University of Natural Resources and Life Sciences, Vienna

Department of Sustainable Agricultural Systems

Division of Livestock Sciences

Prevalence of skin lesions and associated risk factors in organic pigs in six European countries

Master thesis

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Submitted by

Katharina Fohringer

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Supervisors

Prof. Dr. med. vet. Christoph Winckler

Ass. Prof. Dr. med. vet. Christine Leeb

Dr. Gwendolyn Rudolph

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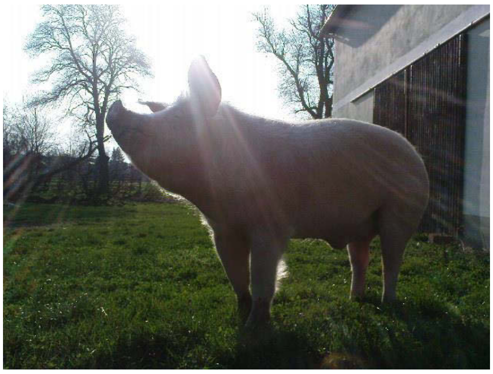

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1. Introduction and objectives

Animal welfare is an important aspect within the internationally agreed organic principles of health, ecology, fairness and care (IFOAM, 2014). Ensuring the needs of animals regarding their natural behaviour (e.g. structuring the pen into a lying, resting and dunging area, free farrowing), is specifically mentioned in the principles of fairness (IFOAM, 2014): “This principle insists that animals should be provided with the conditions and opportunities of life that accord with their physiology, natural behaviour and well-being.” Within the principle of health, it is stressed that not only the absence of illness, but also the mental and social well-being are important.
Therefore in organic pig farming, animal welfare is of particular importance to farmers and their animals not only to fulfil consumers expectations, but also for farmers – not only, but also because high animal welfare can lead to optimal performance.

Skin lesions are an indicator for different aspects of animal welfare (Ekesbo, 1981) as they reflect the animal´s interaction with its physical and social environment. The skin as the largest organ of mammals represents the boundary of the animal to the environment and has important functions: It is a major physical and immunological protection against injury and infection (Summerfield et al., 2015). The skin also regulates water loss, stores vitamins, minerals and fat and regulates the body temperature. It consists of the cutis and subcutis. The cutis is subdivided into the avascular epidermis and the dermis that is highly vascularised and innervated with nerves.

Skin lesions can be caused by an acute (e.g. bites by another pig) or a chronic problem, such as continued mechanical stress (e.g. pressure or rubbing). Even small lesions can be an entrance for bacteria, they might become infected (e.g. abscesses) and finally necrotic (Bickhardt et al., 2004). Lesions are painful and therefore relevant to the animal, furthermore they can be an indicator for stressful situations (e.g. grouping of pigs).

Skin lesions can be found on different parts of the body reflecting varying risk factors and relevance: Animals kept in an environment, which does not allow normal behaviour may become stressed, frustrated and might develop damaging behaviour such as tail and vulva biting (Rodenburg and Koene, 2007). Tail lesions caused by biting might lead to reduced growth rates, infections or abscesses, which can lead to condemnation of the whole carcass (Valros et al., 2004) and reduce animal welfare. On the other hand, lesions from social interactions on neck and shoulder of pigs are commonly observed after mixing of animals and heal quickly.

Due to some differences between conventional and organic pig husbandry (e.g. higher space allowance, provision of an outside run) as well as management factors (e.g. provision of enrichment material, routine tail docking not allowed) risk factors for skin lesions may also be different ones to the currently known factors from conventional farms. Therefore, specific research under organic farming conditions is needed to improve organic pig husbandry systems regarding animal welfare. This study can contribute to support farmers to provide optimal conditions for their animals: Once information on risk factors for the development of injuries is available, those can be recognized and addressed in advance. Therefore an epidemiological study focussing on skin lesions in weaners, finishers and sows was carried out in 47 organic pig farms in six European countries. As potential risk factors such from published literature as well as additional factors based on own hypotheses were chosen.

The objectives of this study are

- to describe the prevalences of skin lesions (tail/ear/body/vulva lesions, short tails, vulva deformations) of organic pigs (weaners/finishers/sows) kept indoors with concrete outside run in six European countries (Austria, Denmark, France, Germany, Italy and Switzerland).
- to identify risk factors for all lesion types regarding housing and management as well as parameters related to the animal (e.g. breed, age/weight, thin/fat sows, runts, ectoparasite infestation, breed) thus under organic farming conditions
    - confirming already known risk factors or
    - identifying additional risk factors of tail and body lesions

2. State of the art – Prevalence and risk factors of different types of skin lesions

2.1. Body lesions

Body lesions are commonly the result of fighting when mixing or regrouping pigs. Under natural conditions, unfamiliar pigs keep an individual distance of up to 50 meters (Stolba and Wood-Gush, 1989). Even in familiar pigs the animals normally keep an average distance of 3.8 meters between their group members, which is mostly not possible even under organic farming conditions. It is also reported that sows in dynamic groups stay in closer contact to familiar sows than to strangers (Spoolder et al., 1996). Consequently, especially when mixing unfamiliar pigs, the limited space is a risk factor for body lesions caused by fighting in order to establish a social hierarchy (Ewbank, 1976 cited in Stukenborg, 2011). Hoy (2009) describes different fighting positions: threatening with open mouth, head-on fighting, banging with their heads, lateral fight by pushing shoulder to shoulder, levering the contrahents and biting, with the fight being ended by flight of the subordinate animal.

