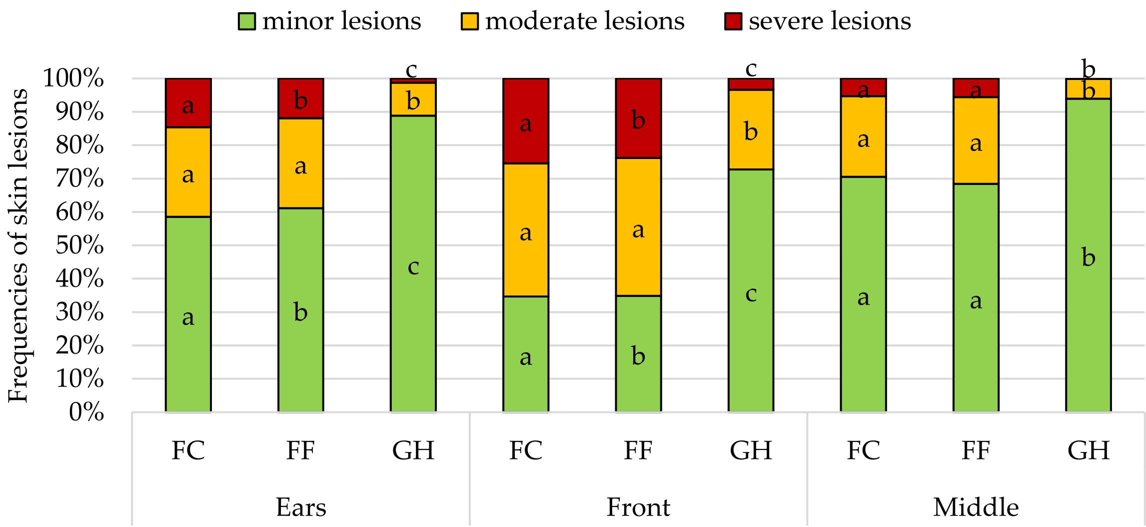

Figure 2. Estimated frequencies (%) of skin lesions per body part and farrowing system on the first day after weaning (FC: farrowing crate; FF: free-farrowing pen; GH: group housing of lactating sows; a-c: different letters indicate significant differences within body part and score level ($p < 0.05$)).

W-f animals showed significantly more severe lesions on the ears than conv piglet, although the difference was small (conv: 7.99 % vs. w-f: 10.74 %; standard error 0.16; $p < 0.05$; Figure 3).

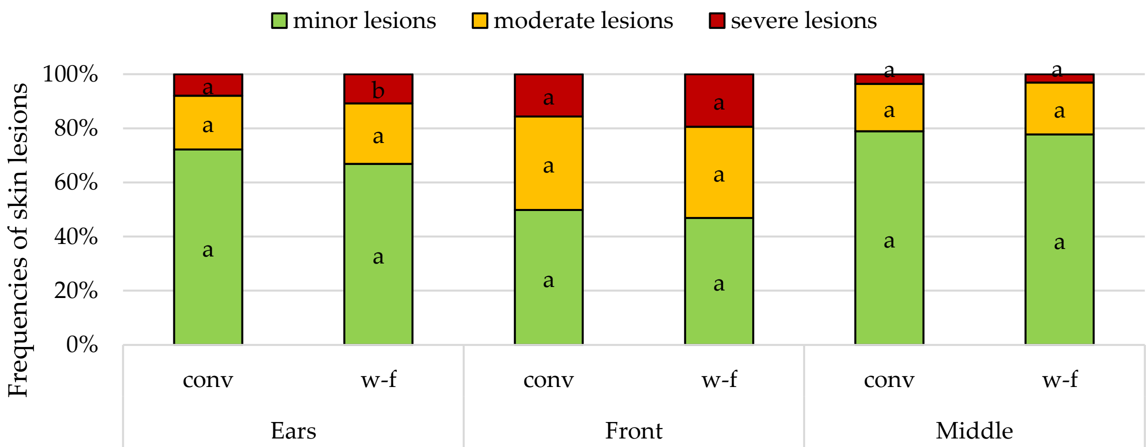

Figure 3. Estimated frequencies (%) of skin lesions per body part and rearing system on the first day after weaning (conv: conventional rearing pen; w-f: wean-to-finish rearing pen; a-b: different letters indicate significant differences within body part and score level ($p < 0.05$)).

On all three body parts, the frequency of the three lesion scores differed significantly for all three weight classes, where heavy animals showed higher lesion scores than medium and light pigs ($p < 0.05$; Table 1).

Table 1. Estimated frequencies of skin lesions in percent and standard errors (se) for the three body parts and weaning weight classes.

	Ears			Front			Middle		
	Weaning Weight Class			Weaning Weight Class			Weaning Weight Class		
	Light	Medium	Heavy	Light	Medium	Heavy	Light	Medium	Heavy
Minor lesions	85.64 [a]	70.25 [b]	52.49 [c]	72.91 [a]	46.95 [b]	26.24 [c]	90.73 [a]	77.91 [b]	64.92 [c]
se	0.15	0.19	0.14	0.12	0.18	0.14	0.17	0.20	0.14
Moderate lesions	11.27 [a]	21.33 [b]	29.01 [b]	21.27 [a]	36.34 [b]	41.99 [b]	8.18 [a]	19.04 [b]	25.41 [b]
se	0.15	0.19	0.14	0.12	0.16	0.12	0.18	0.21	0.15
Severe lesions	3.09 [a]	8.42 [b]	18.51 [c]	5.82 [a]	16.71 [b]	31.77 [c]	1.09 [a]	3.05 [a]	9.67 [b]
se	0.27	0.30	0.18	0.20	0.23	0.15	0.44	0.46	0.24

se: standard error; a–c: Different letters indicate significant differences within body part and score level ($p < 0.05$).

3.2. Serum Cortisol

The individual relative difference in serum cortisol differed significantly within all tested fixed effects ($p < 0.05$). Piglets raised in GH showed a lower cortisol difference than FC piglets, and animals weaned into w-f pens had a higher relative difference than piglets weaned into conv pens (Figure 4).

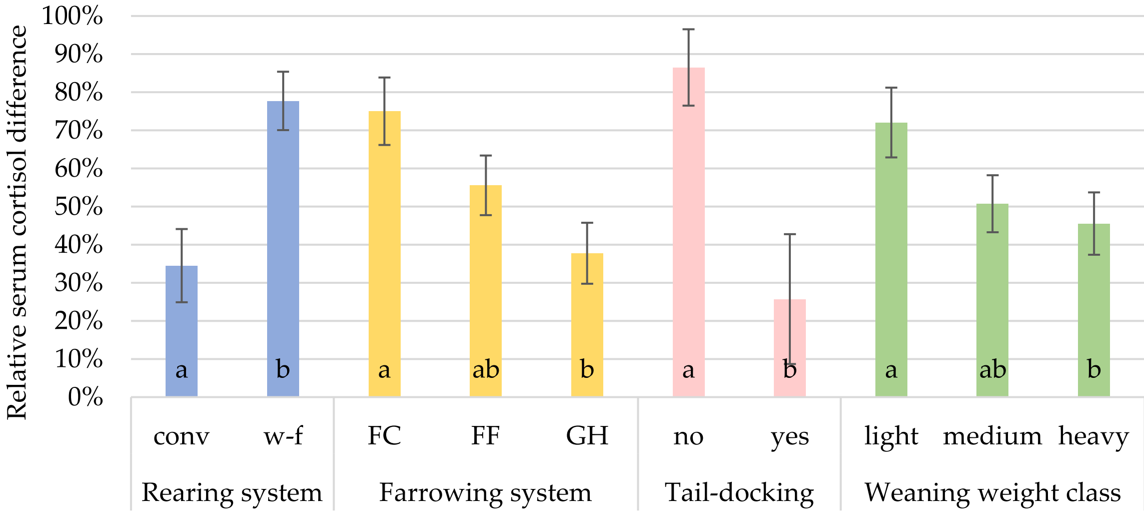

Figure 4. Estimated relative difference of serum cortisol before and after weaning, in percent, for the fixed effects rearing system, farrowing system, tail-docking, and weaning weight class (least square means with standard error bars; conv: conventional rearing pen; w-f: wean-to-finish rearing pen; FC: farrowing crate; FF: free-farrowing pen; GH: group housing of lactating sows; a-b: different letters indicate significant differences within the tested effect ($p < 0.05$)).

The relative cortisol differences also differed significantly between tail-docked and undocked animals ($p < 0.05$): serum cortisol of undocked piglets rose about 86.50 % compared with the pre-value versus 25.72 % for docked piglets. Piglets with low weaning weights showed a higher relative cortisol difference than piglets in the heavy weight class ($p < 0.05$).

3.3. Behavioural Observations

For the number of fights, only farrowing system and sex differed significantly ($p < 0.01$), batch and rearing system had no significant effect. For the duration of fights, all tested effects (batch, rearing system, farrowing system) differed significantly ($p < 0.01$).

Piglets born in GH fought significantly less than piglets born in FC and FF and fought for shorter periods than FC piglets ($p < 0.01$; Table 2). Although piglets weaned into w-f pens did not fight more often than conv piglets, they fought significantly longer than conv piglets ($p < 0.01$). Also, females showed significantly more fights than males ($p < 0.01$).

Table 2. Least square means and standard errors (*se*) of fights per animal and fighting duration (s) during the 24 h after weaning.

	Farrowing System			Rearing System		Sex	
	FC	FF	GH	conv	w-f	m	f
Fights per animal	3.11 [a]	2.37 [a]	1.61 [b]	2.09 [a]	2.48 [a]	2.00 [a]	2.59 [b]
se	0.04	0.03	0.04	0.03	0.03	0.03	0.03
Fighting duration (s)	41.08 [a]	24.63 [ab]	17.76 [b]	20.11 [a]	34.11 [b]	-	-
se	0.07	0.06	0.08	0.06	0.06		

FC: farrowing crate; FF: free-farrowing pen; GH: group housing of lactating sows; conv: conventional rearing pen; w-f: wean-to-finish rearing pen; m: male; f: female; se: standard error; -: effect was not included in the model; a–c: Different letters indicate significant differences within the tested effect ($p < 0.05$).

4. Discussion

Mixing of unfamiliar conspecifics, which is common following weaning in commercial farms, forces pigs to establish a new hierarchy, which is accompanied by aggressive behaviour like biting and pushing, resulting in skin lesions (Hessel et al., 2006; Kanaan et al., 2008; Stukenborg et al., 2011; Bohnenkamp et al., 2013; Peden et al., 2018), a weakened immune system, and impaired productivity (Ekkel et al., 1995). Consequently, weaning together with mixing are considered as the first major stressful events in a piglet's life (Weary et al., 2008). It is well known that mixing of litters increases the incidence of fights, and the more a group is intermixed the more fights may occur (Friend et al., 1983). While these fights result in skin lesions, an early socialisation was found to have long-term benefits for later social behaviour and performance (Friend et al., 1983; D'Eath, 2005; Hessel et al., 2006; Stukenborg et al., 2011; Bohnenkamp et al., 2013; Van Nieuwamerongen et al., 2014). Taking these findings into account, we hypothesized that piglets in this study that could interact with loose-housed sows or were socialized with other conspecifics during the suckling period would show fewer skin lesions after weaning, a lower pre- to post-weaning difference in serum cortisol, and overall less agonistic behaviour compared to piglets farrowed in conventional housing systems with confined sows. Increased space allowance was found to lower the synthesis of corticosteroids, the incidence of aggressive behaviour, and skin lesions (Ewbank and Bryant, 1972; Weng et al., 1998; Prunier et al., 2013; Cornale et al., 2015). For this study, a greater space allowance at weaning was assumed to reduce weaning stress with regard to fewer skin lesions, a lower cortisol difference, and less agonistic behaviour compared to a higher stocking density.

4.1. Farrowing System

In general agreement with the present results, early socialisation of piglets has been found to lead to a reduction in the number and duration of fights and lowers the incidence of skin lesions post-weaning (D'Eath, 2005; Hessel et al., 2006; Bohnenkamp et al., 2013). Piglets raised in group housing showed fewer skin lesions, a lower cortisol difference, and fewer and shorter fights after weaning. Regarding the measured parameters of the present study, piglets raised in the free-farrowing housing did not fully benefit from the farrowing system, showing only marginal differences in skin lesions and no significant differences concerning cortisol differences and the duration of fights per animal post-weaning compared to piglets raised in farrowing crates. In other studies, dams showed a lot of nose-to-nose contacts with their piglets immediately after farrowing prior to lying down (Gundlach, 1968; Andersen et al., 2005) and loose-housing of the sow during farrowing and lactation was shown to have an effect on how piglets deal with their post-weaning environment, suggesting differences in maternal care between loose-housed sows and confined sows (Oostindjer et al., 2011). Loose-housed sows have the opportunity to interact with their piglets, probably improving maternal behaviour and also social behaviour of the piglets (Singh et al., 2017). Still, we cannot make a statement for the sows' behaviour in this study in terms of whether the loose-housed sows interacted more with their piglets than did confined sows. For the milder reaction to weaning of GH piglets concerning serum cortisol, it might be possible that piglets raised in group housing showed higher pre-weaning cortisol due to overall higher energy demands caused by the greater space allowance and the interactions with other litters when compared to that of FC and FF pigs. Arey and Sancha (1996) found a nine-fold increase in play behaviour in group-housed suckling piglets and de Jong et al. (2000) found a higher baseline salivary cortisol of pigs housed under enriched conditions. In a study of Grimberg-Henrici et al. (2018), which was completed in part with the same animals as in the present study, GH piglets had more skin lesions on week 4 of the suckling period, close to weaning, than that of piglets from a single-housing system, therefore suggesting higher activity levels in GH piglets during the suckling period. Yet, the present results show that these GH piglets had fewer skin lesions after weaning than that of FC and FF piglets.

4.2. Rearing System

In this study, the rearing system did not affect the incidence of skin lesions and the number of fights per animal, but it did affect the duration of the fights after weaning. The two rearing systems in this study differed in space allowance, floor type, and gender mixing, but there were no differences in management. Although Cornale et al. (2015) found higher faecal corticosteroid levels in animals kept at higher stocking rates, w-f animals in this study had higher cortisol differences than piglets in the conv rearing pen. This suggests that with greater space allowance in w-f pens came a rise in fighting duration, which did not affect the amount of skin lesions, but the perceived stress. Beattie et al. (1996) found that a greater space allowance led to more aggressive behaviour in the pen compared to pens with a lower space allowance. This is in agreement with a study by Jensen (1984), who showed that with increasing stocking density, the number of social activities decreased. In contrast, Meese and Ewbank (1973) found that with higher space allowance, the number of negative interactions halved, but it has to be mentioned that pigs were raised at 22.5 m^2/pig, which far exceeds common commercial farming conditions. Baxter (1985) observed that a certain circular space is required for pigs to allow anti-parallel pressing, a crucial element of pig fights. Wean-to-finish pens in the present study were 0.83 m wider than conventional pens, which meets Baxter's space requirement for anti-parallel pressing better than the rather narrow conv pens. Turner et al. (2006) focused on injurious aggressive behaviour and suggested that there are aspects in aggressive behaviour that do not lead to lesions but could still cause stress to the pig such as pushing during fights. It is therefore possible that pigs in w-f rearing, that fought longer than conventional pigs, showed more harmless but still stressful fighting elements such as pushing. In addition, the high activity (longer fights) in w-f pens probably stimulated metabolism and therefore the synthesis of gluco-corticoids, such as cortisol (Moberg, 2000). As Turner et al. (2017) found in their study, the longer fights in w-f pens might be beneficial for a more stable hierarchy, as fights for rank were not interrupted by pen structure and pen mates.

4.3. Tail-Docking

Although the routine use of tail-docking is prohibited by law (Council Directive 2008/120/EC), tail-docking is still applied and prevents tail-biting (Hunter et al., 2001; Li et al., 2017), an abnormal behaviour that reduces production efficiency and animal welfare (Sonoda et al., 2013). In the context of the present study, tail-docking was analysed as a side-effect on weaning stress. Tail-docking affected the relative serum cortisol difference after weaning but not skin lesions. Skin lesions on the anterior body are associated with aggressive behaviour concerning fights over dominance rank (Turner et al., 2006; Stukenborg et al., 2012) more so than is tail-biting (Li et al., 2017). Animals with docked tails had a lower serum cortisol difference than animals with undocked tails. A study of Gentz et al. (2020) showed that around 15–20% of undocked piglets were weaned with tail lesions. Minor tail-biting events during the lactation period might cause higher serum cortisol values of undocked piglets before weaning and lead, therefore, to a smaller difference overall. On the other hand, studies of Sutherland and Tucker (2011) showed a temporary stress reaction to tail-docking and suggested that long-term studies are still needed to examine chronic stress in tail-docked pigs. Simonsen et al. (1991) found traumatic neuromas in the tail stumps of docked pigs, weighing about 90 kg, which are known to be painful. As already proposed by Scollo et al. (2013) tail-docked pigs seem to have higher cortisol values than that of undocked pigs in weeks 7, 19, and 28 of the fattening period. De Jong et al. (2000) found a blunted circadian rhythm and lower levels of cortisol in barren housed pigs, explaining those results with chronic stress. It might be possible that piglets with docked tails suffer from chronic stress from the docking procedure and thus do not react as sensitively to weaning in terms of cortisol levels as undocked pigs do. Still, the effect of tail-docking on weaning stress has to be taken with caution.

4.4. Weaning Weight

Piglets who were classified as heavy showed more skin lesions and lower cortisol differences than those of light piglets, but weight classes did not affect the number nor the duration of fights. Prunier et al. (2013) also found a significant increase in the number of skin lesions with increasing live weight. Although Andersen et al. (2000) could not find any effect of weight asymmetry on the number of skin lesions, they also did not detect any impact of weight on the number of fights, which is in line with the findings of the present study. As well, Turner et al. (2006) found no significant correlation between the fighting duration and weight, but did find a significant correlation between the duration spent being bullied and body weight: Lighter pigs were bullied for longer time periods. To sum up, although light and heavy piglets in this study fought the same amount and duration, heavier piglets ended up with more lesions, but light piglets seem to suffer more stress in terms of higher cortisol levels in the first 24 h after weaning. The present results indicate that there might be a difference in the fighting behaviour of smaller and larger piglets, although Bolhuis et al. (2005) found no significant influence of weaning weight on fighting behaviour. Still, Jensen and Yngvesson (1998) showed a tendency for longer fights with high-weighted opponents. Future behavioural observations will be undertaken to detect more detailed differences.

Findings of Meese and Ewbank (1973) and Scollo et al. (2013) confirm the findings of the present study that gender did not affect skin lesions or serum cortisol differences.

5. Conclusions

The present study showed that piglets housed in a group housing system during lactation profit from the early socialisation across multiple litters, resulting in lower weaning stress in the form of agonistic interactions and consequently skin lesions. Apart from other possible positive effects of loose-housing on sow and piglet welfare, piglets in this study born in free-farrowing pens showed only marginal benefits on weaning stress compared to that of piglets raised in pens with a farrowing crate. The greater space allowance in wean-to-finish pens did not have an additional positive effect on weaning, but resulted in positive effects on the incidence of tail-biting, which was not part of the present study. Furthermore, the wean-to-finish housing system also avoids stress during the course of the rearing and finishing period, as no further rehousing and regrouping before finishing was conducted.

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Research Article Two:

Effects of Different Housing Systems during Suckling and Rearing Period on Skin and Tail Lesions, Tail Losses and Performance of Growing and Finishing Pigs

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Simple Summary

Weaning involves multiple stressors and is one of the most critical periods for piglets. It is known that pigs try to compensate stressful events by different coping strategies that might culminate in the biting of other pigs. The reduction in the number of stressors by optimizing housing conditions might be a way to reduce tail-biting, one huge challenge in modern pig production. Since tail docking as a measure to avoid injuries is banned by EU regulations, this study aims to present alternatives to combat tail-biting. The present work shows that the group housing of lactating sows and their litters improves pig welfare after regrouping events in terms of skin lesions. Rearing in the farrowing pen with reduced regrouping positively affected the incidence of tail lesions and losses of undocked pigs. Against expectations, free-farrowing and group housing systems had no negative impact on later performance during rearing or fattening.

