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TAIL BITING IN PIGS: IS IT POSSIBLE TO REAR THE HEAVY PIG AVOIDING TAIL DOCKING?

Direttore della Scuola : Ch.mo Prof. Martino Cassandro
Coordinatore d'indirizzo: Ch.ma Prof.ssa Lucia Bailoni
Supervisore :Ch.ma Prof.ssa Flaviana Gottardo

Dottorando : Annalisa Scollo

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Summary

Tail biting in pigs has been identified as a behavioural problem for decades. It has serious consequences for animal welfare and for the income of the farmers The inability to prevent occurrence of this adverse behavior under commercial farm conditions has resulted in the majority of pig producers considering necessary to dock the tails of all piglets as a preventative measure. This management choice, represents both an animal welfare and an ethical issue, as highlighted in the EU Directive 2008/120 on pig welfare which constrains routine tail docking and emphasizes the need to find alternative preventative strategies.

Tail biting prevalence studies have been conducted in most of the UE Countries, but cross-study comparisons appear difficult for the different populations considered. Moreover, most of the data did not concern heavy pig production, with a lack of a complete description of the problem in a prolonged rearing context.

The first step of this thesis was to identify the real prevalence of tail biting in Italy, completing an European picture. Moreover, an epidemiological approach was adopted in order to identify the management and housing factors influencing tail biting in the specific heavy pig rearing context. The study highlighted a low incidence of lesions in Italy (0.15% of affected animals on a sample of 79,780 animals). This could be related to the great percentage, (close to 100%), of docked pigs, but at the same time suggested that rearing heavy pigs in a prolonged fattening cycle does not seems to worsen the risk of tail biting. Furthermore, were identified several risk factors for tail biting on heavy pig commercial farms. Results could be relevant to the pig industry in order to reduce the economical losses due to tail biting, giving emphasis to the respect of animal welfare legislation regarding space allowance, the availability of adequate environmental enrichment and environmental parameters such as ammonia concentration and temperature . Once a causal risk factor has been demonstrated on farm, measures should be taken to minimize the incidence of tail biting, thereby enhancing animal welfare.

A second step was to evaluate the welfare of undocked pigs in the specific heavy pig rearing context, investigating the feasibility to avoid tail docking in a prolonged fattening phase. Gender and the presence of straw were also considered in their effect on tail biting by evaluating welfare indicators such as blood parameters, culling rate, behavior, and

lesions at ears and tail. Further investigations were conducted on mortality rate, causes of death, and the presence of lung lesions and oesophago -gastric ulcer (OGU) at slaughter.

The outcome of the study suggests that the combined use of solid floors, compliance with the parameters established by EU legislation on the protections of pigs in terms of space allowance, environment parameters, and presence of chains and sawdust as enrichments seems to allow the fattening of heavy pigs without performing tail docking with no outbreak of injurious tail biting. Straw therefore seems to be an important tool in both increasing explorative behavior and preventing biting and lesions, particularly in the early stage of fattening. Furthermore, results at slaughter reveal the beneficial effects of straw on the susceptibility to gastric ulcer in the heavy pigs production system, for which very few data are available on this topic. The straw was beneficial, despite the fact that only a relatively small quantity was provided to pigs, allowing management problems due to slurry outflow obstruction or excessive farmer workload to be avoided.

In a further field study , tail biting was evaluated throughout a entire producing cycle of heavy pigs, starting from weaning to slaughter. The aim was to investigate welfare and tail biting outbreaks also in the weaning phase, having available data of individually marked animals during their whole growth. Slatted floor was chosen as the most common floor type used in the heavy pig production, but even recognized as one of the mayor risk factors for tail biting.

The outcome of the weaning phase was that undocked tails could represent an alternative recipient for exploration behavior in weaning pigs, with the consequence of greater incidence of tail lesions. However, seems that the higher level of lesions was related especially to the age. Probably, the social stress related to the progressive reduction of the space allowance due to the increasing size of the growing animals could be a relevant factor in display of tail biting.

During the fattening phase, to avoid tail docking in pigs with a prolonged rearing cycle as for the heavy pig production, seems to provoke the rise of tail lesions. However, this finding, with the combined use of slatted floors, compliance with the parameters established by EU legislation in terms of space allowance and environmental parameters, and presence of chains and straw in a rack as enrichments, seems not associated to the variation of blood parameters and behavior, suggesting an insufficient intensity to cause severe welfare problems. Nevertheless, potential economical losses due to the injured tails should be considered even if not accompanied by evident poor welfare.

Chapter 1

General introduction

INTRODUCTION

Terminology

Tail biting include a wide range of behaviour in pigs, ranging from gentle oral manipulation of the tail to biting that inflicts skin wounds, amputates portions of the tail, and can extend into gouging the rump (Taylor et al., 2010).

Tail biting in pigs has been an identified behavioural problem for decades. It has serious economic consequences for pig producers, and animal welfare implications for both the individual expressing this abnormal behaviour and the victims of the activity. The inability to prevent occurrence of the behaviour reliably under commercial farm conditions has resulted in the majority of large pig enterprises throughout the world considering it necessary to dock the tails of all piglets as a preventative measure. This, in itself, constitutes both an animal welfare and an ethical issue, as highlighted in the EU Directive 2008/120 on pig welfare which constrains routine tail docking and emphasises the need to find alternative preventative strategies.

Because of the widespread adoption of tail docking in recent decades, it is difficult to assess how the prevalence of the problem has changed over time. However, it is widely believed that the problem has become more severe with the growth in popularity of more intensive production systems. Farm reports, epidemiological surveys and controlled experiments all highlight the absence of straw (or other functional environmental enrichment) and high stocking density as significant risk factors (Schroder-Petersen and Simonsen, 2001).

Understanding the true causation of tail biting is difficult because of its sporadic and unpredictable occurrence, which often thwarts formal experimental approaches. Many factors have been associated with the onset of commercial tail biting outbreaks, including diet formulation, environmental discomfort, health problems and excessive competition for resources. Sadly, most case studies lack sufficient detail about the nutritional and environmental circumstances to help build up a comprehensive database for interrogation.

Recent studies, focused on the animals recorded as perpetrators of tail biting, indicate that there is a genetic component to a tail biting predisposition, and that this trait is positively correlated genetically with lean tissue growth rate (Breuer et al., 2005). Such a finding might explain why the problem has apparently become more severe in modern production. However, the very significant role of the environment as a risk factor cannot be ignored. Whilst the role of the early environment in shaping behavioural strategies predisposing tail biting merits further investigation, evidence suggests that the immediate environment exerts much greater effects (Van de Weerd et al., 2005). To avoid a barren environment must therefore be a priority to reduce tail biting risk beyond the multifactiorial causal mechanisms.

Based on Edwards S.A. (2006)

BEHAVIOURAL BACKGROUND

Pigs in natural and semi-natural conditions

Social structure and social behavior. Both Wild Boars and feral pigs are gregarious animals, and the most common group sizes are two to six individuals. Since pigs are prey animals, group living is believed partly to be an anti-predator strategy, which is supported by the way in which vigilance behaviour is adjusted in the presence of conspecifics (Quenette and Gerard 1992).

The gregarious nature is obvious also in domesticated pigs. Within groups, they form stable, inearapproaching hierarchies, based on age and size (Beilharz 1967, Ewbank 1976). Individual recognition is largely based on smell, whereas sight is relatively unimportant once the social order is established (Baldwin 1974, Meese 1975).

Activity pattern and foraging. In a study of domestic pigs in a semi-natural enclosure (Wood-Gush *et al*. 1990), activity was found to be concentrated to some hours in the morning and the late afternoon - early evening, with resting periods in the middle of the day and during nights. Activity is closely related to forage research, and even when fed full rations of commercial feed, domestic pigs anyhow spend 6-8 hours searching for food. Much food searching is performed by rooting, but grazing and browsing are also prominent foraging behaviours. Unpublished detailed studies of the post-feeding behaviour of free-ranging domestic sows has shown that the pigs often spend one to two hours performing elaborate sequences of foraging behaviour.

During the resting period, permanent resting sites are known from feral pigs and wild boars, and these sites are frequently formed into resting nests, by means of the pigs bedding with grass, twigs and other bedding material (Graves 1984). In hot season, pigs show lower activity, and since pigs have very limited sweating and panting abilities, they rely on wallowing for cooling (Baldwin and Ingram 1967).

Exploration. In an omnivorous species such as the pig, some exploration is expected to be closely linked to foraging behaviour. Exploration develops early under natural conditions and constitutes a substantial part of the time budget of free-ranging domestic pigs (Petersen 1994). Pigs may be motivated to explore even if there are no obvious novel stimuli which may elicit the behaviour.

Weaning. In some sense, aspects of weaning start already during the first week of life in free ranging domestic pigs (Jensen *et al*. 1991), but is not finished until the pigs are on average 13-17 weeks, a weaning age that is similar to wild boars (Jensen 1995, Newberry 1985). Weaning in free-range domestic pigs is characterised by a gradual decrease of suckling frequency, increased proportion of piglet-initiated and sow-terminated sucklings, increased pre-massage time and shortened post-massage time and an increased frequency of sucklings performed with the sow standing (Jensen and Recén 1989, Jensen and Stangel 1992).

Social integration/mixing. Under free-range conditions, domestic pigs enter the herd when they are about 10-14 days old, after the farrowing nest has been abandoned (Jensen and Redbo 1987). The weeks thereafter are associated with a high social activity, but little overt fighting, and the social activity stabilizes at about 8 weeks post partum by which time the pigs may be regarded as being integrated in the group (Petersen *et al*. 1989). However, even if the integration process is completed, social bonds between litter mates continue to be stronger than other bonds in the group (Newberry 1988).
The gradual integration process is in sharp contrast to the intense fighting usually going on in practice when pigs are mixed (Fraser and Rushen 1987).

The intensive swine production charachteristics and the behavioral difficulties in coping with the environment

Space allowance. Intensive housing of pigs developed to make efficient use of the available space with considerable reduction of the individual's living space. Great attention must be paid to allow the individual to have a minimum area for its needs and to perform normally activities such as eating, exploring and social interactions (McGlone and Curtis 1985).

Repeated intrusion or long-term loss of the spatial sphere belonging to each pig increases the frequency of aggressive retaliations within the confined group, and more crowded is the pen, higher is the likelihood of intrusion in the personal space. Thus, the crowding concept is crucial in intensive housing. Crowding can be explained as the movement or activity restriction caused by the physical presence of other individuals (Fraser and Broom 1990).

Barren environment. Wood-Gush and Vestergaard (1991) stressed the importance of exploratory behaviour for the welfare of pigs. Their study concluded that enrichments should be provided and especially novel items increase the pigs interest. Grandin and Curtis (1984) found that, in general, destructible materials elicit more attention from young pigs. The role of straw as a substrate to manipulate after restricted feeding in pig housing of low complexity was discussed by von Borell and Hurnik (1991). Pigs that are provided with straw are reported to be more active and exhibit increased rooting and exploratory behaviour when compared to pigs housed on barren pen (Beattie *et al*. 1995). Oral behaviours of pigs in barren environments often become re-directed towards pen fittings and other pigs (McKinnon *et al*. 1989). Therefore, a major function of straw is to provide a stimulus and outlet for rooting and chewing, resulting in a reduction of such activities directed at pen-mates (Fraser *et al*. 1991). Destructive behaviours like tail biting or oral stereotypic activities (i.e. bar biting) are reported to be reduced by straw (Fraser *et al*. 1991; Spoolder *et al*. 1995).

Floor type. Pigs are either kept on slatted or partially-slatted floors of different materials, or on solid surfaces with bedding. From a technical point of view, flooring materials in unbedded systems should have sufficient perforation or slot width to keep the pens clean from faeces. On the other hand, pigs have a need for a high proportion of solid area for their comfort, with small slot width to prevent injuries. Pigs prefer to separate their dunging/activity area from their lying area. Partially-slatted pens with a solid area allow for this behaviour, although solid areas may become dirty if the pen is inadequately designed or other factors like social stress/crowding and climatic factors lead to this problem.

When considering only unbedded floors, the proportion of slatted floor is often reported as a risk factor for tail biting. Approximately twice as much tail biting has been reported to occur on fully slatted floors compared with half-slatted (Madsen, 1980). Ruiterkamp (1985) reported that the frequency of tail biting behaviours was greater in fully slatted than in part slatted or straw bedded pens, and the number of animals lost during the finishing period as a result of cannibalism was correspondingly much higher.

Feeding. Space allowed for feeding, if grouped pigs are fed on ration basis, is important as a potential source of aggression and then poor conversion efficiency (Ewbank and Bryant 1969). Restricted feed intake and increased competition for feed, because of limited access, are generally confounded under group-housing conditions. Both may affect metabolic state, through reduced nutrient intake, and frustration resulting from thwarted feeding motivation.

Social dominance and mixing. In swine a particular form of social dominance hierarchy develops very early, well before full independence of piglets. In fact, a more or less stable "teat order" rises on the day after birth among littermates.

When unacquainted pigs are mixed they engage in ritualised fighting for more than 24 hours to develop a dominance hierarchy. Heetkamp et al. (1995) calculated that after mixing, there is an increase of heat production caused by increased activity in connection with the development of the social hierarchy. Nevertheless, that increase has no long-term effects. Age does not represent an indicator of probability of fighting paired encounters but is correlated with the amount and duration of fighting (Jensen 1994). The hierarchy is usually fairly stable in its organisation within a few days and rather linear (Brouns and Edwards 1994), although it is possible to record frequent changes of rank, particularly among the middle ranks. This fact accounts for the maintenance of a continuous, although minimal, level of aggression among groups even long after grouping.

TAIL BITING BASIS

Tail biting: from a natural behaviour to a redirected behavior

Several ethological hypotheses behind tail biting have been suggested, all based on our current knowledge of abnormal animal behavior. In particular:

- Tail biting is a normal behaviour, which is directed to pen-mates' tails, at low intensity (Newberry & Wood-Gush, 1988). The behavior may occur at extreme high intensity and frequency whenever the pig is distressed, for instance when living in an inappropriate environment.
- Tail biting involves a normal behaviour pattern, such as suckling, exploration, feeding behaviour, social behaviour and sexual behaviour, which becomes redirected (and misdirected) to pen-mates' tails, when there is lack of proper environmental stimulation (Feddes *et al*., 1993).

Redirected exploratory and feeding behavior in a stimulus-deprived environment have been proposed as causes of tail biting. However, it seems that tail biting could develops from a form of 'quiet' exploration. Van Putten (1980) has suggested that the behaviour begins as a mild form of rooting and gnawing "tail in mouth". It is directed at pen-mates where there is lack of materials such as straw, and is often performed when both biter and victim are lying down.

Three different behavioural patterns for the tail biting development

Two-stage tail-biting. Fraser and Broom (1990) described a 'pre-damage stage' and a 'damaging stage'. During the pre-damage (or non-damage) stage, one pig gently holds the tail of another in its mouth and manipulates it causing no visible damage or distress to the recipient. This is tolerated by the recipient pig and is often found when both pigs are lying down or standing still (Schrøder-Petersen et al., 2004). Schrøder-Petersen and Simonsen (2001) state that the pre-damage stage never causes visible trauma to the tail and term it "tail-in-mouth" behaviour (Schrøder-Petersen et al., 2003). This behaviour is considered to be a normal extension of pigs' natural foraging and exploratory behaviour. The transition to the damaging stage is not well documented, but it is generally accepted that at some point (probably during a 'routine' bout of tail-in-mouth behaviour) manipulation may break the skin (Fraser and Broom, 1990; Schrøder-Petersen et al., 2003). Once the tail is bleeding, the problem can rapidly escalate as other pigs are attracted to the tail (Fraser, 1987).

Two-stage tail-biting does not conform to typical patterns of aggressive or fighting behaviour in pigs, which typically culminate in bites inflicted around the shoulder regions as the animals face each other (Jensen, 1980). Furthermore, a work of Hunter et al. (1999) and also Goossens et al. (2008) showed that when tails were shortdocked, ear biting became more likely. Both the tail and ears seem to be convenient appendages on which to chew, but approaches to the pig's head to chew ears are probably more likely to be interpreted as agonistic behaviour and provoke retaliation (Jensen, 1980).

Sudden-forceful tail-biting. A second form of tail-biting is found in papers by Fraser and Broom (1990). Here, a pig's tail is seized and yanked or bitten forcefully, generally without an observed prior period of gentle manipulation. Injuries can be severe following a single instance of sudden-forceful tailbiting, such as removing the tail tip or portions of skin and flesh. Fritschen and Hogg (1983) may be describing this type of tail-biting when they use the term 'cannibalism' to refer to acute, rapid onset tail-biting behaviour as opposed to a background chronic level of tail-biting.

Sudden-forceful tail-biting is more commonly seen when pigs are unable to access a desired resource, such as feeders (Morrison et al., 2007), is more commonly observed when animals are standing or moving around (Fritschen and Hogg, 1983) and could also be considered an aggressive act due to frustration (Widowski, 2002).

Obsessive tail-biting. A third distinctive form of tail-biting behaviour can be described as ‘obsessive tail-biting’, also referred to as ‘fanatical’ tail biting (Beattie et al., 2005; Van de Weerd et al., 2005). Here, a large amount of forceful tail-biting is performed by one or a few individual animals that grab and yank at tails, sometimes removing portions of skin or amputating sections of the tail, as in the sudden-forceful biting behaviour described above. However, this behaviour pattern differs in that obsessive tail-biters appear to be focused or fixated on biting tails, persistently looking for another tail to bite once one has been grabbed. The behaviour is also not necessarily shown in a thwarting context likely to induce a frustration-like state, although a state of frustration might be related to the initial triggering of the behavior, and ‘obsessive tail-biters’ could spent up to 25% of their time biting tails (Beattie et al., 2005; Van de Weerd et al., 2005).

The involvement of obsessive tail-biters in the two previously described forms of tail-biting is unclear; it is possible that some individuals perform sudden-forceful tail-biting to access a resource but find the act of tail-biting more rewarding than accessing the resource. One interesting observation is that individuals that become obsessive tail-biters are likely to have undergone a growth check prior to the behaviour occurring, and may therefore be significantly smaller (Beattie et al., 2005; Van De Weerd et al., 2005; Edwards, 2006).

Development of biting into outbreaks

Once tail-biting has started, the severity of the problem will depend on the intensity of biting behaviour and the number of pigs engaging in the behaviour, and will not necessarily differ between the forms of initial tail-biting. A bleeding, bitten tail often stimulates tail interest and further biting by other pigs in the pen. The speed with which an outbreak develops will be determined by the individual penmates’ attraction to blood (Fraser, 1987) and diet (McIntyre and Edwards, 2002c), as well as the effectiveness of stockmen in identifying and dealing with initial bitten tails. Presence of obsessive tail-biters within a group may also play a large role in the development of tail-biting outbreaks.

Internal risk factors of tail biting

Genetics. In general, traditional commercial breeds such as the Landrace and Yorkshire (Large White) and their crosses are most likely to be associated with tail-biting, but these are also the breeds most likely to be housed in conditions associated with tail-biting. Anecdotally, the white breeds are thought to be more likely to tail-bite than the coloured breeds, with Landrace considered to have the highest risk of tail-biting (Breuer et al., 2005). However, the influence of genetics on tail-biting may be more relevant at line/strain level rather than between breeds, Schrøder-Petersen and Simonsen (2001) concluded that there was no clear pattern of breed on tail-biting.

Gender. Although gender is often raised as a factor affecting the prevalence of tail-biting, there is no clear pattern relating to which gender is most likely to tail-bite or to become tail-bitten (Schrøder-Petersen et al., 2003; Breuer et al., 2003; Moinard et al., 2003;), although there is some consistency in the finding that barrows are more at risk of being bitten. The three proposed causes of tail-biting could contribute to explaining the range of results. Gilts, barrows and entire males differ both in their potential lean tissue growth rate and voluntary feed intake, and therefore have different dietary needs. Where one diet is provided for all animals, this diet will not be optimal for both sexes and the motivation of one group to perform tail biting due to the motivation to forage increase in order to rectify dietary imbalances. Wallgren and Lindahl (1996) suggested that higher levels of biting in all-male groups may be due to their competitiveness for food. Finally, mounting behaviour by heavier males on females can increase lameness in gilts, potentially increasing females' likelihood of becoming tail-bitten as they are less able to avoid the tail-biters. However, there are still insufficient data to conclude whether obsessive tail biters are more likely to be male or female as.

Age and weight. The tail biting behaviour does not occur with the same frequency throughout the pig's life. Simonsen (1995) found that tail biting increases during the finishing period. Haske-Cornelus *et al*. (1979) found in their investigation that tail biting was observed more frequently in 130-day old pigs than in younger animals. Likewise, Sambraus (1985) claims that tail biting is not a common problem before pigs reach an age of 90–120 days. The problems with tail biting seem to occur when the pigs weigh approximately 40–50 kg, which corresponds to the critical tail biting age mentioned above by Haske-Cornelius *et al*. (1979). It could be connected with the fact that gilts are significantly more aggressive at approximately that weight. It has often been suggested that it is the small pigs, which start an outbreak of tail biting because small pigs are often unable to win a fight by normal agonistic behaviour, head to head or shoulder (Fraser & Broom, 1990), they will attack their bigger pen mates from behind (Wallgren and Lindahl, 1996). Overall, the frequency of tail biting seems to increase as the pigs grow older and heavier, but further research should be carried out.

Gastro-intestinal discomfort. Pelleted food and ground (as opposed to rolled) grains are associated with gastric ulcers, which may increase the motivation of pigs to chew and hence increase the risk of two-stage tail-biting. The presence of straw has been shown to lower the prevalence of gastric ulcers in pigs (Amory et al., 2006) and other stomach and intestine disorders (Christensen et al., 1995) as well as lowering prevalence of tail-biting (Scott et al., 2006).