However, mechanical damage of the skin may also happen when touching sharp edges, protruding nails, screws or drinkers in the pens, especially when victims try to flee from aggressors in narrow pens. Several studies have already dealt with prevalences (tab. 1) and risk factors for body lesions, but mainly on conventional farms.

Table 1 Overview of selected studies focusing on body lesions in fatteners and pregnant sows.

Animal group	Organic/ conventional	Number of farms or animals	Prevalences body lesions [%]	Reference
Fatteners	conventional	60 fatteners	45 mild 28.3 severe	Čobanović et al., 2015
Fatteners	organic	33 farms	12.6	Leeb et al., 2010
Fatteners	conventional	20 finishing pig units	flank: 40.8 both fresh and healed flank lesions: 4.5	Whay et al., 2007
Sows	organic	101 farms	anterior part of the body: 15.5 hind part of the body: 7.9	Dippel et al., 2014b
Sows	conventional	18 loose housed herds 18 confined herds	loose housed sows: 13.1 sows in confined herds: 4.0	Gjein and Larssen, 1995

In the following, potential risk factors for body lesions found in literature are listed for all age categories grouped by type of risk factor:

Mixing of sows

Agonistic behaviour occurs especially when unacquainted pigs are mixed (Stukenborg, 2011) and the number of fights increases with the number of unfamiliar pigs in the group (Arey and Franklin, 1995). The **group management** of sows is known to be key to reduce body lesions since group-housing systems are mandatory and grouping cannot be completely avoided. Sows kept in dynamic groups show more aggressive behaviour than those in stable groups (Leeb et al., 2001). Experience from commercial farms suggests that aggression is lower when sows are mixed into larger groups in contrast to integrating them into smaller groups (Edwards et al. 1993, cited in Arey and Edwards, 1998). The **presence of a boar** was reported to have minimal or no effect on reducing fights in sows during the post mixing period (Arey and Edwards, 1998; Sequin et al., 2006; Lüscher, 1990).

Weight and age

The age seems to have impact on the behaviour of pigs, too. Rasmussen et al. (2006) observed that displacements from the trough appeared more frequently at the age of 14 than at 17 weeks. In equally aged groups, lightweight fatteners waited longer for access to the trough and were more often displaced than heavyweight ones (Rasmussen et al., 2006).
Furthermore, fighting duration and number of bites were significantly lower in groups with large weight asymmetry than in those with small weight asymmetry (Andersen et al., 2000). In general, skin lesions were more severe when fatteners were mixed at a weight of 75 kg, whereas lesions were minor when mixing pigs at 55 kg (Spoolder et al., 2000). However, differences immediately after mixing were only found in terms of the frequency of fights and threats. The number of fights was lower after the second mixing treatment compared to the first one. Spoolder et al. (2000) assumed, that in heavier pigs aggression may result in higher levels of skin damage, as heavier weight pigs apply more force when fighting, and at the same stocking density, heavier pigs will occupy more physical space, which may block escape routes for an attacked animal.

Group size and space

According to Arey and Edwards (1998) there is little evidence for an optimum group size for mixing sows. Also little is known about an ideal space allowance when grouping sows. However, it is reported that an increasing space allowance can help to decrease social interactions and aggressive behaviour in the long term (Arey and Edwards, 1998). A minimum space of between 2.4 and 3.6 m^2/sow is recommended for good welfare (Weng et al., 1998). When subordinate sows have enough space for performing avoidance behaviour, the social hierarchy might be more stable than in small pens (Weng et al., 2008).

A larger space allowance was associated with lower lesion scores in growing-finishing pigs (Turner et al. 2000): Although a higher space allowance of 32 kg/m² had no benefit on the performance of fatteners, it was assumed, that there is evidence for more aggression, when growing-finishing pigs are housed at a higher stocking density of 50 kg/m². Pen design was suggested to have more impact on aggression than space allowance and rectangular pens were found to be better than square pens. Furthermore, pens should be equipped with visual barriers so that attacked pigs could escape more easily (Barnett et al., 1993).

Feed

However, regarding groups of fatteners the animal: feeding place ratio had no significant effect on the frequency of aggressive displacements at the trough. The fatteners were more frequently pushed away from the trough without aggressive interactions as the animal: feeding place ratio (AFR) increased (Rasmussen et al., 2006). The Austrian Animal welfare legislation (1. Tierhaltungsverordnung) prescribes a maximum AFR of 1:4 in dry feeding systems and 1:8 in liquid feeding when pigs are fed ad libitum.