Abstract

Feasible alternatives to stressful weaning and tail-docking are needed to inhibit tail-biting. Therefore, we investigated the effects of housing systems for 1106 pigs that were weaned from: (1) conventional farrowing crates (FC), (2) free-farrowing pens (FF), or (3) group housing of lactating sows (GH) into (1) conventional rearing pens (Conv) or (2) piglets remained in their farrowing pens for rearing (Reaf). Tails were docked or left undocked batchwise. All pigs were regrouped for the fattening period. Pigs were scored for skin lesions, tail lesions and losses. After weaning, Conv-GH pigs had significantly less skin lesions than Conv-FC and Conv-FF pigs. After regrouping for fattening, Reaf-GH pigs had significantly less skin lesions than Conv pigs, Reaf-FC and Reaf-FF. The frequency of tail lesions of undocked Conv pigs peaked in week 4 (66.8 %). Two weeks later, Reaf undocked pigs reached their maximum (36.2 %). At the end of fattening, 99.3 % of undocked Conv pigs and 43.1 % of undocked Reaf pigs lost parts of their tail. In conclusion, the co-mingling of piglets during suckling reduced the incidence of skin lesions. Rearing in the farrowing pen significantly reduced the incidence of tail lesions and losses for undocked pigs. No housing system negatively affected the performance.

Keywords: farrowing systems; early socialisation; rearing in the farrowing pen; tail-biting; average daily gain

1. Introduction

Weaning is one of the most critical periods for piglets, causing an alteration of their welfare, health and performance (Weary et al., 2008). While natural and seminatural weaning happens gradually in a time span of up to 17 weeks (Jensen, 1986), piglets under conventional conditions are normally weaned at 3 to 4 weeks of age (Council Directive 2008/120/EC). In Europe, the piglets are usually undergoing several steps at weaning: besides separation from the sow, they are relocated from the farrowing environment to rearing pens, with a change in feed and regrouping with unfamiliar piglets (aiming for rearing groups of homogeneous weight) on the same day. Although studies on aggression in (weaning) pigs date back to the 1970s, aggression after mixing is still a common problem in pig husbandry (Ewbank and Bryant, 1972; Peden et al., 2018). Already, Friend et al. (1983) showed that the extent of intermixing of a group of pigs directly affected the number of fights. Fights that arose to establish the hierarchy increased the severity of the skin lesion score, especially in pigs that were regrouped during fattening period (Stukenborg et al., 2011). The early socialisation of piglets from different litters before weaning resulted in positive effects for later social behaviour (D'Eath, 2005; Hessel et al., 2006; Bohnenkamp et al., 2013; Peden et al., 2018). For example, when these pigs were grouped, the new hierarchy was established sooner than in groups of less socialized pigs resulting in less skin lesions. These findings were confirmed by a previous study of Lange et al. (2020) who investigated the effects of housing systems during suckling and wean-to-finish-rearing on post-weaning stress 24 h after weaning and relocation in terms of skin lesions, serum cortisol and aggressive behaviour. Several studies show that loose-housing of sows during lactation, even in groups, can be a feasible alternative to confined housing systems: free-farrowing not only improved the welfare of the sow, but also positively influenced the piglets in terms of behaviour and performance (Kutzer et al., 2009; Oostindjer et al., 2011; Singh et al., 2017). Piglets under natural conditions or in single loose-housing farrowing pens experience a lot of nose-to-nose contacts with their mother sow instantly after birth and before the sow intended to lie down (Gundlach, 1968; Andersen et al., 2005). Piglets from single loose-housed sows dealt differently with their post-weaning environment (more playful and exploratory behaviour), suggesting differences in maternal behaviour between loose-housed sows and sows in farrowing crates (Oostindjer et al., 2011). Single loose-housed sows have the chance to interact with their piglets, possibly enhancing the maternal and also social behaviour of the piglets (Singh et al., 2017) even after weaning. Still, the group housing of sows and their litters often raise concerns about cross-suckling and the impaired weight gain of the piglets due to interrupted suckling bouts (Morgan et al., 2014; Nicolaisen et al., 2019b). In general, a better performance at weaning was shown to enhance weight gain at later stages (Collins et al., 2017). Since weaning involves multiple stressors (Weary et al., 2008), the weaning process should be optimized to better prepare the piglets for the rearing and finishing period. It is discussed that pigs try to compensate stressful events by different coping strategies that might result in the oral manipulation of the environment and pen mates, possibly culminating in the biting of other pigs (Benus et al., 1991; Rushen, 1993). The reduction in the number of stressors by optimizing management and housing conditions might be a way to reduce tail-biting, one huge challenge in modern pig production (Schrøder-Petersen and Simonsen, 2001). A study of Gentz et al. (2020) examined docked and undocked pigs that were either conventionally housed after weaning or remained in so-called wean-to-finish housing (W-F). The reduced regrouping event at the beginning of fattening period benefited the W-F pigs in terms of tail lesions and losses, but still tail lesions and losses occurred and the authors concluded that further optimisation of housing systems are necessary. Although routine tail docking is prohibited in the EU since 1994 (Council Directive 2008/120/EC), an audit that was carried out in Germany in 2018 reported that 95% of conventionally housed pigs were tail-docked (European Commission, 2018) and it is still one of the most commonly used measures to reduce tail-biting in pigs (Schrøder-Petersen and Simonsen, 2001; EFSA, 2007). As action plans of the concerned EU member states were initiated to assist farmers in the housing of undocked pigs, substantiating research of tail-biting behaviour of pigs is needed. To the authors' knowledge, almost no scientific publications are available concerning rearing in the farrowing pen. The previous studies of Gentz et al. (2020) and Lange et al. (2020) showed the potential of alternative housing conditions, but both stated that further investigations are needed as, for example, Lange et al. (2020) did not study long-term effects. Long-term effects of the housing system during suckling period on the regrouping behaviour at the beginning of the fattening period are scarcely studied.

Therefore, the aim of this study was to investigate the effects of different housing systems during suckling period followed by rearing in the same system on skin and tail lesions, tail losses and performance of docked and undocked growing and finishing pigs. We hypothesized that piglets from loose-housed sows, either from single loose-housing or group housing, react milder on the weaning stressors by showing less skin lesions, less tail lesions and, therefore, less tail losses. Rearing in the farrowing pen reduces relocation and regrouping at weaning; therefore, we hypothesized a decreased incidence of skin lesions, tail lesions and, consequently, tail losses in this rearing system, especially in regard to the housing of undocked pigs. As cross-suckling can occur in group housing systems of lactating sows, we further hypothesized that the average daily gain of piglets from group housing can be impaired, compared to gains of piglets from single housing systems such as farrowing crates or single loose-housing. We also hypothesized that early socialisation during the lactation period lowers the incidence of skin lesions during a late first regrouping for fattening period.

2. Materials and Methods

2.1. Animals and Housing

The study was conducted on the experimental farm for pigs of the Chamber of Agri-culture for Lower Saxony in Wehnen, Germany. In eight batches between December 2016 and January 2018, in total 1106 crossbred (Piétrain × [Landrace × Large White]) pigs were included in a 3 × 2 × 2 factorial design study from three different farrowing systems: (1) conventional single-housing in farrowing crates (FC; n = 349), (2) single-housing in free-farrowing pens (FF; n = 340), and (3) group housing of lactating sows (GH; n = 417) (Figure 1). All farrowing systems were located in the same building and for each one two compartments were used. FC compartments included eight pens, GH and FF compartments included six pens each. The FC pens measured 2.6 × 2.0 m^2 and had tiles in the lying area of the sow, the rest was a fully slatted plastic floor (slat width = 10 mm, tread area = 11 mm). The open creep area was removed for rearing. The FF pens measured 2.7 × 2.7 m^2. The creep area in the FF pens was a box (1.0 × 0.8 m^2) with two openings which were closed with the proceeding rearing period. The flooring of the FF pen was similar to that in the FC pens. In each of the two compartments of GH, six sows were stalled in single-housing free-farrowing pens until day 6–7 postpartum. Then, single-pens were opened and sows and their litters were able to interact freely in a joint running area (JRA) until weaning. The pens measured 2.0 × 2.5 m^2 each, the joint running area measured 6.1 × 2.4 m^2. The flooring in the GH pens was a partly fully slatted concrete floor (slat width = 10 mm, tread area = 90 mm) and partly fully slatted cast-iron floor (slat width = 11 mm, tread area = 15 mm). The creep areas were similar to those in the FF pens. The floor in the JRA was a fully slatted concrete floor (slat width = 10 mm, tread area = 90 mm). Nipple drinkers for sows and piglets were located in the pens and in the JRA. Sows were moved simultaneously to the farrowing system seven days before the expected farrowing date. Sows in FC were confined permanently during farrowing and suckling period. Sows in FF and GH could move freely and interact with their piglets for the whole suckling period of 26.6 ± 1.5 days (for further details on farrowing pens, see Nicolaisen et al., 2019b).

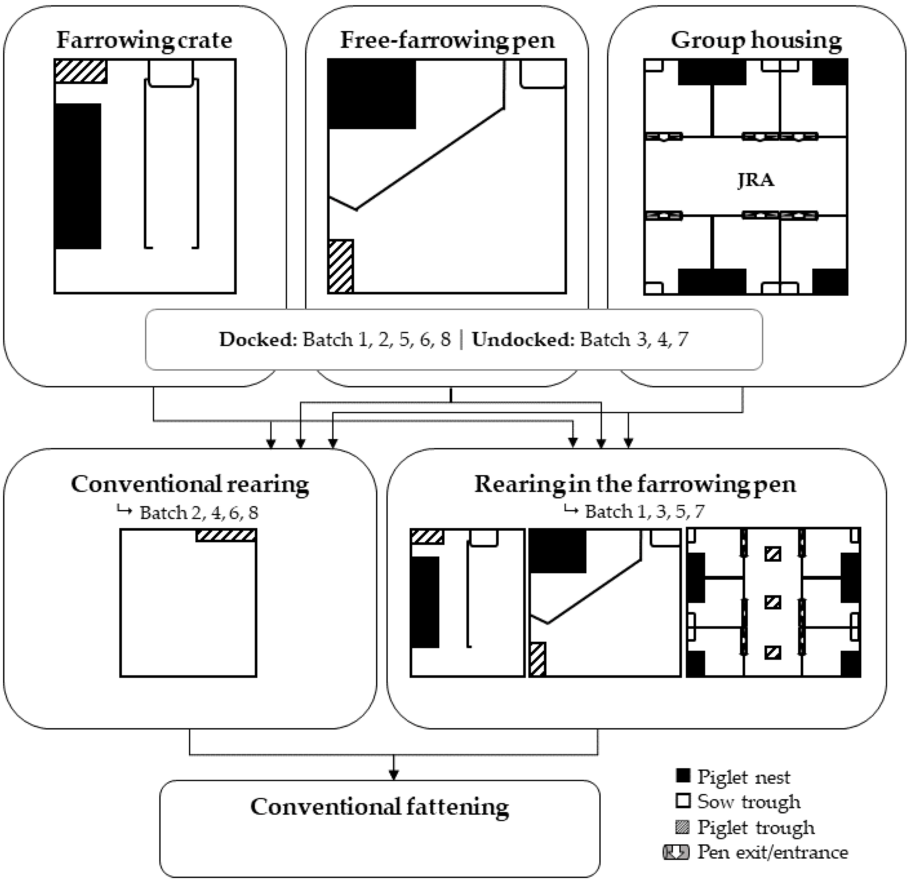

Figure 1. Schematic overview of the experimental design (JRA: joint running area; drawings are not to scale).

In all three farrowing systems, weaning took place on the same day. Until day 4 after birth, all male piglets were castrated and, batchwise, tails were either docked under veterinary advisement using a hot cautery iron or left intact. Piglets were weaned batchwise to one of two different rearing systems: either (1) piglets were relocated and regrouped into conventional rearing pens (Conv; n = 486) or (2) piglets remained in their farrowing system (Reaf; n = 620) for the rearing period. In conventional rearing, a maximum of 23 piglets per equally balanced mixed-sex group were housed on fully slatted plastic floors with a minimum space allowance of 0.37 m^2 per pig (Table 1). In Reaf housing, piglets remained together with their littermates for rearing. Since piglets were not relocated or regrouped for the rearing period, cross-fostering was necessary to guarantee the legally required space-allowance during rearing. Within the first 48 hours after birth, FC and FF litters had to be adjusted to a maximum of 14 piglets per pen. Therefore, and due to suckling piglet mortality (FC = 12.3 %; FF = 25.6 %; GH = 19.9 %; see Nicolaisen et al., 2019a), the space allowance differed between the Reaf systems from 0.37 to 1.46 m^2 per pig (Table 1).

Table 1. Mean, minimum, maximum and standard deviation (SD) of space allowance per pig in square meters [m^2] and of group size per rearing and farrowing system during rearing period.

Rearing System	Farrowing System	N Pens	Space Allowance Mean	Space Allowance Min	Space Allowance Max	Space Allowance SD	Group Size Mean	Group Size Min	Group Size Max	Group Size SD
Conv	FC	8	0.44	0.37	0.77	0.14	20.50	11.00	23.00	4.00
	FF	8	0.49	0.37	1.21	0.29	19.88	7.00	23.00	5.36
	GH	8	0.42	0.37	0.53	0.06	20.25	16.00	23.00	2.49
Reaf	FC	16	0.46	0.37	0.65	0.08	11.50	8.00	14.00	1.79
	FF	19	0.83	0.56	1.46	0.28	9.53	5.00	13.00	2.50
	GH	24 *	0.71	0.67	0.77	0.05	63.50	58.00	67.00	4.04

*: 24 pens reared in 4 groups; SD: standard deviation; Conv: conventional rearing; Reaf: rearing in the farrowing pen; FC: farrowing crate; FF: free-farrowing pen; GH: group housing of lactating sows.

In both rearing systems, the same commercial diet OlymPig® (Agravis Raiffeisen AG, Münster, Germany) was fed ad libitum and manipulable material such as pieces of wood and ropes were provided (one piece of wood and one rope per pen) and renewed continuously. After 37.5 ± 0.5 days of rearing, piglets were relocated, regrouped and sorted by sex for the fattening period. Due to a limited number of identically constructed fattening pens, not all rearing pigs could be studied during fattening—a subset of 791 pigs was moved to the fattening compartments. Batchwise, fattening took place in one of three compartments (compartment I: 18 pigs per pen with a space allowance of 0.88 m^2 per pig; compartment II: 18 pigs per pen with a space allowance of 0.99 m^2 per pig; compartment III: 8 pigs per pen with a space allowance of 0.96 m² per pig). Fattening pigs were housed on fully slatted concrete floors, fed ad libitum and manipulable material such as pieces of wood and ropes (each one per pen) were provided. With an average live weight of 122.7 ± 3.9 kg, which was reached within 159.7 ± 11.9 days of life, pigs were taken to slaughter. Tail-docking was the third factor in the study design. When severe tail lesions (see Section 2.2.2) occurred, manipulable material was renewed, and jute bags and hayracks were additionally installed into the pens. A climate computer regulated ventilation and heating in both rearing systems, starting with an air temperature of 28 °C on the first days after weaning. In addition to diffuse daylight, artificial lighting was provided for 10 hours between 7:30 a.m. and 5:30 p.m. at all farm stages.

2.2. Recorded Traits

2.2.1. Scoring of Skin Lesions

All growing (n = 1106) and finishing pigs (n = 791) were assessed for skin lesions starting on the first day after weaning, following the Welfare Quality® assessment protocol applied to growing and finishing pigs (Welfare Quality®, 2009). The assessment was carried out by two assessors who were trained together. For each assessment, the two persons were present; one being the assessor, the other one an active observer, who justified the given score. The same scoring approach for the three-staged lesion score was used, as published by Lange et al. (2020). During the rearing period, pigs were scored every two weeks for skin lesions. During the fattening period skin lesions were assessed every four weeks (Figure 2).

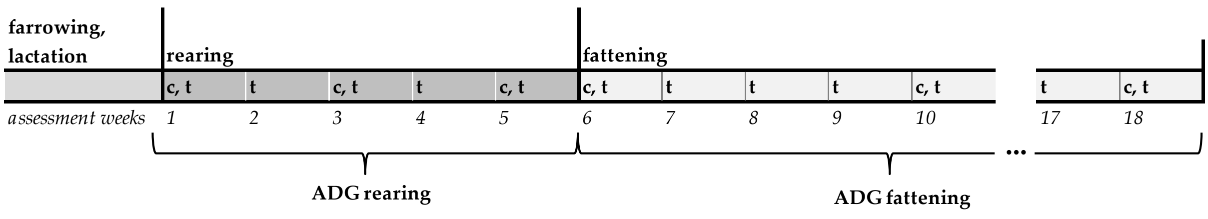

Figure 2. Timeline for the assessed and analyzed parameters over the 18 assessment weeks (c: complete assessment of skin lesions, ear lesions and losses, lameness and manure on the body; t: assessment of tail lesions and losses; ADG: calculated average daily gain).

In total, skin lesions were primarily found on the ears (score 1 = 14.7 %; score 2 = 4.6 %), front (score 1 = 37.1 %; score 2 = 10.5 %), and middle part (score 1 = 22.2 %; score 2 = 4.1 %) and to a negligible amount on hind-quarters (score 1 = 8.9 %; score 2 = 0.8 %) and legs (score 1 = 1.3 %;

score 2 = 0.2 %) (frequencies calculated with the FREQ procedure in SAS® (SAS Institute Inc., Cary, NC, USA)). Due to the very low occurrence of severe lesions, scores were summarized into a binary trait, (0 = no lesions and 1 = skin lesions) for the statistical analysis. As skin lesions after rank fights commonly appear on the anterior body parts, lesions on the first three body parts were statistically analysed (D'Eath, 2005; Stukenborg et al., 2012). Assessment weeks 1 (first assessment after weaning), 5 (end of rearing), 6 (first assessment after regrouping for fattening) and 18 (end of fattening) were included in the analysis to evaluate the crucial periods for skin lesions (Peden et al., 2018).

2.2.2. Scoring of Tail Lesions and Tail Losses

Starting one day after weaning, the tails of all pigs were scored individually weekly for 18 weeks using a modified key, described by Abriel and Jais (2013) (Figure 2). Score 0 was given for intact tails without scratches or bite marks. Slight scratches or minor bite marks were scored as "a lesion" (score 1). A "severe lesion" was defined by deeper, flat lesions (score 2) and a "very severe lesion" was greater than 2 cm with deep, flat lesion (score 3) (Gentz et al., 2020). For the statistical analysis, the tail lesion score was summarized due to the low occurrence of severe and very severe lesions (<2.6 %) into "no lesions" (score 0) and "lesions" (score 1–3). Tail losses were scored in quarters: "original length" (no loss; score 0), "tip loss" (max. ¼ lost; score 1), "half loss" (max. ½ lost; score 2), "major loss" (max. ¾ lost; score 3), and "complete loss" (more than ¾ lost, score 4) (Naya et al., 2018). For the statistical analysis, these scores were also summarized into "intact tail" (score 0) and "tail loss" (score 1–4). Due to a low occurrence of tail losses in docked pigs, only data of undocked pigs went into analysis. To outline the progression of the tail losses, tail losses of assessment weeks 1 (beginning of rearing period), 5 (end of rearing), 10 (middle of fattening) and 18 (end of fattening) were calculated.

2.2.3. Performance

The individual body weights of all pigs were measured at weaning, at the end of the rearing period and 2.8 ± 1.2 days prior to marketing/slaughter (scales from T.E.L.L.-Steuerungssysteme GmbH & Co. KG, Vreden, Germany) and the average daily gain (ADG) was calculated separately for the rearing and fattening period in gram per day (g/d) (Figure 2).

2.2.4. Other Measures

Additionally, pigs were scored for ear lesions, ear losses, lameness and manure on the body every two weeks during the rearing period. During the fattening period these parameters were assessed every four weeks (Figure 2). Ear lesions and losses were scored with the 'German Pig Scoring Key' (German: 'Deutscher Schweine-Boniturschlüssel'; Deutscher Schweine-Boniturschlüssel, 2017). Lameness and manure on the body were scored following the Welfare Quality® assessment protocol applied to growing and finishing pigs (Welfare Quality®, 2009). Since the majority of animals was scored 0 for all of these parameters, no statistical analysis was performed (score 0: ear lesions = 99.1 %; ear losses = 99.5 %; lameness = 98.1 %; manure on the body = 91.0 %; frequencies calculated with the FREQ procedure in SAS® (SAS Institute Inc., Cary, NC, USA)).

2.3. Statistical Analysis

The data analysis was conducted with SAS® 9.4 (SAS Institute Inc., Cary, NC, USA). Due to the non-normally distributed data of skin lesions, tail lesions and tail losses, a general linear model assuming a binomial distribution was applied using the GLIMMIX procedure. For each parameter, all possible fixed effects were tested and only included in further analysis if parameters showed significant influence on the model ($p < 0.05$) and decreased the 'Akaike's information criterion corrected' (AICC; Hurvich and Tsai, 1989) and 'Bayesian information criterion' (BIC; Schwarz, 1978). The model with the lowest values for AICC and BIC was used for further evaluation. Due to the study design and management routines, it was not possible to house Conv and Reaf, and docked and undocked pigs simultaneously per batch during rearing and fattening period. Therefore, the batch effect (batch 1–8) was considered as a random effect.