Health status. Higher levels of tail-biting are often reported from herds or individuals in poorer health, with strong links between respiratory disease and tail-biting (Moinard et al., 2003; Kritas and Morrison, 2007), possibly due to a reluctance or inability of ill pigs to avoid tail-biting (Jensen et al., 2004), or to increased rooting behaviour or frustration in animals with discomfort.

Voluntary feed intake, nutrient partitioning and required amino acid balance all change when immune responses are mounted (Whittemore et al., 2003). Pigs in poor health may increase rooting behaviour in an attempt to find their correct nutritional balance, again increasing the risk of two-stage tail-biting. In addition, the required balance of tryptophan relative to lysine is modified, which might specifically modify neurotransmitters mediating behavior (Le Floc'h and Seve, 2007) such as foraging. Poor health is likely to result in a poorer growth rate, creating a range of sizes within the group and making it harder for small individuals to compete for access food, especially if the ratio of pigs to feed spaces is high, so increasing the potential for sudden-forceful tail-biting.

External risks factors of tail biting

Manipulable objects and substrates. A number of authors have shown that pens with enrichments have lower tail-biting or tail manipulation levels than pens without objects or substrates to manipulate, strengthening the argument that tail-biting originates as misdirected foraging behaviour (Fraser et al., 1991; Beattie et al., 2001; Day et al., 2002; Van de Weerd et al., 2005).

The best manipulable objects to prevent the development of tail-biting are ones that provide sustained interest, rather than just initial interest (novelty) that wanes. These tend to be ingestible, destructible, non-particulate and non-rootable (Van de Weerd et al., 2005). Pigs on straw often have a lower prevalence of tail-biting than pigs without straw. Straw combines many of the properties listed above and is therefore a good quality enrichment substrate (Van de Weerd et al., 2005; Scott et al., 2007) as it can keep pigs occupied for longer than manipulable objects. Straw is a more effective form of enrichment when it is replenished daily (Moinard et al., 2003), potentially because it remains novel and clean, and can be beneficial when provided via a dispenser if it cannot be provided directly onto the pen floor (Fraser et al., 1991; Zonderland et al., 2008).

Floor type. Floor type is thought to be a factor leading to tail biting, especially where slatted floors are used (Hansen & Hagelso, 1980). It was also suggested that tail biting started at an earlier age when the pigs were housed on a slatted floor. Böhmer and Hoy (1993) found that the frequency of fights, body massage, and ear and tail biting was higher when pigs were kept on a slatted floor rather than deep litter. The reason why a slatted floor influences tail biting might be the absence of rooting material as discussed earlier. Slatted floors may also cause high concentrations of noxious gases (Van Putten, 1969) and may cause difficulty in maintaining a stable hierarchy on the slippery floor (Hansen & Hagelsø, 1980).

Diet. A suboptimal diet primarily affects two-stage tail-biting due to the strong links between foraging behaviour, diet selection and gut satiety. In wild or feral suids, foraging behaviour is performed in order to obtain an optimal diet but there is evidence in confined pigs that foraging, and therefore misdirected foraging, may occur both when there is a requirement for more food (lack of satiation), or to obtain a specific balance of nutrients (Jensen et al., 1993).

It has often been suggested that low salt levels are responsible for tail-biting (Paul et al., 2007). Salt-seeking is a stress response shown in many animal species because of increased sodium excretion (Denton et al., 1999), suggesting that stressed pigs may increase foraging and hence be at a greater risk of tail-biting. Nutritional imbalance and low-protein diet can also increase foraging activity, explained as the pigs continue to seek feeds to give the correct balance of nutrients (Jensen et al., 1993). McIntyre and Edwards (2002) found a stronger preference for pigs to chew a blood tail model when on a low energy and low tryptophan diet. Imbalances of amino acids have also been linked to tail-biting. Furthermore, growing pigs fed a diet containing the same level of lysine showed more tail-biting than pigs given a phased diet with age-appropriate lysine levels, indicating both deficits and excesses of protein may trigger problems.

Method of food provision. An absence or delay in the arrival of feed could contribute to increased foraging behaviour, likely leading to frustration due to the capacity to anticipate the arrival of feed when meals are provided regularly. Hand-feeding is associated with lower tail-biting prevalence (Moinard et al., 2003), even if unpredictable arrival of food could act as a stressor which increases the risk of oral manipulation of other objects and penmates (Robert et al., 1991). Housing systems with ad lib feeding and multiple feed spaces have been shown to have lower prevalences of tail-biting and other lesions (Moinard et al., 2003). Tying in with this argument, providing food in too many meals per day is thought to increase disturbance in the pen and increases skin lesions and aggression.

Environmental stressors. Changes in environmental conditions, for example, lighting, stray voltage, stockman behaviour, changed feed composition, unpredictable feeding, and disturbance (Robert et al., 1991; Jensen et al., 2004) can challenge homeostatic mechanisms, for example, thermoregulation, and lead to stress responses such as activation of the hypothalamic–pituitary–adrenal (HPA) axis. 'Stress' and stressors appears to play a role in the aetiology of tail-biting perhaps due to an associated increase in restlessness and irritability that could lead to increases in both two-stage and sudden-forceful tail-biting and in the development of obsessive tail-biting.

Space, stocking density and group size. The review by Schrøder-Petersen and Simonsen (2001) and the large-scale survey by Moinard et al. (2003) concluded that tail-biting is associated with high stocking density. Similarly, restricted lying area per pig can induce tail-biting for increased tension within the pen and reduced quality of rest. Pigs may also be more restricted in their movement around the pen, increasing frustration at being unable to reach resources when they wish.

Climatic environment. Temperature, build up of certain gases, humidity, dust, etc. may act as stressors leading to increased discomfort and chronic stress: thermal stress, resulting from temperatures that are higher or lower than the pigs' thermal comfort zone, increases tail-biting (Schrøder-Petersen and Simonsen, 2001). A trend is often found for more tail-biting during autumn and spring. An additional stressor to pigs during these weather patterns will be their effect on the ventilation in the and it is highly probable that tail-biting in pigs will occur under long-term inappropriate humidity and ventilation conditions. Furthermore, environments containing high levels of ammonia and carbon dioxide are aversive to pigs, so keeping them under these conditions will be stressful (Jongman et al., 2000). It may also be presumed that suboptimal levels of temperature, humidity, ammonia, dust etc. can combine to create an aversive environment even when no single factor may be markedly different from acceptable values (Done et al., 2005).

Anatomy and spread of infection

There are three possible routes whereby infection from a tail wound can spread: firstly, the tail has a direct venous drainage, which allows a rapid spread of infection throughout the longitudinal venous sinuses of the vertebral canal. Secondly, the tail wound often involves not only the skin, but also the tail muscles and vertebrae, resulting in abscesses in the adjacent tissue and osteomyelitis in the caudal vertebrae. Infection may spread via the sacral lateral lymph nodes. A third route for spread of infection to be considered is via the cerebrospinal fluid (Huey, 1996). However, this route may be more speculative than the other two because the spinal cord (*filum terminale*) in pigs terminates at the sacral vertebrae.

The risk of infection to other organs will almost always be present in tail-bitten pigs. The wounded tail may become contaminated leading to abscesses of the hindquarters and the posterior segment of the spinal column. Secondary infection may occur in lungs, kidneys and other parts of the body, as a result of pyaemia (Fraser & Broom, 1990). This risk of severe infection due to the many routes and the rapid dispersion throughout the pig's body, emphasizes the importance of preventing the syndrome. It is also important to bear in mind, that even in healthy looking tails, there can be minor inflammatory reactions presumably caused by the chewing activities of pen-mates (Simonsen *et al*., 1991). Further, even mild tail damage restricted to puncture wounds can quite readily set up pyaemia.

Other sequelae to tail biting. Other severe sequelae are reduced weight gain, cannibalism and transmission of disease. Wallgren and Lindahl (1996) found a significant decrease in weight gain in severely tail-bitten pigs. The risk of cannibalism is another important consequence of tail biting. The reason for this is that the bleeding tail often encourages further biting, both from the principal biter and other pigs in the pen (Fraser, 1987). The ultimate result of cannibalism caused by tail biting is death (Van Putten, 1969; Fritschen & Hogg, 1983). A consequence of tail biting not often mentioned, is the transmission of disease between pigs, by ingestion of infected flesh and blood. In a prevalence survey conducted by Cowen *et al*. (1990) it was indicated that tail biting was important in the primary transmission of trichinosis. Additionally, pig-to-pig transmission of *Toxoplasma gondii* may also be possible.

Welfare implications

The behavioural and putative 'psychological' state of tail-biting pigs has been discussed by some authors. Van Putten (1969) suggested that pigs with no straw to root in become restless and redirect their rooting and chewing behaviour to the tails and ears of pen mates. Thwarting access to a preferred substrate or not satisfying the feeding motivation may result in a state of frustration that motivates the redirected behaviour (Schrøder-Petersen and Simonsen, 2001). More generally, many authors suggest that 'stress' may underlie the development of tail-biting behaviour, partly based on observations that tail-biting appears to occur under conditions that seem likely to be stressful (e.g. overcrowding, poor air quality, barren environments, (Schrøder-Petersen and Simonsen 2001; Moinard et al. 2003), and also that animals experiencing an outbreak, and perhaps prior to the outbreak sometimes appear 'restless,' active and agitated. Stress is usually not clearly defined, but the implication is that poor welfare or a negative (affective) state may accompany and perhaps underlie the expression of tail-biting and other forms of abnormal behaviour.

In contrast to the above suggestions that tail-biters may be experiencing some negative state or poor welfare, some researchers have emphasised the 'calm' and 'quiet' nature of tail-in-mouth behaviour that occurs in the absence of obvious clinical damage to the tail (Van Putten, 1980). Schrøder-Petersen et al. (2004) suggested that this form of behaviour may be linked to general exploration of the environment, and particularly social exploration. Manipulation of the tail might therefore also occur in a relatively non-aroused state including in more extensive environments where foraging substrate is available (Newberry and Wood-Gush, 1988) as well as in more barren environments where there is little stimulation (Petersen, 1994). It therefore seems likely that the behaviour and psychological state of tail-chewing or tailbiting pigs may vary according to situation. Low level and non-damaging chewing behavior may be performed by pigs that are relatively calm, but also by those that are experiencing some level of stress or frustration. When tails are damaged and blood is present, motivation to investigate tails may increase amongst previously uninterested pigs and lead to intense and focused biting behaviour perhaps driven by an attraction to blood (Fraser, 1987).

Chewing or biting that leads to damage to the tail such as breaking of the skin, may result in irritation or pain, an increase in tail movement and avoidance behaviour (Schrøder-Petersen and Simonsen, 2001). Pigs with open tail wounds may be reluctant to eat, as standing at the feeder exposes the tail to further attacks. Severe tail wounds may lead to loss of blood, weakness and lack of appetite. In these cases, the animals are likely to be in a state of pain or distress and anxiety, with consequent poor welfare.

CURRENT SITUATION ON TAIL BITING

Under-reporting of tail-biting: abattoir and farm studies

Abattoirs provide the largest access point for data on health status of pigs including the prevalence of tail-bitten animals, but only on the animals they receive. Severely tail-bitten pigs will be culled or may die on farm and will not be put through the abattoir system (Penny et al., 1972). Furthermore, abattoir records are likely to under-record tail-biting in animals that are received, often recording only the more severe cases (Taylor et al., 2010); also, healed tail wounds are rarely assessed and may be indistinguishable from docked tails.

Abattoir data can provide information linking tail-biting to gender, season, tail docking status, other carcass damage (Widowski, 2002) but are limited in scope for detailed identification of the factors contributing to tail-biting on the farm. For this, additional information on-farm are needed, but these data are rarely combined into a true national picture. Prevalence recorded on-farm can give a more complete picture of pigs involved in tail-biting and the conditions under which they are kept.

Recorded prevalence and losses

The incidence of tail biting in European countries has been prevalently estimated by monitoring of tail damage on carcasses at the abattoir. This offers the advantage of simple and rapid monitoring of animals from many farms, but will underestimate the real prevalence of tail biting. Data collected as part of routine national meat hygiene monitoring schemes suggest lower prevalence than recorded in specific experimental investigations.

A summary of published information (Table 1), suggests that in docked pigs the prevalence of pigs with any signs of tail lesion at the abattoir is ~3%, with 0.5-1% fresh injury and infection. In undocked pigs the prevalence of lesions is higher at 6-10%, with up to 30% damaged tails reported in a Finnish study (Valros et al., 2004), with 2-3% severe

Location of study	Level of data collection	Percentage or number of tail-bitten pigs	Prevalence level[a]	Number of pigs in study	Reference
Abattoir Sweden	Routine	1-2 %	Pig	Swedish national herd	Holmgren and Lundeheim (2004)
Farm Sweden	Animal health service	2.7 %	Pig	233 fattening barns	Holmgren and Lundeheim (2004)
Farm England	Veterinary inspection	1.2 %	Pig	4000,000	NADIS (2007)
Abattoir England	Veterinary inspection	0.39 %	Pig	43,000	A. Knowles (personal communication); BPHS data
Farm Denmark	Clinical exam	Mean 1.2 %	Pig	151,000	Busch et al. (2004)
Abattoir Denmark	Meat inspection data	Mean 0.62 %	Pig	151,000	Busch et al. (2004)
Farm Denmark	Scientific study	1.26 %	Pig	154,347	Petersen et al. (2008)
Farm England	Postal survey	66%	Farm	46 farms over previous year	Chambers et al. (1995)
Abattoir England	Scientific study	4.27 %	Pig	62,971	Hunter et al. (1999)
Farm Belgium	Scientific study	2.12 %	Pig	38,59	Smulders et al. (2008)
Farm Belgium	Scientific study	14.3 %	Pen	38,559	Smulders et al. (2008)
Abattoir Sweden	Routine abattoir inspection	1.9 %	Pig	15,914	Keeling and Larsen (2004)
Abattoir Sweden	Scientific unit	6.2 % and 7.2 %	Pig	7682 + 8232 (15,914)	Keeling and Larsen (2004)
Abattoir Finland	Scientific study	34.6 %	Pig	10,852	Valros et al. (2004)
Abattoir England	Routine abattoir inspection	2 tail-bitten, 49 fine	Pig	Sample of 51	P.T.E. Statham (unpublished data)
Farm England	Scientific study	16 severily tail-bitten, 33 mildly tail-bitten	Pig	Sample of 51	P.T.E. Statham (unpublished data)

Table 1. *Differences between tail-biting prevalence depending on location of study and level of tail inspection (Taylor et al., 2010).*

[a] Pig level prevalence means that for every 100 pigs inspected x were tail bitten; pen level means that for every 100 pens inspected x contained tail bitten pigs. Rows with matching superscript letters indicate comparable data sets, for example pigs from the same population scored by different observers or using different methodologies.

damage and infection. There is only limited information on the relationship between abattoir prevalence and on-farm prevalence of damaged tails.

Estimates of the prevalence of farms experiencing tail biting, and the prevalence of injured pigs on farm, are less frequent. The review of Taylor et al. (2010) suggests that 30-70% of farms have some degree of problem, with estimates of the prevalence of injured tails on farm varying widely but of the order of 1-5%.

Moinard et al. (2003) reported that in 1999 in British farms, the estimated financial loss due to tail biting was 3.5 million pounds. These losses are due to reduced weight gain, on-farm veterinary treatment and culling, and condemnation of carcasses at slaughter (Penny and Hill, 1974).

The EFSA tail biting survey

In the context of a data collection performed by the European Food Safety Authority in order to develop the Scientific Report annexed to the EFSA Journal (2007), missing data on tail biting were directly collected through a survey among the Member States .

EU Country	Percentage of tail bitten pigs	Data source
Austria	30 of farms with bitten pigs; 20 to 30 of bitten pigs in those affected farms	Survey non available-Expert Opinion
Belgium	2-5	Survey non available-Expert Opinion
Cyprus	1-2	Survey non available-Expert Opinion
Denmark	1.2 to 3.1	Busch et al. (2004); Bonde et al. (2006)
England	0.9	NADIS (2006)
Estonia	1	Survey non available-Expert Opinion
Finland	< 5 (up to 30 for the whole life span, considering minor lesions)	Survey non available-Expert Opinion
France	n.a.	Survey non available
Germany	n.a.	Survey non available
Greece	n.a.	Survey non available
Rep. of Ireland	3	Survey non available-Expert Opinion
Italy	n.a.	Survey non available
Latvia	50 (mainly in big, intensive standard commercial farms)	Survey non available-Expert Opinion
Lithuania	n.a.	Survey non available
Netherlands	1	Survey non available-Expert Opinion
Portugal	5-50	Survey non available-Expert Opinion
Slovenia	<1	Survey non available-Expert Opinion
Spain	n.a.	Survey non available
Sweden	1.3-1.5	Survey non available-Expert Opinion
Non-UE Contry	**Percentage of tail bitten pigs**	**Data source**
Norway	1-2	Survey non available-Expert Opinion
Switzerland	0.6 to 1.6	Schnider (2002)

Table 2. *Percentage of tail biting in surveyed countries (EFSA, 2007).*

n.a. = data not available

considering expert opinion and scientific works on-farm. Percentage of tail biting in surveyed countries are reported in Table 2. It is important to note the complete absence of data on the Italian situation.

Results from abattoir monitoring

Data on abattoir monitoring were collected for the Scientific Report EFSA (2007). In most of the surveyed countries (Austria, Cyprus, France, Germany, Greece, Italy, Latvia, Lithuania, Portugal, Slovenia, Spain, Switzerland) neither routine records of tail biting condemnations nor recent national surveys of tail bitten carcasses at abattoir were reported. Data collected from abattoirs showed the distribution and the impact of tail biting condemnations. Again, a lack of data about Italian situation.

- **Belgium**: data exist only for quality label products. Tail biting: <1%.
- **Estonia**: condemned carcasses due to tail lesions: 1-1.3%, only in docked pigs.
- **Finland**: overall percentage of condemned carcasses: 0.67%-2.13%. Considering abscesses as relevant indicators for earlier and healed lesions, the estimation for overall percentage was <5%.
- **Ireland**: carcasses with tail lesions: 0.8%. Almost all partial and 40% of total condemnations were due to tail lesions in either undocked or docked, but with long stump pigs.
- **Netherlands**: overall percentage of condemned carcasses: 0.1%.
- **Norway**: overall percentage of tail biting condemnations: 0.5% and no case was reported for docked pigs.

For some other countries, abattoir surveillance programs were reported as following:

- **Denmark**: recording of condemnation and tail lesions is performed at abattoir, but specification on causes of condemnation is not routinely given. Bonde et al., (2006) reported an overall of 0.9-1.0% pigs (2001-2003) and 1.2-1.4% pigs (2004-2006); these results led to an increased focus on tail lesions/infections at the Danish abattoirs from 2004. Particularly, in 2004 the survey indicate a percentage of 1.4 docked pigs and of 1.06 % undocked organic pigs.
- **England**: the causes of condemnations are not routinely traceable. Meat Hygiene Service statistics for 2005 indicated a percentage of 0.19 of carcasses condemned for pyaemia. Hunter et al., (1999) indicated that the 2.4% of docked pigs showed healed or mild wounds, 0.6% was chewed without swelling and 0.1% inflammation/infection; the 6.9% of undocked pigs had healed or mild lesions, 1.8% showed no swelling and 0.5% inflammation/infection.
- **Sweden:** tail biting condemnations at abattoirs are routinely recorded. The percentage of carcasses condemned due to tail lesion was 7-8% of those recorded with tail biting (0.1 % of total). National surveys of tail bitten carcasses at abattoirs reported a percentage of pigs with signs of tail biting of 1.4%.

Current practices to prevent tail biting: the tail docking

The practice of tail docking on farms has increased as a result of increased tail biting problems following intensification of pig production and the adoption/generalization of slatted floor. Nowadays, the percentage of piglets that are docked varies probably with the housing system and the legislation (Fig. 1).

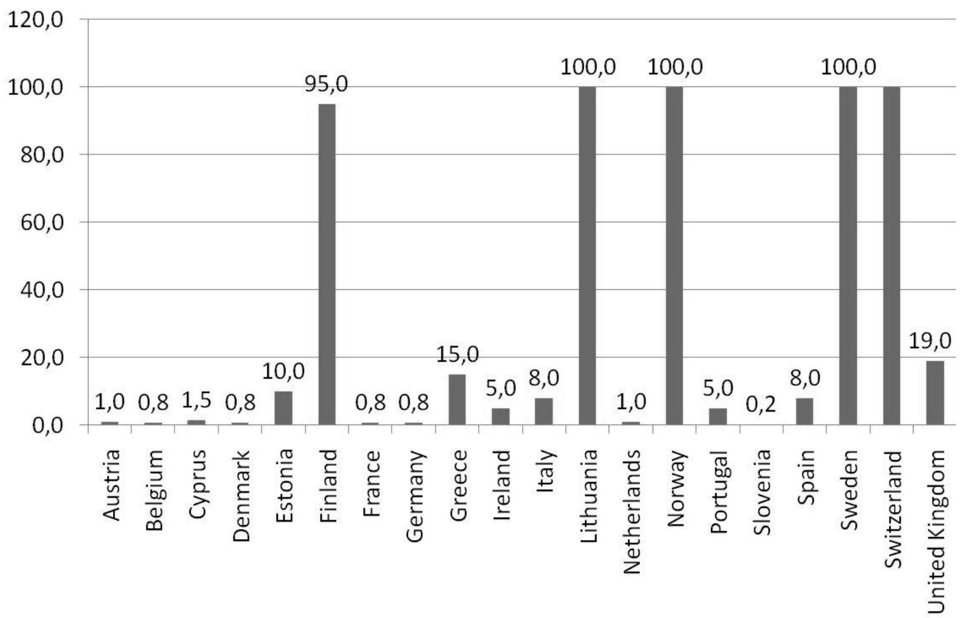

Figure 1. *Percentage of undocked pigs in surveyed countries (EFSA, 2007).*

Tail docking is usually performed by the farmer or his employees within a few days after birth. It is carried out with scalpels, scissors/wire cutters or by cautery with a hot iron. As a general rule, no anaesthetic or analgesic treatments are performed to reduce the pain. When scissors or wire cutters are used, they are usually dipped in an antiseptic for disinfection but usually no antiseptic is applied on the tail before or after docking. The length of the tail that is removed by docking is variable: from only the tip of the tail to up to ¾ of the tail, or more.