The design of the feeding place showed a significant influence on the extent of lesions of sows (Leeb et al., 2001). More injuries on the hind quarters of sows were found in sows fed with electronic sow feeder systems compared to individual feeding stalls. This can be explained on the one hand as a consequence of queuing at the entrance for access to the feeding station, as ESFs do not allow simultaneous feeding. Furthermore, in feeding stations/individual stalls, where the sow is not protected from behind, her hind quarter is exposed to bites from pen mates. Also Barnett et al. (2001) recommended lockable feeding stalls to prevent aggressive behaviour around feeding. Roughage can contribute to improve satiety of sows when restrictively fed: Sows kept in groups with an electronic sow feeder without additional roughage had a 1.7 times higher risk of body lesions than sows in groups that had access to additional roughage (Gjein and Larssen, 1995). Permanent access to straw bedding reduced aggression levels in stable groups, but had no beneficial effect on fighting among weaners, fatteners and sows during the mixing period (Arey and Edwards, 1998).

2.2. Tail lesions and reduced tail length

Although much is known about a wide range of hazards, the exact triggering mechanisms of tail biting remain elusive (EFSA 2007). Tail biting is an abnormal behaviour of multi-factorial origin and is considered an unpredictable event on farms (Moinard et al., 2003). However, in the following section an overview will be given on the most important risk factors, mainly studied on conventional pig farms.

Table 2 Overview over selected studies describing prevalences of tail injuries and reduced tail length in Europe

Animal group	Organic/ conventional	Number of farms/animals	Mean prevalences tail lesions [%]	Median prevalences reduced tail length [%]	Reference
Weaners	organic	39 farms	0.0 % (median, all obvious lesions)	3.4 %	Leeb et al., 2010
Fatteners	organic	33 farms	0.5 % (median, all obvious lesions)	13.3 %	Leeb et al., 2010
Fatteners	conventional	EU (estimate)	1–5 % (all types, estimated value)	-	EFSA, 2007
Fatteners	conventional	36.632 animals	23.6 % mild 1 % severe lesions 0.5 % necrosis	-	Karnholz, 2014
Fatteners	conventional	-	3 % affected pigs per farm	-	Heinonen et al., 2001
Fatteners	conventional	3190 animals	11.4 % tail lesions	-	Sinisalo et al., 2012
Fatteners	conventional	154.347 animals	1.3 % tail lesions	-	Petersen et al., 2008
Fatteners	conventional	4491 animals	7.5 % moderate 2.3 % severe lesions	-	Van Staaveren et al., 2015

The loss of the tail tip or parts or the tail can have different reasons and prevalences (table 2). Tails can be docked, which is not the case on organic farms as the EU Regulation on organic production (889/2008) prohibits routine tail docking. Injured tails usually originate in tail biting outbreaks in weaners or fatteners, which can be caused by various risk factors. In many studies it is reported, that the main factor for tail biting is an unsatisfied exploratory behaviour. As on organic farms pigs have access to litter and/or enrichment material, this abnormal behaviour should occur less frequently here. However, tail injuries also happen on organic pig farms (Leeb et al., 2010; Dippel et al., 2014b). Furthermore, most studies focus on fatteners (Schrøder-Petersen and Simonsen, 2001; Karnholz, 2014; Van Staaveren et al.,

2015) but as tail biting may already occur in weaning pigs, there is still lack of knowledge for this age group. Furthermore the loss of parts of the tail can be caused by necrosis that may originate from mycotoxins (Jäger, 2013; Harlizius and Hennig-Pauka, 2014). Ischemia in the tail and ears in piglets is speculated to be caused by ergot intoxication that can cause vasoconstriction and endothelial damage (Kanora and Maes, 2009) resulting in necrosis. Mostly this is described in suckling piglets, new-born piglets were described with black tails that fall off after some time (Harlizius and Hennig-Pauka, 2014).

As already mentioned, the most important hazard concerning the outbreak of tail biting in weaners and fatteners concerns the lack of provision of sufficient litter and enrichment material (Moinard et al., 2003; Zonderland et al. 2008; Tölle, 2009). Additionally, the straw length was found to have influence on the behaviour of pigs (Day et al., 2008). Whilst chopped straw increased tail-biting in weaners and fatteners, the provision of full-length or half chopped straw led to a decrease of tail lesions. Day et al. (2008) point out, that the use of chopped straw is better than no enrichment, nevertheless they recommend the provision of long straw.
The provision of a small amount of straw (2 x 10 g/pig/day) twice a day on the floor was more effective in reducing bite marks on the tails than the provision of straw in racks (Zonderland et al., 2008). Van de Weerd et al. (2006) concluded, that the provision of long straw in a rack reduced tail biting, but this was less effective than permanent straw bedding.
Besides bedding, additional roughage can reduce tail biting outbreaks. Roughage influences the well-being and the behaviour of pigs positively, as it has not only a digestive, but also an enrichment purpose. Pigs in organic husbandry systems should be able to express their natural rooting and grazing behaviours. Presto et al. (2009) found out, that although straw was provided indoors, additional enrichment material in form of roughage made pigs more actively exploring and foraging, which consequently reduced redirected behaviour among growing/finishing pigs. The type of roughage is considered of not much importance, as long as it is chewable, rootable and all animals have access simultaneously. Kallabis (2013) confirmed a positive effect of the provision of roughage as it reduced ear and tail biting.