Each model for the skin lesion scores included the fixed effects farrowing system (FC, FF, GH), rearing system (Conv, Reaf) and assessment week (1, 5, 6 and 18). Sex (male, female) was only significant for the model of the skin lesions on the front body part and thus included into the respective model. For the front and ears model, the interaction of rearing system × farrowing system × assessment week was tested as significant and, therefore, included; for the middle body part, the interaction of farrowing system × assessment week was tested as significant. Batch and animal identities were added as random effects.

The model for the prevalence of tail lesions included the fixed effects rearing system (Conv, Reaf), docking status (docked, undocked), assessment week (1–18) and the interaction of rearing system × docking status × assessment week. Batch and animal identities were added as random effects.

The fixed effects farrowing system (FC, FF, GH), rearing system (Conv, Reaf), assessment week (1, 5, 10 and 18), sex (male, female) and the interaction of rearing system × assessment week were included in the model of tail losses. Batch and animal identities were added as random effects.

The data on average daily gain (ADG) were analyzed in two models, one for rearing and one for fattening period, using the MIXED procedure in SAS® 9.4 (SAS Institute Inc., Cary, NC, USA). Both models included the fixed effects farrowing system (FC, FF, GH), docking status (docked, undocked) and their interaction (docking status × farrowing system). The model for the fattening period included sex (male, female) as significant fixed effect. The weight at the beginning of each period was used as a covariable to take the different initial weights of the respective animals into account. Batch and animal identities were added as random effects. Residuals fulfilled requirements to assume variance homogeneity as well as a normal distribution.

For all models, the significance of differences in the least square means was adapted by the Bonferroni-correction to adjust for multiple comparisons.

3. Results

3.1 Skin Lesions

For all three body parts, the farrowing system and the assessment week had a significant effect on skin lesions of growing and finishing pigs ($p < 0.05$). The rearing system affected skin lesions on the front and ears significantly ($p < 0.05$) but not on the middle ($p > 0.05$). For the front and ears, the interaction of rearing system × farrowing system × assessment week was significant ($p < 0.05$) and the interaction of farrowing system × assessment week affected the skin lesion score on the middle body part. Sex only affected skin lesions on the front body ($p < 0.05$).

In week 1, significantly fewer Conv-GH pigs had skin lesions on the front body than Conv-FC and Conv-FF pigs ($p < 0.0001$) and on the ears than Conv-FC pigs ($p = 0.0316$; Figure 3). Pigs from Conv-GH did not differ from pigs raised in the farrowing pen ($p = 1.0$). Pigs from Reaf did not significantly differ among the farrowing systems ($p > 0.6$). Numerically, more Reaf-GH pigs had skin lesions on the front and ears than Reaf-FC or Reaf-FF pigs. On the middle body part, significantly more pigs born in FC had skin lesions than pigs born in GH in week 1 (FC = 9.0 %^{a}; FF = 6.6 %^{ab}; GH = 2.8 %^{b}; $p = 0.0272$). In week 5, at the end of the rearing period, no significant differences between the groups could be detected on the front and the middle ($p > 0.05$) but, on the ears, less Reaf-GH pigs had lesions than Reaf-FC pigs ($p = 0.048$). In week 6, all groups showed the highest occurrence of skin lesions on the front body. Conv Pigs did not significantly differ in the number of skin lesions ($p = 1.0$). On the front and the ears, significantly less Reaf-GH pigs had skin lesions than the other experimental groups ($p < 0.03$). Reaf-FC and Reaf-FF did not differ from the Conv pigs concerning skin lesions on the front body ($p = 1.0$). On the middle body part, significantly less GH and FC pigs had skin lesions than FF pigs in week 6 (FC = 65.9 %^{a}; FF = 82.1 %^{b}; GH = 50.1 %^{a}; $p < 0.02$). In week 18, at the end of fattening period, no significant effect of the housing systems could be found ($p > 0.69$) (pigs with skin lesions on middle body part: FC = 12.3 %; FF = 7.7 %; GH = 11.5 %).

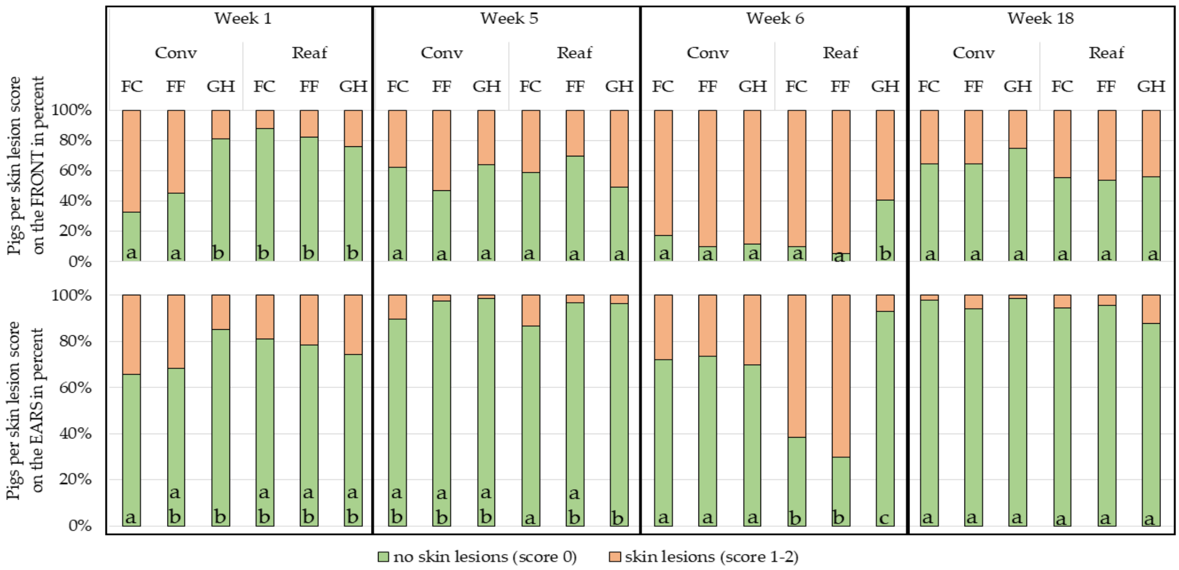

Figure 3. Estimated frequencies of skin lesions in percentages for the interaction rearing system × farrowing system × assessment week per body part (Conv: conventional rearing; Reaf: rearing in the farrowing pen; FC: farrowing crate; FF: free-farrowing pen; GH: group housing of lactating sows; a–c: different letters indicate significant differences of score 0 (no lesions) within week and body part ($p < 0.05$)).

Within the housing systems Conv-FC, Conv-FF, Conv-GH, Reaf-FC and Reaf-FF a significant increase in the number and severity of skin lesions could be found between the end of rearing (assessment week 5) and the beginning of fattening (assessment week 6) ($p < 0.0001$), except for the housing system Reaf-GH. Only Reaf-GH pigs showed no significant difference in skin lesions on the front body part and the ears after regrouping for fattening ($p = 1.0$). Significantly more female than male pigs had skin lesions on the front body (Score 1: 53.7 % vs. 48.5 %; $p = 0.0272$).

3.2 Tail Lesions and Tail Losses

The rearing system, docking status, assessment week and the interaction of rearing system × docking status × assessment week significantly affected the incidence of tail lesions ($p < 0.05$). Significantly less docked pigs had tail lesions than undocked pigs (docked = 7.4 %; undocked = 15.8 %; $p < 0.0001$).

In week 1 of the rearing period, Conv and Reaf, docked and undocked, pigs started with around the same level of tail lesions (Figure 4; Table 2). In a range from 2.1 % (docked Reaf) up to 10.2 % (undocked Reaf) of the animals suffered from tail lesions in the beginning. In week 2, the number of undocked Conv pigs with tail lesions increased (20.5 %), while undocked Reaf pigs kept the preceding level of tail lesions (10.4 %). Conv undocked pigs reached a peak in tail lesions in week 4 of the rearing period (66.8 %). Two weeks later, in assessment week 6, Reaf undocked pigs reached their maximum in tail lesions (36.2 %). Tail lesions of docked Conv pigs peaked in week 4 (24.2 %) and of docked Reaf pigs in week 5 (16.4 %). After reaching the peak, the estimated frequency of tail lesions declined over the fattening period, for undocked Conv as well as Reaf pigs. Through most of the assessment weeks, undocked Conv and undocked Reaf pigs did not differ significantly ($p > 0.05$), except for week 4 and 8 where significantly more Conv pigs had tail lesions than Reaf pigs ($p < 0.02$). Still, docked and undocked pigs within their housing systems did differ significantly ($p < 0.05$; Table 2). While less docked Conv pigs had consecutively, from week 2 until week 8, less tail lesions than undocked Conv pigs, equivalent differences for Reaf pigs could only be found in weeks 5, 6 and 16.

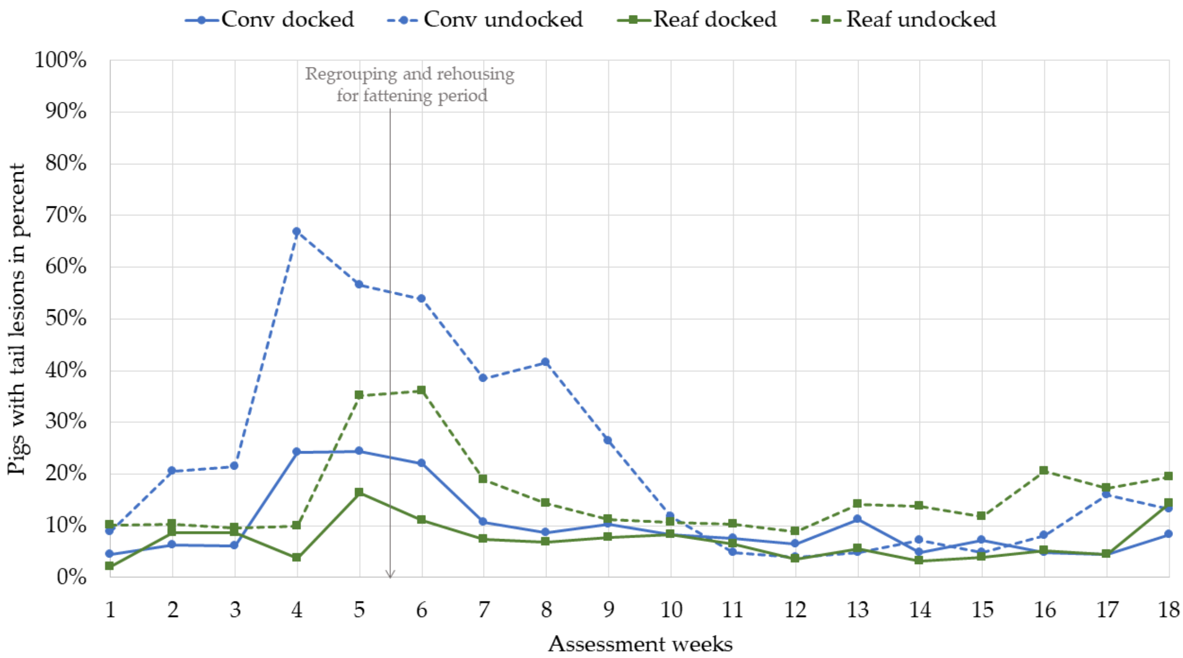

Figure 4. Frequency in the percentage of back transformed tail lesion estimates for docked and undocked pigs per rearing system over 18 assessment weeks (Conv: conventional rearing, Reaf: rearing in the farrowing pen). For a better clarity of the figure, significances are shown in Table 2.

Table 2. Multiple comparison of the least-square means differences of the interaction assessment week × rearing system × docking status by Bonferroni within the assessment week ($p < 0.05$).

	Assessment Week																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Conv docked	a	a	a	a	ac	ac	a	a	a	a	a	a	a	a	a	a	a	a
Conv undocked	a	b	b	b	b	b	b	b	a	a	a	a	a	a	a	ab	ab	a
Reaf docked	a	ab	ab	c	a	a	a	a	a	a	a	a	a	a	a	a	ab	a
Reaf undocked	a	ab	ab	c	bc	bc	ab	a	a	a	a	a	a	a	a	b	b	a

Conv: conventional rearing; Reaf: rearing in the farrowing pen; a–c: Significant differences within the assessment week ($p < 0.05$).

The amount of tail losses of undocked pigs was affected significantly by the rearing system, the farrowing system, assessment week, sex and the interaction of rearing system × assessment week ($p < 0.05$).

In the first assessment week, no significant differences between the housing systems could be found (Figure 5). In both rearing systems, 100.0 % of the pigs started with intact tails. At the end of the rearing period (week 5), two thirds of Conv animals (65.3 %) lost parts of their tails, while 96.3 % of Reaf pigs still had intact tails ($p < 0.0001$). In the middle, and the end of fattening (week 10 and week 18), few Conv pigs still had an intact tail. In comparison, 43.1 % of Reaf pigs lost part of their tails before the end of fattening. Concerning the impact of the farrowing system, significantly more FC pigs had intact tails than GH pigs (intact tails: FC = 94.4 %[a]; FF = 88.7 %[ab]; GH = 65.7 %[b]; $p = 0.0021$). In any case, 77.9 % of males and 91.9 % of female pigs had intact tails ($p = 0.0219$).

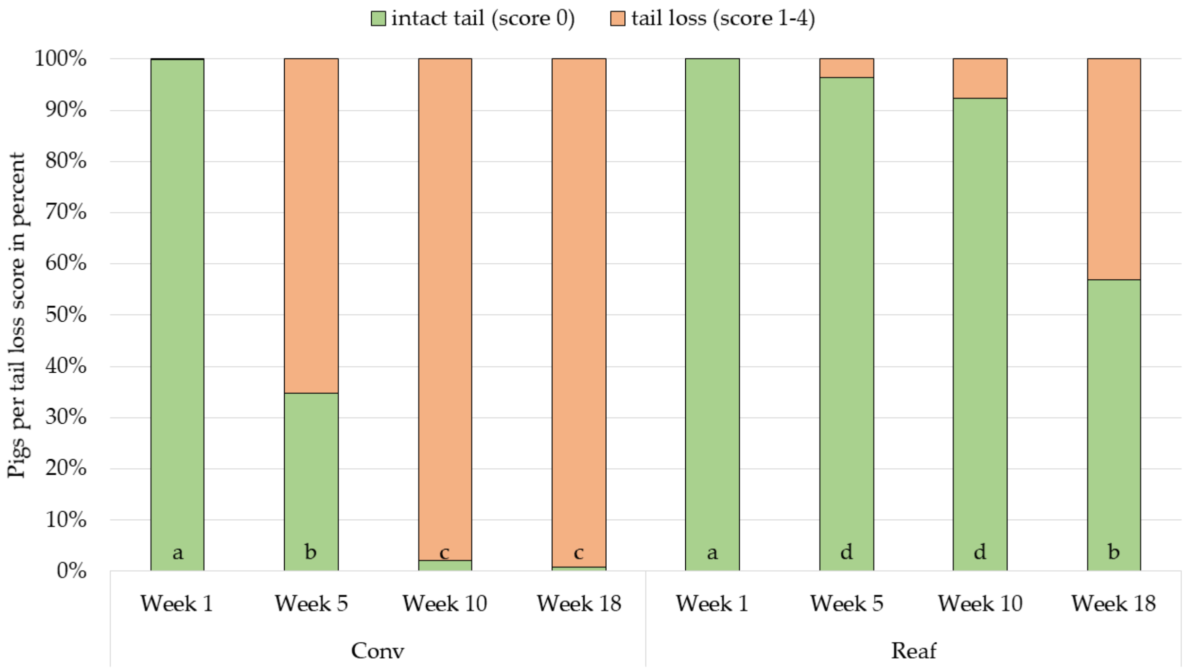

Figure 5. Frequency in percent of back transformed tail loss estimates of the interaction of rearing system × assessment week of undocked pigs (Conv: conventional rearing; Reaf: rearing in the farrowing pen; a–d: different letters indicate significant differences of score 0 (no losses) across housing system and assessment week ($p < 0.05$).

3.3 Performance

In the rearing and fattening period, the average daily gain was significantly affected by the docking status, the farrowing system and their interaction docking status × farrowing system ($p < 0.05$). The ADG in fattening period was affected significantly by sex ($p < 0.05$).

Docked pigs gained 11 g/d more than undocked pigs (516.4 g/d vs. 505.0 g/d, respectively; $p = 0.0147$) during rearing period. In fattening period, undocked pigs had higher ADG than docked pigs (1063.2 g/d vs. 1022.0 g/d; $p < 0.0001$). With 487.1 g/d, pigs born into FC had significantly lower ADG during rearing than pigs from FF and GH (FF = 519.9 g/d, GH = 524.9

g/d; $p < 0.0001$). During fattening period, pigs born in GH had significantly higher ADG than FF pigs (FC = 1044.2 g/d [ab]; FF = 1031.6 g/d [a]; GH = 1052.1 g/d [b]; $p = 0.0227$). Considering the interaction of docking status and farrowing system, docked GH pigs gained significantly more weight daily than docked FC and FF pigs ($p < 0.001$) during rearing period (Figure 6). In the same period, undocked FC pigs had significantly lower ADG than undocked FF and GH pigs ($p < 0.02$). In fattening period no significant differences could be detected between docked pigs (docked FC = 1008.9 g/d; docked FF = 1020.5 g/d; docked GH = 1036.6 g/d; $p > 0.09$). Undocked FC fattening pigs gained significantly more than undocked FF fattening pigs ($p = 0.0208$). Males gained significantly more weight daily than females during fattening period (1067.7 g/d vs. 1017.5 g/d; $p < 0.0001$).

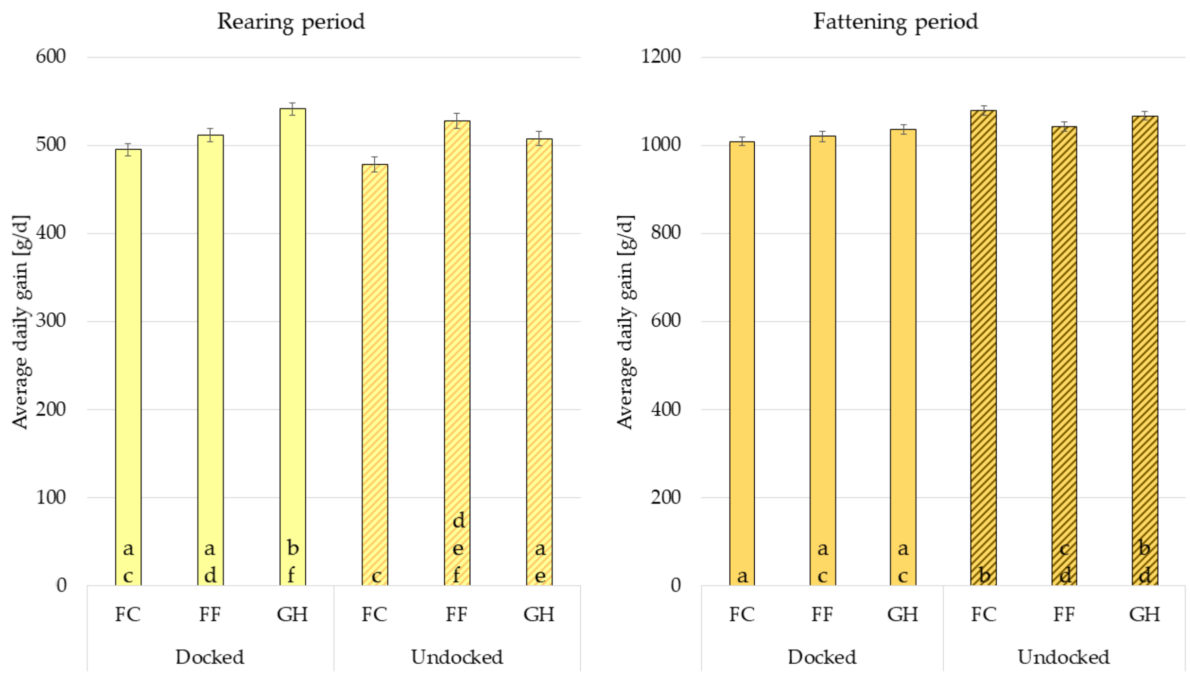

Figure 6. Estimated average daily gain in gram per day for the interaction of docking status × farrowing system (FC: farrowing crate; FF: free-farrowing pen; GH: group housing of lactating sows; a–f: different letters indicate significant differences within the rearing or fattening period ($p < 0.05$)).

4. Discussion

Up to now only little scientific knowledge is available concerning the rearing in the farrowing pen and the long-term effect of the farrowing system on the regrouping behaviour at fattening period. Especially the effects of rather late first regrouping for fattening on skin lesions, tail lesions and losses and performance was up to now not studied.