Welfare and health consequences of tail docking

Docking itself is likely to be a source of pain since the tail is innervated already in neonatal pigs (Simonsen et al., 1991). Behaviour confirmed that docking the tail probably induces pain (Prunier et al., 2001). However, time to first suckling and main time-budget during the 12 hours following docking were similar in docked and control piglets (Prunier et al., 2001), and none changes in plasma profiles of cortisol and ACTH were observed

(Prunier et al., 2005). This suggests that painful stimuli due to tail docking are not sufficient to elicit a physiological stress response.

In addition to acute pain, docked pigs may suffer from long-term pain as described in humans after amputation (Jensen and Rasmussen, 1997), such as phantom limb pain that is any painful sensations referred to the absent limb, and pain localized to the stump. In docked pigs, during and after the process of repair, Simonsen et al (1991) and Done et al (2003) observed the presence of neuromas (random proliferation of axons and glial support cells) that are known to be very sensitive in other species and have been associated with stump pain in humans with amputated limbs. Therefore, the tail stump of docked pigs might be sensitive to touching.

The tissue lesion due to tail docking may constitute a route for bacterial entry and hence favour local or systemic infection but experimental evidence regarding this possible consequence is scarce.

EU legislation

Current EU legislation (Council Directive 2008/120/EC) authorizes pig producers to perform tail docking but with some limitation that theoretically leads to ban docking on a routine basis.

Council Directive 2008/120/EC

All procedures intended as an intervention carried out for other than therapeutic or diagnostic purposes or for the identification of the pigs in accordance with relevant legislation and resulting in damage to or the loss of a sensitive part of the body or the alteration of bone structure shall be prohibited with the following exceptions: (…) docking of a part of the tail.

(…) Tail-docking must not (…) be carried out routinely but only where there is evidence that injuries to (…) other pigs' ears or tails have occurred. Before carrying out these procedures, other measures shall be taken to prevent tail-biting and other vices, taking into account environment and stocking densities. For this reason inadequate environmental conditions or management systems must be changed.

Any of the procedures described above shall only be carried out by a veterinarian or a person trained (…) and experienced in performing the applied techniques with appropriate means and under hygienic conditions. If (…) docking of tails is practiced after the seventh day of life, it shall only be performed under anesthetic and additional prolonged analgesia by a veterinarian.

In short, tail docking should not be performed on a routine basis in EU countries. In some countries, there is a specific legislation further limiting tail docking. In a damaged herd in Denmark, suckling piglets can be tail docked only between days 2 and 4 of life. The tail should be docked as little as possible and never more than ½ of the tail. In Sweden, Finland and Lithuania docking is not allowed. In Switzerland and in Norway, tail docking is also strictly regulated and permitted only with the use of anesthesia.

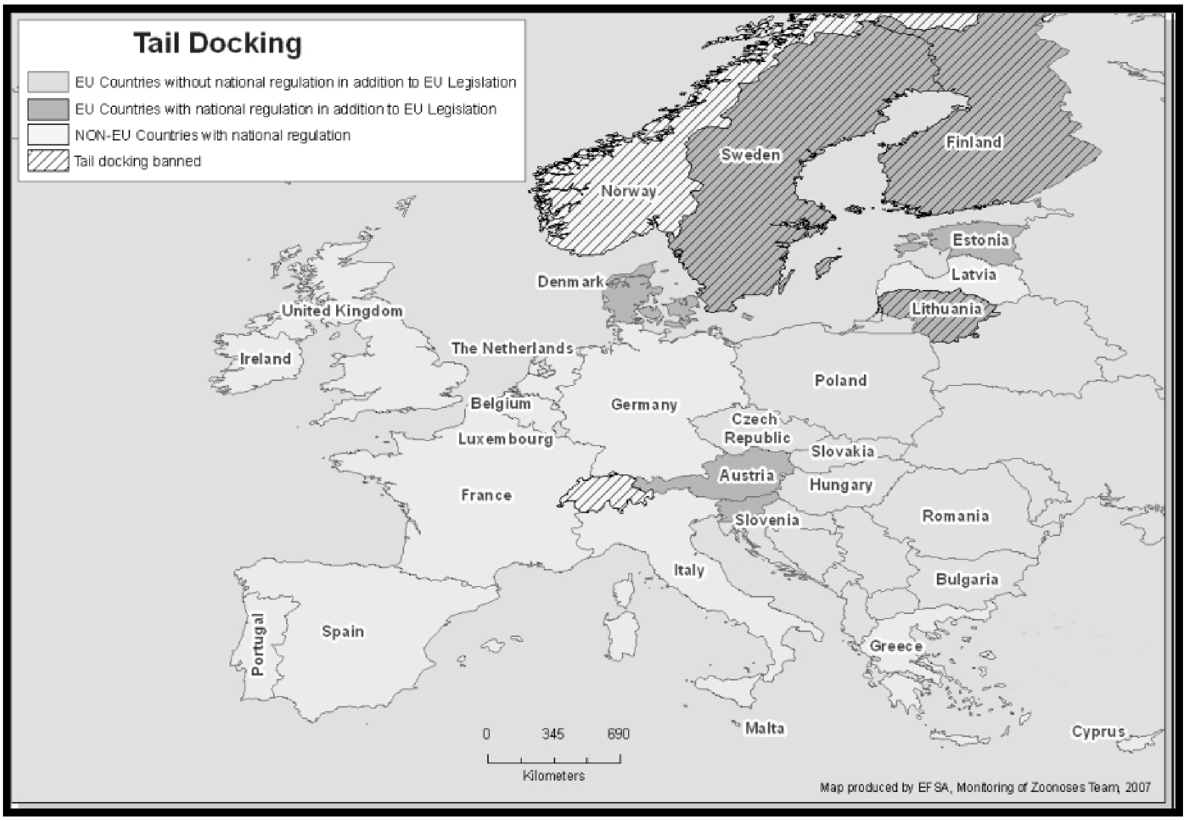

Figure 2. *Legislation on tail docking (EFSA, 2007).*

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Chapter 2

Tail biting in Italian pig farms rearing heavy pigs: prevalence and risk factors

TAIL BITING IN ITALIAN PIG FARMS REARING HEAVY PIGS: PREVALENCE AND RISK FACTORS

Scollo A.[1], Contiero B.[1], Edwards S.A.[2], Gottardo F.[1]

[1]Dipartimento di Medicina Animale, Produzioni e Salute, University of Padova – Legnaro (PD);

[2]School of Agriculture, Food and Rural Development, Agriculture Building University of Newcastle.

INTRODUCTION

Understanding the real cause of tail biting is difficult for its sporadic and unpredictable occurrence, and because it appears to have multifactorial origins (Edwards, 2006). A wide range of possible risk factors have been described for the light pig, such as diet formulation (Fraser et al., 1991), environmental discomfort (Scott et al., 2006; Scott et al., 2007; Van de Weerd and Day, 2009), health problems (Kritas and Morrison, 2007) and excessive competition for resources (Schrøder-Petersen and Simonsen, 2001).

The inability to prevent outbreaks of tail biting under commercial farm conditions has resulted in the wide adoption of tail docking as a preventative measure (EFSA, 2007), but this practice seems to be only a symptomatic solution to the problem without guarantee of avoidance (Moinard et al., 2003). Tail biting prevalence studies have been conducted in most of the UE Countries (EFSA, 2007), but cross-study comparisons appear difficult for the different populations considered. Indeed, collection of bitten pigs at the slaughter house was considered in the majority of researches, however these investigations had left out pigs culled or died on farm and never put through the abattoir system. The majority of all clinically tail-bitten pigs could be recorded on the farm, but these data are rarely combined into a true national picture (Taylor et al., 2010). Moreover, most of the data did not concern heavy pig production, with a lack of a complete description of the problem in a prolonged rearing context.

To observe tail biting on farm can allow to obtain detailed identification of the factors contributing the onset of the problem, which is demonstrated to be difficult to reproduce experimentally (Ewbank, 1973). Furthermore, because the multifactorial nature of tail biting means that not always the risk factors concurrently occur in individual farm circumstances (Taylor et al., 2012), an epidemiological approach on large scale could provide clearer information about the nature of the problem (Smulders et al., 2008).

Aim of the present study was to identify the real prevalence of tail biting in Italy, completing an European picture. Moreover, an epidemiological approach was adopted in order to identify the management and housing factors influencing tail biting in the specific heavy pig rearing context.

MATERIALS AND METHODS

Farms sample

The research considered a sample of 30 commercial heavy pig farms spread in the northeastern Italy and randomly selected within a list nominated by veterinarian practitioners and managers of producers organizations. The survey covered an area with a high pig industry profile, in which heavy pig is involved in the PDO production. All the farms were contacted by telephone and informed of the project in order to obtain their consensus. Visits were carried out from March to October 2012.

Data collection

As suggested by Moinard et al. (2003), each farm's record represents data carried out from pigs belonged to the same system, which was defined as one or more rooms with pigs of similar age, sex ratio, group size, pen design, ventilation, lighting and feeding systems and management.

On each farm visit, strict levels of biosecurity were applied. The farmers were interviewed throughout a face-to-face anonymous questionnaire to ensure a high response rate, and on-farm animal observations were conducted by a trained observer. Questionnaire had been designed by the research team with help of pigs specialist, and its topics covered a detailed range of farm and management characteristics: general information about the farm, hygiene and illness prevention measures, general management practices, climate, feeding management and production traits of the observed animals. Topics based on risk factors evaluated by Taylor et al. (2012) for the prevention of tail biting, for a total of 36 issues assessed (Table 1).

A further collection of data was carried out by an observer after the farmer had been interviewed, as a method of verification for the answers which could be corrected if needed. Information on the pigs was also carried out observing all the pens and recording the tail lesions. It must be noted that it was impossible to identify every mild lesion generated during the prior stages of the cycle, however Smulder et al. (2008) commented that severe lesions generated in the earlier stage of life and a proportion of mild lesions induced early on in life, which develop into severe lesions in later stages, would still be detectable later on.

The number of tail lesions was recorded using a binomial method, scoring 0 the animals without any lesions, and 1 animals with tail injuries ranging from superficial scratches with blood to missed parts of tail due to severe biting behavior. All the observations took place using live observations performed by an observer standing very still and the pen was only entered when the severity of the lesion was in doubt, to minimize the disturbance.

In total, during the study 79,780 animals were observed.

Category	Topic
Background and Medical History	Breed (or breeds) of pig
	Rearing phase
	Total number of rearing animals on the unit
	Number of pigs per pen
	Routine vaccinations received
	Pharmacological supplements received
	Respiratory and enteric disorders
Management and environment	Stocking density
	Type of floor
	Mixed gender per pen
	Temperature and humidity
	Lux
	Ammonia and CO_2 levels
	Human detection of mucosal irritation for aversive atmosphere
	Provision to maintain a thermo-neutral temperature
	Ventilation
	Quality of the dunging area
	Drinkers and space at trough
	Space for recumbent and lying permitted
	Meal distribution and type of food
Mixing History	Transports between farms
	Mixing different groups during transports
	Mixing different groups on-farm
Nutrition	Sodium provision in the diet
	Lysine percentage in the diet
Environmental enrichments	Earlier provision of enrichments before arriving at this farm
	Actual provision of enrichments

	Type and characteristics of the enrichment Limited access to the enrichment Cleanliness of the enrichment Intervals of replacing of the enrichment
Straw provision	Quality of straw (chopped vs. long) Frequency and method of distribution of straw Time of availability of straw
Tail biting and Related management	Pigs culled due to lesions caused by biting Pigs currently removed from the pen due to tail lesions Tail docking technique

Table 1. *Topics for the face-to-face questionnaire*

Statistical analysis

Data from the questionnaires were entered into a database. Statistical analyses were performed using the SAS program (SAS 9.1, SAS Institute Inc., Cary, NC). Chi-squared tests with Marascuilo procedure were performed to verify the association between presence of tail biting and the environmental factors, animal characteristics and managerial aspects investigated. When a significant association ($P < 0.05$) was found between a given classification factor and presence of tail biting, relative risk and 95% confidence intervals (PROC FREQ, SAS 9.1, SAS Institute Inc., Cary, NC) were calculated to determine the risk of injuries at tail level when some environmental, animal and management situations are detected.

RESULTS

Tail biting prevalence

Table 2 depicts the average percentage of animals affected by tail lesions per production phase and the percentage of farms with at least one affected animal.

Results showed an higher prevalence of tail biting in the weaning units considering the percentage of farms with at least one animal with injuries. However, considering the percentage of injured animals on the total of pigs observed, the fattening units showed the greater level of tail biting.

Production phase	Farms with at least one affected animal (%)	Affected animals (%)
Weaning units	17.6	0.05
Fattening units	11.1	0.34
Total	15.4	0.15

Table 2. *Prevalence of tail biting expressed as the percentage of farms with at least one affected animal by tail biting and the percentage of animals affected on the total number of pigs observed.*

Tail biting risk factors

Results concerning the relative risk analysis have been reported in Table 3.

Risk Category	Confronti	RR	Confidence interval 95%	*P*
Background and Medical History				
Breed (or breeds) of pig	Danish vs. other	2.71	0.47 – 15.75	0.258
Productive cycle	Closed vs. open	1.17	0.19 – 7.07	0.867
Season	Hot vs. cold	2.14	0.38 – 12.24	0.388
Rearing phase	Weaning vs. fattening	1.59	0.19 – 13.15	0.660
Number of pigs per pen	<25 vs. >25	1.17	0.19 – 7.07	0.867
Respiratory and enteric disorders	Absence vs. presence	3.50	0.42 – 29.39	0.208
Management and environment				
Stocking density [a]	High vs. low	5.00	0.39 – 64.39	0.186
Type of floor	Slatted vs. full	1.56	0.21 – 11.61	0.656
Ammonia level	>10ppm vs. ≤10ppm	2.50	0.29 – 21.40	0.686
Human detection of aversive atmosphere	Presence vs. absence	2.25	0.38 – 13.27	0.365

Provisions to maintain a thermo-neutral temperature	No vs. yes	1.75	0.24 – 12.86	0.592
Type of ventilation	Artificial vs. natural	1.88	0.22 – 15.63	0.547
Delimited dunging area	No vs. yes	1.59	0.19 – 13.15	0.660
Dirty lying area	Yes vs. no	1.00	0.16 – 6.07	0.990
Space for lateral lying [b]	Yes vs. no	1.33	0.16 – 10.94	0.786
Drinkers in the lying area	Yes vs. no	3.50	0.42 – 29.39	0.208
One drinker each 10 pigs	No vs. yes	1.11	0.14 – 8.94	0.925
Space at trough	Insufficient vs. good	3.00	0.36 – 25.21	0.277
Feed distribution	Manual vs. automatic	6.75	1.2 – 55.36	0.037
Meals	Ad libitum vs. rations	1.78	0.23 – 13.49	0.561
Type of food	Pellet vs. liquid	1.36	0.23 – 8.24	0.735
Mixing History				
Mixing different groups during transports	No vs. yes	1.58	0.22 – 11.58	0.659
Mixing different groups on-farm	No vs. yes	1.09	0.18 – 6.48	0.923
Environmental enrichments				
Rootable substrates	Yes vs. no	1.17	0.19 – 7.07	0.867
Objects	Yes vs. no	1.60	0.27 – 9.62	0.606
Tail biting and Related management				
Tail Length after	Long docked vs.	8.14	1.01 – 65.88	0.018

docking	short			
Pigs currently removed from the pen due to tail lesions	Yes vs. no	12.6	1.63 – 97.12	0.002

Table 3. *Relative risk analysis for the factors considered in the study, analyzed at farm level.*

[a] High: over the level permitted by the law; Low: under the level permitted by the law.
[b] Yes: all the pigs could lying recumbent laterally in the same moment; No: only a part of the pigs could lying recumbent laterally in the same moment.

The three most important factors influencing the incidence of tail biting at farm level were the method of feed distribution (P = 0.037), the tail length after docking (P = 0.018) and the presence of pigs in the current rearing cycle removed from the pen due to tail lesions (P = 0.002). The risk to observe tail biting in pigs was greater when the feed distribution was manual rather than with an automatic system (RR = 6.75), and when the tails were long docked leaving more than ½ of their length (RR = 8.14). Furthermore, the presence of pigs moved into the sickbay for tail injuries in the current productive cycle showed a greater risk of high incidence of the problem (RR = 12.6).

However, relative risks related to other factors analyzed were clearly high even if not supported by a significant difference in the statistical analyses. The tendency to show a greater relative risk for tail biting was detected in pigs of Danish genetic (RR = 2.71), in absence of respiratory and enteric disorders (RR = 3.50). Concerning management and environment parameters, this tendency was showed with high stoking density (RR = 5.00), with ammonia levels greater than 10 ppm (RR = 2.50) and temperature inside the barn was higher than 25℃ (RR = 2.14), when drinkers wer e collocated in the lying area of the pen (RR = 3.50) and in case of an insufficient space at the trough (RR = 3.00).

DISCUSSION

Until very recently, little research had been done on the relative importance of different management factors in reducing tail lesions (Smulders et al., 2008). Furthermore, very limited data are referred to heavy pigs, which could present intensified problems due to the prolonged rearing cycle. Therefore, an epidemiological study in the specific context of the heavy pig is an important step in helping clarify the multifactorial problem of the tail biting. Moreover, this approach allowed to improve the European picture concerning tail biting data, which presented a lack of investigation regarding the Italian situation.

In the present study, 0.15% of the animals were affected by tail biting lesions. Although Elbers et al. (1992) and Busch et al. (2004) reported in their study a prevalence observed at slaughter lower than 1%, several other authors showed at farm level considerably higher number of lesions (Tiilikainen, 2000; Smulders et al., 2008; Holmgren and Lundeheim, 2004). An hypothesis for the low prevalence observed in the present study could be explained with low number of pigs reared with the intact tail compared to other European surveyed countries. Indeed many of the authors who reported an higher level of tail biting, conducted their study in restrictive tail docking legislation and therefore results were referred to high percentage of undocked animals. In some European countries is applied a national regulation in addition to the European legislation, and were tail docking is completely banned undocked pigs are closed to 100% (EFSA, 2007). This hypothesis is supported by McIntyre (2003) who observed that pigs with their tail intact were the recipients of more tail-directed behaviors.

In the present study, 36 topics concerned a greater number of different risk factors were evaluated. From the data processing some factors emerged for their importance in the display of tail biting. This discussion focuses on those showed a relative risk > 2. As reported by Moinard et al. (2003), it is possible that some of these factors are casually associated with tail biting considering that their statistical significance is weaker. This may be of use to others studying aspects of tail biting in pigs. It is also worth considering reasons for non- significance. These are random error, limits of detection due to the power of the study, no variation in a variable, e.g. if nearly all or all farms provide animals with environmental enrichments, then it is not possible to detect an association between tail biting and this practice, and finally there is truly no association.

This study revealed three main risk factors related to the management which affect the incidence of tail biting lesions: the method of feed distribution, the tail length after docking and the presence of pigs in the current rearing cycle removed from the pen due to tail lesions. Regarding the method of feed distribution, it is known that pigs anticipate the arrival of feed when meals are provided regularly (Terlouw et al., 1993), such that when food does not appear, pigs show inappropriate oral behaviour (Rushen,1985), potentially including tail biting. Problems with the feeding system were noted by many farmers as an important factor in tail-biting (Paul et al., 2007). In this study, the hand-fed pigs showed higher relative risk of tail biting, possibly due to the occasional occurrence of time variation and delays in food provision. The unpredictable arrival of food could act as a stressor which increases the risk of oral manipulation of other objects and pen-mates (Robert et al., 1991).

The tail length after docking confirmed the hypothesis proposed for the low prevalence recorded in the present study: pigs with a long-docked tail presented an higher relative risk of tail lesions compared to short-docked animals. This is in agreement with the findings of McIntyre (2003) concerning the tail length. In the management of the tail, also the medical history of the herd showed importance. The presence of pigs moved to the sickbay for tail injuries during the rearing cycle showed a greater risk of high incidence of the problem, likely due to the development in some pigs of the inclination to bite or the discovery of blood taste (Taylor et al., 2012).

Further factors were identified for their higher relative risk of tail biting such as genotype. Taylor et al. (2012) highlight the lack of clear implications between pig breed for tail biting, however in the present study Danish pigs showed a greater relative risk and this result could reflect the different behavior of genetic lines producing leaner meat (Moinard et al., 2003) as Danish pigs (Hobbs et al., 1998). Moreover, in the present study was detected a greater relative risk of tail biting in absence of respiratory and enteric disorders. This is in contradiction with literature, which reported the association between tail biting and disease, probably due to their stressor role on the animal that lower the threshold for development of the other (Schrøder-Petersen and Simonsen, 2001). It is possible that pathologies could provoke the development of tail biting in case of mild illness, but when respiratory and enteric disorders are severe, as reported in the present study, animals could present a form of apathy and reduced activity towards environment and pen-mates.