Restricted access to resources

When pigs are fed restrictively or the animal: feeding place ratio is too wide, they might act restless and unsatisfied because of hunger. The provision of roughage can lead to better satiety and consequently to less ear- and tail-biting behaviour (Kallabis, 2013). Moinard et al. (2003) reported a higher risk of a tail biting outbreak for feeding systems with five or more growing pigs per feeding place, whereas Gonyou and Lou (2000) reported, that the optimal number of pigs per feeder is still unclear. In a study of Rasmussen et al. (2006) the animal:

feeding place ratio did not significantly influence the number of displacements at the trough involving aggressive interactions. Zwicker et al. (2013) found out that, when roughage was offered in racks, displacements at the racks decreased with an increasing number of racks.

Access to water is an essential need to ensure health and welfare for pigs. Limited water provision can be a risk factor for tail biting(Guideline on Council Directive 2008/120/EC, 2014). Normally pigs drink from open surfaces based on the ground (e.g. lake) in contrast to nipple drinkers. A test report of the Bavarian LfL (Anonymous, 2013) evaluated the influence of drinker type on tail lesions in weaning pigs, which showed, that animals in pens equipped with nipple drinkers had less injured tails than animals in pens, where water was provided in troughs. The animals with access to water in troughs were restless, stressed and appeared to compete for water, which they used for enrichment purpose and wallowing.

Weight and age

It has been demonstrated in several studies, that older animals are more likely to bite or to be affected by tail biting: Tail-in-mouth-behaviour significantly increased with age (Schrøder-Petersen et al., 2003) and also tail damage increased from 23 kg to 90 kg (Schmolke et al., 2003). The starting point for tail biting is not completely clear, as it varied in different studies, however, it occurs mostly at some stage after weaning: from day 5 after weaning with a sudden stop as the pigs were moved to the fattening unit (Zonderland et al., 2008) or two to three weeks after weaning, followed by loss of the tail after two weeks (Veit, 2016). Day et al. (2002) observed tail biting or chewing from around 10 to 20 weeks of age, but also starting of chewing and biting of the tail later, from 30 kg upwards with indication of a decrease with increasing age, was described (Van de Weerd et al., 2005).

Sex and group composition

The EFSA Scientific opinion on the risks associated with tail biting (EFSA, 2007) concludes from several studies that female pigs are more likely to direct tail in mouth-behaviour to males than vice versa. One explanation for that might be, that female pigs - as they reach sexual maturation - become more interested in anogenital investigation and anal massage directed at (castrated) male pigs (Schrøder-Petersen and Simonsen, 2001). Therefore, often less tail-in-mouth-behaviour or tail biting is observed in single-sex groups (Schrøder-Petersen et al., 2003) than in mixed-sex groups. Lowest levels of tail in mouth-behaviour were found in all-male groups, whereas all-female groups and mixed-sex groups showed higher levels (Schrøder-Petersen et al., 2004). However, in the same study the hypothesis that females perform more tail in mouth-behaviour than males could not be confirmed.

Although mixing of unfamiliar pigs may be a trigger of tail-biting (Schrøder-Petersen and Simonsen, 2001) it is difficult to identify, because it may be linked with simultaneously occurring changes such as of diet, weaning or mixing (EFSA, 2007).

Breed

Breed had a significant effect on rope-directed behaviour of pigs after weaning and on harmful behaviour such as tail and ear-biting (Breuer et al., 2003): Duroc pigs chewed the rope more frequently and for a longer duration than Landrace und Large-White pigs. Furthermore, Duroc performed more pig-directed biting behaviour than Landrace pigs, with Large-Whites being intermediate. These results do not go along with other observations, which suggest that floppy-eared breeds such as Landrace are more predisposed to tail-biting (Fraser and Broom, 1990). Also the commercially desirable trait of high lean meat content and low backfat thickness (e.g. in Pietrain) may be regarded a predisposition for tail-biting (Breuer et al., 2005). It has to be taken into account, that "conventional" breeds (e.g. Landrace, Large White and their crosses) are usually housed in indoor systems, whilst "unconventional" breeds (e.g. Duroc, Schwäbisch Hällisch) are more likely to be kept in extensive production systems (Taylor et al., 2010).

Health

It has been suggested, that a low health status is a risk factor for the occurrence of tail-biting. Weak individuals such as runts are physically smaller, they are often pushed away from the trough by larger animals and start tail biting, when queuing for food. Animal health and welfare also includes infestation with ectoparasites. Pigs that are infested with mange mites are restless and stressed (Colyer, 1970; Tölle, 2009) because of the massive itching.

Group size and space allowance

The effect of group size has been described controversially and also controlled experimental studies, that demonstrate a relationship between stocking density and tail-biting risk are rare (EFSA, 2007). However, in one study tail-biting was more likely to appear with increasing group size (Chambers et al., 1995).