4.1 Skin Lesions

In accordance with a previous study of Lange et al. (2020) and our first hypothesis, mainly the farrowing system affected the occurrence of skin lesions at regrouping occasions (here: week 1 and week 6) with GH piglets showing fewer skin lesions after weaning and regrouping for fattening than piglets born in FF or FC. According to the findings of Lange et al. (2020) but against our hypothesis, FF piglets in the present study did not fully benefit from the loose farrowing system, showing no differences in skin lesions compared to FC pigs. In week 1, significantly more Conv-GH pigs were scored 0 for skin lesions than Conv-FF and Conv-FC pigs. In comparison, Reaf-GH pigs had less skin lesions at their first regrouping event in week 6, than their counterparts born and reared in the FF and FC pens. Likewise, Bohnenkamp et al. (2013) found that GH pigs had fewer scratches after weaning than piglets of single housed sows. They also found a decreased number of fights and fighting duration in GH pigs. Hessel et al. (2006), who observed the behaviour of piglets that were co-mingled during the lactation period, noticed that early socialized piglets showed less fighting behaviour than control groups, especially in the first 4 hours after weaning. D'Eath (2005) showed that mixing litters prior to weaning even had long-term effects on the social behaviour of the pigs: when the experimental pigs were mixed again after weaning, they formed the new stable hierarchy more rapidly. All these findings were confirmed in a study of Kutzer et al. (2009) who also found that co-mingled piglets had less skin lesions than single-housing piglets that had no contact to other litters. They further conclude that the differences in skin lesions must originate from a difference in severity in fights for hierarchy. Direct behavioural observations were not done in the present study, but, as Turner et al. (2006) and Bohnenkamp et al. (2013) assumed, the assessment of skin lesions can be used to determine the intensity of agonistic behaviour of pigs. To conclude, it can be assumed that GH pigs in the present study fought less and/or for a shorter period after regrouping at weaning and after rearing in the farrowing pen (Reaf-GH) and had consequently fewer skin lesions than (Conv and Reaf) FF and FC pigs. In weeks 5 and 18, when animals were familiar with each other and their housing conditions, no significant differences between the experimental groups could be detected. Still, the average number of skin lesions on the front body part was rather high. This may be due to the decreasing space allowance, as these time points mark the end of each period (growing, fattening). This is in accordance with findings of Ewbank and Bryant (1972), who showed that the decrease in space increased the occurrence of agonistic behaviour within the pig group. In summary, the present work confirms that the co-mingling of piglets during the suckling period has immediate advantages on the incidence of skin lesions after regrouping at weaning. Nevertheless, early socialisation before weaning had no long-term effect on a second regrouping at fattening (Conv).

4.2 Tail Lesions and Tail Losses

As expected, the docking status had a strong impact on the incidence of tail lesions and tail losses. Although routine tail docking is prohibited in the EU since 1994 (Council Directive 2008/120/EC), it is still one of the most commonly used measures to reduce tail-biting in pigs (Schrøder-Petersen and Simonsen, 2001; EFSA, 2007; European Commission, 2018). However, this is ethically questionable and under discussion in many countries. In the present study, tail losses were primarily observed on the tails of undocked pigs and only to a negligible amount on tails of docked pigs, which is why the latter were excluded from the statistical analysis, as done in other studies, e.g., Abriel and Jais (2013) and Gentz et al. (2020).

Despite the docking status, the interaction of rearing system, docking status and assessment week affected the incidence of tail lesions significantly. According to our hypothesis, undocked animals reared in the farrowing pen had significantly fewer tail lesions than undocked pigs that were regrouped and rehoused for rearing. The weaning process, often accompanied by mixing, is considered as the first major stressful event in a piglet’s life (Weary et al., 2008). Regrouping inevitably leads to hierarchical fights, causing skin injuries and negatively affecting animal welfare (Ewbank and Bryant, 1972; Friend et al., 1983; D’Eath, 2005; Bohnenkamp et al., 2013; Lange et al., 2020). In the present study, undocked piglets reared in the farrowing pen in particular seemed to benefit from the absence of regrouping at weaning. Likewise, a study of Gentz et al. (2020) showed that tail lesions were reduced and remained on a lower level for undocked pigs which were housed under reduced regrouping conditions. Besides the reduced regrouping at weaning, rearing in the farrowing pen and conventional rearing differed in space allowance and group size during the rearing period. As already mentioned, the decrease in space allowance increased the amount of aggressive behaviour of pigs in a study conducted by Ewbank and Bryant (1972). Gentz et al. (2020) also found fewer tail lesions and losses in the housing system with a greater space allowance. These findings can be confirmed by the present study, leading to the assumption that the reduction in the number of external stressors, such as regrouping and space allowance, can reduce the incidence of tail lesions and consequently of tail losses. It remains to be mentioned that the difference in space allowance in Reaf housing results from higher piglet losses, especially in the FF and GH housing systems (Nicolaisen et al., 2019a). Higher piglet loss should not only be considered in welfare matters, but also taken into account in economic considerations. Additionally, the feasibility of rearing in the farrowing pen should be discussed. In short, to practice rearing in the farrowing pen, farmers will need to rethink their housing systems. Rearing pens would become redundant, instead more farrowing pens should be installed to maintain the previous workflow. This might create costs, which then again might be saved through less management measures as, for example, one cleaning step is pared down. More studies, especially from an economic point of view, are needed.

As the third major factor which affected the incidence of tail lesions, the assessment week should be discussed. In the present study, the frequency of tail lesions slightly rose for conventionally reared undocked pigs around week 2, culminating in week 4. For undocked pigs reared in the farrowing pen tail lesions increased in week 5 and culminated in week 6. Generally, it is common for undocked pigs to start tail-biting or the so-called tail-in-mouth behaviour in the first two weeks after weaning (Schrøder-Petersen et al., 2003; Abriel and Jais, 2013; Naya et al., 2018; Gentz et al., 2020). In accordance to the present findings, these studies showed that undocked pigs in enriched environments started to bite later in time compared to conventionally housed undocked pigs. Naya et al. (2018) and other studies also discussed the provision of enrichment material and showed that the offering of organic manipulable material such as straw (EFSA, 2007), peat (Vanheukelom et al., 2011) or straw–peat mixtures (Veit et al., 2016; Naya et al., 2018) influences the behaviour of the piglets positively in terms of less aggressive biting (Vanheukelom et al., 2011) and less tail losses (Veit et al., 2016). Still, all authors state that the sole provision of organic enrichment material over a limited time period cannot eliminate welfare altering behaviour completely.

The farrowing system did not affect the frequency of tail lesions, so it seems that acute housing conditions have a greater impact on tail lesions than former housing conditions during lactation or early socialisation (Abriel and Jais, 2013; Gentz et al., 2020). Still, the farrowing system affected the extent of individual tail loss. Significantly more pigs born in GH suffered from tail loss than pigs born in farrowing crates or free-farrowing pens. Gentz et al. (2020) who examined similar farrowing systems, found no significant but numerical differences between the farrowing systems concerning tail loss. In their study, GH pigs also had more tail losses after rearing period than pigs from the other two farrowing systems. The fact that our results show that GH pigs did not have more tail lesions, but still more tail losses than the other groups might be explained by the type of biting behaviour. On one hand, direct behavioural observations could have brought more details on the individual biting behaviour (Taylor et al., 2010). GH pigs might have bitten each other in a more damaging way than FF and FC pigs. On the other hand, another explanation could be the condensation of the scoring keys for tail lesions and tail losses. Tails of GH pigs were slightly more often scored with severe and very severe tail lesions than tails of FF and FC pigs. In fact, tails of GH pigs were also scored more often with higher tail loss scores than FF and FC pigs, but due to the overall low occurrence of severe tail lesions and large tail losses this could not be presented in the results.

4.3 Performance

The average daily gain in this study was affected by the docking status and the farrowing system. While docked pigs had higher daily gains than undocked pigs during rearing, undocked pigs had higher gains during fattening period. A study of Sinisalo et al. (2012) found significant differences in the ADG between victims and non-victims of tail-biting. Victims of tail-biting gained 33.4 g/d less than non-victims. Pigs in this study were not classified as victims or non-victims, and no data are presented on whether all undocked pigs were bitten at least once. Since tail lesions in the present study occurred with the highest frequency at the end of rearing, it is likely to have many victims of tail-biting in this period. This may explain that undocked pigs had lower ADG during the rearing period than docked pigs. After regrouping for fattening, all animals were housed under similar conditions and undocked pigs obviously managed to overcome the preceding impaired ADG resulting in higher ADG of undocked pigs during fattening period. Sinisalo et al. (2012) stated that there were other more distinct effects on ADG than tail-biting, i.e., sex and breed. Since pigs in the present study belonged to one breed, no breed effect could be examined, but the ADG in the present study differed significantly between females and barrows. This well agrees with findings of Collins et al. (2017) who found higher ADGs in male than in female pigs during the finisher period.

Against our hypothesized expectations of impaired weight gain due to cross-suckling, pigs born in GH had comparably high ADGs during rearing and fattening, irrespective whether docked or undocked. Morgan et al. (2014) found a rather low rate of cross-suckling in their study (average 2.9 % alien piglets on total suckling events) and no housing effect on the weight at weaning of the piglets. In the study of Nicolaisen et al. (2019b), which was conducted in the same project and, therefore, done with partly the same animals as the present study, at least one alien piglet could be detected at a sow's udder in 35 % of all suckling bouts. Still, GH pigs had significantly higher ADG than FC piglets in the present study, especially during rearing. Hessel et al. (2006) who studied co-mingling during lactation also found a tendency of GH pigs to gain more weight. The authors stated that early socialized piglets seem to be better prepared to overcome the usual growth lag after weaning. In the study of Kutzer et al. (2009), piglets born in farrowing crates had significantly lower body weight gain over the first four days after weaning compared to loose-housing and group housing piglets. In accordance to the present study, weight gain was highest in GH piglets and the lowest in FC piglets. In contrast, D'Eath (2005) could not detect differences in growth between treatments following mixing.

4.4 Other Measures

Measures for ear lesions, ear losses, lameness and manure on the body were assessed, but not statistically analysed due to an overall very low occurrence. Lühken et al. (2019) examined air hygiene during suckling period in the same three farrowing systems on the same research farm as described in the present study. In their study, they conclude that FF and GH not only offered better welfare for the sows through free movement, but also acceptable air quality. These findings of good hygiene can be augmented by our findings that the majority of pigs in this study did not show manure on the body, although raised consecutively in the farrowing system.

5. Conclusions

Piglets housed in a group housing system during lactation profited from co-mingling and early socialisation, resulting in lower incidences of skin lesions after regrouping events, especially for a late first regrouping for the fattening period. Piglets born in free-farrowing pens showed only marginal benefits on the examined parameters compared to piglets raised in pens with a farrowing crate. The incidence of tail lesions and losses was mainly affected by the acute housing during rearing and fattening than by the housing system during lactation. The reduced regrouping as part of rearing in the farrowing pen resulted in positive effects on the incidence of tail lesions and losses in undocked pigs. Group housing and rearing in the farrowing pen did not negatively affect the performance during rearing or fattening. Nevertheless, the high piglet mortality during suckling period in the two free-farrowing systems (FF and GH) should be reduced before a clear recommendation can be given.

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Institutional Review Board Statement: The authors declare that the experiment was in accordance with current German law. As such, no part of this research was subject to approval of an ethics committee.

Data Availability Statement: None of the data were deposited in an official repository. The generated and analyzed data sets used in the current study are available from the corresponding author on reasonable request.

Informed Consent Statement: Informed consent was obtained from the manager of the experimental farm (Heiko Janssen) and the assessors (Anita Lange, Michael Hahne).

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Research Article Three:

Old breeds, new solutions? Effects of two different traditional sire breeds on skin lesions, tail lesions, tail losses, performance and behaviour of rearing pigs

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Abstract

Some studies indicated a relation of modern, fast growing, lean meat producing hybrid pigs and the occurrence of tail-biting, one of the major issues of conventional pig husbandry. Therefore, this study investigated the effects of different local, traditional sire breeds on behaviour and performance of rearing pigs. Between December 2019 and November 2020, a total of 1,561 piglets were weaned from hybrid sows (BHZP Landrace x BHZP Large White) that were paired with either Swabian-Hall (SH), Bentheim Black Pied (BB) or BHZP-Piétrain (Pi) boars. Tails of the piglets were left intact (43.5 %) or docked (56.5 %) and male piglets were castrated. Piglets were reared conventionally on fully slatted plastic flooring in mixed-sex groups. Starting one day after weaning, skin lesions were scored once per pig, tail lesions and losses were scored weekly until the end of rearing. The average daily gain was documented for the suckling and rearing period. Activity behaviour of focal pens was analysed using video recordings. Differences between modern and traditional breeds were found in this study for aggressive and non-aggressive biting pronounced by skin and tail lesions and tail losses. Significantly fewer BB pigs had severe skin lesions on the front body than SH or Pi pigs ($p < 0.05$). Also, piglets that were classified as light (< 5.6 kg) at weaning showed skin lesion score 0 more often than piglets that were classified with a medium (≥ 5.6 to ≤ 8.3 kg) or heavy (> 8.3 kg) weaning weight ($p < 0.05$). In the first half of the rearing period, significantly more BB pigs were assessed with no tail lesions and tail losses than SH and Pi pigs ($p < 0.01$). However, these differences disappeared in the second half of rearing. Either docked or undocked, Pi pigs had significantly higher average daily gains than SH and BB pigs ($p < 0.05$). The activity of the focal pens was not influenced by the sire breed or the frequency of tail lesions (LOW vs. HIGH incidence). To conclude, the use of the traditional sire breed BB has the potential to reduce injurious behaviour in the offspring. However, adjustments to the housing and feeding should be taken to further reduce the incidence of tail lesions and losses and to enhance performance.

Keywords: sire line; aggressive behaviour; tail-biting; average daily gain; activity

Implications

Since tail docking in pigs as a measure to avoid tail-biting is banned by EU regulations, this study aimed to evaluate one option to reduce this behavioural disorder by testing whether hybrid pigs of traditional breeds might show less injuring behaviour by obtaining performance standards under conventional housing conditions. The study reports differences in aggressive and non-aggressive biting between modern and traditional hybrid breeds, as significantly fewer piglets from Bentheim Black Pied sires were scored with skin lesions after weaning and tail lesions and losses for the first four weeks of rearing.

1. Introduction

Conventional pig farmers face many challenges, one of which leading to economic losses and tremendous animal welfare impairment triggered by multifactorial causes: tail-biting. Although tail-biting was already addressed as a problem in the 1940s (Schrøder-Petersen and Simonsen, 2001), it is still a common and unsolved issue in modern pig husbandry. Especially the housing of undocked pigs under the minimum standards of the Council Directive 2008/120/EC, further referred to as conventional conditions, seems to be prone to this damaging cannibalistic behaviour (EFSA, 2007). Research showed that weaning age and management (e.g. Schrøder-Petersen and Simonsen, 2001; Naya et al., 2018; Lange et al., 2020), husbandry systems and manipulable materials (e.g. EFSA, 2007; Gentz et al., 2020; Lange et al., 2021), feed and feeding systems (Schrøder-Petersen and Simonsen, 2001), sex (Zonderland et al., 2010) and genetics (e.g. Schrøder-Petersen and Simonsen, 2001; Breuer et al., 2005; Sonoda et al., 2013; Ursinus et al., 2014b) are risk factors for the onset of tail-biting behaviour.

While the original European pig was a lean, long legged creature, bred to suit pannage, the cross-breeding with Asian pig breeds around the 1750s laid the foundation of the modern, high-profit hybrid pig breeds (White, 2011). Due to changing diets and eating habits in the human society, commercial pig breeding programs then again turned former fat and slowly growing pigs soon into a fast growing, lean meat producing pig with a better feed conversion rate by promoting hybrids which are based on few lines of genotypes (White, 2011; Weißmann, 2014). At the same time, the intensification of livestock farming and the frequency of tail-biting started to increase from the 1950s until today (Schrøder-Petersen and Simonsen, 2001).

Differences between breeds were found for behaviours like foraging and exploratory behaviour and aggressive interactions (Sonoda et al., 2013). Prunier et al. (2020) described tail-biting (non-aggressive biting) to derive from unsatisfied natural needs for rooting and foraging behaviour. Aggressive biting is said to occur in cases of rank fights and/or when pigs compete for a limited resource. When competing at the feeding trough, this sudden-forceful biting can be directed towards the tail (Taylor et al., 2010; Prunier et al., 2020). Still, it is unanswered why some pigs in a pen or pens in a batch express tail-biting and other individuals or whole groups don't, while they are housed under exactly the same conditions. Often genetic factors or coping strategy of the pigs and the individual perception of the housing environment are named but not further specified (Prunier et al., 2020). Brunberg et al. (2013) reported an individual genetic difference between tail biters or tail bitten pigs and neutral pigs, that were neither tail bitten or tail biters, in terms of different gene expressions. Breuer et al. (2005) as well as Ursinus et al. (2014) showed that tail-biting was associated within breeds between performance and phenotype: heavy, fast growing but lean pigs had a higher potential for tail-biting than their opposites.

These findings lead to the question whether cross-breeding of modern, high-gain breeds with rather slow-growing, traditional pig breeds could reduce injurious behaviour in the pigs, especially concerning tail-biting and preserve their performance. In the EU, several old breeds can be found which are usually housed under organic conditions (Leenhouwers and Merks, 2013; Čandek-Potokar et al., 2019). As only 1% of commercial pigs in Germany are housed under organic conditions (DESTATIS, 2021), local breeds are often part of a cultural heritage and can be found on the Red list of domestic livestock breeds (Federal Office for Agriculture and Food, 2019). Two of these endangered local breeds in Germany are the Swabian-Hall swine (SH) and the Bentheim Black Pied (BB), both currently on the "observation list" indicating that their population size runs between 200 to 1000 individuals mostly due to a special breeding program. The SH originates southwest Germany (Baden-Württemberg) which is still the main breeding area and resulted from the crossbreeding of Chinese Meishan and local landrace pigs (Petig et al., 2019). Due to its low content of lean meat, this breed had its peak in the 1950s and disappeared almost completely in the following decades. Today, the SH is preserved by the Farmers' Association of Swabian-Hall (BESH), which was founded particularly to save this old breed and find new marketing strategies (Petig et al., 2019; Federal

Office for Agriculture and Food, 2021). Like the SH, the BB pig, a crossbreed of local variations of Landrace pigs (marsh pigs) from northwest Germany (Lower Saxony) and Berkshire and Cornwall pigs, lost economic importance due its low lean meat content (Biermann et al., 2014; Federal Office for Agriculture and Food, 2021). Besides other breeding programs, the Association for the Preservation of the Bentheim Black Pied pig (German: Die Swatbunten – Verein zur Erhaltung des Bunten Bentheimer Schweines e.V.) advises farmers free of charge in the marketing of this traditional breed.

The objective of the present study was to investigate to what extent the use of traditional sire breeds in conventional pig livestock systems influences injurious behaviours and performance of growing piglets. Therefore, the offspring of today's commonly used, "modern" hybrid sows paired with either "modern" Piétrain boars (Pi) or traditional, SH or BB boars were assessed under practical conventional conditions for skin lesions, tail lesions, tail losses, performance and activity behaviour during the rearing period.