Among the environmental parameters, a greater relative risk for tail biting was observed when the temperature inside the barn was higher than 25°C. Several authors found an increase in aggression and ear and tail biting at high temperature (Lohse, 1977; Haske-Cornelius et al., 1979). Similarly, an ammonia level higher than 20 ppm was associated to tail biting, probably due to the aversive effects of the noxious gas to pigs, so keeping them under these conditions is considered stressful (Smith et al., 1996; Jongman et al., 2000).

In agreement with the finding of several authors (Schrøder-Petersen and Simonsen, 2001; Moinard et al., 2003) a high stocking density was found to act as a risk factor for the development of tail biting, Penny et al. (1981) suggested that tail-biting outbreaks occur when pigs begin to ‘fill their pens’, and it seems likely that the reduced space per pig increases tension within the pen, with the animals' quality of rest and other behaviours reduced by constant disturbance. Pigs may also be more restricted in their movement around the pen, increasing frustration at being unable to reach resources. This supposition could explain also the higher risk of tail lesions in pens where drinkers were located in the lying area, with an increased disturbance of resting pigs by pen-mates looking for drinking water. Similarly, an insufficient space per pig at the trough could increase the competition for food and the potential for some pigs to become frustrated, with consequent high risk for a tail biting outbreak.

In conclusion, this study allowed to complete the European picture for the prevalence of tail biting highlighting a low incidence of lesions in Italy. It Is likely that this results could be related to the great percentage, (close to 100%), of docked pigs reared ,anyway cannot be excluded that the prolonged fattening cycle of the heavy pigs does not seems to worsen the risk for tail biting. However, further investigation on undocked heavy pigs should be necessary.

Furthermore, this study has identified among commercial pig farms several risk factors for tail biting on heavy pig. Results could be relevant to the pig industry in order to reduce the economical losses due to tail biting, therefore more attention should be paid to the respect of law requirements regarding stocking density, environmental parameters and the availability of the resources for the environmental enrichment. Once a causal risk factor has been demonstrated on farm, measures should be taken to minimize the incidence of tail biting, thereby enhancing animal welfare.

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Chapter 3

Is it possible to rear heavy pigs avoiding tail docking? Role played by gender and presence of straw in the control of tail biting: I. Physiological parameters, behavior and skin lesions

IS IT POSSIBLE TO REAR HEAVY PIGS AVOIDING TAIL DOCKING? ROLE PLAYED BY GENDER AND PRESENCE OF STRAW IN THE CONTROL OF TAIL BITING: I. PHYSIOLOGICAL PARAMETERS, BEHAVIOR AND SKIN LESIONS

Scollo A. [1], Di Martino G. [2], Bonfanti L. [2], Stefani A. [2], Schiavon E. [2], Marangon S. [2], and Gottardo F. [1]

[1]*Dipartimento di Medicina Animale, Produzioni e Salute, University of Padova – Legnaro (PD);*

[2]*Istituto Zooprofilattico Sperimentale delle Venezie, 35020 Legnaro, Padova.*

SUBMITTED TO RESEARCH IN VETERINARY SCIENCE

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ABSTRACT

The study aimed to evaluate the welfare of fattening undocked pigs in the specific rearing context of the heavy pig. At the same time, gender and presence of straw were considered to understand if these factors interact with the presence of tail in the display of tail biting. A factorial design 2 × 2 × 2 was adopted to test the effects of presence of tail, gender, and availability of straw on: blood parameters [total protein, albumins, globulins, albumin/globulin ration, total antioxidants (TAS), Haptoglobin (Hp), and cortisol], culling rate, behaviour (lying, exploring substrate/object, ear and tail biting) and the occurrence of ear and tail lesions at different weeks during a 6-month fattening period. The study used 672 pigs housed in 24 single-sex group pens with solid floor. All pens were enriched with a metal chain, a rubber covered chain, and sawdust. Half of the pens equally distributed among the combination of treatments had a feeding rack containing long straw. Gender differences were detected for total protein ($P < 0.001$) and Hp ($P < 0.001$), which were more likely due to normal physiological differences than to chronic stress. No gender differences were found in behavior, except for a greater risk of ear biting for barrows at wk 9 of fattening. Barrows had also a greater risk of tail lesions at the beginning of fattening. Availability of straw was significantly associated with lower Hp ($P < 0.001$) and lying ($P < 0.001$), and with greater interest in exploring enrichments ($P < 0.001$), straw in particular. Availability of straw was also associated with a lower risk of tail biting at wk 3, 9, and 18 and ear biting at wk 3 and 9. Compared to docked ones, undocked pigs showed lower serum cortisol ($P < 0.02$) and lying ($P < 0.001$) and increased risk of tail and ear biting at wk 3 and 9. However, the risk of tail lesions was greater for docked pigs at week 14. The outcome of the study suggests that compliance with the EU regulation for the protection of pigs seems to allow heavy pigs to be fattened without performing tail docking with no outbreak of injurious tail biting. The availability of straw, however, seems to be an important tool in increasing explorative behavior and preventing biting and lesions, mainly in the early stage of fattening. Regardless of the factors considered, the extension of the fattening cycle and the progressive reduction of space allowance due to the growing size of pigs seemed not to increase tail and ear biting or lesions.

Key words: blood parameters, behavior, gender, heavy pig, straw, tail docking

INTRODUCTION

Tail biting is mostly unpredictable due to its multi-factorial origin, and therefore tail docking is widely used for its prevention (Zonderland et al, 2008), even if European animal welfare legislation (EU Directive 2008/120) obliges farmers to rear pigs undocked unless a large proportion of the animals shows tail damage and to adopt all management tools that can prevent tail biting (Moinard et al., 2003). In the few European Countries where tail docking is completely banned, the percentage of docked pigs is close to zero, but in the others, this mutilation is still performed on at least 75% of the pigs (EFSA, 2007). When the fattening period is prolonged, as in the case of heavy pigs (9 months and 160 kg of BW) for the production of protected destination of origin hams (PDO), the percentage of docked pigs is nearly 100%.

Heavy pig production faces additional tail biting risks posed by age and sexual maturity, progressive reductions in space allowance, and prolonged rearing in a boredom environment.

Taylor et al. (2010) studied the role of age and gender in the development of tail biting in pigs slaughtered at 100-120 kg but the effects of the same factors in heavy pigs were not investigated. Furthermore, environmental enrichments could prevent tail biting, and straw seems to be one of the most effective (Van de Weerd et al., 2009). Farmers tend not to use this substrate widely, however, due to the increased amount of labor it requires.

Given that tail docking is still widely used in Europe despite the legal recommendation (EU Directive 2008/120) that the practice should be avoided, our study aimed to evaluate the feasibility to fatten undocked pigs in the specific heavy pig rearing context. Gender and the presence of straw were also considered in their effect on tail biting especially in undocked pigs by evaluating welfare indicators such as blood parameters, culling rate, behavior, and lesions at ears and tail.

MATERIALS AND METHODS

All experimental procedures and animal care were carried out in accordance with Italian legislation on the protection of animals used for experimental and other scientific purposes (Gazzetta Ufficiale, 1992).

Animals, Facilities, and Management

This research focused on the study of development of tail biting during fattening phase of the heavy pigs under different experimental rearing condition. However, to ensure at the beginning of the study an adequate number of animals and similar conditions among experimental treatments in terms of health status, body weight and absence of tail damages at the beginning of the experiment, the post-weaning phase has involved a larger number of pigs from which we selected a subsample for the fattening phase.

Before the beginning of the study, the post-weaning phase involved a starting number of 735 commercial crossbred piglets (Landrace × Large White) housed in 21 pens of 35 animals each. The groups were created 28 days after birth according to gender and presence of tail, considering that tails were docked by removing 2/3 of their length in half of the animals by means of cauterization at 5 days of age in the farrowing room. Pens had a slatted floor and was available any specific environmental enrichment.

The post-weaning phase lasted 52 days, therefore at the beginning of the fattening cycle the pigs aged 80 days. During travel from the post-weaning site to the fattening unit, pigs were divided according to gender and tail presence merging pigs from different groups within the same combination of treatments. Upon arrival at the fattening unit, a subsample of 672 of pig (mean BW = 25 ± 3 kg) was selected for the study.

The experimental phase was carried out in a commercial open-site fattening unit, and the fattening cycle lasted 30 weeks from October 2009 to May 2010.

This study evaluated the effects of tail presence (docked vs. undocked pigs), gender (barrows vs. females), and availability of long straw in a feeding rack as further environmental enrichment (absence vs. presence of straw) using a 2 × 2 × 2 factorial design.

According to the experimental design, at the beginning of the fattening phase the 672 selected pigs were randomly allotted within combination of gender and presence of tail in a total number of 24 group pens containing 28 pigs each. Half of the pens, equally distributed between gender and tail presence group treatments, were provided with a feeding rack where straw was available. In this way, each of the total 8 factors combination was represented by 3 group pens. The 24 total pens were distributed in two rows and divided by a corridor used for meal delivery and animal health checks. Experimental treatments were distributed using a randomized block criteria.

Pens characteristics were exactly the same for all treatments in terms of space allowance, space at feeding trough, type of floor, and number and position of drinkers. More than 80% of the pen floor was concrete solid floor; whereas the additional outdoor defecation area had a slatted floor (7.5 m2). From the beginning of fattening, the space allowance was 1.02 m2/pig, the individual space allowance at the feeding trough was 0.4 m/pig, and drinking water was available ad libitum through a nipple (one per pen). As basic

	Days of fattening		
Item	**0-51**	**52-127**	**128-208**
Chemical composition of the diet:			
DM, %	87.5	87.5	87.5
Crude protein ,% of DM	16.60	15.8	14.00
Ether extract,% of DM	5.20	4.8	3.20
Ash, % of DM	5.40	5.2	5.00
Crude fibre, % of DM	4.00	4.3	4.60
Non-structural carbohydrates, % of DM	68.8	69.9	73.2
Lysine, % of DM	1.15	0.83	0.72
Feed amount delivered:			
As fed, l/head/d	5.5±1.6	9.6±2.2	11.7±2.2
DM, g/head/d	1197±353	2176±520	2690±513

***Table 1**. Diet composition and amount of feed delivered to the pigs at different phases of fattening*

environmental enrichment, each pen in all treatments contained chains (one metal and one rubber-covered, both hanging from the wall), and sawdust (2 kg/pen distributed on the floor 3 times a week).

All the pigs were fed twice a day, at 0700 h and 1500 h, with two equal liquid meals distributed by an automatic system. Throughout the experiment, the pigs received the same liquid diet, and the amounts of water and solid feed were increased throughout the fattening period according to the nutritional requirements of the animals. The ratio between liquid/solid in the meal ranged from 4.3 to 4.6 for the entire fattening cycle. In terms of chemical composition and amount delivered (Table 1), the feeding plan used was formulated according to the nutritional requirements of heavy pigs (Bertacchini and Campani, 2001).

The pigs were inspected by the stockman twice a day to record the number of dead pigs and to identify severe injuries related to tail biting requiring specific treatment in the sickbay.

Light and noise were checked twice a month during the entire fattening cycle using a multi-function environmental analyzer (Lafayette mod. DT-8820; Marcucci S. p. A., Vignate (MI), Italy) to keep levels below the threshold set by pig welfare protection legislation (EU

Directive 2008/120). Also CO_2 concentration and ammonia levels were recorded in different parts of the fattening unit using a DRAGER X-am7000 (Dräger Safety AG & Co. KGaA, Lübeck, Germany) to ensure that all pens maintained the same experimental conditions.

Blood Sample Collection and Analyses

Blood samples were collected from the same animals (ear tagged) at 7, 19, and 28 weeks of fattening using 6 randomly selected focus pigs in each pen for a total of 144 pigs. Blood was collected from the jugular vein using 4-ml sterile vacuum tubes containing K-EDTA (Vacutest Kima srl, Arzergrande, PD, Italy). Blood samples were stored at 4℃ during transportation to the laboratory, centrifuged at 2, 400 × g for 10 minutes at 20℃, and stored at -20℃ before analysis. The parameters analyzed were: total protein, albumins, globulins, albumin/globulin ratio (A/G ratio), total serum antioxidants (TAS), Haptoglobin (Hp), and cortisol. The parameters to measure were chosen on the basis of their role as pig health status and welfare indicators. Hp, as acute phase protein (APP) fraction, may be considered an unspecific health status marker (Murata et al., 2004; Petersen et al., 2004). APPs migrate in the alpha and beta globulin region of the serum protein electrophoretic pattern (Kaneko, 2008), altering total protein composition and subsequently albumin/globulin ratio.

TAS was quantified due to its response to oxidative stress (Brambilla et al., 2002), while cortisol was evaluated because it is considered one of the main stress hormones (Kaneko, 2008).

Total serum protein was measured by a colorimetric kit with Biuret reagent (TP, F. Hoffman-LaRoche Ltd,) using a BM Hitachi 911 analyzer (F. Hoffman-LaRoche Ltd, Basel, Switzerland). The A/G ratio was calculated by determining the concentration of different protein fractions through serum electrophoresis with a Hydrasis LC semi-automated analyzer (Sebia, Lisses, EVRY Cedex, France) on 0.8% agarose gel (Hydragel 30 Protein, Sebia, Norcross, Georgia). Haptoglobin concentration was determined by an ELISA kit (Phase Haptoglobin, Tridelta Develpoment ltd, Maynooth, County Kildare, Ireland). Serum cortisol concentration was determined by an immunologic chemiluminescent kit (LKCO1, Medical System,) applied to the Immulite One automated analyzer (Immulite One, Medical System, Genoa, Italy).

Behavioural Observations

Behaviour was evaluated at 3, 9, 18, and 29 weeks of fattening by direct observation using a scan-sampling technique (Martin and Bateson, 2007) with a 2-minute interval between scans. At each scan recorded the number of animals per pen lying inactive or exploring (licking, suckling, rooting, biting, chewing) different substrates/objects (chains, sawdust, straw). Each observation session was carried out for 4 consecutive days in the same week, considering that 3 trained observers controlled 6 pens per day. One observer recorded the behavior performed by the pigs in 2 pens watched alternately. The pigs were observed for 2 uninterrupted hours in the morning (from 1000 h to 1200 h) when the animals had greater probability of being quiet, and 1 h before and 1 h after the afternoon meal when they were more agitated because of feed delivery. The number of events such as conflicts, ear biting and tail biting (Table 2) was also recorded during observation using the behaviour sampling technique (Altmann, 1974).

Behaviour	Definition of the behaviour	Method of observation
Exploring[1] straw in the rack	Pigs sniffing and chewing straw in the rack.	Scan Sampling
Exploring[1] straw fallen on the floor	Pigs sniffing, rooting and chewing straw fallen on the floor.	
Exploring[1] sawdust	Pigs sniffing, rooting and chewing sawdust on the floor.	
Lying inactive	Pigs in lateral or sternal lying, resting or sleeping.	
Exploring[1] nipple drinker	Pigs touching or holding the nipple.	
Exploring[1] metal chain	Pigs sniffing and chewing metal chain.	
Exploring[1] metal rubber covered chain	Pigs sniffing and chewing metal rubber covered chain.	
Conflicts	Aggressive interaction among two or more pigs.	Behaviour sampling
Ears biting	A pig had in the mouth an ear of a pen mate and bite it.	
Tail biting	A pig bite the tail of another pig.	

***Table 2**. Description of behaviors observed and methods adopted for their recording.*

[1]Exploring behaviour considered licking, suckling, rooting, biting, chewing a certain substrate/object.

Ear and Tail Lesions

Two trained veterinarians visually evaluated alterations in each pig's ears and tail at 3, 14, and 22 weeks of fattening in accordance with Widowski et al. (2003) and Sutherland et al. (2008). The ears of each pig were scored using a 3-point scale (0: no lesions; 1: mild lesions with hair loss, redness, irritation, scratches or small abrasions; 2: severe lesions with bleeding and loss of tissue). The tails were checked for length (0: intact tail; 1: presence of more than half the tail; 2: presence of less than half the tail), severity of injuries (0: no lesions; 1: mild lesions with hair loss, redness, irritation, scratches or small abrasions; 2: severe lesions with loss of tissue), and presence of blood (0: no blood; 1: fresh and red blood; 2: old and dark blood visible as a scab).

Statistical Analyses

For all blood parameters, outliers were detected following the recommendation of the International Federation of Clinical Chemistry (Solberg, 1987), and values more than 3 standard deviations away from the mean were discarded. The data were then analyzed for their Gaussian distribution, and coefficients of skewness and kurtosis were computed by PROC UNIVARIATE (SAS 9.2, SAS Institute Inc., Cary, NC) to measure distribution asymmetry and peakedness. Variables with Shapiro-Wilk values (W) ≥ 0.95 were considered normal, whereas all other variables were log transformed before analysis to adjust for their lack of normality. Gaussian and transformed data were statistically processed by PROC MIXED (SAS 9.2, SAS Institute Inc., Cary, NC). Analysis of repeated measurement data was based on the mixed model with a compound symmetric parametric structure on the covariance matrix. The model considered the fixed effects of gender, tail presence, provision of straw, week of fattening, and their interactions (of first and second level), and pen within tail × gender × straw was the subject effect (covariance parameter) in the analysis.

LS means were compared using the Bonferroni test.

Behavioral data from scan sampling were transformed into frequencies by dividing, for each scan, the number of animals that engaged in a given behavior by the total number of animals housed in that pen.

Given that straw was not provided in half of the pens, two new variables were created. The first variable considered the interest shown by pigs in all the environmental enrichments available in the pens; the second variable measured only the interest shown in enrichments other than straw (i.e., sawdust and different types of chains). As regards interest in straw in the feeding rack and straw fallen on the floor, only the pens in which the specific environmental enrichment was available were considered.

The normal distribution of all these variables was then tested with PROC UNIVARIATE (SAS 9.2, SAS Institute Inc., Cary, NC). Variables with Shapiro-Wilk values (W) ≥ 0.95 were considered normal, whereas all other variables were log transformed before analysis. Data were processed adopting the same statistical model used for the physiological parameters. For behaviors such as interest towards straw in the feeding rack and straw fallen on the floor, the fixed effects included in the model were tail presence, gender, and week of fattening.

Regarding ear and tail lesions, only mild lesions were detected, and none of the pigs had reduced tail length caused by tail biting; for this reason, only the presence/absence of lesions and not the severity of lesions or the reduction in tail length was considered in the statistical analyses.

The percentage of pigs with tail and ear biting and tail and ear lesions out of the total number of pigs was calculated for each observation, and a PROC LOGISTIC (SAS 9.2, SAS Institute Inc., Cary, NC) was used to assess which of the factors considered in the study were associated with a risk of biting and lesions.

RESULTS

For most of the variables, were not found relevant interactions among the three factors considered in the study (tail, gender, straw); therefore, the results of the main effects have been reported in Tables and Figures. Significant interactions have not been shown in the tables but they were described in the text.

During the fattening period, 12 pigs died; these deaths were equally distributed among the experimental groups. Moreover, none of the pigs was moved into the sickbay as consequence of severe tail lesions due to tail biting.

The results of blood analyses by tail presence shown differences between docked and undocked pigs only in the cortisol levels, resulted lower in undocked ones (Table 3). Few differences by tail presence were shown also in the behavior analyses, with lower lying behavior and greater number of conflicts in undocked pigs (Table 4). The presence of an intact tail was furthermore a risk factor for tail and ear biting behavior at weeks 3 and 9, but it was a protective factor against tail lesions at week 14 (Table 5).

Gender affected Total protein, TAS, and Hp parameters. In particular, total protein and Hp were greater in females than barrows, whereas TAS was lower (Table 3). The presence of straw was also significantly associated with lower Hp levels and, in particular, an interaction between availability of straw and presence of tail ($F = 12.71$; $P < 0.05$) showed that undocked pigs with the presence of straw had the lowest Hp level (With straw: 49.37; Without straw: 80.14). None of the behaviors were affected by gender, whereas presence of straw affected most of the behaviors studied except for exploring the nipple drinker and the occurrence of conflicts (Table 4). Pigs in pens with straw showed less lying behavior and greater interest in exploring environmental enrichments. This latter behavior was more relevant in undocked pigs than in docked ones, as suggested by the significant interaction between availability of straw and presence of tail ($F = 13.04$; $P < 0.05$; Undocked: 26.6; Docked: 20.9). However, when straw was available, all the other objects/materials were significantly less explored.

The gender factor showed the risk of ear biting and tail lesions to be significantly lower in females than in barrows at week 9 (OR of 1.70) and week 3 (OR of 2.27) (Table 6) respectively. The presence of straw in the pen instead, significantly decreased the risk of tail biting for the prolonged time of weeks 3, 9, and 18, and demonstrating to be a protective factor for the lesions at the same anatomical region at the beginning of the fattening period (OR 2.12 at week 3). As found for tail biting, ear biting was lower in pens with straw at weeks 3 and 9 (Table 7).

Regardless tail docking, gender, and presence of straw, week of fattening had a strong independent effect on the studied parameters. Blood analyses shown that Total protein and TAS increased throughout the fattening period (Figure 1A and 1F). At the second blood sample collection (19 weeks of fattening), albumin and cortisol peaked (Figure 1B and 1E), whereas Hp had the lowest concentration (Figure 1D). The greatest globulin level was recorded at the end of the fattening period (Figure 1C). Were significantly affected by week of fattening also the behavioral observations. Lying behavior increased until week 18 and then remained stable (Figure 2A). Interest in environmental enrichments decreased over time for all types of substrates/objects (Figure 2B). The trend of interest in different environmental enrichments during the fattening cycle is shown in Figures 2C, 2D, and 2E. Pigs with straw available showed decreased interest in straw fallen on the floor, starting from fattening week 18 (Figure 3A). Interest in the straw contained in the rack was more stable over time, even if a peak occurred at week 18 (Figure 3B). The number of conflicts during fattening was low and continued falling until stabilizing at week 18 (Figure 2F).