A larger space allowance was associated with lower tail lesion scores (Turner et al. 2000; Schrøder-Petersen and Simonsen, 2001). Although a higher space allowance of 32 kg/m² had no benefit on the performance of fatteners, there is evidence for increased aggression when pigs are housed at a higher stocking density of 50 kg/m² (Turner et al., 2000).

2.3. Ear lesions

Most studies that deal with ear lesions only describe prevalences of ear lesions that are suggested to be triggered by ear-biting or infections. Ear lesions are described as the appearance of open wounds, crust and bleeding on one or both ears (Petersen et al., 2008). However, often the term “ear necrosis” is also used synonymously, which can be questioned, as a necrosis is caused by insufficient blood supply followed by sloughing of the skin (Cameron, 2006). Ear lesions/necrosis occur as bilateral or unilateral injuries of any part of the ear with symptoms such as erosions, black crusts, black necrosis or ulcers on the tips and posterior edge of the pinna in pigs (Cameron, 2006). Ear lesions/necrosis especially occur in young pigs on the tip and around the posterior edge of the pinna, in growers at the base of the ear.

Ear lesions, as well as tail lesions, can be seen as highly relevant parameters for measuring the welfare of weaners and fatteners. So far it is not known to which extent those injuries impact pig performance. However, Park et al. (2013) reported that the poor visual appearance could interfere with the sale of affected pigs and raise welfare concerns.
Only few studies describe prevalences of ear lesion (tab 3) and it is not possible to differentiate the origin of lesions or missing tissue as no/few definitions of lesion are given.

Table 3 Evaluated prevalences of ear lesions/necrosis

Animal group	**Organic/ conventional**	**Number of farms/animals**	**Mean prevalences [%]**	**Reference**
Weaners	conventional	-	up to 80 % of pigs affected in one pen	(Cameron, 2006).
Weaners	conventional	9 farms, 72 animals	necrosis range from 10–100 % of piglets	Weißenbacher-Lang et al., 2012
Weaners	conventional	4990 animals	13.1 % (3.9 % severe, 4.8 % mild, 4.4 % weak lesions resp. necrotic changes)	Pejsak et al., 2011
Fatteners	conventional	90 herds, 154.347 finishers (assessed in slaughterhouse)	2.3 % (median)	Petersen et al., 2008
Fatteners	conventional	23 farms	31.6 % (early stages) 44.2 % (mid stages) 54.8 % (late stages)	Park et al., 2013

Ear lesions are assumed to have similar risk factors as tail lesions: It is discussed, that whilst some pens show tail-biting, animals in similar pens on the same farm may show ear-biting (Blackshaw, 1981). In a study of Goossens et al. (2008) ear biting was observed more often when tails were docked and the shorter the tails were docked, the higher were the prevalences of ear-biting behaviour and ear wounds.

Until now little is understood regarding the risk factors that influence severity and prevalence of ear necrosis (Park et al., 2013). The reasons for ear necrosis remain complex and multifactorial (Weißenbacher-Lang et al., 2012; Pejsak et al., 2011). Ear-biting can cause bacterial infections leading to ear necrosis, but also ear necrosis caused by bacterial infection might provoke ear-biting outbreaks (Park et al., 2013). Ear lesions/necrosis in weaners might be favoured by mycotoxins, copper and magnesium deficiency, overstocking, high ammonia concentrations and poor hygienic conditions (Cameron, 2006; Pejsak et al., 2011; Weißenbacher-Lang et al., 2012). Other risk factor mentioned in literature are fully slatted flooring without straw, high humidity, dry feed, low availability of drinkers per pig, early weaning, fighting, dirt on the tips of ears and concurrent mange (Park et al., 2013). Animals that are infested with mange, or when wounds are healing, suffer from severe itching and seem to feel relieved when pen mates nibble on their ears. This nibbling may lead to ear lesions that are likely to attract even more pen mates.

2.4. Vulva lesions and deformations

Although vulva lesions are reported to have little impact on reproductive performance (Bryan, 2014) injuries of the vulva are associated with pain. They can bleed intensively, parts can be bitten off and lead to deformations and scar tissue. Table 4 shows selected prevalences of vulva lesions or deformations found in previous studies.

Table 4 Overview of recent on-farm studies on prevalences of vulva lesions and deformations

Organic/ conventional	Number of farms/animals	Mean prevalence of Vulva lesions [%]	Mean prevalences vulva deformations [%]	Reference
organic	40 farms	4.3 % (median)	3.2 % (median)	Leeb et al., 2010
conventional	410 farms	70 % (of all farms)	-	Rizvi et al., 1998
conventional	1177 sows	-	16 %	Leeb et al., 2001
organic	101 farms in six European countries	3.5 % (median)	-	Dippel et al., 2014b
organic	1111 sows	5.1 %		March et al., 2014

Feeding

Spoolder et al. (2009) interpreted vulva biting as an act out of frustration rather than an act of aggression. Vulva lesions are caused by bites of pen mates, in most cases because of competition for limited resources like feed or water. As pigs prefer eating simultaneously, restricted access to feed may lead to frustration and competition (Spoolder et al., 2009; Marchant-Forde, 2009). Generally, restricted feeding is mentioned as a general problem causing lesions of the rear part of the body such as vulva biting. Krause et al. (1997) recommend simultaneous feeding as the best solution to prevent injuries of the rear part of the body.