2. Material and methods

2.1 Animals and housing

Between December 2019 and November 2020, the study was conducted on a farrow-to-feeder farm in Lower Saxony, Germany. Over three batches, a total of 130 db.Viktoria hybrid sows (BHZP Landrace x BHZP Large White) from the Bundes Hybrid Zucht Programm (BHZP; Ellringen, Germany) were paired with either SH (N = 9), BB (N = 7) or as control with BHZP-Pi (N = 9) boars. The matings were systematically balanced by line, boar and parity, therefore boars were used repeatedly for the three batches. Due to the small population size of both traditional sire breeds, the selection of boars was limited. The boars were bought from multiple small-scale breeders and the chosen boars were neither half nor full siblings. The average daily gain (ADG) of BB pigs is 300 g per day and the lean meat content is around 42 % (Nordschwein e.V., 2018). For SH finishing pigs an ADG of 725 g per day (Čandek-Potokar et al., 2019) and a lean meat content of 52 % (Petig et al., 2019) are reported. In comparison, for the offspring of BHZP-Pi boars, an ADG of 913 g per day and a lean meat content of at least 60 % are reported (BHZP, 2022). The sows and litters were housed in conventional farrowing crates for a suckling period of 26.5 ± 1.5 days. Litter standardization took place sirewise in the first three days after farrowing. During these first three days after birth, male piglets were castrated and tails were left intact (43.5 %) or docked (56.5 %) litterwise using a cautery iron. Due to the limited availability of identically constructed compartments, from a total of 2,087 piglets, 1,561 piglets (Pi = 518; SH = 487; BB = 556) were weaned into the three experimental conventional rearing compartments including eight pens, each equipped with fully slatted plastic flooring (2.4 x 4.0 = 9.6 m²). To exclude an effect of the compartment, one compartment was filled with undocked pigs, the other two with docked pigs alternating from batch to batch. The pens per compartment were assigned to the breeds as followed: batch 1 = 2 Pi, 3 SH, 3 BB pens, batch 2 = 3 Pi, 3 SH, 2 BB pens and batch 3 = 3 Pi, 2 SH, 3 BB. Regardless of the breed, the pigs were reared in equally balanced mixed-sex groups of 24.8 ± 1.6 pigs per pen and received a conventional dry feed diet ad libitum in long troughs (week 1: 13.6 MJ ME/kg; from week 2 until week 8 (end of rearing): 13.2 MJ ME/kg; Rothkötter Mischfutterwerk GmbH, Meppen, Germany). Water was provided in general via four nipple drinkers per pen. Room temperature and ventilation was controlled by a climate computer, starting at 28 °C on the first day after weaning. To monitor the actual temperature and humidity, all pens were equipped with Tinytag Plus 2 TGP-4500 dataloggers (Gemini Data Loggers Ltd, Chichester, West Sussex, UK). The provision of the enrichment materials was managed as follows: in general, each pen was equipped with one chain that held one piece of wood and with additional round troughs which were filled with alfalfa hay once daily directly after weaning until the end of rearing. At the beginning of the second rearing week, one long cotton rope was tied to the pen walls of undocked piglets so that part of the rope would lie on the floor to satisfy rooting behaviour. Throughout the whole rearing period these ropes were renewed immediately when necessary, in particular when they were worn-out and/or too short. When first tail-biting in the pre-injury stage (Schrøder-Petersen & Simonsen, 2001) was observed through visual inspection by the farm staff, all pens were equipped with additional round troughs which were filled with fresh water daily for the rest of the rearing period. As soon as wounds and traces of blood could be detected, a moisture-absorbing hygiene powder (Stalosan® F, Denmark) was applied on the pen as well as on the injured animals and repeated when necessary. Animals that were severely injured and suffered high tail losses (N = 31) were relocated for treatment and rehabilitation, as well as aggressive tail-biters (N = 15). These animals were hence excluded from the study. As tail-biting occurred nonetheless, two novel objects were introduced to the animals in the second batch and three in the third batch, additionally to all manipulable material. In the middle of the rearing period (week 4) of batch 2 and 3, each pen received a pig ball (diameter: 30 cm) which remained in the pens until the end. At the end of rearing (week 7) of batch 2 and 3, each pen received the fruit of a Cucurbitaceae (batch 2: water melon; batch 3: pumpkin). In the beginning of the third batch (week 1), all pens were equipped with jute sacks additionally. After 47.8 ± 0.7 days of rearing, the pigs were rehoused for fattening.

2.2 Recorded traits

2.2.1 Scoring of skin lesions

All weaning pigs (N = 1,561) were assessed by the same person for skin lesions on the day after weaning, following the Welfare Quality® assessment protocol applied to growing and finishing pigs (Welfare Quality®, 2009). Accordingly, no or up to four lesions were scored as 0, five to ten lesions were scored as 1 and more than ten lesions were scored as 2 (for further details see Lange et al., 2020).

2.2.2 Scoring of tail lesions and tail losses

The tails of all pigs were scored individually and weekly during the rearing period (eight assessments) using a German pig scoring key (Deutscher Schweine-Boniturschlüssel, 2017). Intact tails without scratches or bite marks were scored as 0. Minor scratches or small bite marks were scored as 1 (“minor lesion”). Deep, flat lesions were scored as 2 (“severe lesion”) and deep lesions greater than 2 cm were scored as 3 (“very severe lesion”). According to the scoring key, a tail of complete length was scored 0. When a maximum of 1/3 was lost, the tail was scored 1. Score 2 was given when a maximum of 2/3 was lost and score 3 was given when more than 2/3 of the tail was missing. Score 4 was given for a total loss, when only a stump of maximum 1 cm or less was left.

2.2.3 Performance

The individual body weight of all pigs was measured at birth, weaning and at the end of the rearing period. The average daily gain was calculated for the suckling (ADG_S; N = 2,087) and for the rearing period (ADG_R; N = 1,439). To take the weaning weight into account as a fixed effect in the analysis, weaning weights were divided into three classes: light (< 5.6 kg), medium (≥ 5.6 to ≤ 8.3 kg) and heavy (> 8.3 kg).

2.2.4 Video recording of activity behaviour

Preliminary data analyses of the tail lesions revealed pen-individual differences within pigs from the same sire breeds: in the same batch, pens of Pi and/or BB pigs showed different incidences of tail lesions. We examined the distributions of the tail lesion scores for each pen per batch and based on the frequency of the scores, focal pens were classified as "low incidence of tail lesions" (LOW) or "high incidence of tail lesions" (HIGH). For batch 2 and 3 each, one LOW Pi and one LOW BB pen was compared with one HIGH Pi and one HIGH BB pen (N = 8 pens). As pens with SH pigs did not differ as notable as some Pi and BB pens, they were not considered for closer behaviour analysis. For these eight focal pens continuous video recordings were available. The cameras (AXIS M3024-LVE, Axis Communications AB, Lund, Sweden) were placed above the respective pens. Pigs were filmed for 48 hours starting after the first lesion assessment on the afternoon one day after weaning (d1, d2). To investigate any changes in the activity pattern an additional 48h-block was video recorded from day five and six after weaning (d5, d6). To identify varying levels of activity an unsupervised machine learning (ML) approach proposed by Wutke et al. (2020) has been used, which applies a convolutional neural network and a trained classifier. This ML model was trained on resting behavior and estimates the changes in the activity levels between consecutive frames. The resulting output is an unitless activity score based on pixel changes and normalised mean squared error values indicating the activity level for a given video sequence (for further details see Wutke et al., 2020).

2.3 Statistical analysis

Skin lesions occurred mainly at the ears (score 1 = 31.7 %; score 2 = 46.5 %) and front (score 1 = 32.9 %; score 2 = 30.0 %) and to a lesser amount on the middle part (score 1 = 11.7 %; score 2 = 3.5 %), hind-quarters (score 1 = 2.6 %; score 2 = 0.7 %) and legs (score 1 = 0.1 %; score 2 = 0.1 %) (frequencies calculated with the FREQ procedure in SAS® (SAS Institute Inc., Cary, NC, USA)). Therefore, only lesions at the ears and front were included in the statistical analysis.

Due to the moderate occurrence of severe and very severe tail lesions, score 2 and 3 were summarised to score 2 ("severe tail lesions") for the statistical analysis. Also, the tail loss scores were summarised into "intact tail" (score 0), "moderate tail loss" (score 1) and "severe tail loss" (scores 2-4). Since tail lesions and losses in docked pigs did not occur or only to a very low amount (Tail lesion score 1-3: docked = 2.0 %, undocked = 29.8 %; Tail loss score 1-4: docked = 0.1 %, undocked = 31.7 %), only data of undocked pigs were further analysed statistically (N = 600).

The data set of the skin lesion scores, tail lesion scores and tail loss scores were analysed using the statistical language R (R core team, 2016) following the procedure as described by Lange et al. (2020). For all three parameters, a generalised linear model assuming a multinomial distribution was applied. The fixed effects batch (1-3), sire breed (Pi, SH, BB), weaning weight class (light, medium, heavy), sex (female, male), assessment week (1-8), docking status (docked, undocked; only applied on the model for skin lesions) and biologically reasonable interactions were tested, but excluded from the analysis when no significant influence on the model ($p > 0.05$) could be found and the AICC (Akaike's information criterion corrected; Hurvich and Tsai, 1989) and BIC (Bayesian information criterion; Schwarz, 1978) were increased. The fixed effects that were retained in each of the final models (skin lesion scores: batch, sire breed and the weaning weight class; tail lesion scores: batch, sex, assessment week × sire breed; tail loss scores: batch, sex, assessment week × sire breed, weaning weight class) were then tested with vector generalised linear models within the VGAM package in R (Yee, 2015). To perform a Tukey post-hoc comparison on all marginal models, the glht (general linear hypothesis testing) function of the multcomp R-package (Hothorn et al., 2008) was applied. The fitted values of the glht function are shown in the results section.

The data on the average daily gains (ADG_S, ADG_R) were analysed with SAS® 9.4 (SAS Institute Inc., Cary, NC, USA) using the MIXED procedure. All biologically reasonable fixed effects and interactions (batch, docking status, sire breed, sex) were tested and for the ADG_S only the docking status, sire breed and their interaction were retained in the final model. For the ADG_R additionally the batch was added in the model as it showed a significant influence ($p < 0.05$) and decreased the AICC (Hurvich and Tsai, 1989) and BIC (Schwarz, 1978). To factor the individual initial weights of the piglets at the beginning of each period, the birth or the weaning weight was used as a covariable respectively. For the ADG_S the sow and for the ADG_R the pen was added as random effect.

The data of the activity scores were normalised by log transformation and thereafter analysed with the MIXED procedure in SAS® 9.4 (SAS Institute Inc., Cary, NC, USA). From all biologically reasonable effects (batch, sire breed, tail lesion class, day after weaning, time of day), only the batch, day after weaning (d1, d2, d5, d6) and the time (0h-23h) were tested significant. Other effects and their interactions (sire breed, tail lesion class) were tested but not significant and therefore excluded from the model. For both MIXED models, residuals fulfilled requirements to assume variance homogeneity as well as a normal distribution according to visual inspection of residuals. Finally, the significance of differences in the least square means was adapted by the Bonferroni-correction to adjust for multiple comparisons. For readability reasons, results present the log-transformed activity data which were back transformed by the rise of 10 to the power of the estimates.

3. Results

3.1 Skin lesions

In the first 24 hours after weaning, the batch, sire breed and weaning weight class had a significant effect on the incidence of skin lesions on the front and the ears ($p < 0.001$).

On both body parts, severe lesions (score 2) were found significantly less in the second batch than in the first and third batch (front: batch 1 = 32.8 %[a], batch 2 = 27.7 %[b], batch 3 = 31.1 %[a]; ears: batch 1 = 52.9 %[a], batch 2 = 44.2 %[b], batch 3 = 44.8 %[a]; $p < 0.05$ respectively). Significantly fewer pigs with the BB sire breed have been scored with severe skin lesions (score 2) on the front body part ($p < 0.05$; figure 1). On the other hand, the offspring of Pi boars have been scored significantly more often with score 0 (no or minor lesions) on the ears. While 57.5 % of the animals which were classified as “heavy” at weaning were scored with severe skin lesions, only 28.3 % of medium and 10.7 % of light weighing animals had severe skin lesions on the front body. On the ears, three out of four heavy piglets were scored with severe skin lesions (heavy = 74.5 %[a], medium = 44.7 %[b], light = 26.1 %[c]; $p < 0.001$; figure 1).

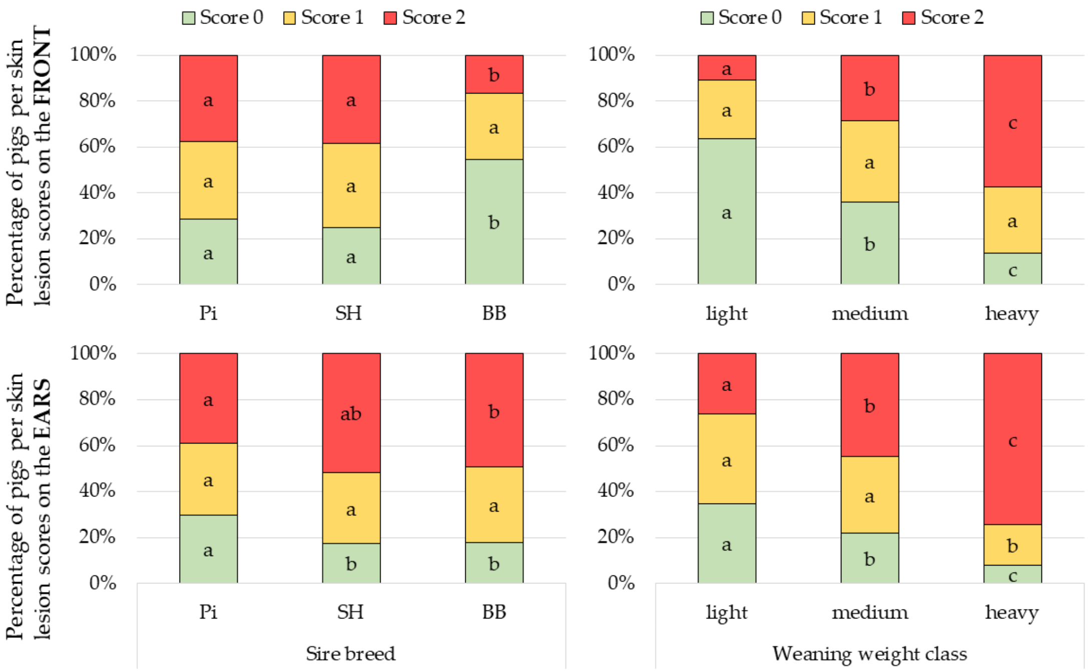

Figure 1. Estimated frequencies (in %) of skin lesions per body part (front, ears) on the first day after weaning in dependence of weaning weight class (light, medium, heavy) and sire breed (Pi: Piétrain sire; SH: Swabian Hall sire; BB: Bentheim Black Pied sire; a-c: different letters indicate significant differences within effect, body part and score level ($p<0.05$)).

3.2 Tail lesions and tail losses

Of in total 600 undocked pigs only 49 pigs had no tail lesion throughout the eight assessment weeks (22 Pi, 4 SH, 23 BB). The incidence of tail lesions was affected significantly by the batch, sex and the interaction of sire breed and assessment week ($p < 0.05$). In the second batch, significantly more pigs were scored with severe tail lesions (batch 1 = 12.0 %^{a}, batch 2 = 20.4 %^{b}, batch 3 = 13.2 %^{a}; $p < 0.05$) while there was no difference in the incidence of "no tail lesion" (batch 1 = 65.8 %^{a}, batch 2 = 61.6 %^{a}, batch 3 = 65.9 %^{a}; $p > 0.1$). No tail lesions were found on 66.6 % of the female and 62.3 % of the male pigs ($p = 0.00138$). Complementarily, significantly fewer female pigs were scored with severe tail lesions than male pigs (female = 13.2 %^{a}, male = 17.1 %^{b}; $p < 0.001$).

On the first assessment after weaning (assessment week 1), no significant differences concerning tail lesions could be found between the different sire breeds (figure 2). Already in week 2, significantly fewer pigs from Pi sires were scored with no tail lesions and more Pi pigs were scored with moderate tail lesions than pigs from both traditional breeds ($p < 0.01$). In the following two weeks (week 3 and 4), pigs from SH sires did not differ anymore from Pi pigs, but significantly more piglets from BB boars were scored with no tail lesions in week 4 than their counterparts ($p < 0.01$). In assessment week 5, significantly more SH offspring was scored with severe tail lesions than Pi pigs ($p < 0.01$) and pigs from BB boars did not differ anymore from the offspring of the two other sire breeds. In the following week (week 6), significantly fewer Pi pigs suffer severe tail lesions than SH and BB pigs ($p < 0.02$). In the last two weeks of rearing (week 7 and 8), no significant differences could be detected between the piglets from different sire breeds.

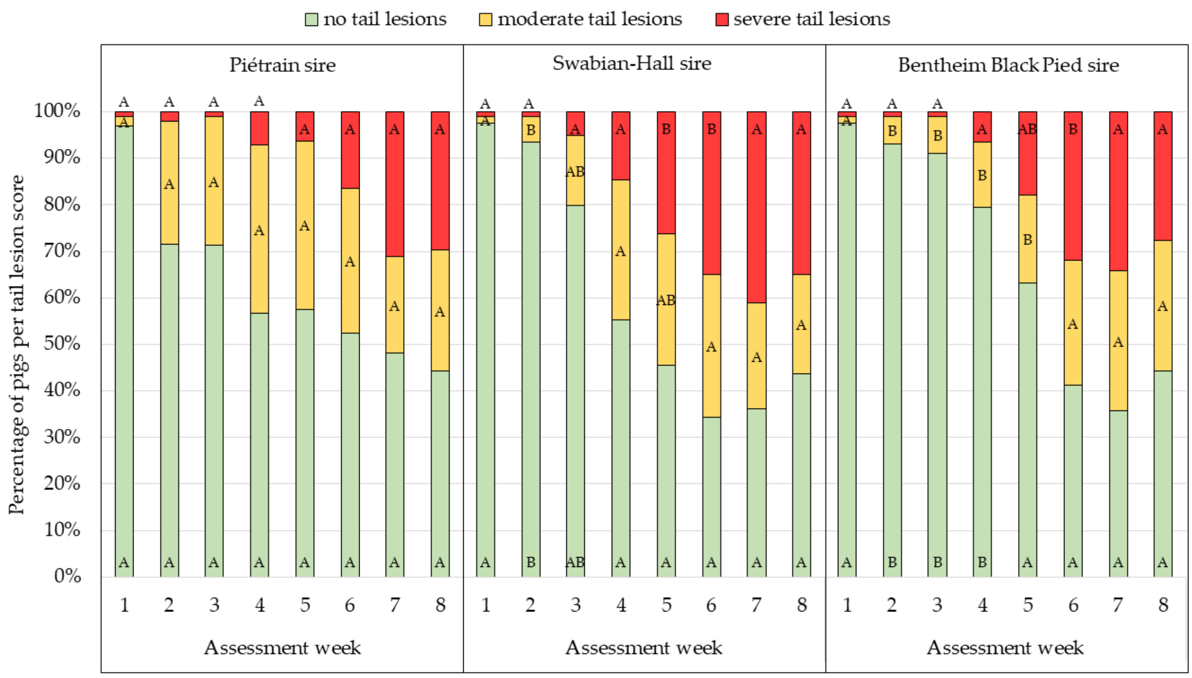

Figure 2. Estimated frequencies (%) of tail lesions per sire breed and assessment week (A-B: different letters indicate significant differences between sire breeds but within assessment week and score level ($p < 0.05$)).

Of all 600 undocked pigs, 32 Pi, 7 SH and 39 BB pigs left the rearing period of 8 weeks with complete tails. Tail losses of undocked pigs were affected significantly by the batch, sex, weaning weight class and the interaction of assessment week and sire breed ($p < 0.001$). In the second batch, significantly more pigs were scored without tail losses (batch 1 = 61.1 %^{a}, batch 2 = 69.3 %^{b}, batch 3 = 57.8 %^{c}; $p < 0.01$) but in the first batch the frequency of severe tail losses was lower than in the respective other two batches (batch 1 = 14.2 %^{a}, batch 2 = 19.1 %^{b}, batch 3 = 20.2 %^{b}; $p < 0.01$). Significantly more female than male pigs were scored without tail losses (male = 61.1 %, female = 64.6 %; $p < 0.003$) and fewer with severe tail losses (male = 20.1 %, female = 15.3 %; $p < 0.001$). Significantly more pigs that were classified as heavy at weaning were scored without tail losses (light = 60.6 %[a], medium= 61.7 %[a], heavy = 68.9 %[b]; $p < 0.001$) and accordingly fewer were scored with severe tail losses (light = 20.0 %[a], medium = 18.5 %[b], heavy = 13.3 %[c]; $p < 0.001$).

For the first three assessment weeks, no significant differences could be found between the pigs from the different sire breeds (figure 3). In assessment week 4, significantly more BB pigs were scored without tail losses and significantly fewer BB pigs suffered moderate tail losses ($p < 0.01$). In week 5 and 6, significantly more SH pigs were scored with severe tail losses than Pi and BB pigs ($p < 0.01$). No significant differences could be found for tail losses in assessment week 7 and 8.