	Tail[1]			Gender[2]			Straw[3]				*P-value*			
Item	**Docked**	**Undocked**	***F***	**B**	**FE**	***F***	**No**	**Yes**	***F***	**SEM**	**Tail**	**Gender**	**Straw**	**Wk of fattening**
Df of error	17			17			17							
Blood parameters:														
Total protein, g/L	64.1	64.0	0.1	63.3	64.9	14.4	64.1	64.1	0.1	0.28	0.82	<0.001	0.84	<0.001
Albumin, g/L	28.2	27.6	1.5	27.4	28.4	3.8	27.8	27.9	0.0	0.34	0.23	0.07	0.88	<0.001
Globulin, g/L	35.9	36.2	0.4	35.5	36.2	0.5	35.9	35.9	0.0	1.01	0.54	0.47	0.96	<0.001
Albumin/Globulins	0.80	0.77	0.9	0.78	0.79	0.1	0.79	0.78	0.1	0.02	0.35	0.75	0.83	<0.01
Haptoglobin, mg/dL	62.9	64.8	0.2	46.8	80.9	93.1	73.5	54.2	29.8	1.07	0.61	<0.001	<0.001	<0.001
TAS, nmol/L	0.75	0.74	0.3	0.76	0.74	4.9	0.74	0.75	0.8	0.01	0.38	0.04	0.59	<0.001
Cortisol, nmol/L	66.0	55.2	6.5	58.0	62.8	1.1	64.1	56.8	3.1	1.05	0.02	0.30	0.10	<0.001

Table 3. *Least square means for gender, provision of straw and presence of tail of physiological parameters in fattening pigs.*

[1]Docked = tail docked pigs in the first wk of life; undocked = pigs with intact tail.
[2]B = barrows; FE = females.
[3]No = absence of straw as environmental enrichment; yes = straw always available in the feeding rack.

	Tail[1]			Gender[2]			Straw[3]				*P-value*			
Item	**Docked**	**Undocked**	***F***	**B**	**FE**	***F***	**Docked**	**Undocked**	***F***	**SEM**	**Tail**	**Gender**	**Straw**	**Wk of fattening**
Df of error		17			17			17						
Behaviors:														
Lying	53.3	48.6	8.7	51.1	51.1	0.0	55.0	47.1	22.4	1.17	<0.001	0.98	<0.001	<0.001
Rooting sawdust	5.1	4.7	0.3	4.8	5.1	0.1	6.5	3.7	11.0	1.12	0.59	0.73	<0.001	<0.001
Exploring chain	2.9	3.2	1.5	3.3	2.8	2.5	3.8	2.4	18.6	1.08	0.24	0.13	<0.001	<0.001
Exploring rubber chain	2.6	2.7	0.3	2.9	2.4	2.7	3.2	2.2	12.0	1.08	0.62	0.12	0.03	<0.001
Exploring all the enrichments	17.3	19.7	2.1	19.3	18.3	0.7	13.9	23.8	72.5	0.82	0.17	0.41	<0.001	<0.001
Exploring enrichments different from straw	8.5	7.6	0.8	8.6	7.5	1.0	11.7	5.5	35.3	1.09	0.38	0.32	<0.001	<0.001
Exploring nipple drinker	1.43	1.36	0.7	1.39	1.40	0.0	1.38	1.40	0.1	1.04	0.42	0.97	0.80	<0.001
Conflicts	1.8	2.1	5.4	2.0	2.0	0.0	1.9	2.0	0.4	1.05	0.03	0.92	0.54	<0.001

Table 4. *Least square means for gender, provision of straw and presence of tail of behaviors of fattening pigs (% of animals involved in a specific activity).*

[1]Docked = tail docked pigs in the first wk of life; undocked = pigs with intact tail.
[2]B = barrows; FE = females.
[3]No = absence of straw as environmental enrichment; yes = straw always available in the feeding rack.

Item	Age (Wk of fattening)	Docked, (%)	Undocked, (%)	Odds	95% confidence interval	*P*
Tail						
Biting	3	0.07	0.21	0.31	0.20 - 0.48	<0.001
	9	0.05	0.11	0.41	0.23 - 0.72	0.01
	18	0.01	0.04	0.33	0.12 - 1.00	0.05
	29	0.01	0.01	0.50	0.09 - 2.73	0.42
Lesions	3	8.86	5.75	1.54	0.83 - 2.83	0.17
	14	16.95	8.15	2.08	1.26 - 3.44	0.01
	22	2.69	1.21	2.22	0.68 - 7.31	0.19
Ear						
Biting	3	0.82	1.01	0.81	0.69 - 0.94	0.01
	9	0.56	0.83	0.67	0.56 - 0.80	<0.001
	18	0.26	0.22	1.18	0.87 - 1.58	0.30
	29	0.05	0.05	1.00	0.54 - 1.87	0.99
Lesions	3	34.61	36.05	0.96	0.70 - 1.33	0.82
	14	34.40	24.93	1.38	0.97 - 1.95	0.07
	22	16.72	11.86	1.41	0.90 - 2.23	0.14

Table 5. *Effect of docked tail on prevalence (%) and odds ratios (Docked/Undocked) for tail and ears biting and lesions in pigs at different weeks of fattening.*

Item	Age (Wk of fattening)	B, (%)	FE, (%)	Odds	95% confidence interval	*P*
Tail						
Biting	3	0.14	0.15	0.93	0.64 - 1.36	0.71
	9	0.08	0.08	0.94	0.56 - 1.57	0.80
	18	0.02	0.04	0.53	0.21 - 1.33	0.17
	29	0.00	0.01	0.20	0.02 - 1.71	0.14
Lesions	3	10.24	4.51	2.27	1.20 - 4.29	0.01
	14	12.37	10.57	1.17	0.73 - 1.88	0.35
	22	2.18	1.85	1.18	0.39 - 3.55	0.77
Ear						
Biting	3	0.89	0.93	0.96	0.83 - 1.12	0.59
	9	0.88	0.52	1.70	1.42 - 2.03	<0.001
	18	0.26	0.22	1.20	0.89 - 1.62	0.30
	29	0.06	0.04	1.50	0.80 - 2.83	0.21
Lesions	3	43.98	31.87	1.38	1.00 - 1.90	0.05
	14	33.93	24.95	1.36	0.96 - 1.92	0.09
	22	16.10	12.29	1.31	0.83 - 2.06	0.25

Table 6. *Gender effect on prevalence (%) and odds ratios (B/FE) for tail and ears biting and lesions in pigs at different weeks of fattening.*

Item	Age (Wk of fattening)	No straw, (%)	Straw, (%)	Odds	95% confidence interval	*P*
Tail						
Biting	3	0.17	0.10	1.67	1.13 - 2.48	0.01
	9	0.11	0.02	5.53	2.72 - 11.27	<0.001
	18	0.04	0.01	4.14	1.38 - 12.38	0.01
	29	0.02	0.01	2.08	0.38 - 11.35	0.40
Lesions	3	9.67	4.56	2.12	0.23 - 0.84	0.01
	14	10.60	12.93	0.82	0.76 - 1.99	0.41
	22	1.22	2.77	0.44	0.71 - 7.64	0.16
Ear						
Biting	3	1.10	0.73	1.50	1.29 - 1.75	<0.001
	9	0.88	0.52	1.69	1.41 - 2.02	<0.001
	18	0.26	0.22	1.17	0.87 - 1.57	0.30
	29	0.07	0.04	1.74	0.91 - 3.29	0.09
Lesions	3	40.6	33.26	1.22	0.89 - 1.68	0.22
	14	31.9	25.95	1.23	0.87 - 1.73	0.25
	22	12.9	14.84	0.87	0.55 - 1.37	0.55

Table 7. *Effect of straw provision on prevalence (%) and odds ratios (No straw/Straw) for tail and ears biting and lesions in pigs at different weeks of fattening.*

DISCUSSION

The analysis of the blood parameters showed a substantial overlap of the results obtained in docked and undocked pigs, with the exception of cortisol. This parameter was found to have a greater concentration in docked pigs, probably related to the greater prevalence of tail lesions observed at the week 14.

Regarding the analysis of behavior, the avoidance of tail docking showed some consequential differences between groups. All the exploratory activities were performed equally, but undocked pigs showed a lower lying behaviour and a greater number of conflicts, added to greater risk of tail and ear biting until 9 weeks of fattening. However, this increase in activity in undocked pigs did never result in greater prevalence of lesions, both at tail and ears level, but rather the abolition of the docking appears to be a protective factor for the development of tail injury at 14 weeks of fattening. Also Moinard et al. (2003) observed that tail docking significantly increased the risk of recording cases of evidence of blood around the tail. In the present study, it therefore appears that conflicts and biting in undocked pigs were more referred to a social interaction and an explorative behavior than to a form of aggression

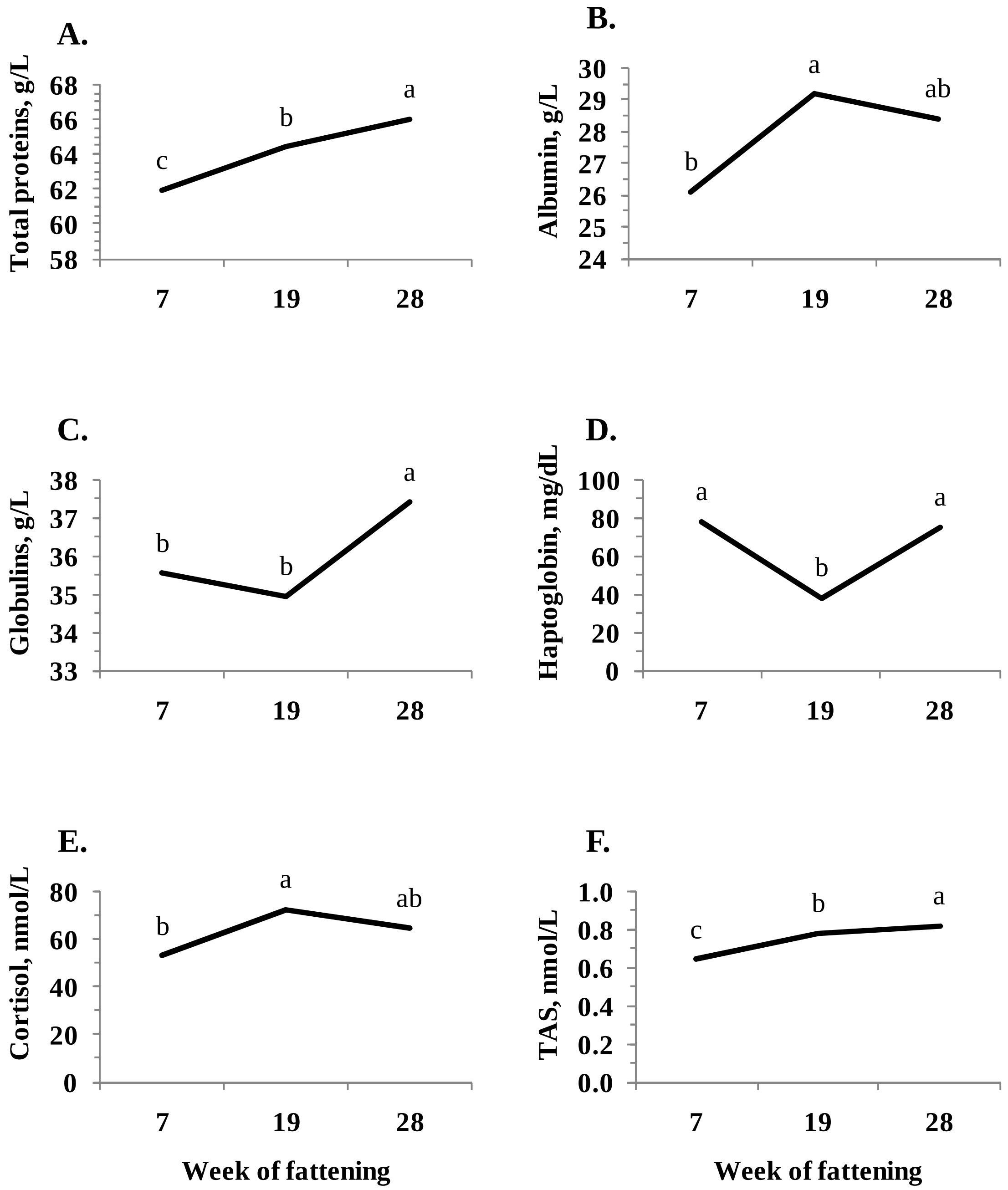

Figure 1. *Total proteins (A; SEM over week of fattening = 0.37), albumin (B; SEM over week of fattening = 0.35), globulins (C; SEM over week of fattening = 1.01), haptoglobin (D; SEM over week of fattening = 4.25), total antioxidants (TAS) (E; SEM over week of fattening = 0.01), and cortisol (F; SEM over week of fattening = 1.05) in serum of pigs at week 7, 19, 28 of fattening. Different letters (a, b, c) mean significant differences at P < 0.05 at different weeks of fattening.*

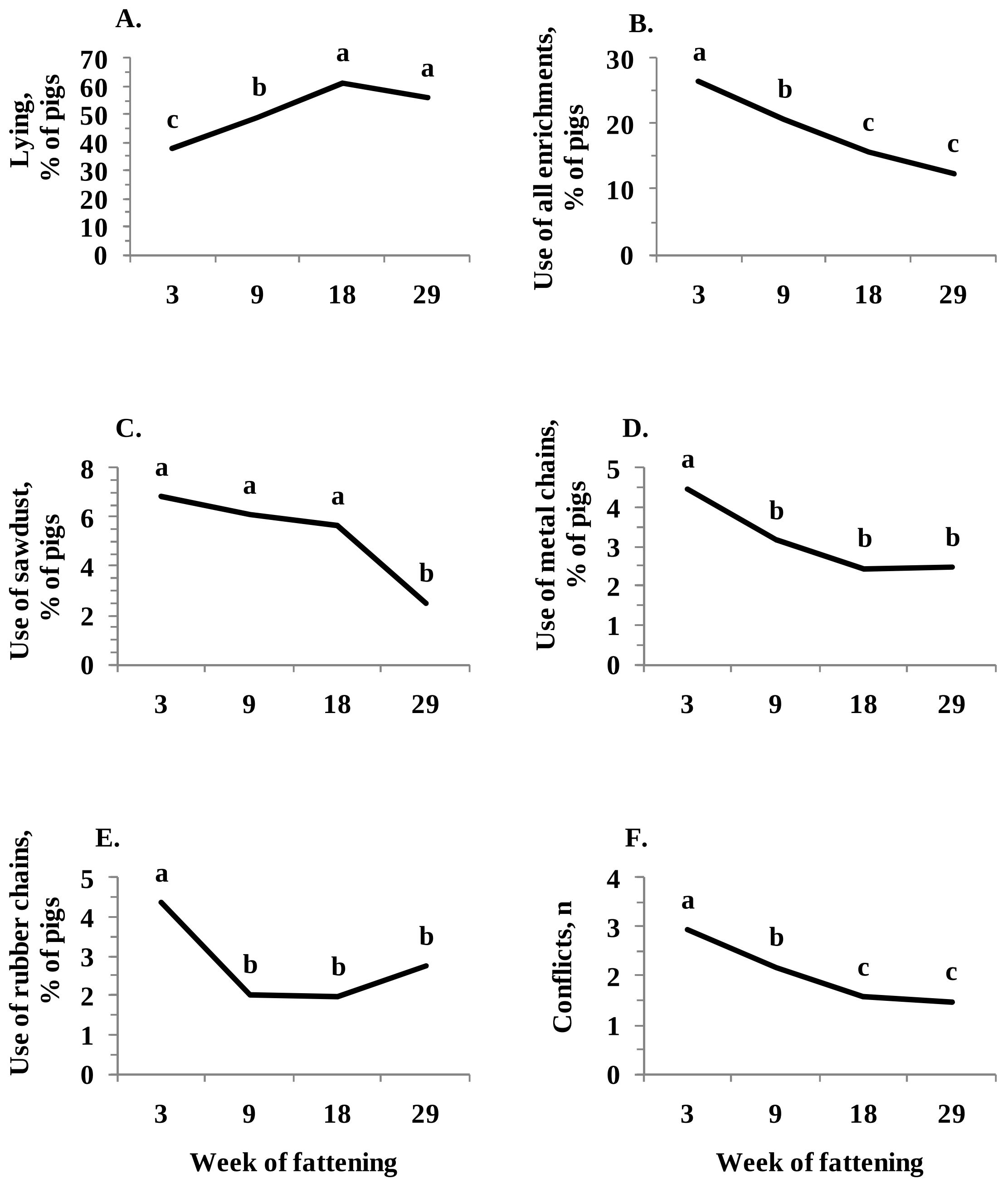

Figure 2. *Lying behaviour (A; SEM over week of fattening = 1.49), use of all enrichments available in the pen (B; SEM over week of fattening = 1.22), use of sawdust (C; SEM over week of fattening = 1.17), use of metal chains (D; SEM over week of fattening = 1.09), use of rubber chains (E; SEM over week of fattening = 1.1), and conflicts (F; SEM over week of fattening = 1.07) of pigs at week 3, 9, 18, 28 of fattening. Different letters (a, b, c) mean significant differences at P < 0.05 at different weeks of fattening.*

(Day et al., 1995). However, neither can completely exclude the hypothesis that this biting behavior represents a tail-in-mouth behavior (TIM) that precedes outbreaks of tail biting as suggested by Schrøder-Petersen et al. (2004). Fraser (1987) described two stages of tail biting and defined as “first stage” when animals show an interest in the tail without causing any visible injury, even if inflammation can be detected at the microscopic level (Simonsen et al., 1991). The second “injury-stage” with wounds and bleeding, will not be reached unless other stressful factors intervene.

By contrast, in our study the greater prevalence of tail lesions recorded in docked pigs at week 14 was not preceded by a greater level of tail biting behavior in the previous weeks. It is likely that the outbreak of tail biting, when not preceded by a period of tail manipulation without lesions, could be related to an aggressive behavior with the intention of provoking a conflict (Widowski et al., 2003). On the basis of what reported, in our study the interest in tails may be ascribed to different motivations in docked and undocked pigs: in the first it may be more related to an aggressive behavior, instead in the latter it may be a form of social interaction and exploration.

Gender did never interact with the tail factor, although there were differences between barrows and females in the observed parameters. The values of all blood parameters obtained considering gender were within normal physiological range (Kaneko, 2008), and their variation seems to be mainly related to the week of fattening and to the coming of sexual maturity of the females. The increase in Total protein with week of fattening might have been due to the physiological increase in globulins and the anabolic effect of sexual and growth hormones (Kaneko, 2008). Females showed also greater Hp concentration than barrows, in agreement with Richter (1974), Lipperheide et al. (1998) and Piñeiro et al. (2009) that attributed the findings to a different physiological state. Should be considered that the increase of Hp level in pigs is associable with several other factors besides gender, such as clinical sign of lameness, respiratory disease, diarrhea, tail biting, and ear necrosis (Petersen et al., 2002). Increased Hp at slaughter was found to be related also to the presence of lesions and chronic abnormalities (Kaneko, 2008). However, we did not attribute the greater Hp concentrations in females to injury or aggressiveness because, in the light of the similar heath status between gender and the absence of further differences in the behavioral data, females showed a lower prevalence of tail lesions and ear biting behavior than barrows. Lesions and aggressiveness observed in barrows can probably be attributed to the classic head-to-head conflict behavior reported by Jensen (1980), but the events was probably not sufficiently stressful to cause the variation of blood parameters. As suggested by Alsemgeest et al. (1995), mild stress has no significant effect on cortisol, Hp and other APPs. According to Wallgren and Lindhal (1996), the greater occurrence of tail lesions in barrows than in females could be related to the fight for feed.

Regardless of gender, after the lowest Hp value observed at week 19, by the end of the fattening period it rose again to the level recorded at week 7. This Hp trend may be related to the progressive reduction of the space available due to the increasing size of the growing animals, and this hypothesis is supported by the results of the study by Amory et al. (2007), who observed a decrease in Hp when the space allowance in finisher pens was increased.

In our study, no specific explanation can be provided for the lower TAS observed in females, whereas the increase in TAS throughout the fattening period might indicate an improvement in the oxidative state of the animals.