Providing concentrated feed on the floor increases the risk for competition and aggressive behaviour in contrast to feeding sows in feeding stalls (Arey and Edwards, 1998). In contrast, no agonistic actions directed towards the hind quarters of sows in systems with feeding stalls were observed (Krause et al., 1997). Especially not lockable feeding stalls can be the main risk factor for lesions on the hind quarter of the sows as they are not protected from behind during feeding time. Prevalences of hind quarter injuries and vulva lesions are lower when feed stalls are lockable (Leeb et al., 2001). In one study, vulva lesions in sows were linked with thinner sows (Bryan, 2014), but the reason for this was unclear. Perhaps the feeding stalls were not lockable and the bitten sows did not get enough feed.

Also a strong relationship between vulva biting and electronic sow feeding systems can be found. A high number of agonistic interactions between group-housed gilts happen around the entrance of electronic sow feeders (Krause et al., 1997). Especially the exit direction of electronic feeding stations has high impact on the prevention of vulva lesions. When feeding stations are designed with separate entrances and exits so sows can walk through instead of exit backwards, vulva biting does not disappear completely, but decreases in prevalence (Bench et al., 2009). In order to minimize fighting for access to the electronic feeding station, the provision of roughage is recommended. Straw or hay cannot completely avoid agonistic interactions but can decrease the number of interactions (Krause et al., 1997). Gjein and Larssen (1995) evaluated that the risk of vulva biting was 2.6 times higher in group-housed sows when no roughage was provided compared with sows that had access to roughage.

Increasing group size was found to have influence on vulva injuries in pregnant sows (Rizvi et al., 1998), because larger groups have more hierarchy positions to resolve (Arey and Edwards, 1998). Concerning the group composition, keeping sows rather in stable than in dynamic groups fighting among familiar sows was found to be rare or at a lower level (Arey and Edwards, 1998). Furthermore, vulva biting in pregnant sows can be linked with the presence of a boar in groups of sows (Rizvi et al., 1998).

3. Animals, material and methods

This chapter provides information on the general characteristics of the farms, general data collection, assessed risk factors and the statistical evaluation. All pictures displayed: copyright BOKU.

3.1. Recruitment of farms and characterisation of farms studied

The present study forms part of the CoreOrganic II project ProPIG, which aimed at investigating the interaction of animal health and welfare with feeding and environmental impact (www.coreorganic2.org/propig). Interviews and direct observations of this master thesis were carried out from August to October 2013 on selected 47 organic pig farms in six European countries, namely Austria, Denmark, France, Germany, Italy and Switzerland. The participating farms were visited three times in the ProPiG project, but for the present master thesis only one visit (the third one) was relevant. The husbandry systems on the selected farms were characterized by an indoor area with straw bedding and a (partly) slatted outdoor run.

The following inclusion/ criteria were defined (Rudolph, 2015):

- certified organic for at least two years
- preference for combined farrow-finish farms
- more than 20 sows in the herd and at least 100 finishing places
- no small farms with less than 10 sows in the herd
- no special needs person’s farms, research and teaching farms

The following number of farms per country was assessed: 15 in Austria, 7 in Switzerland, 4 in France, 7 in Denmark, 13 in Germany and 1 in Italy. Information on number of farms per country and animal group, number of animals assessed and farm size may be found in table 5.

Table 5 Characterisation of the assessed farms and animals. AT = Austria, DE = Germany, CH = Switzerland, DK = Denmark, FR = France, IT = Italy.

	Number of farms per country and animal group (n)						Total number of farms (n)	Total number of assessed animals (n)	Median group size (n, Min–Max)
Animal group	**AT**	**DE**	**CH**	**DK**	**FR**	**IT**			
Weaners	11	6	4	7	2	0	**30**	3171	34 (13–260)
Fatteners	12	10	6	7	4	0	**39**	5801	22,5 (5–92)
Pregnant sows	11	7	4	0	3	1	**26**	845	9 (2–30.5)

3.2. Data collection

Data were collected on-farm by 6 trained observers starting with an interview (management and productivity data) followed by scoring the animals (lesion scoring) and measuring husbandry details (resource scoring) within the pig barn. Data were collected by an automated recording and feedback Software Tool ('Pigsurfer'), which had been developed for this purpose.