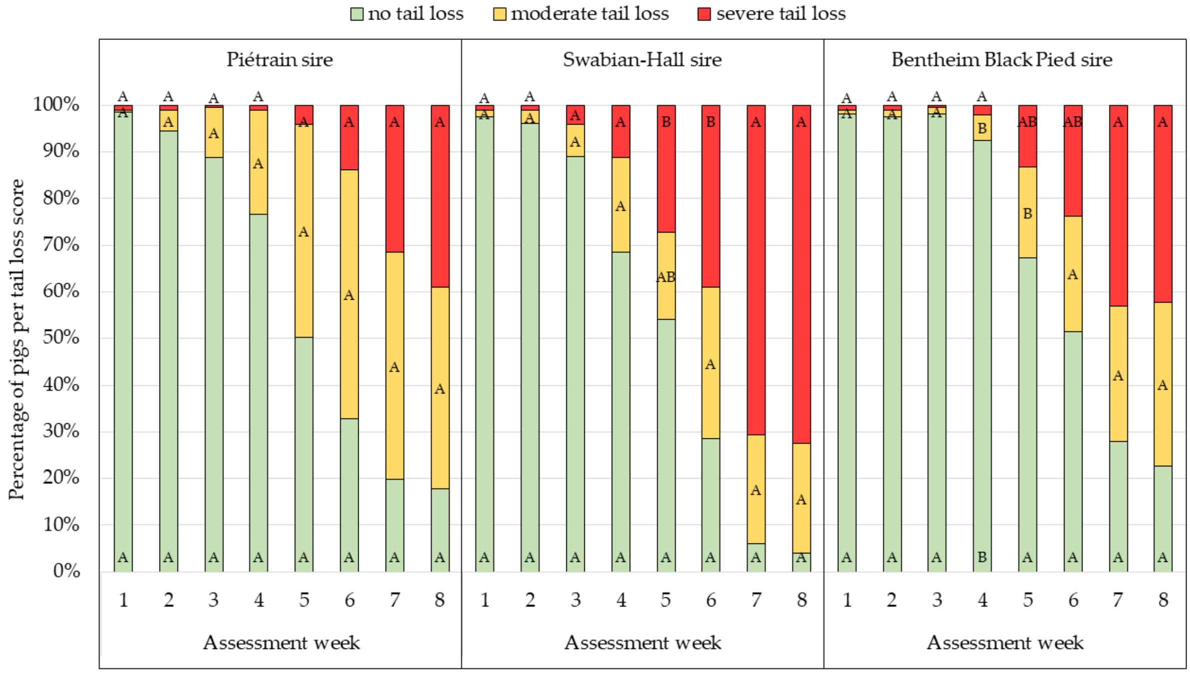

Figure 3. Estimated frequencies (%) of tail losses per sire breed and assessment week (A-B: different letters indicate significant differences between sire breeds but within assessment week and score level ($p < 0.05$)).

3.3 Performance

On average, piglets from SH sires were the heaviest at birth and at weaning (birth weight: Pi = 1.37 ± 0.32 kg, SH = 1.46 ± 0.32 kg, BB = 1.34 ± 0.27 kg; weaning weight: Pi = 6.81 ± 1.31 kg, SH = 7.33 ± 1.34 kg, BB = 6.94 ± 1.27 kg; mean ± standard deviation respectively).

The docking status and the sire breed significantly influenced the ADG during the suckling period. Docked piglets from Pi sires had higher gains than undocked Pi piglets ($p < 0.0002$).

However, docked offspring from SH or BB Pied sires did not differ significantly from their respective undocked counterparts (figure 4).

The ADG during the rearing period was significantly affected by the batch and the interaction of sire breed and docking status ($p < 0.0001$). Pigs from the first batch had significantly higher daily gains than pigs from the second and third batch (batch 1 = 451.7 g/d[a], batch 2 = 375.5 g/d[b], batch 3 = 428.7 g/d[c]; $p < 0.0001$). Within the sire breed, docked pigs gained significantly more daily than the respective undocked pigs ($p < 0.0001$; figure 4). Overall, docked offspring of Pi sires had the highest ADG, followed by undocked Pi pigs. Undocked BB piglets had the lowest ADG compared to the other groups.

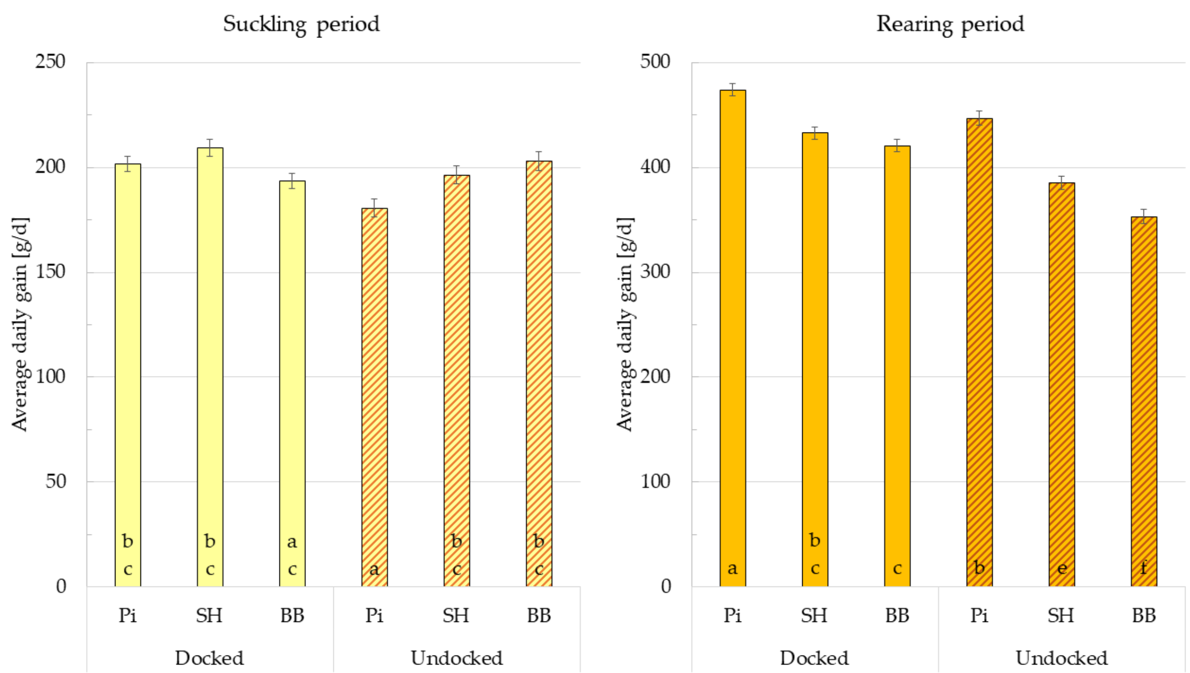

Figure 4. Estimated average daily gain (g/d) during suckling and rearing period for the interaction of sire breed and docking status (Pi: Piétrain sire; SH: Swabian Hall sire; BB: Bentheim Black Pied sire; a–f: different letters indicate significant differences within period ($p<0.05$)).

At the end of rearing period, Pi pigs were on average the heaviest, followed by SH and BB pigs (mean ± standard deviation: Pi = 28.4 ± 5.2 kg, SH = 27.3 ± 4.6 kg, BB = 25.6 ± 4.5 kg).

3.4 Activity behaviour

Only the batch, daytime and the observation day affected the activity score significantly ($p < 0.0001$). The pens in the third batch showed a higher activity than pens in the second batch

(7.10 vs. 12.01; $p < 0.0001$). According to the significant differences between the daytimes, one can identify several time blocks: the night from 20:00 to 03:00, the early morning from 04:00 until 06:00, the day from 07:00 until 16:00 and the evening from 17:00 until 19:00 (figure 5). The lowest activity was observed during the night hours, slowly rising in the early morning, jumping up at 7:00, peaking at 11:00 and 13:00, then descending continuously with a drop after 16:00. While observation day 1, 2 and 6 did not differ significantly, pens showed a significant increase in activity on observation day 5 ($p < 0.0001$).

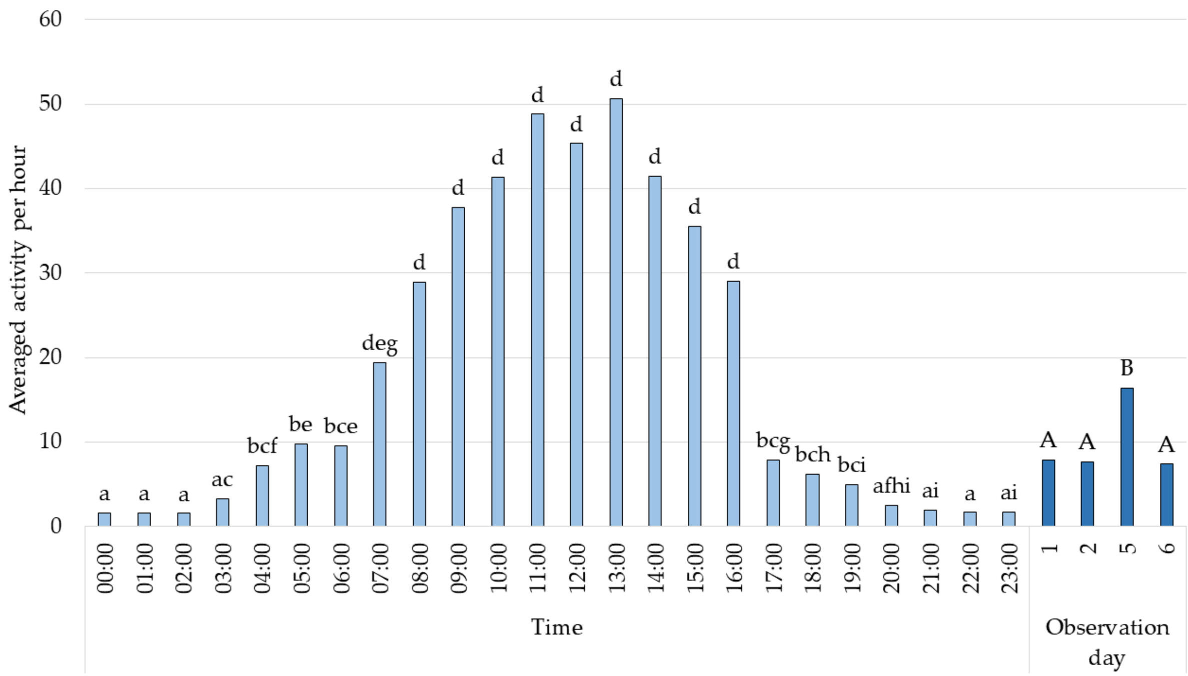

Figure 5. Back transformed least square means of the activity score for the time of day as well as for the observation day (a–i, A-B: different letters indicate significant differences within the effect ($p < 0.05$))

4. Discussion

To our knowledge, no publications are available reporting about the effects of crossbreeding traditional sire breeds with "modern" hybrid sows on the injurious and activity behaviour as well as performance of their undocked offspring, especially under conventional housing conditions. So far, there is no literature available discussing behavioural studies with local, traditional pig breeds.

For this study, we examined the offspring from local sire breeds (Swabian-Hall, Bentheim Black Pied) for skin lesions after weaning, tail lesions and tail losses during rearing as these represents different types of biting behaviours. In their review, Prunier et al. (2020) divided into aggressive and non-aggressive biting. Aggressive biting occurs at rank fights or any biting interaction which is motivated by the formation of a hierarchy. Tail-biting or, as the authors name it, non-aggressive biting is disjointed from hierarchy fights and caused through unsatisfied natural needs like foraging and exploration behaviour. For our research, we studied both – aggressive and non-aggressive biting – by examining the resulting skin and tail lesions and tail losses for three different sire breeds.

Chu et al. (2017) did not differentiate between biting motivation and described European pigs as aggressive in general and concluded that is why their tails need to be docked and teeth have to be clipped. The authors studied behavioural differences of Chinese Mi pigs and European pigs (Landrace x Large White; LLW) and found that fewer Mi pigs had skin lesions than LLW pigs in general and even after a mixing test. They assume a genetic background, as animals were examined at the same age and environment. Bergeron et al. (1996) studied behavioural differences between Yorkshire, Meishan and their crossbreds and found that purebred Yorkshire pigs manipulated chains and drinkers more often than the Chinese pure- and crossbred pigs. In the logic of these results, the Swabian-Hall pigs should have been less aggressive at rank fights after weaning and later on at tail biting as they carry genes of Chinese (Meishan) pigs, but only the opposite could be confirmed. Concerning tail lesions and tail losses SH pigs did not perform better than the control group of Pi pigs. Additionally, SH pigs could not compete concerning the ADG and is therefore overall not suited for the rearing under the described conditions.

Finding differing incidences of tail lesions (and losses) within the same breed and batch, but for different pens directly bordering one another, although they were managed equally, led to our hypothesis that other parameter than time of the year (batch), climate, light, feed, sex, genetics (dam, sire), pen structure, manipulable material, group size, space allowance, handling or hygiene (D'Eath et al., 2014) might decide over the occurrence of tail-biting, like for example individual coping strategies for weaning stress (Lange et al., 2020; Prunier et al., 2020). In the present paper, significantly fewer pigs with BB sires had severe skin lesions on the front body on the first day after weaning than the offspring of Pi and SH sires. Somehow, BB piglets might have fought less injuring, presumably shorter and/or less frequently than their counterparts. Taking this and the comparably late onset of tail-biting into account, one could suggest that piglets from BB boars could adjust better to the challenges of weaning, regrouping and relocation, at least for the first weeks of rearing. At around week four, BB pigs reached their threshold leading to a tail-biting outbreak, until no differences could be detected anymore between the breeds. Veit et al. (2017) interpreted rank order fights as frustrating and competitive and therefore leading to sudden-forceful tail-biting (Taylor et al., 2010). They studied the influence of litterwise weaning and rearing on the incidence of tail lesions and losses but found no preventive effect. On the contrary, the studies of Gentz et al. (2020), Lange et al., 2020 and Lange et al., 2021 found that the reduction of mixing reduced (weaning) stress and consequently the frequencies of tail lesions and tail losses. In the latter study, litterwise rearing even delayed the onset of tail-biting by three weeks and halved the incidence of tail lesions for piglets reared in the farrowing environment. However, the sample size of the presented activity observations of eight pens (400 animals) was quite limited and the observation period possibly to short. Also, it has to be mentioned that the used method to detect pen activity does not differentiate between behaviours and individuals. Although differences between breeds and pens were not statistically significant, there might have been differences in the behaviour patterns, as some activity could have been due to fighting and other due to playing. Direct observation could provide more details on this behalf.

The effect of the batch was tested significant for all models used in the present paper. While fewer pigs of the second batch were scored with severe skin lesions, more pigs were scored with tail lesions and tail losses. As the effects of the sire breed, sex, weight and docking status was already considered in the model, other factors must have impacted the incidence of skin lesions, tail lesions and losses. Although the climatic conditions were controlled automatically, the temperature was increased of around 1.5 °C for the last two weeks of the second batch (data not presented), as these weeks fell into early summer (middle of May until beginning of June). Due to the fact that the second batch was conducted between spring and summer (April-June), the natural lightning might have influenced the behaviour of the pigs additionally (Schrøder-Petersen and Simonsen, 2001). The overall lowest ADG were present in the second batch, which might be explained by the increased incidence of tail lesions and losses (Sinisalo et al., 2012). The increased activity in the third batch, compared to the second batch, might be due to the provision of jute sacks after weaning in the third batch. Although the gradual batchwise increase of enrichment material aimed to decrease painful injurious tail-biting behaviour, it might have influenced the outcomings of this study.

In the present study significantly more female pigs had no tail lesions and consequently no tail losses than male pigs. No homogeneous results can be found in the literature regarding the influence of the sex on tail biting. A study of Lange et al. (2021) found no significant differences between the sexes for tail lesions but for tail losses: 22.1 % of the male and 8.1 % of female pigs had lost part of their tails ($p = 0.0219$). Zonderland et al., (2010) suggested that females perform more tail-biting than males. This might probably explain why females were less affected by tail-biting than males in our study. However, Brunberg et al. (2011) found no significant effect of the sex on received tail bites but females performed significantly more severe tail bites per hour in their study than males. Then again Zonderland et al. (2011) stated that biters were not more often female than they were male. The review of D'Eath et al. (2014) recapitulated these rather inconsistent findings through out literature concerning the relation of sex and tail-biting.

The weaning weight affected the incidence of skin lesions on the first day after weaning as well as tail losses, but not tail lesions. On the first assessment after weaning, significantly fewer light piglets suffered severe skin lesions and were scored 0 than medium and heavy piglets. A study of Lange et al. (2020) also found more heavy piglets with skin lesions on the first assessment after weaning, but found no significant effect of the weaning weight class on the number or the duration of fights. However, Bohnenkamp et al. (2013) found the lowest amount of fights and fighting duration in light piglets and Melotti et al. (2011) reported that pigs with a heavy weaning weight fought longer after regrouping in their study. Taking these reports into account, one could assume that heavy piglets in the present study fought differently from the light ones. Unfortunately, no direct behaviour observations are currently available and should be undertaken in the future. According to tail losses, more heavy pigs were scored with complete tails and more light piglets with severe tail losses, but the incidence of tail lesions was not affected by the weaning weight class. In short: light piglets suffered more severe losses than heavy piglets caused by equal lesions. One explanation could be the scoring key for tail lesions (and tail losses) as it was not fitted to different diameters of tails, but was equal for all sizes of tails. Assuming that tails of light piglets might have been smaller and/or thinner than those of heavy piglets, a deep tail lesion equal to or greater than 2 cm (score 2 and 3) would be proportionally bigger and causing more damage on a tail of a light piglet than on the tail of a heavy piglet.

In accordance with other studies, the average daily gain was significantly affected by the docking status with poorer gains in undocked pigs (Lange et al., 2021) as tail bitten pigs have an impaired weight gain (Sinisalo et al., 2012; Valros and Heinonen, 2015). Another strong effect on the average daily gain remains the breed (Sinisalo et al., 2012). In order to anticipate the expected lower growth rate of a traditional pig breed (Basque) compared to a conventional pig breed (Large White), Lebret et al. (2015) included their Basque pigs three to five months earlier than the Large White pigs so all pigs could be slaughtered at the same weight around the same time. Since differences in growth rates could not be considered in the on-farm management of the current study and all animals were weaned, reared and fed analogously, the Pi piglets performed best concerning the ADG. Lebret et al. (2015) also examined whether the local breed, which is usually housed under alternative conditions (outdoor access, extensive free-range), will perform equally under conventional housing conditions and didn't find differences for e.g. intramuscular fat within breeds. Therefore, one can assume, that the traditional breeds from the present study did perform similarly as they would have in other housing systems. A study of Čandek-Potokar et al. (2019) recorded performance traits of 20 European local pig breeds, like the SH and Black Iberian pig. In accordance with the findings of the present study, SH piglets had by far the highest average daily gains during suckling period (363 g/d). But overall, they found lower average daily gains compared to modern breeds, during rearing and especially during fattening period. They stated that the ADG depended much on the feeding systems and with an ad libitum feed provision, the local pig breeds increased their feed intake. They seem to have a higher ingestion capacity compared to modern breeds (Čandek-Potokar et al., 2019). Čandek-Potokar et al. (2019) concluded that there is a lack of knowledge for feed requirements of traditional pig breeds and for now, it remains unanswered whether the offspring of the traditional boars of the present study would have performed better if the feed composition and amount and/or the length of the rearing period was adjusted to their growth rate.

5. Conclusion

The results of the present study show that the sire breed does influence injurious behaviour in pigs. After weaning and regrouping, significantly fewer BB pigs had severe skin lesions on the front body than SH or Pi pigs. In the first four weeks of rearing, significantly more BB pigs were scored with no tail lesions and tail losses than their counterparts. At the end of the rearing period, no significant differences could be detected between the different breeds for tail lesions and losses. Pi pigs had the highest average daily gain during rearing period, docked or undocked. No significant effect of the sire breed or the tail lesion class could be found on the activity behaviour of the focal pens. Tail-biting remains a multifactorially caused issue, however, this study showed that the (sire) breed should not be neglected in further investigations. In order to combat injurious behaviour, enriched housing conditions and adjusted feeding could enhance the presented breed effect for future studies.

Ethics approval

The authors declare that the experiment was in accordance with current German law and the formal approval was certified by the Head Animal Welfare Officer of the University of Göttingen (no. E7-20).

Data and model availability statement

None of the data were deposited in an official repository. The generated and analysed data sets used in the current study are available from the corresponding author on reasonable request.

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Declaration of interest

None.

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General Discussion

The aim of the present dissertation was to investigate the effects of different housing systems during suckling, rearing and fattening period and of different sire breeds on behaviour and performance of growing and finishing pigs, particularly for pigs with undocked tails. By examining skin lesions, aggressive behaviour and individual serum cortisol differences of piglets 24 hours after weaning, differences in the perception of post-weaning stress could be found for piglets from conventional farrowing pens, free-farrowing pens and group housing of lactating sows and litters. After evaluating these short-term effects, the long-term effects of the three different farrowing environments were studied for growing and finishing pigs that were weaned either to conventional pens or reared litterwise in the farrowing unit. Therefore, skin lesions after weaning, tail lesions and losses during rearing and fattening and the average daily gain for rearing and for fattening period were assessed. Finally, the potential of two different traditional sire breeds on performance and particularly injurious behaviour of rearing pigs was investigated in terms of skin lesions after weaning, tail lesions and losses during rearing period and the average daily gain. Also, the activity behaviour for two time-frames during the first week after weaning was analysed.