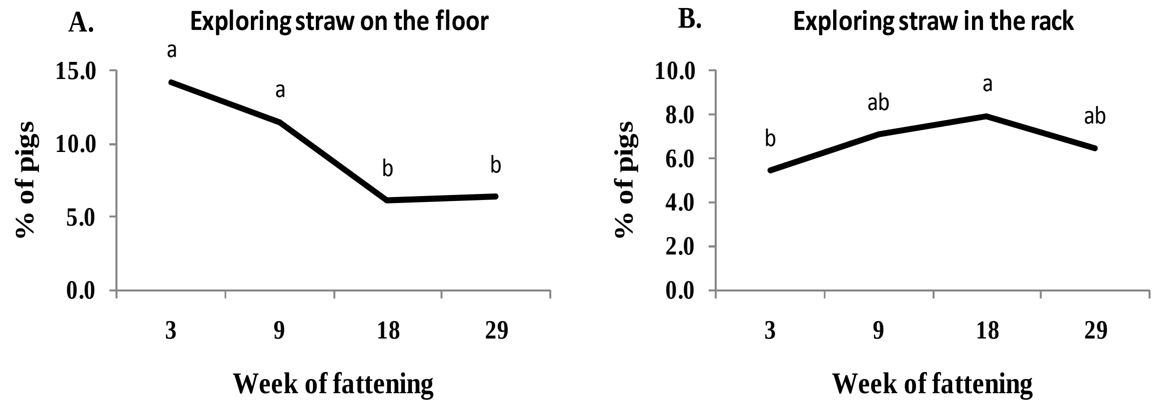

Figure 3. *Exploring straw on the floor (A; SEM over week of fattening = 0.75) and exploring straw in the rack (B; SEM over week of fattening = 0.5) of pigs at week 3, 9, 18, 28 of fattening. Different letters (a and b) mean significant differences at P < 0.05 at different weeks of fattening.*

The straw factor has been shown strong independent effects on some of the observed parameters and also some interactions with the tail factor. As reported for gender in the blood analyses, also the presence of straw in the feeding rack decreased the Hp level, in particular in undocked pigs. This result could be related to both a lower stress level, as suggested also by the lower cortisol concentration in undocked pigs, and to lesser tail lesions with consequently reduced inflammatory response showed by both undocked animals and pigs with availability of straw.

In the behavior analyses, the availability of straw in the feeding rack increased the motivation to perform the total explorative behavior, again especially in undocked pigs, and reduced the average percentage of lying animals. According to Van de Weerd and Day (2009), the presence of suitable environmental enrichments in the pen enhances the wellbeing of pigs by allowing them to perform more of their species-specific behavioral repertoire and accommodates a wider range of behavioral choices.

In our study, availability of straw in the pen decreased the pigs' interest in all the other enrichments but increased total exploratory activity. The pigs showed greater interest in materials that allow rooting (i.e., sawdust and straw) than the biting and licking of chains (regardless of whether or not the chain was covered in rubber). The pigs were consistently more interested in straw than sawdust, probably because straw is also edible and chewable (Van de Weerd et al., 2005). Moreover, straw is a more effective form of enrichment when it is continuously available or replenished daily (Hunter et al., 2001; Moinard et al., 2003), possibly because it remains novel and clean. Although available daily in similar amounts to straw, sawdust was rapidly dispersed, leaving the pigs without this enrichment.

Throughout the fattening period, we observed an overall decrease in explorative behaviors except for the interest in straw in the feeding rack. This constancy is likely maintained because the pigs had to perform some work to remove it from the rack, which kept them occupied for longer time than with other objects that can be manipulated or straw fallen on the floor (Scott et al., 2006).

Besides the overall decrease in explorative behaviors, we observed an increase in lying even when straw was available, though to a lesser extent. This decrease in explorative behavior could be due to a process of habituation after prolonged exposure to the same environmental enrichments, as reported by Day et al. (2002) and Docking et al. (2008). We expected the pigs to become more aggressive and competitive at older age, mainly due to their increase in size and the consequent reduction of space, even if the allowance remained within the limits established by the EU legislation. Interestingly however, the results obtained showed not only the increase in general animal inactivity reported in literature (Petersen et al., 1995; Jensen et al., 2010) but also a decrease of exploration, social interaction, and competitiveness. This loss of interest in any redirecting activities and lack of exploratory behavior suggest a condition of apathy rather than full adaptation to the rearing environment (Broom, 1991).

The hypothesis of apathy could be supported by the fact that decreased interest in environmental enrichments did not increase adverse behavior such as tail and ear biting. Both of these behaviors were instead greater in pens without straw, confirming the results of several studies (Guy et al., 2002; Van de Weerd et al., 2005; Scott et al., 2006). In agreement with literature, we observed straw to be a relevant protective factor against tail and ear biting and tail lesions, especially at the beginning of the fattening cycle when social stress created by the new environment and the new pen-mates is very intense. On the other hand, the disappearance of significant differences between groups with and without straw at the end of the fattening cycle may have been due to the normal decrease in biting after the peak at about 50 kg reported by Van de Weerd (2005).

Regardless of gender and straw availability, the extension of the fattening cycle and the progressive reduction of space allowance due to the growing size of the animals seems not to increase tail and ears biting and lesions in undocked pigs. The outcome of the study suggests that the combined use of solid floors, compliance with the parameters established by EU legislation in terms of space allowance and environment, and presence of chains and sawdust as enrichments seems to allow the fattening of heavy pigs without performing tail docking with no outbreak of injurious tail biting. Straw therefore seems to be an important tool in both increasing explorative behavior and preventing biting and lesions, particularly in the early stage of fattening.

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Chapter 4

Is it possible to rear heavy pigs avoiding tail docking? Role played by gender and presence of straw in the control of tail biting: II. Mortality, lung lesions and oesophago-gastric ulcers

IS IT POSSIBLE TO REAR HEAVY PIGS AVOIDING TAIL DOCKING? ROLE PLAYED BY GENDER AND PRESENCE OF STRAW IN THE CONTROL OF TAIL BITING: II. MORTALITY, LUNG LESIONS AND OESOPHAGO-GASTRIC ULCERS

Di Martino G. [1], Capello K. [1], Scollo A. [2], Gottardo F. [2], Stefani A. L. [1], Rampin F. [1], Schiavon E.[1], Marangon S.[1] and Bonfanti L. [1]

[1]*Istituto Zooprofilattico Sperimentale delle Venezie, 35020 Legnaro, Padova*

[2]*Dipartimento di Medicina Animale, Produzioni e Salute, University of Padova – Legnaro (PD);*

SUBMITTED TO RESEARCH IN VETERINARY SCIENCE

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ABSTRACT

The aims of this study were to evaluate whether straw provision in little amounts, tail docking and gender have an effect on welfare in Italian heavy pigs. A 2x2x2 factorial design was adopted to test the effects of these variables on: mortality during fattening, lung lesions and oesophago-gastric ulcers (OGU) scored at slaughter.

The results showed no significant differences among the experimental groups for mortality or lung lesions. Straw presence was significantly associated with a decreased occurrence of OGU; the protective effect was more evident in undocked pigs (OR: 0.16, 95% CI: 0.09-0.28) compared to docked pigs (OR: 0.41, 95% CI: 0.25-0.69). Males were more likely than females to have OGU (OR=1.52, 95% CI: 1.08-2.12). To conclude, undocked tails did not affect the considered parameters, yet the consumption of small amounts of straw improved welfare by reducing the susceptibility to OGU.

Keywords: Italian heavy pig; gastric ulcer; straw; tail docking

INTRODUCTION

In Europe, the majority of consumers consider animal welfare as a priority for livestock production (EU Commission, 2007), and in response to public opinion, an increasing number of regulations have been issued. With particular reference to intensively kept pigs, Council Directive 2008/120/EC (EU Council, 2008) requires farmers to allow pigs to express their exploratory behaviour via the use of straw, wood, sawdust, compost, peat, or a combination of these; this Directive also prohibits the use of tail docking as a routine surgical procedure for preventing tail biting later in life.

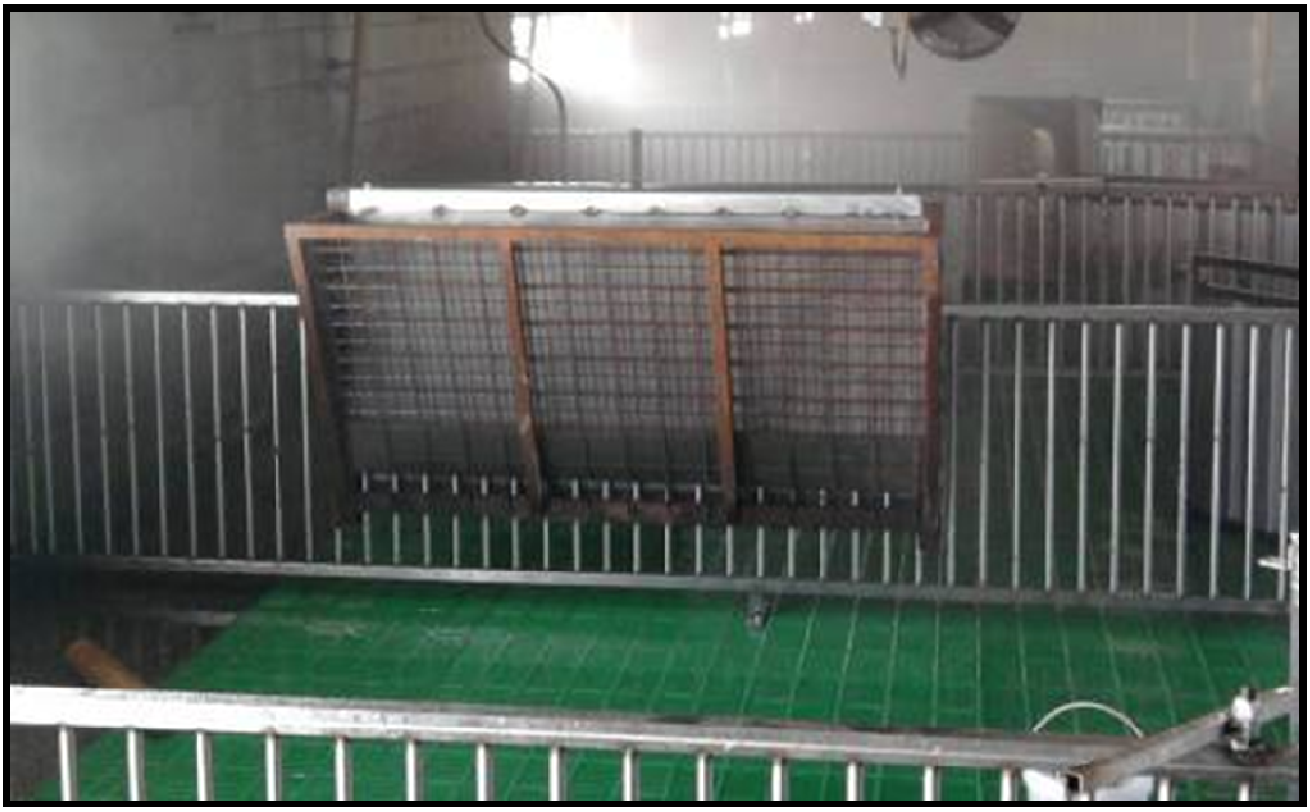
Several studies have demonstrated that environmental enrichment, especially the provision of straw, can reduce tail biting and aggressive behaviour (EFSA, 2007). However, because most pig husbandry facilities in Europe have slatted floors, large amounts of straw would block the slurry-based manure systems (Zonderland et al., 2008). To address this problem, small amounts of straw provided in manger racks have been used, and in light pigs this practice has been shown to have positive effects on aggressive behaviour (Van Putten, 1980; Fraser et al., 1991; Bøe, 1992; Day et al., 2001; Day et al., 2002) and tail biting (Zonderland et al., 2008), without negatively affecting production (Jordan et al., 2008) and causing only slight management problems (Zonderland et al., 2008). Until recently, no studies had been published on the effects of straw provided to Italian heavy pigs reared for Protected Designation of Origin (PDO) Parma and San Daniele ham. This type of production differs from others in Europe because it has a longer fattening cycle (at least 9 months of age), heavier animals (at least 160 kg live weight), and higher quality standards.

In light of these considerations, we conducted a previous study to evaluate the effects of straw provision on the health of Italian heavy pigs during the fattening period on a farm in northern Italy. According to the results, the availability of straw was significantly associated with lower haptoglobin levels, less lying behaviour, greater interest in exploring enrichments, and a lower risk of tail biting and ear biting; moreover, tail presence did not increase the risk of tail lesions (undocked vs docked pigs). The same study generated data which have been analyzed and discussed in the present paper in order to assess the effects of straw provision, tail docking and gender on mortality, causes of death, and the presence of lung lesions and oesophago-gastric ulcer (OGU) at slaughter.

MATERIALS AND METHODS

Animals, management and experimental design

The study was performed on 672 commercial crossbred pigs reared for PDO Parma and San Daniele ham (Landrace x Large White; 336 males and 336 females) on a farm in northern Italy. The farm was chosen because it represents an average-sized farm for heavy pigs in this area. The pigs were reared in a commercial open-site fattening unit, with a 30-week growing cycle (October-May). They were housed in 24 single-sex group pens containing 28 pigs each (the maximum number of pigs allowed in relation to the floor area, in compliance with Council Directive 2008/120/EC). The 24 pens were distributed in two rows and divided by a corridor. All pens consisted of an indoor area with a solid floor and an outdoor defecation area with a slatted floor. The unobstructed floor area in each pen was 28.6 m2 for the entire fattening period. Drinking water was available ad libitum through a nipple (one per pen). As environmental enrichment, all of the pens contained chains (one metal and one rubber-covered, both hanging from the wall).



The pigs came from the same conventional weaning unit, in which straw was not available. Half of the animals (n=336) were tail-docked on the fifth day of life, cutting 2/3 of the tail's length; at the same time all males were surgically castrated (in compliance with Council

Directive 2008/120). During the weaning phase, the pigs had been divided into groups based on gender and tail docking. However, during transport, this division was not maintained. At the fattening unit, the pigs were again divided into groups based on gender and tail docking, although the composition of the groups in terms of individual animals was not the same as that in the weaning unit.

Upon arrival at the fattening unit, all of the pigs were of the same age (80 days), and their average body weight was about 25 kg. Pigs were manually fed twice a day, at 07.00 h and 15.00 h, with two equal liquid meals consisting of 3 parts water and 1 part commercial dry feed containing wheat, corn and soybean meal (87.5% of dry matter). Animals were vaccinated once against Mycoplasma hyopneumoniae (Stellamune Once, Elanco) in the second week of life, and three times against Aujeszky disease virus at 70, 106 and 180 days of life (Akipor Flu, live attenuated virus, stock bartha, deleted gE, Merial).

In 12 of the 24 pens, long straw was available at all times in a metal rack attached to the wall (9-kg capacity and 5x5 cm mesh); the rack was refilled about three times per week. Total straw consumption was recorded at the end of the fattening period by subtracting the remaining amount from the initial one.

A 2x2x2 factorial design was adopted to test the effects of the availability of straw (absence vs. presence), long tail presence (docked vs. undocked pigs), and gender (castrated males vs. females) on the parameters considered. The experimental treatments were distributed according to a completely randomized design.

All experimental procedures and animal care were carried out in accordance with Italian legislation on the protection of animals used for experimental and other scientific purposes (Gazzetta Ufficiale, 1992).

Serologic analysis

Serum samples were taken at the first day of fattening from 22 randomly selected animals, in order to detect antibodies to the most common porcine diseases in the area: PRRS (Kit

ELISA “Porcine Reproductive and Respiratory Syndrome Virus Antibody Test Kit”; Idexx Laboratories) and PCV2 (kit ELISA “Primacheck Circovirus IgG/IgM”, Ingenasa). Within-herd sampling was designed to provide 90% confidence level of detecting at least one positive animal, assuming a within-herd prevalence of at least 10% (Puvanendirana et al., 2011). Blood was collected from the jugular vein in Vacutainer® tubes, inverted 5 times to mix the clot activator and allowed to sit vertically at 20–24 ℃ for a minimum of 30 min. Samples were cooled to 4℃ and shipped within 2h to the IZSVe la boratory, where the analyses were performed. Sera were drawn off, aliquoted, and frozen at −20 ℃ until use.

Mortality and gastric and lung scoring

The mortality rate during the fattening period was calculated for each of the experimental groups. To identify the cause of death for pigs that died during the fattening period, post-mortem examination was performed, including bacteriological and virological assays. OGU detected during necropsy was recorded and scored, using the same methods described below for the slaughtered pigs.

All of the animals were transported to the abattoir on the same day; their average weight at slaughter was 169 kg. To trace the animals at slaughter, a lot number was assigned to each of the experimental groups. After slaughter, the pigs were examined for the presence of OGU. In particular, the stomach was opened along the greater curvature; the contents were removed; and the stomach was inverted and washed. A four-point scoring system based on the method of Robertson et al. (2002) was used to classify the pars oesophagea: 0 = normal (no lesions, pearly white coloured); 1 = hyperkeratosis (no lesions, mucosal thickening, yellow coloured); 2 = mucosal erosions; and 3 = severe ulcer. In accordance with this scoring system, we considered those animals with a score of 2 or 3 to be affected by OGU. The lungs of the pigs were also inspected, and lesions were scored according to the method of Ostanello et al. (2007). In particular, 7 lobes were examined, and a score was assigned to each of them using the following criteria: 0 = absence of lesions; 1 = lesion involving less than 25% of the lobe; 2 = lesion involving 25-49% of the lobe; 3 = lesion involving 50-74% of the lobe; and 4 = lesion involving more than 75% of the lobe. The 7 scores were then totalled to obtain an overall lung score (maximum score = 28).

Statistical analysis

For all of the data analyses, presence of straw, tail docking, and gender were considered as the main factors; the interactions among these three factors were added in the models, and, if not significant, were further removed using a backward elimination process. The animal was the experimental unit. The tables show the results of the final models.

Regarding OGU, a reclassification of the scores was adopted following the method proposed by Robertson et al. (2002). We thus compared the scores 0 and 1 (normal mucosa/pre-OGU stage) to scores 2 and 3 (OGU), using logistic regression. Furthermore, a polytomous logistic regression was carried out, given the classification of the scores into three categories: 0 and 1 together, 2 and 3.

The lung lesions were analyzed comparing the absence of lesions (score 0) with the presence of lesions (scores 1-4), again by means of a logistic regression analysis (scores 1-4 were combined because very few animals were found to have had lung lesions). To perform the logistic regression analyses, the reference categories of the three main factors were: absence of straw, presence of tail, and female, and the results were expressed as Odds Ratios (OR) with 95% confidence intervals (95% CI). All of the statistical analyses were performed using the software SAS v. 9.1 (SAS Inst., Inc., Cary, NC).

RESULTS

Serology and mortality

Serology performed on the first day of fattening showed that all 22 of the tested pigs were negative for PCV2 and that all were positive for PRRS. During the fattening period, 12 pigs died (mortality of 1.8%), and the same number of pigs died in each of the experimental groups (n=6) (Table 1). In all cases, death was attributed to PRRS or PCV2 infection. Among the pigs that died during the fattening period, severe OGU (score 3) was found in one animal without straw, and mild OGU was found in 2 animals with straw (Table 1) The PRRS virus was first isolated (by PCR) in a pig that had died at day 9 of fattening, and the first PCV2 virus was isolated (by PCR) in a pig that had died at day 25 of fattening. The mean amount of straw consumption per pig was 70 g/day.

	Straw		Tail		Gender	
	No	Yes	Docked	Undocked	Male	Female
From 1 to 7 weeks[b]						
Mortality, n. (%)	4 (1.2)	5 (1.5)	5 (1.5)	4 (1.2)	5 (1.5)	4 (1.2)
Etiology	PRRS; PCV2	PRRS; PCV2	PRRS; PCV2	PRRS; PCV2	PRRS; PCV2	PRRS; PCV2
Gastric ulcer	1 case	2 cases	2 cases	1 case	2 cases	1 case
From 8 to 18 weeks						
Mortality, n. (%)	2 (0.6)	1 (0.3)	1 (0.3)	2 (0.6)	1 (0.3)	2 (0.6)
Etiology	PCV2	PCV2	PCV2	PCV2	PCV2	PCV2
Gastric ulcer	None	None	None	None	None	None
From 19 to 30 weeks	0	0	0	0	0	0
Mortality, n. (%)	0	0	0	0	0	0
From 1 to 30 weeks						
Mortality, n. (%)	6 (1.8)	6 (1.8)	6 (1.8)	6 (1.8)	6 (1.8)	6 (1.8)

Table 1. *mortality , etiological diagnosis and gastric ulcer evidence (score 2-3) in 672 heavy pigs during fattening period; data were stratified by straw provision, long tail presence and gender.*

[a] weeks of fattening

Lung and gastric scores

The effects of straw provision, long tail presence, and gender on the lung scores for the slaughtered pigs are shown in Table 2. Overall, the mean lung score was very low; for 72% of pigs, the total score was 0. No significant effect on the total lung score was found for any of the three variables.

	Straw		Tail		Gender	
	No	Yes	Docked	Undocked	Male	Female
N[a] (%)	91 (28.8)	87 (27.0)	95 (29.3)	83 (26.4)	84 (26.5)	94 (29.3)
OR (95%CI)	0.91 (0.64-1.29)		0.86 (0.61-1.22)		0.87 (0.61-1.23)	

Table 2. *Effect of straw provision, long tail presence and gender on lung scores (scores 1 to 4 are added) of slaughtered heavy pigs; the results were expressed as Odds Ratio (OR) with 95% confidence interval (95%CI).*

[a] number of lungs with score 1 to 4

The effects of straw provision, long tail presence, and gender on OGU scores for the slaughtered pigs are shown in Table 3. Overall, OGU was diagnosed in 47.2% of the pigs. The results of the logistic regression analysis (Table 4) showed that males were more likely to have OGU than females (OR=1.52, 95% CI: 1.08-2.12). Taking into account the significant interaction between tail and straw (P = 0.007), straw provision was found to have been associated with a lower occurrence of OGU, though the protective effect of straw was more evident in undocked pigs (OR = 0.16, 95% CI: 0.09-0.28), compared to docked pigs (OR = 0.41, 95% CI: 0.25-0.69). Considering the results of the polytomous logistic regression, in particular, comparing scores 2 with scores 0-1, no differences were observed between males and females (OR: 0.91, 95% CI: 0.60-1.37). The analysis revealed no significant interaction between tail and straw; thus only two ORs could be calculated: 0.61 (95% CI: 0.41-0.93) for tail and 0.27 (95% CI: 0.17-0.41) for straw.