3.2.1. Lesion scoring

Animal-based parameters were assessed using clinical measures directly observed on the animal (see Appendix 3). The visual assessment was carried out from inside the pen from a distance of approximately 0.5 m (maximum distance 2 m). In each pen, the number of animals with different types of skin lesions was counted. Only one side of each animal was assessed, i.e. for half of the pigs the left and for the other half the right body side. If possible, the animal-based parameters were assessed in all animals in all pens/paddocks of the farm. If this was not possible, the following sampling strategy was applied (Rudolph 2015):

- <10 pens/paddocks: full sampling
- 10-25 pens/paddocks: 10 pens/paddocks (randomised selection of pens across fields/buildings/animal categories etc.)
- >25 pens/paddocks: 15 pens/paddocks (as random as possible choice of pens across fields/buildings/animal categories etc.)
- <25 animals in pen/paddock: full sampling

- 25-100 pigs in pen/paddock: 25 animals (randomly 5 pigs in 5 different places)
- >100 pigs in pen/paddock: 50 animals (randomly 5 pigs in 10 different places)

3.2.1.1. Body lesions

Body lesions were scored for pregnant sows and fatteners. Pigs that had at least three red scratches, wounds or crusts on the body except head and legs were counted as having lesions (fig. 1 and 2). Only scratches with a minimum length of 3 cm and round wounds or crusts with a minimum diameter of 1 cm were taken into account.

Figure 1 Body lesions: Example of scratches on the flank

Figure 2 Body lesions: Example of a wound

3.2.1.2. Tail lesions and 'short tails'

Tail lesions and 'short tails' were observed in weaners and fatteners. For tail lesions, animals with any scab or fresh wound on the tails were considered (Fig 3). Tails were assessed as 'short tails' (Fig 4), when they were obviously shorter than 'natural' length, which was defined as tails with hairs on its tip (fig. 5). A tail, for which a part was missing (whether it was incrusted, injured or not) was included in both categories - lesion and short tail.

Figure 3 Tail lesion (also counted as short tail)

Figure 4 Short tail

Figure 5 Normal tail with hairs on its tip

3.2.1.3. Ear lesions

Ear lesions were observed for weaners and fatteners by counting the number of animals per pen with red discoloration (> 1cm), crusts or missing parts of the ear tips and/or earlobes (fig. 5 and 6).

Figure 6 Ear lesions: missing parts of the ear lobes

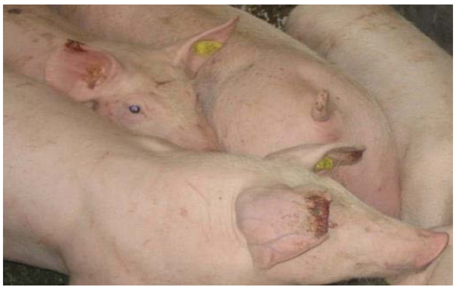

Figure 7 Missing parts of the ear tips

3.2.1.4. Vulva lesions and deformations

Vulva lesions were observed for pregnant sows. An injured vulva (fig. 8) showed "bleeding wounds or scabs of any size". A deformed vulva (fig. 9), which may be regarded the long-term effect of a vulva injury (scar or healed lesion), was defined as "vulva of abnormal shape or with parts missing".

Figure 8 Vulva lesion

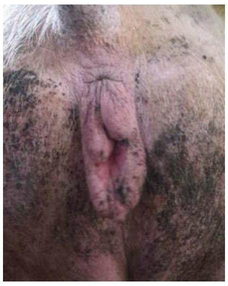

Figure 9 Vulva deformation

3.2.2. Assessment of potential risk factors

All investigated risk factors were selected based on a literature research or own hypotheses (table 6). Information on potential risk factors was obtained through the interview with the farmer, assessment of treatment and productivity records and direct observations of the housing system (see Appendix 1). The interview contained questions on farm level for all animal groups. All questions were evaluated according to the rule ´in dubio pro malum´, so that answers like ´every third day´ or ´hay just in winter´ were counted as ´weekly´

respectively ´no enrichment at the time of the farm visit´ because the data were to reflect the current situation as exactly as possible.

In the next step direct observations of the housing environment were carried out. Criteria for environmental parameters were defined in a resource scoring sheet (see Appendix 2). Data on husbandry (e.g. group size, pen size, straw length) were recorded for all pens and all animal groups separately. Also the method of provision of concentrated feed (trough/spread on the floor/single feed stall/ electronic sow feeder) and availability of food (ad libitum/restricted) was evaluated. Additionally, to these measures the number of troughs, the diameter or length of the troughs (for evaluation of the animal: feeding place ratio), the number of functional drinkers and the type of drinkers were recorded for weaners and fatteners. For pregnant sows, the pen design (obvious division between lying area and feeding place/availability of lying niches) was assessed additionally. Lying niches were defined as providing space for a maximum of eight sows and being closed on three sides. Concerning the feeding management, the exit direction of electronic sow feeders respectively the lockability of single feed stalls was assessed.

For the risk factor amount of straw [t] per year information was solely available at farm level. Due to the fact that most farms had at least two animal groups data had to be transferred by using the conversion formulas for livestock units (www.freiland.or.at/?download=GVE-schluessel.pdf):

Young pigs 8–32 kg live weight: 0.07 LSU
Young pigs 32–50 kg live weight: 0.15 LSU
Fatteners >50 kg live weight: 0.15 LSU
Sows >50 kg live weight, empty gilts: 0.15 LSU
Sows >50 kg live weight, pregnant gilts: 0.3 LSU
Sows >50 kg live weight, elder sows and boars: 0.3 LSU

For each age group that was present on farm the number of animals was multiplied with the appropriate conversion factor. Then the results of all age groups were summed up to LSU on farm. Then the amount of straw per year on the farm was divided by the LSU value.