Housing during suckling period

Group housing of gestating sows from four weeks after service until one week before the expected farrowing date is already mandatory since 2013 in the EU (Council Directive 2008/120/EC) and since 2021, the permanent fixation of sows, whether gestating or lactating, is banned. In the present dissertation, two alternative farrowing environments, namely the free-farrowing pen and group housing of lactating sows and litters, were compared with farrowing crates. While other studies reported benefits for the piglets from loose-housed sows in terms of the experience of maternal behaviour and a better coping strategy towards weaning stress (Andersen et al., 2005; Oostindjer et al., 2011; Singh et al., 2017; Andersen and Ocepek, 2022), the results of the present dissertation could only detect minor significant and numerical improvements for post-weaning stress or any positive long-term effects for piglets from free-farrowing pens compared to piglets from confined sows. In contrast, piglets from group housing showed less skin lesions after regrouping events, a smaller difference in pre- to post-weaning serum cortisol and less fighting behaviour, but tails of group housing pigs were scored slightly more often with severe and very severe tail lesions than tails of free-farrowing and farrowing crate pigs. Also, tails of group housing pigs were scored more often with higher tail loss scores. In short, group housing of lactating sows and litters reduced short-term weaning stress for the piglets, but could not avert long-term injurious tail-biting behaviour. Although fights to establish a social hierarchy cease within the first days after regrouping (Meese and Ewbank, 1973; Friend et al., 1983; Hoy, 2009; Stukenborg et al., 2011) and tail-biting can persist throughout rearing and fattening period (Schrøder-Petersen and Simonsen, 2001), the main objective should not be a weighing of importance or a compromise but a solution to reduce or extinguish both. In terms of natural behaviours of sows and their offspring, group housing of lactating sows and litters supposedly comes closest to group structures of wild boars (Jensen, 1986; Špinka et al., 2000). Still, wild boar groups naturally are matrilineal, meaning they consist mainly of female family members and the integration of unrelated wild sows into the group has not been observed (Gundlach, 1968; Meynhardt, 1984; Hoy, 2009). In pig husbandry, static small sow groups throughout several farrowing cycles are probably closest to natural group formations, but usually impracticable due to asynchronous pregnancy statuses, less flexibility for the farmer and the given housing capacities (Li and Gonyou, 2013). From the piglet's point of view, a farrowing environment was shown to be beneficial, where sows were single-housed but litters could commingle (D'Eath, 2005). Besides group structure, there is also a need of improvement concerning the number of piglet losses due to crushing, as it was inexcusably high but could at least be lowered by temporary confinement of the sows during the last batch of the first study (Research Article One). Lambertz et al. (2015), Nicolaisen et al. (2019a) and Lohmeier et al. (2020) studied loose-housing farrowing systems with or without temporary crating, and pronounced the importance of the pen design, as well, as Grimberg-Henrici et al. (2019) who examined two sizes of free-farrowing pens and concluded that sows in the bigger pens crushed significantly less piglets than in the smaller pens (7.1 m^2 vs. 8.3 m^2). Andersen and Ocepek (2022) who studied two types of free-farrowing pens, also found more crushed ("overlain") piglets in the smaller pens (7.7 m^2 vs. 8.3 m^2). These findings do somehow conflict the demands of the TierSchNutztV which require even smaller farrowing pens of only 6.5 m^2. Thinking ahead, the pen size is also of important matter when considering rearing in the farrowing pen.

Weaning

All piglets of the present dissertation were weaned abruptly at the age of three to four weeks (TierSchNutztV), despite the knowledge that weaning under (semi-)natural conditions is a slow process that can take up to 17 weeks (Meynhardt, 1984; Jensen, 1986). With increased weaning age the post-weaning feed intake seemed to be higher (Weary et al., 2008), but no beneficial impact of a prolonged suckling period could be found on the onset of tail-biting in rearing piglets (Naya et al., 2018). Nevertheless, the piglets in the study of Naya et al. (2018) were weaned at the age of five weeks, meaning the suckling period was only extended by one week which might have not been enough. Piglets that are housed under organic regulations are weaned at 40 days (almost six weeks) of age and have reportedly less injuries (Lindgren et al., 2014). Still, skin lesions on the udder of single-housed sows increased with increasing age of the suckling piglets and sow welfare should therefore also be considered in this context (Lohmeier et al., 2019). Dudink et al. (2006) could reduce weaning stress in terms of decreased aggression by conditioning the piglets on the arrival of enrichment material. Through the announcement of straw and mixed seeds authors could reduce social conflicts significantly at weaning.

Housing during rearing and fattening period

The rearing in the farrowing pen has been shortly mentioned by Jungbluth et al. (2017) as playing a subordinate role in conventional pig husbandry and with this only little scientific knowledge is available concerning the rearing in the farrowing pen up to now. Especially long-term effects on the relatively late first regrouping for fattening period have not been investigated elsewhere to the authors knowledge. By reducing regrouping and relocation after weaning, the results of the present dissertation showed that rearing in the farrowing unit diminished the incidence of skin lesions after weaning, halved the incidence of tail lesions during rearing and fattening and consequently halved the number of animals with tail losses at the end of fattening. Taking these findings into account, together with the now legally required farrowing pen size of 6.5 m² and the required minimum space allowance for rearing piglets (0.35 m² until 30 kg live weight (TierSchNutztV)), 18 piglets could remain in the farrowing pen for the rearing period. As sows have at best 15-16 functional teats (Hoy, 2012) and breeding led to large litter sizes (Rutherford et al., 2013; Hansen, 2021), probably cross-fostering will be necessary to standardize group sizes. With 15-16 piglets per pen, the space allowance would result in 0.41-0.43 m² per pig. Considering rearing in the farrowing pen until the live weight of 30 kg, this space allowance would also be in accordance with the requirements of the German Animal Welfare Initiative (German: Initiative Tierwohl; ITW), a funding programme which aligns farmers, the meat industry and retailers and where participating farmers are directly compensated by retailers. The ITW implements standards that exceed the demands of the TierSchNutztV, e.g. in terms of space allowance (10% more than legally demanded), natural light, climate, but also training programmes for the farmers. Already 50 % of the marketed pork in Germany is produced under the ITW standards (Initiative Tierwohl, 2022). As farmers do have the urge to improve the welfare of farm animals, but probably are insecure in deciding what to improve first and by how much (Fernandes et al., 2021), rearing in the farrowing pen might be a good opportunity to try out an alternative on a small scale. However, there is currently no scientifically sound knowledge on the feasibility, especially in terms of economic matters, of this alternative rearing method (Federal Office for Agriculture and Food, 2021a). Simply thought, farmers will need to reorganise their management. They will need more farrowing pens which then replace rearing pens. Farmers will save time at weaning in terms of one reduced cleaning step and by omitting the relocation (and probably transportation) of the piglets as only the sow has to be removed. On the other hand, they have to remove the farrowing crate/partition if necessary and piglet troughs need to be installed. There are several alternatives to rearing in the farrowing pen and the ITW standards and the large number of labels in Germany where each stands for specific alternative husbandry conditions, especially for growing and finishing pigs, made it somehow necessary to establish a superordinate grouping tag like "Haltungsform" (Haltungsform, 2022) which gives an overview of the housing conditions behind the different marketing labels. In addition, the German Federal Ministry of Food and Agriculture is currently working on a comparable label that will be nationally obligatory for livestock products, launching with pork earliest at the end of 2022 (Federal Ministry of Food and Agriculture, 2022). There will be five categories for housing conditions. The first and basic stage is the housing under the standards of the TierSchNutztV. The second stage already requires 20 % more space allowance in structured pens, the third stage requires 46 % more space and permanent contact to the outdoor climate, meaning one side of the pen/stable has to be open so that the pigs can perceive sunshine, wind and/or rain. The fourth stage insists on access to outdoor runs and an 86 %

greater space allowance than the minimum standard. The fifth stage equals the standards of the European Council Regulation on Organic Agriculture 2018/848, which not only demands a greater space allowance but also poses requirements to e.g. feed, environmental enrichment, floor conditions and medical treatments (Federal Ministry of Food and Agriculture, 2022). Housing pigs under organic regulations entails the loose-housing of sows during lactation and the offering of enough straw (or other suitable material) for all pigs to lie down comfortably (EU Regulation 2018/848). The offering of straw turned out to be an effective measure against tail-biting (Hunter et al., 2001; Schrøder-Petersen and Simonsen, 2001; D'Eath et al., 2014) which was confirmed under organic housing conditions by Lindgren et al. (2014) who reviewed that organically housed pigs had fewer skin and tail lesions (at slaughter) than conventionally housed pigs. However, only 0.8 % of pigs in Germany were housed in accordance with organic regulations in 2020 (Statistisches Bundesamt, 2021). Löser (2005) names high maintenance and investment costs and unsecure marketing chains amongst others as the main reasons for the low presence of organic pork in Germany. Another concept which exceeds the regulations of the TierSchNutztV but does not fully meet the requirements of organic pork production is the open stable concept by the association for the promotion of keeping pigs in open stables (German: Verein zur Förderung der Offenstallhaltung von Schweinen e.V.). This pig housing concept demands structured pens with outdoor runs, lying areas with straw bedding, a space allowance of 1.5 m² per pig and promotes the successful housing of undocked pigs. During the investigations of rearing in the farrowing pen in the present dissertation the space allowance also exceeded the minimum standards of the TierSchNutztV, partly reaching 1.5 m² per pig, which might have contributed to the decrease in tail lesions and tail losses (Moinard et al., 2003; Gentz et al., 2020). In addition, it would be interesting for future studies to investigate rearing in the farrowing pen with an increased provision of straw which in turn implies partly solid floors, in order to further reduce the incidences of unwanted injurious behaviour. As wean-to-finish systems also showed auspicious impacts on tail-biting behaviour, a combination of both, namely rearing and fattening in the farrowing pen could be promising, but is currently not practicable due to the flooring regulations of the TierSchNutztV (Gentz et al., 2020) and in terms of efficient space utilisation (DeDecker et al., 2005).

Breeding

The assumption has been raised as to whether commercial pig breeding companies were focusing too much on performance traits like lean meat content and by that influencing unwanted abnormal behaviour like tail-biting (Brunberg et al., 2013; D'Eath et al., 2014). With the transformation into fast growing hybrid pigs with an enhanced feed conversion (White, 2011), tail-biting has evolved parallelly to a behavioural disorder from the 1950s until now (Schrøder-Petersen and Simonsen, 2001). Alike tail-biting in pigs, feather pecking in poultry is an abnormal cannibalistic behaviour which is also triggered by multifactorial causes and is leading to impaired welfare and economic loss (Rodenburg et al., 2013). One of these causes is the genetic background of the birds, resulting in so-called low and high feather pecking lines (Rodenburg et al., 2013). Many studies on the relation of behaviour and the pig's breed have been conducted (e.g. Bergeron et al., 1996; Brunberg et al., 2013; Sonoda et al., 2013; Chu et al., 2017), but to the authors' knowledge no publication is available which studied the undocked offspring of traditional sire breeds (Swabian-Hall and Bentheim Black Pied) and "modern" hybrid sows, particularly under conventional housing conditions. The present dissertation found differences in the incidences of skin lesions, tail lesions and losses, and performance between the offspring of Piétrain, Bentheim Black Pied or Swabian-Hall boars. In short, Bentheim Black Pied pigs showed less skin lesions after weaning and fewer tail lesions and losses in the first weeks of rearing compared to Swabian-Hall and Piétrain piglets. However, these significant differences could not last until the end of the rearing period and the "modern" Piétrain piglets performed better in terms of average daily gains during rearing period than both traditional breeds. The investigation of activity behaviour in the first week after weaning showed no differences neither for the chosen breeds nor between the pens with low or high mean tail lesion score levels. For the present dissertation the approach was chosen to use experimental sires (Bentheim Black Pied, Swabian-Hall) but conventional dams (Landrace x Large White). It is widely known that the breeding goals of sows lie in fertility and reproduction performance, while boar breeds are oriented towards performance and meat quality (Wähner, 2012) which was depicted in the performance results of the present dissertation. Adhering to the analogy of feather pecking and tail-biting, Groothuis et al. (2005) reviewed that social experiences of the mother bird, like interactions and/or social density, influenced hormone contents of the eggs and therefore impacted the offspring's post-hatching behaviour. Alike, but in pigs, Beattie et al. (1996) found that the prenatal experiences of the sow influenced the behaviour of the piglets up to the age of 13 weeks. Taking these findings into account, it would have been interesting to examine different traditional dam breeds, instead of or in addition to different sire breeds. However, for Bentheim Black Pied and Swabian-Hall sows rather small litters of 10-11 piglets are reported (Petig et al., 2019; Federal Office for Agriculture and Food, 2021b) compared to 15-16 live born piglets for Landrace x Large White sows (Wähner, 2012; BHZP, 2022). Considering the reported lower average daily gains of the piglets from traditional sires, the smaller litter sizes of traditional dams might be compensated by the use of conventional sires leading to an enhanced performance of the offspring. However, the transition from one sow breed to another is in an on-farm trial practicably impossible, especially with unknown outcomings, and if at all only feasible on a research farm. Still, it was important to investigate the outcomes on a commercial farm, with the aim to deliver knowledge of practicable relevance for farmers.

Applied methods

The data curation for the present dissertation took place on two research farms (Research Article One and Two) and on a commercial farm (Research Article Three). Edwards (2007) reviewed the compromise for welfare assessment between highly controlled systems, like research farms or laboratories, and commercial systems. On a research farm many parameters can be controlled and the farm workers are trained, however, the results of the study might be far from the practice. In on-farm trials many effects might be confounded and the study of single parameters might get difficult. However, the author then concluded that the compromise of both approaches offers the best way to acquire applicable welfare science (Edwards, 2007).

Assessment protocols

In order to assess the skin lesions of piglets after weaning the Welfare Quality® assessment protocol for growing and finishing pigs was used for all three presented studies (Welfare Quality®, 2009). As described in the protocol one side of the pig was inspected from a distance of around 0.5 meters. The body was divided into five parts (ears, front, middle, hind-quarters and legs) and the tail area was not considered in this assessment. The Welfare Quality® assessment protocol insists on counting the scratches and wounds on each part of the body and then scale the scratches and/or wounds down to a three-staged score (a, b, c). The assessment protocol further suggests to summarise the scores for the different body parts into one individual level score per pig and then finally into the herd level score. The purpose of the Welfare Quality® assessment protocol is to produce an overall assessment of animal welfare in the investigated unit (e.g. the farm, the compartment, the herd) by a so-called bottom-up approach through around 30 measure like the assessment for wounds on the body. For the three studies of the present dissertation, the same approach of assessment has been adapted from the Welfare Quality® assessment protocol. Changes have been made in terms of the documentation of lesions. The assessors did not record each scratch, but scored the lesions directly (a, b, c) on-farm for each body-part. However, in this way piglets that were completely free of scratches or wounds were scored with the same score (a) as piglets with up to four scratches on the respective body part. This approach seemed time-saving, but also limited the possibilities of analysis, as no single scratches and wounds could have been evaluated in retrospect. Still, for the second study the assessed skin lesion scores even had to be summarised into a binary trait due to the very low occurrence of severe lesions. Another approach to use the on-farm time more efficiently, could have been to reduce the skin lesion assessment to the front body (ears, front, middle), as already for example Turner et al. (2006) and Stukenborg et al. (2011) reported that these lesions represent aggressive encounters reliably and were only used in the final statistical analysis of each of the three studies. The authors of Welfare Quality® assessment protocol state, that only through training and validation by the Welfare Quality® consortium a reliable application of the protocol is possible. The one to three assessors (A1-A3) of the present dissertation were not officially trained by the consortium. Instead they trained the application of the protocol together and justified each assessment in front of each other and an on-farm test of the inter- and intra-observer reliability showed a strong correlation between assessments (inter-observer reliability: A1:A2=0.81, A1:A3=0.76 and A2:A3=0.82; intra-observer reliability: A1=0.85, A2=0.94, A3=0.73). For all three studies, the skin lesion scores were initially assessed on the day after weaning and after relocation to fattening pens, in other words 24 hours after regrouping and potential fights to establish a social hierarchy. While some studies reported a cease in rank fights within the first 24 hours after regrouping (Meese and Ewbank, 1973; Friend et al., 1983), others investigated fighting behaviour and/or the resulting skin lesions after 40-48 hours after regrouping and found this time point suitable (Bohnenkamp et al., 2013) or even to early as fights had not finished yet (Stukenborg et al., 2011). The results of the three studies showed that most animals were injured already after 24 hours. Also, for all three studies, piglets were examined for skin lesions prior to weaning either by Grimberg-Henrici et al. (2018), Lohmeier et al. (2019) and Nicolaisen et al. (2019) or, like in the third study, directly as part of the study design. Therefore, the amount of skin lesions before weaning was known, considered and discussed. Alike Turner et al. (2006), Stukenborg et al. (2011) and Schrader et al. (2020), the Welfare Quality® assessment protocol offers the same on-farm scoring approach for growing and finishing pigs. As no weight was given to the age or size of the pig, weaning piglets of 5 kg were scored in the same manner as 110 kg fattening pigs, although four scratches on the ear of a piglet presumably mean a greater damage proportionally than on the ear of a grown fattening pig and a differentiation of age, size or weight should be considered in future studies. Tail lesions were assessed using a modified version of the scoring key described by Abriel and Jais (2013) for the second study (Research Article Two) and for the third study (Research Article Three) the German pig scoring key (Deutscher Schweine-Boniturschlüssel, 2017) has been used. In terms of tail lesions, both keys are identical. For the second study, the key by Abriel and Jais (2013) was modified for tail losses: instead of assessing tail losses in thirds, they were assessed in quarters and in addition to the given key, the score "complete loss" was added (no loss, max. ¼ lost, max. ½ lost, max. ¾ lost, complete loss). The German pig scoring key sets out the assessment of tail losses in thirds (no loss, max. ⅓ lost, max. ⅔ lost, more than ⅔ lost, complete loss). For the second study, the scores for tail lesions and tail losses had to be summarised into a binary trait each and for the third study into three-staged scores due to the low occurrence of the high score values. By comparison, the Welfare Quality® assessment protocol provides a rather simple and combined binary scoring key for tail lesions, where the tail gets either score 0 for no lesions or minor lesions and score 2 for fresh blood, swelling or infection on the tail and/or partial tail losses. The Association for Technology and Structures in Agriculture (German: Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V.; KTBL) offered separate keys for tail lesions and tail losses where tail lesions are scored as a binary trait (no lesions/swelling/scabs vs. lesions/swelling/scabs) and tail losses in thirds, but the latter parameter was excluded from the protocol in the latest edition (Schrader et al., 2016, 2020). Both, the Welfare Quality® and the KTBL assessment protocol are practice-oriented guidelines for the on-farm self-assessment by farmers. Honeck et al. (2019) reviewed the vast variability of available scoring keys for tail lesions and losses and stated that the choice of assessment protocol depends very much on the focus of the study and that the extent of observation details must be weighed against time and effort. However, they propose the usage of at best one uniform scoring key as published results would be easier to compare. In terms of scoring interval, the KTBL guidelines propose to assess the tails semi-annually while others scored tails weekly (Statham et al., 2009; Naya et al., 2018; Gentz et al., 2020) or even twice a week (Abriel and Jais, 2013). The tails of the present dissertation were scored weekly and the results peaked at around 70 % of pigs with injured tails. By assessing the tails more often, the response time is presumably shorter to take suitable countermeasures against tail-biting – however, Abriel and Jais (2013) reported higher peaks, namely that all undocked piglets had injured tails and that applied countermeasures worked individually different. Alike the scoring key for skin lesions and as discussed in the third study, the assessment protocols for tail lesions and losses were not adjusted to different sizes and ages of pigs and should probably be reconsidered in the future.