Score	**No straw**		**Straw**		**Docked**		**Undocked**		**Male**		**Female**	
	n.	**%**	**n.**	**%**	**n.**	**%**	**n.**	**%**	**n.**	**%**	**n.**	**%**
0	12	3.85	92	28.48	37	11,53	67	21,34	46	14.47	58	18.30
1	103	33.01	128	39.63	118	36,76	113	35,99	107	33.65	124	39.12
2	95	30.45	49	15.17	85	26,48	59	18,79	61	19.18	83	26.18
3	102	32.69	54	16.72	81	25,23	75	23,89	104	32.70	52	16.40
Total	312	100	323	100	321	100	314	100	318	100	317	100

Table 3. *Effect of straw provision, long tail presence and gender on gastric ulcer susceptibility of slaughtered heavy pigs.*

Regarding score 3, a significant gender effect was observed: the probability of having a severe ulcer was higher for males than for females (OR = 2.49, 95% CI: 1.65-3.78). As observed with the logistic regression analysis, the significant interaction between tail and straw highlighted a significant protective effect of straw, which was more evident in undocked pigs (OR = 0.14, 95% CI: 0.07-0.29) compared to docked pigs (OR = 0.45, 95% CI: 0.26-0.79).

Output Logistic Regression Analysis (base outcome: scores 0 + 1)			
Factor	**OR**	**95% CI**	**p-value**
STRAW[a]	0.41	0.26-0.64	<.000
TAIL[b]	1.04	0.65-1.65	0.857
GENDER[c]	1.52	1.08-2.12	0.014
TAIL x STRAW	0.39	0.20-0.77	0.007
Output Polytomous Logistic Regression Analysis (base outcome: scores 0 + 1)			
Factor	**OR**	**95% CI**	**p-value**
Score 2			
STRAW[a]	0.37	0.21-0.64	<.000
TAIL[b]	0.83	0.48-1.43	0.513
GENDER[c]	0.91	0.60-1.37	0.663
TAIL x STRAW	0.49	0.21-1.15	0.102
Score 3			
STRAW[a]	0.46	0.26-0.79	0.006
TAIL[b]	1.30	0.75-2.24	0.339
GENDER[c]	2.49	1.65-3.78	<.000
TAIL x STRAW	0.32	0.14-0.73	0.007

Table 4. *Results of logistic regression analysis and polytomous logistic regression analysis based on the comparison between gastric scores 0+1 vs 2+3 and scores 0+1 vs 2 and 3.*

a Presence vs. Absence | Docked
b Undocked vs. Docked | No straw
c Male vs. Female

DISCUSSION AND CONCLUSIONS

The serological testing performed at the beginning of the fattening period (at 11 weeks of age) indicated that the animals had been infected with PRRS during weaning, and the positivity rate was the same for each of the experimental groups. Although none of the pigs were positive for PCV2 at the beginning of the fattening period, PCV2 infection was found to have been a cause of death beginning at 14 weeks of age. Infection with these viruses occurred within the expected temporal range: PRRS infection mainly occurs from 4 to 8 weeks of age, whereas PCV2 infection occurs later (at 8-16 weeks of age) (Gutierrez et al., 2012). The experimental treatments did not seem to have any significant effect on mortality during fattening, which fell within the expected range for Italian heavy pig production and was lower than the national mean (2,6% for Corradini et al., 2004).

Based on these results, we can consider the population to have been in good health. The good health status was also confirmed by the lung scores, which were much lower than those reported by Ostanello et al. (2007) in 10,041 Italian heavy pigs: 40.4% with a score of 0, 45.7% with a score of 1-4 and 13.9% with a score of 5-26. Lung scoring can be useful for acquiring information on Porcine Enzootic Pneumonia at slaughter. Although the primary agent is Mycoplasma hyopneumoniae, the disease has been recognized as a multifactorial syndrome that results from the interaction of infectious agents (viruses, mycoplasmas and bacteria), environmental conditions, and host factors (Hill et al., 1992; Merialdi et al., 2012).

OGU is a common condition in swine (Friendship, 2003). It occurs more frequently than ulceration of the fundic region (Doster, 2000) and can result in mortality (Driesen et al., 1987) and reduced feed efficiency (Elbers et al., 1995; Ayers et al., 1996), with subsequent economic losses. In our study, none of the animals died from OGU, and during necropsy it was detected in only 3 animals, which died from PRRS and PCV2. The low frequency of OGU could be explained by the pigs' overall good health, which did not allow marked differences to be expressed.

OGU has several predisposing factors: feeding practices, fineness of feed particles, feed nutrient content (Wondra et al., 1995), infections (Friedership, 2003; Amory et al., 2006) and stress (Pfeiffer, 1992; Dybkjaer et al., 1994; Queiroz et al., 1996; Doster, 2000). In our study, all of the pigs were subjected to the same conditions in terms of husbandry and slaughter, and health problems were equally distributed among the experimental groups; thus all of the differences are presumably attributable to the experimental effects. The results showed that the presence of straw, though provided in small amounts, may represent an important protective factor against the onset of OGU. The explanation may be related to the protective action of continuous chewing and ingestion of small amounts of fibres, and further studies are needed to investigate this effect also with solid feed and ad libitum diet. The better welfare of the pigs that had been provided with straw was also confirmed by the lower level of serum haptoglobin found in the same animals at the end of fattening period.

The finding that females had lower scores for OGU may be attributed to the protective effect of estrogens, as demonstrated in female mice (Shimozawa et al., 2008). This gender difference has not been reported in fattening light pigs (Elbers et al., 1995; Robertson et al., 2002), probably because of the different physiology (i.e., hormonal production) of younger animals. Moreover, stress related to prolonged intensive conditions may have exacerbated this male predisposition in older age. This hypothesis seems to be confirmed by the higher overall prevalence of OGU in our study (47.2%), compared to the 30% overall prevalence reported by Robertson et al. (2002) in 15,741 slaughtered light pigs from 136 Australian herds with different management variables.

These authors also found that the prevalence of OGU was associated with certain husbandry conditions that were not adopted in our study, in particular: ad libitum diet (OR = 13,7), automatic feeding system (OR = 7,8) and pelleted ration (OR = 384). Thus additional studies will need to be performed taking into consideration these conditions.

The mean amount of straw consumption per pig (70 g/pig/day) was comparable to that reported for light pigs: 63 g/pig/day for Fraser et al. (1991); 92 g/pig/day for Day et al. (2002); 100 g/pig/day for Jordan et al. (2008), Day et al. (2001) and Van Putten (1980); and 192 g/pig/day for Bøe (1992). Given that this was a small amount of straw, there were no management problems due to slurry outflow obstruction or excessive farmer workload. In fact, the feeding rack used in the study minimized straw waste and only a slightly hindered slurry outflow was observed in some pens at the end of the fattening cycle, yet it was not specifically due to straw. Moreover, the net used for the straw rack was 5x5cm square, which seemed to be a good solution for avoiding straw waste and allowing pigs to spend a lot of time investigating and smelling straw, as opposed to rapidly emptying the rack. These results are in accordance with the indications of European Food Safety Authority: the ideal enrichment must be edible, odorous, chewable, deformable and destructible and among all the items tested, straw has provided the most remarkable results in reducing aggressiveness (EFSA, 2007).

Our results revealed no significant differences between docked and undocked pigs in terms of lung and OGU scores: we can thus assume that under the above-mentioned experimental conditions, long tail presence did not compromise animal health. These results were also confirmed by the previous finding that among the same pigs there were no differences in tail lesion scores and haptoglobin levels during the fattening period. Thus the prolonged fattening period for Italian heavy pigs seems to have had no influence on tail biting, as reported for light pigs (EFSA, 2007). However, considering the complex and multifactorial nature of tail biting (EFSA, 2007), further studies will be needed to confirm this result, also in different husbandry and environmental conditions (e.g., flooring, type of feed, period of year).

To conclude, the results of this study reveal the beneficial effects of straw on the susceptibility to gastric ulcer in Italian heavy pigs, for which very few data are available. The straw was beneficial, despite the fact that only a relatively small quantity was provided to pigs, allowing management problems due to slurry outflow obstruction or excessive farmer workload to be avoided. The results also support previous investigations about the feasibility of rearing heavy pigs under routine conditions without tail docking. This evidence is potentially useful for producers raising heavy pigs in conventional confinement systems, although further studies on pigs raised under different husbandry conditions will be needed.

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Chapter 5

Tail biting in heavy pigs:
impact of gender and undocked tail on welfare indicators:
I. Weaning phase

TAIL BITING IN HEAVY PIGS:

IMPACT OF GENDER AND UNDOCKED TAIL

ON WELFARE INDICATORS:

I. WEANING PHASE

Scollo A. [1], Di Martino G. [2], Bonfanti L. [2], Stefani A. [2], Schiavon E. [2], Marangon S.[2], and Gottardo F.[1]

[1]*Dipartimento di Medicina Animale, Produzioni e Salute, University of Padova – Legnaro (PD);*

[2]*Istituto Zooprofilattico Sperimentale delle Venezie, 35020 Legnaro, Padova.*

BACKGRAUND

In the present study, tail biting was evaluated throughout an entire producing cycle of heavy pigs, starting from weaning to slaughter. The aim was to investigate welfare and tail biting outbreaks both in the weaning and the fattening phase, having available data of individually marked animals during their whole growth. Slatted floor was chosen as the most common floor type used in the heavy pig production, but even recognized as one of the mayor risk factors for tail biting.

MATERIALS AND METHODS

All experimental procedures and animal care were carried out in accordance with Italian legislation on the protection of animals used for experimental and other scientific purposes (Gazzetta Ufficiale, 1992).

Animals, Facilities, and Management

This study evaluated the effects on several health and welfare indicators of tail presence (docked vs. undocked pigs) and gender (castrated males vs. females) according to a 2 × 2 factorial design during the weaning (phase 1) and the following fattening phase (phase 2). The experiment involved a total 448 commercial crossbred pigs (Landrace × Large White). The number of group pens used for each treatments was 1:1 for gender and 2:5 for tail treatment with a greater number of pigs with intact tail, choice supported by an ethical point of view and by statistical analysis. Tails were docked by removing 2/3 of their length by means of cauterization at 5 days of age in the farrowing room.

The study in total lasted 36 weeks from December 2010 to August 2011 and it was carried out in two commercial open-site. The first was specialized in the weaning phase and the other ones in the fattening phase .

Weaning Phase. The weaning phase lasted 56 d and at the beginning of this part of the experiment, piglets were aged 26 ± 1 d and weighted 8.39 ± 1.46 kg and they were transported by trucks from the farrowing unit to the weaning site. Piglets were housed according to the combinations of gender and presence of tail in 14 group pens of 32 animals each with a space allowance of 0.32 m2/pig. The pens were distributed in two rows and divided by a corridor used for all management procedures and animal health checks. In each pen a nipple and a trough (0.6 m length) were accessible and therefore drinking water and feed were available ad libitum through.

The pens had a plastic slatted floor. In each pen were available as environmental enrichments a plastic chain hanging from the wall, a wooden block leave on the floor, and a feeding rack containing long straw.

In order to monitor the same pigs from the weaning to the fattening (phase 1 and 2 of the study) a sample of 10 animals per pen was selected and ear marked with transponder tags. A total number of 140 pigs was therefore individually identified during the entire duration of the study.

Health and Environment. During both weaning and fattening phases, the pigs were inspected by the stockman twice a day to record the number of dead pigs and to identify severe injuries related to tail biting requiring specific treatment in the sickbay. Light and noise were checked twice a month using a multi-function environmental analyzer (Lafayette mod. DT-8820; Marcucci S. p. A., Vignate (MI), Italy) in order to keep levels below the threshold set by pig welfare protection legislation (EU Directive 2008/120). Also CO2 concentration and ammonia levels were recorded in different parts of the rows using a DRAGER X-am7000 (Dräger Safety AG & Co. KGaA, Lübeck, Germany) to ensure that all pens maintained the same experimental conditions.

Procedures

Blood Sample Collection and Analyses. Blood samples were collected from the ear tagged animals at 39, and 66 days of age during the weaning phase. Blood was collected from the jugular vein using 4-ml sterile vacuum tubes containing K3EDTA (Vacutest Kima srl, Arzergrande, PD, Italy). Samples were stored at 4℃ during transportation to the laboratory, centrifuged at 2, 400 × g for 10 minutes at 20℃, a nd stored at -20℃ before analysis.

The parameters analyzed were haptoglobin (Hp), albumin/globulin ratio (A/G ratio), and cortisol, which were chosen on the basis of their role as pig health status and welfare indicators. Hp, as acute phase protein (APPs) fraction, may be considered an unspecific health status marker (Murata et al., 2004; Petersen et al., 2004). APPs migrate in the alpha and beta globulin region of the serum protein electrophoretic pattern (Kaneko, 2008), altering total subsequently albumin/globulin ratio. Cortisol was evaluated because it is considered one of the main stress hormones (Kaneko, 2008).

Haptoglobin concentration was determined by an ELISA kit (Phase Haptoglobin, Tridelta Develpoment ltd, Maynooth, County Kildare, Ireland). The A/G ratio was calculated by determining the concentration of different protein fractions through serum electrophoresis with a Hydrasis LC semi-automated analyzer (Sebia, Lisses, EVRY Cedex, France) on 0.8% agarose gel (Hydragel 30 Protein, Sebia, Norcross, Georgia). Serum cortisol concentration was determined by an immunologic chemiluminescent kit (LKCO1, Medical System,) applied to the Immulite One automated analyzer (Immulite One, Medical System, Genoa, Italy).

Behavioural Observations. Behaviour was evaluated at 39, and 66 days of age during the weaning phase in all the animals reared in 10 randomly chosen pens. Data were carried out by direct observation using a scan-sampling technique (Martin and Bateson, 2007) with a 2-minute interval between scans. Each scan recorded the number of animals per pen lying inactive or exploring (licking, suckling, rooting, biting, chewing) different substrates/objects such as chains and straw. Each observation session was carried out by trained observers that recorded each one the behavior performed by the pigs in 2 pens watched alternately. The pigs were observed for 2 uninterrupted hours in the morning (from 1000 h to 1200 h). The number of events such as conflicts, tail biting and ear biting was also recorded during observation using the behaviour sampling technique (Altmann, 1974) (Table 1).

Behaviour	Definition of the behaviour	Method of observation
Exploring straw in the rack	Pigs sniffing and chewing straw in the rack.	Scan Sampling
Exploring straw fallen on the floor	Pigs sniffing, rooting and chewing straw fallen on the floor.	
Exploring nipple drinker	Pigs touching or holding the nipple.	
Exploring chain	Pigs sniffing and chewing the chain.	
Lying inactive	Pigs in lateral or sternal lying, resting or sleeping.	
Eating	Pigs eating meal in the trough.	
Conflicts	Aggressive interaction among two or more pigs.	Behaviour sampling
Ears biting	A pig had in the mouth an ear of a pen mate and bite it.	
Tail biting	A pig bite the tail of another pig.	

***Table 2**. Description of behaviors observed and methods adopted for their recording.*

Skin Lesions. Two trained veterinarians visually evaluated alterations in each pig's anterior body (head, neck, shoulders), main body (trunk, abdomen), posterior body (rump, genitals), tail, and ears at 30, 53, and 79 days of age during the weaning phase. Data were carried out in accordance with Widowski et al. (2003) and Sutherland et al. (2008), scoring each anatomical area with a 3-point scale (0: no lesions; 1: mild lesions with hair loss, redness, irritation, scratches or small abrasions; 2: severe lesions with bleeding and loss of tissue). In addition, tails were checked also for length (0: intact tail; 1: presence of more than half the tail; 2: presence of less than half the tail).

Statistical Analyses

Data obtained from weaning and fattening phases were separately investigated. Analysis for their Gaussian distribution were carried out, and coefficients of skewness and kurtosis were computed by PROC UNIVARIATE (SAS 9.2, SAS Institute Inc., Cary, NC) to measure distribution asymmetry and peakedness. Variables with Shapiro-Wilk values (W) ≥ 0.95 were considered normal, whereas all other variables were log transformed before analysis to adjust for their lack of normality. Gaussian and transformed data from blood samples were statistically processed by PROC MIXED (SAS 9.2, SAS Institute Inc., Cary, NC) and LS means were compared using the Bonferroni test. The model considered the fixed effects of tail presence, gender, age, and their interactions (of first and second level), and pen within tail × gender was the subject effect (covariance parameter) in the analysis.

Behavior and skin lesions were processed adopting a PROC GENMOD (SAS 9.2, SAS Institute Inc., Cary, NC) using the Poisson distribution, with the same fixed effects and interactions considered for blood parameters. For the analysis, behavioral data from scan sampling were transformed into frequencies by dividing, for each scan, the number of animals that engaged in a given behavior by the total number of animals housed in that pen. Regarding the skin lesions, only mild ones were detected, and none of the pigs had reduced tail length caused by tail biting; for this reason, only the presence/absence of lesions and not the severity of lesions or the reduction in tail length was considered in the statistical analyses.

RESULTS

None of the pigs was moved into the sickbay as consequence of severe tail lesions due to tail biting. Results regarding blood parameters, behavior and skin lesions are reported in Tables 2, 3, and 4 respectively.

Analyses by tail presence did not show differences between docked and undocked pigs in the blood parameter. However, interactions between factors showed a greater cortisol level in undocked females compared to undocked barrows (P = 0.041) and a greater Hp level in docked pigs at 39 days than at 66 days of age (P = 0.006).

Undocked pigs presented lower explorative activity regarding nipple drinker and chain (P = 0.038 and P = 0.02 respectively), concomitantly to a greater lying behavior (P = 0.02). Exploration of nipple drinker was lower especially at 33 days of age, as demonstrated by the significant interaction between tail presence and age for this parameter (P = 0.02). A similar interaction showed also a lower eating behavior of undocked pigs at the same age (P = 0.04).

	Tail		Gender[1]		Age (d)		*P-value*		
	Docked	Undocked	B	F	39	66	Tail	Gender	Age
Albumin/Globulins	0.75	0.75	0.73	0.77	0.76	0.74	0.65	0.10	0.051
Haptoglobin, mg/dL	111.2	111.2	104	94.9	93.1	105.8	0.12	0.83	0.005
Cortisol, nmol/L	163.1	163.1	155	168	125.1	198.6	0.83	0.57	<.0001

Table 3. *Least square means for presence of tail, gender and age of physiological parameters in weaning pigs.*

[1]B = barrows; FE = females;

Furthermore, undocked pigs showed higher tail biting behavior (P = 0.004) and tail lesions (P < 0.0001). Again, an interaction between tail presence and gender was observed also in skin lesions at the main area of the body (trunk, abdomen), with its greater frequency in the undocked females.

Gender did not affect blood parameters and behavior, however females showed a greater frequency of lesions in the anterior (head, neck, shoulders) and posterior (rump, genitals) areas of the body (P = 0.016 and P = 0.002 respectively), while barrows showed higher frequency of tail lesions (P = 0.005).

Blood parameters showed significant differences only for the age of the animals. Hp and cortisol levels were greater at 66 days of age (P = 0.005 and P < 0.0001 respectively) compared to levels observed at 39 days of age. The increase of Hp levels was enhanced in barrows rather than in females, as reported by an interaction between gender and age for this parameter.

At the age of 66 days, pigs showed also greater interest in exploring the straw fallen on the floor from the rack (P = 0.004), and greater tail biting behavior (P < 0.0001). Moreover, age affected the frequency of lesions detected in all the body areas considered. At the beginning of the study (30 days of age) lesions were more frequent in the anterior body area and in the ears (both P < 0.0001). Both these variables showed an interaction between tail presence and age: lesions at the anterior body area were more frequent at 30 days of age especially in docked pigs, conversely to the age of 53 days which showed greater frequency in the undocked ones (P = 0.005); lesions at ears at the end of the weaning phase were very decreased but more frequent in docked pigs (P = 0.035).

	Tail		**Gender[1]**		**Age (d)**		***P-value***		
	Docked	**Undocked**	**B**	**F**	**39**	**66**	**Tail**	**Gender**	**Age**
Straw in the rack	1.99	1.93	1.69	2.22	0.01	0.02	0.88	0.15	0.53
Straw on the floor	0.69	1.09	0.72	1.15	0.002	0.01	0.53	0.94	0.004
Nipple drinker	0.9	0.7	0.7	0.9	0.02	0.03	0.038	0.052	0.054
Exploring chain	1.3	0.6	0.7	1.2	0.03	0.02	0.02	0.08	0.13
Lying inactive	13.7	20.4	18.4	15.2	0.56	0.54	0.02	0.06	0.96
Eating	3.3	2.8	3.1	3.0	3.0	3.1	0.09	0.92	0.58
Conflicts	0.5	0.7	0.6	0.6	0.02	0.02	0.33	0.92	0.41
Ears biting	0.05	0.6	0.1	0.2	0.009	0.01	0.09	0.64	0.09
Tail biting	0.02	0.19	0.05	0.08	0.04	0.09	0.004	0.70	<.0001

***Table 4.** Least square means for presence of tail, gender and age of behaviors of weaning pigs (frequency of animals involved in a specific activity).*

[1]B = barrows; FE = females;

	Tail		**Gender[1]**		**Age (d)**			***P-value***		
	Docked	**Undocked**	**B**	**F**	**30**	**53**	**79**	**Tail**	**Gender**	**Age**
Anterior body	0.20	0.20	0.18	0.23	0.31[a]	0.15[b]	0.17[b]	0.83	0.016	<.0001

Main body	0.05	0.05	0.04	0.06	0.09^{a}	0.02^{b}	0.07^{a}	0.79	0.072	0.0002
Posterior body	0.06	0.07	0.04	0.09	0.004^{b}	0.007^{b}	0.05^{a}	0.38	0.002	<.0001
Ears	0.21	0.17	0.18	0.20	0.83^{a}	0.09^{b}	0.09^{b}	0.16	0.10	<.0001
Tail	0.02	0.15	0.14	0.09	0.01^{b}	0.01^{b}	0.34^{a}	<.0001	0.005	<.0001

Table 5. *Least square means for presence of tail, gender and age of skin lesions of weaning pigs (frequency).*

[1]B = barrows; FE = females;
a,b different letters indicate a significant statistical difference.