Behavioural observations

With the aim to investigate post-weaning stress for the first study, fighting behaviour during the first 24 hours after regrouping was analysed by four trained observers who examined video recordings manually. Manual video analysis is known to be time consuming and might be influenced by subjective perceptions, while automatic behaviour analysis has the potential to be fast, objective and therefore more efficient (Rushen et al., 2012; Chen et al., 2019). In order to detect differences between pig pens with a low or high mean tail lesion score the activity behaviour during the first week after weaning was analysed automatically by using an unsupervised machine learning approach for Research Article Three. Against expectations, no differences could be found. However, the used approach only estimated the pixel movement between consecutive frames and interpreted these as activity levels, meaning no distinction in different behaviours has been made. Chan et al. (2019) who also automatically analysed video data of pigs, managed to detect aggressive behaviour (head knocking, biting and anti-/parallel pressing) with a high accuracy of 97.5 %, sensitivity of 98.2 %, specificity of 96.7 % and precision of 96.8 %, but not without errors. Still, authors conclude that their approach can be used to detect aggressive behaviour in pigs reliably. However, it is questionable how time saving and cost efficient the automated approach would have been at this time, as the technology is still in development. Alike the behavioural observations for Research Article

One, Chen et al. (2019) could not manage to analyse video recordings from the night time. The authors also reported low ceilings and large pens as the main challenges of gaining a good quality of video data as camera angles should be consistent and not distorted for the different pens. Also, for automated video analysis, special cameras can be required, such as depth cameras and programmes for analysis need to be developed or bought (Rushen et al., 2012). In order to develop programmes, a training and test data set needs to be created by labelling videos manually for the specific behaviour pattern which can be time consuming (Chen et al., 2019; Wutke et al., 2020). Still, when the flaws of the automated video or image evaluation can be further reduced and these models can be implemented regularly, at least in combination with manual approaches, the range of behavioural measures and of course the amount of observed data can be extended in order to assess animal welfare even more accurately. In addition, the observation of other behaviours that reflect the affective state such as pleasure or happiness (Fraser, 2008) might be worthwhile, for instance play behaviour as it is a positive indicator of animal welfare and sensitive to negative conditions (Dudink et al., 2006; Hoy, 2009). However, there are several diverging definitions of play behaviour, sometimes including play fight behaviour which leaves room for misinterpretation (Dudink et al., 2006; Hoy, 2009; Šilerová et al., 2010; Weller et al., 2019). As discussed in Research Article Two and Three, detailed observations of the different types of tail-biting behaviour are missing and could have complemented the research data (Schrøder-Petersen and Simonsen, 2001; Schrøder-Petersen et al., 2003; Taylor et al., 2010). Picking up the analogy of feather pecking, the study of Rodenburg and Koene (2003) for example showed that high feather pecking birds showed more pecking interactions with conspecifics, while low feather pecking birds pecked the environment more often and that this behaviour remains unchanged. Concerning tail-biting, it might be of interest to study potential differences in the explorative behaviour of pigs in pens with low and high mean tail lesion scores. Still, the approach to investigate the activity level seemed promising in order to predict tail-biting and results might have been more conclusive with an increased sample size (Statham et al., 2009; Ursinus et al., 2014; Munsterhjelm et al., 2016).

Conclusion

The present dissertation showed the potential of the housing system during suckling and rearing period as well as of the sire breed for the reduction of injurious behaviour, especially for pigs with undocked tails. The early socialisation of the piglets through group housing during suckling period decreased aggressive interactions and consequently the amount of skin lesions. Litterwise rearing in the farrowing pen without relocation and/or regrouping halved the incidence of tail lesions and tail losses. The combination of suckling and rearing in the group housing system proved to be beneficial for the regrouping at the beginning of fattening period. All without impacting the pigs' expected performance positively or negatively. Still, temporary crating and an increased provision of straw should be considered for future approaches to (further) reduce piglet losses and injurious behaviour. The use of traditional sire breeds showed some promising potential as significantly fewer Bentheim Black Pied pigs had severe skin lesions after weaning and tail lesions and tail losses for the first four weeks of the rearing period compared to Swabian-Hall or Piétrain pigs. However, Swabian-Hall piglets seemed not to be suitable for conventional rearing and the offspring from both traditional sire breeds could not compete with Piétrain pigs considering performance. For future investigations the use of Bentheim Black Pied dams crossed with modern Piétrain boars might preserve the positive behavioural aspects of the traditional breed by enhancing the performance of the piglets and/or the adjustment of the feeding should be considered. Since Bentheim Black Pied sows are successfully housed in free-farrowing pens (under organic conditions), the combination of the three studies – group housing during suckling and rearing of crossbred Bentheim Black Pied pigs – might be able to provide promising results.

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Summary

Conventional pig farmers and more particularly their pigs face many challenges throughout different production stages that can alter the welfare and health of the animals and impair the farmers economy and motivation in the long run. In Germany, all pig production stages are regulated but these regulations are seen increasingly critical by different stakeholders as they outline only minimum husbandry and management standards. On one hand, first amendments of the "Animal Welfare Livestock Husbandry Ordinance" (German: Tierschutz-Nutztierhaltungsverordnung), that for example decrease the duration of continuous confinement of lactating sows or prohibit the castration of piglets without anaesthesia, and on the other hand, the introduction of so-called animal welfare labels for livestock products, show both the willingness by government, trade and customers to improve husbandry conditions but it also increases the urge for substantiating research, as some problems like aggressive interactions at regrouping and tail-biting during rearing and finishing period are still unsolved for conventional housing practices.

The objectives of this dissertation were to investigate the effects of different housing systems during suckling, rearing and finishing period and of different sire breeds on the behaviour and performance of growing and finishing pigs. In particular, the aim was to study whether loose-housing of lactating sows and their litters (single and group housing), reduced regrouping events (single-phased vs. two-phased rearing and/or fattening) or the use of traditional sire lines could improve the well-being of rearing and fattening pigs in terms of reducing skin lesions, tail lesions, tail losses, serum cortisol levels and maintain or at best increase average daily gains, especially for undocked pigs.

Research Article One studied how farrowing and rearing systems affect skin lesions, serum cortisol, and aggressive behaviour as indicators for weaning stress of piglets. Therefore, 3144 piglets were weaned between May 2016 and March 2018 from three different farrowing systems: farrowing crates (FC), single-housing free-farrowing pens (FF), and group housing of lactating sows and litters (GH). After weaning and regrouping, the piglets were moved to conventional rearing pens (conv; 5.7 m^2) or to so-called wean-to-finish pens (w-f; 12.4 m^2). One day after weaning, the piglets' behaviour was observed and the animals were assessed for skin lesions. One week before and one day after weaning the piglets were blood sampled in order to analyse the individual difference in serum cortisol. Significantly more piglets raised in FC and FF had moderate and severe skin lesions than piglets from GH. Also, piglets born in GH showed lower differences in serum cortisol, and fought less and for shorter durations than piglets born in FC and FF. Greater cortisol differences and significantly longer fights could be found in piglets that were weaned into w-f pens compared to piglets in conv pens. The first research study concluded, that group housing during the suckling period reduced the weaning stress for piglets with regard to skin lesions, serum cortisol, and aggressive behaviour. The greater space allowance of wean-to-finish pens showed no benefits concerning the studied parameters compared to the space allowance of conventional rearing pens.

The first research article showed the potential of alternative housing systems for weaning stress, but no long-term effects were investigated, especially in regard to the housing of undocked pigs. The aim of **Research Article Two** was to present practicable alternatives to stressful weaning and tail-docking. Therefore, 1106 pigs were weaned from: conventional farrowing crates (FC), free-farrowing pens (FF), or group housing of lactating sows (GH) into either conventional rearing pens (Conv) or the piglets remained in their farrowing pens for rearing (Reaf). Batchwise, the tails of the pigs were docked or left undocked. For this study, all pigs were relocated and regrouped for the fattening period. Starting one day after weaning, the pigs were assessed weekly for tail lesions and losses and every two weeks during rearing period and every four weeks during fattening period for skin lesions. The average daily gain was calculated separately for the rearing and fattening period. The results showed that significantly less Conv-GH pigs had skin lesions than Conv-FC and Conv-FF pigs after weaning. After the regrouping for fattening, significantly less Reaf-GH pigs had skin lesions than Conv pigs, Reaf-FC and Reaf-FF. While the incidence of tail lesions of undocked Conv pigs reached its peak in week 4 (66.8 %), tail lesions of undocked Reaf pigs reached their maximum (36.2 %) two weeks later. At the end of fattening, almost all of the undocked Conv pigs (99.3 %) and less than half of the undocked Reaf pigs (43.1 %) endured tail loss. To conclude, the group housing of piglets during suckling period reduced the incidence of skin lesions. The incidence of tail lesions and tail losses of undocked pigs could be significantly reduced by rearing in the farrowing pen. Moreover, no housing system affected the performance negatively.

As research article one and two revealed promising effects of the housing systems on the occurrence of injurious behaviour, i.e. on the incidence of skin and tail lesions and tail losses, the focus of **Research Article Three** was then to investigate the potential of different local, traditional sire breeds for the behaviour and performance of rearing pigs. Therefore, hybrid sows (BHZP Landrace x BHZP Large White) were paired with either Swabian-Hall (SH), Bentheim Black Pied (BB) or BHZP-Piétrain (Pi) boars. In total 1561 piglets were weaned of which tails were either left intact (43.5 %) or docked (56.5 %), and all male piglets were castrated. The piglets were housed conventionally on fully slatted plastic floors in mixed-sex groups. Starting on the first day after weaning, skin lesions were scored once and tail lesions and losses were scored weekly until the end of rearing. Also, the average daily gain was calculated for the rearing period and the activity behaviour was analysed for focus pens. The results showed that significantly fewer BB pigs had severe skin lesions on the front body than SH or Pi pigs. Moreover, significantly more BB pigs were assessed with no tail lesions and tail losses for the first four weeks of the rearing period, compared to SH and Pi pigs but these significant differences dissolve in the last four weeks of rearing. However, numerically more SH pigs were scored with moderate and severe tail losses at the end of rearing. In terms of performance, Pi pigs had significantly higher average daily gains than SH and BB pigs, whether docked or undocked. Against previous expectations, no significant effect of the sire breed or mean tail lesion score could be detected on the activity behaviour of the focus pens.

In **conclusion**, the present dissertation could confirm that both, the housing system and the sire breed, have an effect on the behaviour and performance of growing and finishing pigs. The amount and duration of aggressive behaviour and thus the incidences of skin lesions could be decreased by reducing regrouping events at weaning through group housing during the suckling period and/or through litterwise rearing in the farrowing system, all without affecting the piglets' expected performance. This decrease in weaning stress lowered the incidence of tail lesions and tail losses of undocked pigs significantly. Significantly fewer BB pigs had severe skin lesions compared to SH or Pi pigs. Also, significantly more BB pigs were scored without tail lesions and tail losses for the first four weeks of the rearing period. However, piglets from the two traditional sire breeds could not compete with docked and undocked Piétrain pigs in terms of performance which possibly might be compensated by an adjustment of the feeding regime.

Zusammenfassung

Konventionelle Schweinehalter und insbesondere deren Tiere werden im Laufe der verschiedenen Produktionsabschnitte vor einige Herausforderungen gestellt, die das Wohlbefinden und die Gesundheit der Tiere, sowie kurz- und langfristig die Wirtschaftlichkeit und Motivation des Landwirts beeinträchtigen können. In Deutschland werden alle Produktionsphasen, von der Sauenhaltung, über die Ferkelerzeugung bis hin zur Mast, u.a. mit der Tierschutz-Nutztierhaltungsverordnung reguliert, welche aber von verschiedenen Stakeholdern stark kritisiert wird, da sie nur die Mindestanforderungen an Haltung und Management festlegt. Erste Erneuerungen der Verordnung, die beispielsweise die Dauer der Fixierung von Sauen im Ferkelschutzkorb herabsetzen, sowie die Markteinführung von Produktlabeln, zeigen sowohl die Bereitschaft von Bundesregierung, Handel und Konsumenten die Tierhaltungsstandards zu verbessern, als auch die Notwendigkeit für wissenschaftliche Untermauerung und Validierung.

Das **Ziel der vorliegenden Dissertation** war es, die Einflüsse verschiedener Haltungssysteme während Säuge-, Aufzucht- und Mastperiode und von verschiedenen Eberrassen auf Verhalten und Leistung von Aufzucht- und Mastschweinen zu untersuchen. Im engeren Sinne sollte überprüft werden, ob Abferkelsysteme ohne Fixierung der Sau (Freie Abferkelung und Gruppenhaltung laktierender Sauen), reduzierte Umgruppierungen nach Absetzen (einphasige vs. zweiphasige Aufzucht und/oder Mast) oder der Einsatz von traditionellen, lokalen Eberrassen das Auftreten von Hautverletzungen, Schwanzverletzungen und -verlusten und die Serumkortisolwerte verringern können, bei bestenfalls gesteigerten täglichen Zunahmen, insbesondere für die Haltung unkupierter Schweine.

In der **ersten Studie** wurde der Einfluss verschiedener Abferkel- und Aufzuchtvarianten auf den Absetzstress, also das Auftreten von aggressivem Verhalten und Hautverletzungen sowie die Veränderung der Serumkortisolwerte von Absetzferkeln untersucht. Dafür wurden zwischen Mai 2016 und März 2018 insgesamt 3144 Ferkel entweder aus konventionellen Ferkelschutzkörben (FSK), freier Abferkelung (FA) oder aus Gruppenhaltung laktierender Sauen (GH) abgesetzt. Nach dem Absetzen wurden die Ferkel entweder in konventionelle Aufzuchtbuchten (konv; 5,7 m²) oder in sogenannte Wean-to-finish-Buchten (w-f; 12,4 m²) umgestallt. Einen Tag nach dem Absetzen wurden die Ferkel auf Hautverletzungen

untersucht und das Verhalten für 24 Stunden beobachtet. Blutproben zur Bestimmung der individuellen Serumkortisolunterschiede wurden eine Woche vor und einen Tag nach dem Absetzen genommen. Signifikant mehr FSK und FA Ferkel hatten mittel- und hochgradige Hautverletzungen nach dem Absetzen als GH Ferkel. Außerdem wiesen die GH Ferkel geringere Unterschiede bei den Serumkortisolwerten auf, und kämpften nachweislich weniger und kürzer als FSK und FA Schweine. Ferkel, die in die größeren w-f Buchten abgesetzt wurden, hatten größere Differenzen bei den Kortisolwerten und zeigte längere Kämpfe als Ferkel in konv Buchten. Zusammengefasst ergab die erste Studie, dass die Gruppenhaltung, in Hinblick auf Hautverletzungen, Serumkortisol und aggressivem Verhalten während der Säugeperiode den Absetzstress reduzieren konnte. Das höhere Platzangebot der w-f Buchten zeigte in Bezug auf die untersuchten Parameter keine Vorteile gegenüber den konv Buchten.

Die erste Studie zeigte das Potential alternativer Haltungssystems zur Reduktion von Absetzstress, es wurden aber keine Langzeiteffekte untersucht, insbesondere nicht in Bezug auf die Haltung unkupierter Ferkel. Das Ziel der **zweiten Studie** war es also, praktikable Alternativen für das stressfreie Absetzen und Halten langschwänziger Schweine aufzuzeigen. Zu diesem Zwecke wurden zwischen Dezember 2016 und Januar 2018 1106 Ferkel aus FSK, FA oder GH entweder in konventionelle Buchten (Konv) abgesetzt oder sie verblieben für die gesamte Aufzuchtperiode im Abferkelsystem (AiA). Durchgangsweise wurden die Schwänze der Ferkel kupiert oder blieben intakt. Nach der Aufzuchtperiode wurden ausnahmslos alle Ferkel umgruppiert und in konventionelle Mastbuchten verbracht. Beginnend mit dem ersten Tag nach dem Absetzen, wurden die Schweine wöchentlich auf Schwanzverletzungen und -verluste begutachtet. Hautverletzungen wurden in der Aufzucht alle zwei und in der Mastperiode alle vier Wochen festgehalten. Die täglichen Zunahmen wurden jeweils für die Aufzucht- und die Mastperiode berechnet. Die Ergebnisse zeigen, dass signifikant weniger Konv-GH Ferkel Hautverletzungen nach dem Absetzen aufwiesen, als Konv-FSK und konv-FA Ferkel. Nach dem Umgruppieren in den Mastbuchten hatten signifikant weniger AiA-GH Ferkel Hautverletzungen als alle Konv-Varianten, AiA-FSK und AiA-FA Schweine. Während die unkupierten Konv Schweine den Höchststand an Schwanzverletzungen in Aufzuchtwoche 4 erreichten (66,8 %), erreichten AiA Schweine diesen erst zwei Wochen später auf einem niedrigeren Niveau (36,2 %). Am Ende der Mast wiesen 99,3 % der unkupierten Konv Schweine und 43,1 % der AiA Schweine Schwanzverluste auf. Insgesamt zeigte sich also, dass die GH während der Säugeperiode auf das Auftreten von Hautverletzungen nach Umgruppieren reduzieren konnte. Die Häufigkeit und der Schweregrad von Schwanzverletzungen und folglich Schwanzverlusten bei unkupierten Schweinen wurde signifikant durch die Aufzucht im Abferkelsystem gemindert. Zusätzlich wurde die Leistung in keinem der Haltungssysteme nachweislich beeinträchtigt.

Nachdem die erste und zweite Studie vielversprechende Effekte des Haltungssystems auf das Auftreten von verletzendem Verhalten, genauer gesagt auf das Ausmaß von Haut- und Schwanzverletzungen und Schwanzverlusten, aufgezeigt haben, lag der Fokus der **dritten Studie** auf der Untersuchung des potentiellen Einflusses von lokalen, traditionellen Eberrassen auf das Verhalten und die Leistung von Aufzuchtschweinen. Dafür wurden zwischen Dezember 2019 und November 2020 insgesamt 1561 Nachkommen von BHZP-Landrasse x BHZP-Edelschwein Sauen und entweder Schwäbisch Hällischen (SH), Bunte Bentheimer (BB) oder BHZP-Piétrain (Pi) Ebern, abgesetzt. Die Schwänze der Ferkel blieben entweder intakt (43,5 %) oder wurden kupiert (56,5 %) und alle männlichen Ferkel wurden kastriert. Die Aufzucht erfolgte unter konventionellen Bedingungen in gemischtgeschlechtlichen Gruppen. Am ersten Tag nach Absetzen wurden die Hautverletzungen einmal und die Schwanzverletzungen und -verluste fortlaufend wöchentlich bis zum Ende der Aufzucht festgehalten. Zusätzlich wurden die täglichen Zunahmen für die Aufzuchtperiode bestimmt und das Aktivitätsverhalten konnte für Fokus-Buchten analysiert werden. Den Ergebnissen zufolge wiesen signifikant weniger BB Ferkel Hautverletzungen am Vorderkörper auf als SH oder Pi Schweine. Darüber hinaus wurden in den ersten vier Wochen der Aufzuchtperiode, verglichen mit SH und Pi Ferkeln, nachweislich weniger BB Schweine mit Schwanzverletzungen und/oder -verlusten festgestellt. Diese Unterschiede waren in der zweiten Hälfte der Aufzucht nicht mehr signifikant, dennoch wiesen am Ende nummerisch mehr SH Schweine mittel- und hochgradige Schwanzverluste auf. Ungeachtet des Kupierstatus erreichten Pi Ferkel signifikant höhere tägliche Zunahmen, als SH und BB Schweine. Entgegen der Erwartungen, konnte kein signifikanter Effekt der Eberrasse oder des mittleren Schwanzverletzungsscores auf das Aktivitätsverhalten der Fokus-Buchten festgestellt werden.

Basierend auf diesen drei Studien kann geschlussfolgert werden, dass das Haltungssystem und die Eberrasse das Verhalten und die Leistung von Aufzucht- und Mastschweinen beeinflussen kann. Die Anzahl und Dauer von aggressiven Auseinandersetzungen und folglich die Häufigkeit und Schwere von Hautverletzungen wurde durch das Aussparen von Umgruppierungen, wie etwa bei GH und/oder der wurfweisen Aufzucht bei AiA, maßgeblich gesenkt, ohne dabei die Leistung negativ zu beeinträchtigen. Diese Minderung des Absetzstresses verringerte das Auftreten von Schwanzverletzungen und -verlusten signifikant. Signifikant weniger BB Ferkel hatten hochgradige Hautverletzungen verglichen mit SH und Pi Schweinen und zeigten in der ersten Hälfte der Aufzucht auch deutlich weniger Schwanzverletzungen und -verluste. Dennoch konnten die BB Ferkel diesen Vorteil nicht bis zum Ende der Aufzucht aufrechterhalten und bezüglich der Leistung konnten die Kreuzungstieren aus traditionellen Eberrassen nicht mit den Pi Ferkeln konkurrieren. Eine Anpassung der Fütterung könnte niedrigeren täglichen Zunahmen gegebenenfalls ausgleichen.

Eidesstattliche Erklärung

1. Hiermit erkläre ich, dass diese Arbeit weder in gleicher noch in ähnlicher Form bereits anderen Prüfungsbehörden vorgelegen hat.
   Weiter erkläre ich, dass ich mich an keiner anderen Hochschule um einen Doktorgrad beworben habe.

Göttingen, den 30.06.2022 ....

Anita Lange

2. Hiermit erkläre ich eidesstattlich, dass diese Dissertation selbständig und ohne unerlaubte Hilfe angefertigt wurde.

Göttingen, den 30.06.2022 ....

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