At the opposite, lesions at the posterior body area and at the tail were more frequent at the end of the weaning phase (79 days of age; both P < 0.0001). Skin lesions at the main body area showed instead a fluctuating frequency with greater levels at the beginning and at the end of the weaning phase but lower levels in the middle (53 days of age; P = 0.0002).

DISCUSSION

The analysis of the blood parameters during the weaning phase showed a substantial overlap within tail factor and gender. However, tail presence was associated with behavioral differences between docked and undocked pigs. Undocked animals showed lower exploratory activity regarding nipple drinker and chain, and parallel increase in lying behavior Although lower activity was described in pigs reared in barren environment (Beattie et al., 2000; Fraser et al., 1991), it is important to highlight that pigs could not restrict their explorative activities to inanimate materials but could spent time on manipulative oral behaviors directed at pen-mates: undocked tails could seem to be convenient appendages on which to chew and redirect the attention (Taylor et al., 2010). It is possible that the exploratory activity of pigs have been distributed among environmental enrichments and long tails, lowering levels of exploration towards other objects. The greater incidence of tail biting in undocked pigs could support the hypothesis of a redirected activity towards tails, and this behavior is reported as tolerated by the recipient pig and often found when both pigs are lying down or standing still (Schrøder-Petersen et al., 2004) explaining the high incidence of lying behavior in the present study. The greater incidence of tail biting was probably related to the consequent high level of lesions at tail.

Gender factor was associated only with lesions differences. Females showed a greater incidence of lesions in the forelimb and hindlegs posterior body, but a lower presence of injuries at tail level compared with barrows. This is in contradiction with Colson et al. (2006), who showed no difference in aggressive behavior between gender in the weaning phase. In the present study, lesions suggest a different fighting patterns between gender: typical of hierarchies development in females, and suggesting frustration in barrows (Taylor et al., 2010).

For all the groups, both cortisol and Hp levels increased up to 66 days, in contradiction with physiological trend reported in literature. Kattesh et al. (1990) and Eurell et al. (1992) found that sieric cortisol and Hp levels were highest in pigs at the beginning of the weaning phase and decreased throughout the growth. Increased cortisol and Hp levels in the present study were not accompanied neither by increased body lesions and conflicts, nor by worsening health status, but were only associated to higher incidence of lesions at tail and rump. Although it is possible that blood parameters were influenced by the inflammatory and stress response to the back lesions, a further suggestion could be the social stress related to the progressive reduction of the space allowance due to the increasing size of the growing animals. Hypothesis is supported by the results of the study by Amory et al. (2007), who observed this association between Hp and space allowance. Social stress due to the density could explain the increased incidence of lesions limited to the back region of the body, suggesting a competitive/frustrating interactions between pigs for resources (Taylor et al., 2010). In fact, the back approach to the pen-mates does not conform to typical patterns of aggressive or fighting behaviour in pigs, which typically culminate in bites inflicted around the shoulder regions as the animals face each other (Jensen, 1980). Suggestion is supported by the decreased incidence of lesions at ears, anterior and main body throughout the weaning period.

In conclusion, undocked tails could represent an alternative recipient for exploration behavior in weaning pigs, with the consequence of greater incidence of tail lesions. However, seems that the higher level of lesions was related especially to the age. Probably, the social stress related to the progressive reduction of the space allowance due to the increasing size of the growing animals could be a relevant factor in display of tail biting. To control space allowance parameter during the entire weaning cycle could help to reduce consequence of aggressive behavior towards pen-mates.

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Chapter 6

Tail biting in heavy pigs: impact of gender and undocked tail on welfare indicators: II. Fattening phase

TAIL BITING IN HEAVY PIGS:

IMPACT OF GENDER AND UNDOCKED TAIL

ON WELFARE INDICATORS:

II. FATTENING PHASE

Di Martino G. [2], Scollo A. [1], Gottardo F.[1], Stefani A. [2], Schiavon E. [2], Marangon S.[2], and Bonfanti L. [2]

[1]*Dipartimento di Medicina Animale, Produzioni e Salute, University of Padova – Legnaro (PD);*

[2]*Istituto Zooprofilattico Sperimentale delle Venezie, 35020 Legnaro, Padova.*

MATERIALS AND METHODS

Animals, general management and procedures have already been described in Chapter 5 and are summarized below.

All experimental procedures and animal care were carried out in accordance with Italian legislation on the protection of animals used for experimental and other scientific purposes (Gazzetta Ufficiale, 1992).

Animals, Facilities, and Management

This study evaluated the effects on several health and welfare indicators of tail presence (docked vs. undocked pigs) and gender (castrated males vs. females) according to a 2 × 2 factorial design during the weaning (phase 1) and the following fattening phase (phase 2). The experiment involved a total 448 commercial crossbred pigs (Landrace × Large White). The number of group pens used for each treatments was 1:1 for gender and 2:5 for tail treatment with a greater number of pigs with intact tail, choice supported by an ethical point of view and by statistical analysis. Tails were docked by removing 2/3 of their length by means of cauterization at 5 days of age in the farrowing room.

The study in total lasted 36 weeks from December 2010 to August 2011 and it was carried out in two commercial open-site. The first was specialized in the weaning phase and the other ones in the fattening phase .

Fattening Phase. At the beginning of the fattening cycle the pigs were aged 82 ± 1 d and weighted 34.82 ± 5.77 kg. Animals were moved by trucks from the weaning to the fattening unit. On the truck the pigs were divided according to gender and tail presence, with a merge only of pigs from different pens within the same combination of treatments. Upon arrival at the fattening unit, pigs were allotted according with combination of gender and presence of tail in 22 group pens containing 19 pigs each. The pens had a concrete slatted floor with a space allowance of 1.04 m2/pig. Each pen was provided with a metal chain hanging from the wall and a feeding rack containing long straw as environmental enrichments. Dry pellets for feedings were available through a trough (1.2 m of length) by a partially ad libitum system, with delivering set on a daily matter intake of 1.8 kg/pig during the first week of fattening, with a gradual increase up to 2.4 kg/pig during the last week. In terms of chemical composition and amount delivered, the feeding plan used was formulated according to the nutritional requirements of heavy pigs (Bertacchini and Campani, 2001). Drinking water was available ad libitum through one nipple drinker and one drinking bowl per pen. The 140 ear tagged pigs were equally divided into the 22 pens, and 14 additional animals were provided with transponders tag up to the achievement of 7 ear tagged pigs within each pen, for a total number of 154 ear tagged pigs.

Health and Environment. During both weaning and fattening phases, the pigs were inspected by the stockman twice a day to record the number of dead pigs and to identify severe injuries related to tail biting requiring specific treatment in the sickbay. Light and noise were checked twice a month. Also CO2 concentration and ammonia levels were recorded in different parts of the rows using a DRAGER X-am7000 (Dräger Safety AG & Co. KGaA, Lübeck, Germany) to ensure that all pens maintained the same experimental conditions.

Procedures

Blood Sample Collection and Analyses. Blood samples were collected from the ear tagged animals at 110, 212, and 255 days of age during the fattening phase. The parameters analyzed were haptoglobin (Hp), albumin/globulin ratio (A/G ratio), and cortisol, which were chosen on the basis of their role as pig health status and welfare indicators.

Behavioural Observations. Behaviour was evaluated at 106, 148, 197, and 274 days during the fattening phase in 16 randomly chosen pens. Data were carried out by direct observation using a scan-sampling technique (Martin and Bateson, 2007) with a 2-minute interval between scans. Each scan recorded the number of animals per pen lying inactive or exploring different substrates/objects such as chains and straw. The pigs were observed for 2 uninterrupted hours in the morning (from 1000 h to 1200 h). The number of events such as conflicts, tail biting and ear biting was also recorded during observation using the behaviour sampling technique (Altmann, 1974).

Skin Lesions. Two trained veterinarians visually evaluated alterations in each pig's anterior body (head, neck, shoulders), main body (trunk, abdomen), posterior body (rump, genitals), tail, and ears at 82, 156, 221, and 255 days of age during the fattening phase. Data were carried out in accordance with Widowski et al. (2003) and Sutherland et al. (2008).

Statistical analysis. Statistical analysis was described in the dedicated paragraph in Chapter 5.

RESULTS

During the fattening period, mortality and culling rate were due to respiratory syndrome confirmed by serological, virological and anatomo-histopathological investigations (positive analysis for Porcine Reproductive and Respiratory Syndrome virus, Influenza virus and Actinobacillus pleuropneumoniae). Pigs died or culled were spread into the four experimental groups without significative differences (P > 0.05): 7 % of undocked barrows, 9 % of docked barrows, 9 % of undocked females, and 9 % of docked females. Results regarding blood parameters, behavior and skin lesions are reported in Tables 1, 2, and 3 respectively.

	Tail		Gender[1]		Age (d)			*P-value*		
	Docked	Undocked	B	F	110	212	255	Tail	Gender	Age
Albumin/ Globulins	0.69	0.68	0.68	0.69	0.67^{b}	0.75^{a}	0.64^{b}	0.47	0.51	<.0001
Haptoglobin, mg/dL	165.3	175.2	153.2	187.2	255.2^{a}	132.1^{b}	123.4^{b}	0.42	0.0009	<.0001
Cortisol, nmol/L	111.2	104.6	132.9	82.9	120.2^{a}	112.5^{ab}	90.9^{b}	0.54	<.0001	0.001

Table 1. *Least square means for presence of tail, gender and age of physiological parameters in fattening pigs.*

[1]B = barrows; FE = females;
a,b different letters indicate a significant statistical difference.

Docked and undocked pigs did not show differences in blood parameters, except a greater level of cortisol in docked barrows compared to the other experimental groups showed by an interaction between tail and gender (P = 0.022). In the behavioral analysis, undocked pigs showed lower frequency in the activity of exploring the straw in the rack, and lower belly-nosing stereotypy (P < 0.0001 and P = 0.025 respectively). The lower frequency of exploration of the straw in the rack in undocked pigs was showed both in barrows and in females, as confirmed by the interaction between gender and tail presence (P < 0.0001). Undocked animals showed also greater frequency of skin lesions at the tail but lower frequency at the ears (P = 0.002 and P = 0.05 respectively).

Analysis by gender showed statistical differences in blood parameters: barrows had greater levels of cortisol (P < 0.0001), and females had greater levels of Hp (P = 0.0009). The greater level of cortisol in barrows decreased throughout the fattening period but remained statistically higher than females level (interaction between gender and age: P =

0.004). Behavior investigation showed in females a greater activity in exploring the straw fallen from the rack on the floor (P = 0.045). Moreover, frequency in skin lesions recorded at the ears was greater in barrows (P = 0.025).

	Tail		Gender[1]		Age (d)				*P-value*		
	Docked	**Undocked**	**B**	**F**	**106**	**148**	**197**	**274**	**Tail**	**Gender**	**Age**
Straw in the rack	0.62	0.41	0.51	0.53	0.39^{b}	0.32^{b}	0.52^{a}	0.45^{a}	<.0001	0.33	<.0001
Straw on the floor	0.08	0.06	0.05	0.09	0.08^{a}	0.01^{b}	0.18^{a}	0.12^{a}	0.15	0.047	0.018
Nipple drinker	0.68	0.69	0.68	0.69	0.77	0.95	0.55	0.55	0.94	0.94	0.056
Exploring chain	0.15	0.20	0.15	0.19	0.35^{a}	0.27^{a}	0.10^{b}	0.09^{b}	0.49	0.41	0.016
Lying inactive	12.0	13.0	12.7	12.2	12.2	11.8	12.5	13.3	0.11	0.46	0.10
Eating	1.53	1.41	1.57	1.37	1.86^{a}	1.63^{a}	1.29^{b}	1.18^{b}	0.17	0.11	0.043
Conflicts	0.13	0.11	0.10	0.15	0.22	0.16	0.08	0.08	0.53	0.41	0.15
Ears biting	0.10	0.07	0.07	0.09	0.21^{a}	0.18^{a}	0.06^{b}	0.02^{c}	0.11	0.39	0.023
Tail biting	0.02	0.03	0.02	0.03	0.04^{ab}	0.05^{a}	0.02^{bc}	0.01^{c}	0.75	0.39	0.05
Belly nosing	0.04	0.02	0.02	0.03	0.07	0.03	0.02	0.008	0.025	0.41	0.053

Table 4. *Least square means for presence of tail, gender and age of behaviors of fattening pigs (frequency of animals involved in a specific activity).*

[1]B = barrows; FE = females;
a,b different letters indicate a significant statistical difference.

Age showed a strong effect on most of the variables considered. Hp and cortisol levels decreased during the fattening cycle (P < 0.0001 and P = 0.001 respectively), instead A/G ratio showed a fluctuating level with lower levels at the beginning (especially in barrows; interaction between gender and age: P = 0.0002) in and at the end of the fattening phase but greater levels in the middle (P < 0.0001). Lower level of A/G ratio at 110 days was more accentuated in barrows compared to females, as showed by the interaction between gender and age (P = 0.0002). Moreover, the fluctuating trend of A/G ratio was more pronounced in docked pigs, with an the highest peak at 212 days and the lowest level at 255 days (interaction between tail presence and age: P = 0.0006).

The behavioral activities of exploring chain and eating decreased throughout the fattening cycle (P = 0.016 and P = 0.043 respectively), while the activity of exploring straw in the rack increased (P < 0.0001). Exploration of straw fallen on the floor from the rack showed a negative peak only at 148 days of age (P = 0.018). The frequency of tail and ear biting showed a decrease (P = 0.05 and P = 0.023 respectively). Although the frequency of the lying behavior was stable during the fattening period, an interaction between tail presence and age showed greater frequency in undocked pigs at 148 and 197 days (P = 0.045).

Frequency of skin lesions in the anterior and main body areas decreased during the fattening period (P = 0.0002 and P = 0.0003 respectively), instead frequency in the posterior body decrease at 156 days of age but rise again at the end of fattening (P = 0.0002). Lesions at tail and ears showed fluctuating frequency, especially in tail (P = 0.013 and P = 0.009 respectively). Tail lesions at 82 days of age were greater in barrows than in females, but at 156 days their frequency was inverted and greater in females (interaction between gender and age: P = 0.022).

	Tail		**Gender**[1]		**Age (d)**				***P-value***		
	Docked	**Undocked**	**B**	**F**	**82**	**156**	**221**	**255**	**Tail**	**Gender**	**Age**
Anterior body	0.28	0.33	0.33	0.31	0.49^a	0.10^c	0.35^b	0.32^b	0.25	0.49	0.0002
Main body	0.19	0.25	0.24	0.23	0.37^a	0.10^b	0.16^b	0.31^b	0.09	0.40	0.0003
Posterior body	0.17	0.22	0.20	0.22	0.31^a	0.06^b	0.13^b	0.33^a	0.09	0.38	0.0002
Ears	0.51	0.43	0.51	0.40	0.44^a	0.37^b	0.54^a	0.49^a	0.049	0.025	0.013
Tail	0.01	0.19	0.16	0.12	0.22^a	0.05^b	0.22^a	0.06^b	0.002	0.42	0.009

Table 5. *Least square means for presence of tail, gender and age of skin lesions of weaning pigs (frequency).*

[1]B = barrows; FE = females;
a,b different letters indicate a significant statistical difference.

DISCUSSION

During the fattening phase, the blood parameters showed no differences between docked and undocked pigs. Regarding behaviour, there were showed only lower exploratory activity towards straw in the rack and belly nosing in undocked pigs. As suggested for the weaning phase, it is possible that pigs could not restrict their explorative activities to inanimate materials but could spent time on manipulative oral behaviors directed at pen-mates in case of interesting stimulus as the availability of a long tail, that could seems to be convenient appendages on which to chew and redirect the attention (Taylor et al., 2010). This assumption could be supported by the greater incidence of tail lesions in undocked pigs. However, this hypothesis did not explain the lower interest of undocked pigs only in straw in the rack and not in the others environmental enrichments. The redirection of the interest towards tails seems did not provoke the development of stereotypy, potentially induced by a reduced welfare, on the contrary abnormal behavior as belly nosing was showed in docked pigs. Belly nosing is described by Lawrence and Terlouw (1993) as indicators of poor welfare and their study highlight the association between stereotypies, stress and lack of stimuli. In the present study, undocked pigs could showed lower belly nosing through the interest showed towards long tails as further stimulus and recipient of exploratory behavior. Concomitantly to higher number of tail lesions in undocked pigs, docked ones showed higher ear lesion, in agreement with Goossens et al. (2008) who showed that when tails were short-docked, ear biting became more likely.

Regarding blood parameters, gender showed an association with Hp and cortisol levels. Females showed greater Hp concentration than barrows, in agreement with, Lipperheide et al. (1998) and Piñeiro et al. (2009) that attributed the findings to a different physiological state. Should be considered that the increase of Hp level in pigs is associable with several other factors besides gender, such as clinical sign of lameness, respiratory disease, diarrhea, tail biting, and ear necrosis (Petersen et al., 2002). However, we did not attribute the greater Hp concentrations in females to injury or aggressiveness because, in the light of the similar heath status between gender, females showed a lower prevalence of ear lesions than barrows. The greater ear lesions frequency showed in barrows could be related to their higher cortisol level, even if barrows present a physiological average basal cortisol concentrations higher than females (Ruis et al., 1997). Behavior showed a substantial overlap between gender, except for the frequency showed in exploring the straw fallen on the floor that was greater in females.

Regardless the experimental group, Hp and cortisol decreased during the fattening phase, in agreement with the literature. Piñeiro et al. (2009) reported the progressive decrease of Hp levels in pigs after a peak at 12 weeks of age, instead Ruis et al. (1997) describe the decrease of sieric cortisol reaching a rather stable and adult level at 20 weeks of age. Albumin/Globulins ratio showed a peak at 212 days of age, but no specific explanation can be provided in the present study.

Throughout the fattening period the activities of exploring chain, eating and biting tail and ears decreased. These results showed the increase with age in general animal inactivity reported in literature (Jensen et al., 2010) and the decrease of exploration, social interaction, and competitiveness probably due to a process of habituation after prolonged exposure to the same environment, as reported by Day et al. (2002) and Docking et al. (2008). The only activity steady during the fattening period was the exploration of the straw, both in the rack and fallen on the floor probably for their desirable characteristics of chewiness and edibility (Van de Weerd et al., 2005). Moreover, straw is a more effective form of enrichment when it is continuously available or replenished daily (Hunter et al., 2001; Moinard et al., 2003), possibly because it remains novel and clean.

Frequencies of lesions at all body areas were highest at the beginning of the fattening phase, and decreased to the lowest level at 156 days of age. After, lesions in some body areas (ears and posterior body) rose up again. These results suggest early aggressive behavior occurred for the formation of dominance hierarchies when animals are newly mixed (O'Connell and Beattie, 1999) ended after the first weeks, and the new rise at the end of fattening, probably due to the reduced space allowance for the increasing size of the growing animals.

In conclusion, to avoid tail docking in pigs with a prolonged rearing cycle as for the heavy pig production, seems to provoke the rise of tail lesions. However, this finding, with the combined use of slatted floors, compliance with the parameters established by EU legislation in terms of space allowance and environment, and presence of chains and straw in a rack as enrichments, seems not associated to the variation of blood parameters and behavior, suggesting an insufficient intensity to cause severe welfare problems. Nevertheless, potential economical losses due to the injured tails should be considered even if not accompanied by evident poor welfare. Straw was confirmed an important tool in increasing explorative behavior.

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General conclusion

The study highlighted a low incidence of lesions in Italian heavy pig (0.15% of affected animals on a sample of 79,780 animals). This could be related to the great percentage, (close to 100%), of docked pigs, but at the same time suggested that rearing heavy pigs in a prolonged fattening cycle does not seems to worsen the risk of tail biting. Furthermore, were identified several risk factors for tail biting on heavy pig commercial farms. Results could be relevant to the pig industry in order to reduce the economical losses due to tail biting, giving emphasis to the respect of animal welfare legislation regarding space allowance, the availability of adequate environmental enrichment and environmental parameters such as ammonia concentration and temperature . Once a causal risk factor has been demonstrated on farm, measures should be taken to minimize the incidence of tail biting, thereby enhancing animal welfare.

The outcome of the study suggests that the compliance with the parameters established by EU legislation on the protections of pigs in terms of space allowance, environment parameters, and presence of rootable and chewable enrichments including straw seems to allow the fattening of heavy pigs without performing tail docking with tail biting under control. The undocked tails could represent an alternative recipient for exploration behavior in weaning pigs, with the consequence of greater incidence of tail lesions, but seems that the higher level of lesions was related especially to the age rather than tail presence. Probably, the social stress related to the progressive reduction of the space allowance due to the increasing size of the growing animals could be a relevant factor in display of tail biting.

Straw therefore seems to be an important tool in both increasing explorative behavior and preventing biting and lesions, particularly in the early stage of fattening. Furthermore, results at slaughter reveal the beneficial effects of straw on the susceptibility to gastric ulcer in the heavy pigs production system, for which very few data are available on this topic. The straw was beneficial, despite the fact that only a relatively small quantity was provided to pigs, allowing management problems due to slurry outflow obstruction or excessive farmer workload to be avoided.