Table 6 Overview on potential risk factors for different lesion types of weaners, fatteners and pregnant sows

Animal group		**Weaners**			**Fatteners**				**Pregnant sows**		
Area	**Risk factor**	**Ear Lesions**	**Tail Lesions**	**Short tails**	**Ear lesions**	**Tail lesions**	**Short tails**	**Body lesions**	**Vulva lesions**	**Vulva deformations**	**Body lesions**
Litter & enrichment	type of litter (straw/sawdust/soil/other)	X	X	X	X	X	X	X	X	X	X
	straw/Livestock Unit (t)	X	X	X	X	X	X	X	X	X	X
	straw length (long/chopped/half chopped)	X	X	X	X	X	X	X	X	X	X
	enrichment (yes/no)	X	X	X	X	X	X	X	X	X	X
	type of enrichment (straw/hay/grass/silage/other)	X	X	X	X	X	X	X	X	X	X
	frequency of enrichment provision (daily/weekly)	X	X	X	X	X	X	X	X	X	X
	method of provision (floor/rack/trough)	X	X	X	X	X	X	X	X	X	X
Feeding management	method of provision of concentrated feed (trough/floor/single feed stall/ESF)	X	X	X	X	X	X	X	X	X	X
	animal:feeding place ratio (n)	X	X	X	X	X	X	X	X	X	X
	ad libitum/restrictive feeding	X	X	X	X	X	X	X	X	X	X
	lockability of feeding stalls (not lockable/by sow/by farmer)								X	X	X
	Electronic sow feeder: exit direction (front/rear)								X	X	X
	animals/drinker (n)	X	X	X	X	X	X	X	X	X	X
	type of drinkers (nipple, bowl, trough)	X	X	X	X	X	X	X	X	X	X
Animal based parameters	breed (conventional, unconventional,	X	X	X	X	X	X	X	X	X	X
	crossbreed)	X	X	X	X	X	X	X			
	weight (kg)										
	prevalence of thin sows (%)								X	X	X
	prevalence of fat sows (%)								X	X	X
	prevalence of runts (%)	X	X	X	X	X	X	X			
Animal based	short tails at arrival (yes/no)				X	X	X	X			

Animal group		Weaners			Fatteners				Pregnant sows		
Area	**Risk factor**	**Ear Lesions**	**Tail Lesions**	**Short tails**	**Ear lesions**	**Tail lesions**	**Short tails**	**Body lesions**	**Vulva lesions**	**Vulva deformations**	**Body lesions**
parameters	short tails on arrival: estimated by farmer				X	X	X	X			
	(%)										
Group	group size (n)	X	X	X	X	X	X	X	X	X	X
management	whole pen sold at once (yes/no)										
	late mixing (>75 kg; yes/no)				X	X	X	X			
	fattening of intact boars (yes/no)				X	X	X	X			
	mixed sex groups (yes/no)										
	time of integration of gilts				X	X	X	X			
	(after arrival/after insemination/after first				X	X	X	X			
	farrowing/after second farrowing)								X	X	X
	stable/dynamic groups (yes/no)								X	X	X
	boar on farm (yes/no)										
	direct contact between sows and boar								X	X	X
	(yes/no)								X	X	X
Ectoparasites	prevalence of animals with ectoparasite										
	infestation (%)				X	X	X	X	X	X	X
Husbandry	obvious division of lying area and feeding										
system	place (yes/no)								X	X	X
	lying niches (yes/no)								X	X	X
	pen length:width ratio	X	X	X	X	X	X	X	X	X	X
	space allowance (m^2/animal)	X	X	X	X	X	X	X	X	X	X

3.3. Inter-observer repeatability testing

In preparation for the farm visit an observer training was carried out by an experienced pig assessor (gold standard). IOR was calculated as level of exact agreement (%) with a tolerance of +/- 1 animal. Sufficient reliability was set as agreement of at least 70 percent. The five assessors achieved agreement of 100 percent in most parameters except in body lesions in weaners and fatteners (tab. 7), where only one observer reached sufficient reliability. There was also insufficient reliability in resource scoring in the gestation stalls. Only two assessors reached sufficient reliability in case of the distribution of feed (trough, single feed stalls or on the ground) and only one in case of drinker type. Even none of five observers reached the 70 % reliability level for the number of functional drinkers. Nevertheless, these potential risk factors were kept for the analysis because of their high relevance for animal welfare.

Table 7 Level of agreement (%) of five observers with gold standard during inter-observer repeatability testing of animal-based assessment in sows (n=22–23) and groups of weaners/fatteners (n=8–41).

Parameter	N observers > 70% agreement with gold standard (+/- 1) weaners/fatteners	Min–Max (%)	N pigs or groups	N observers > 70% agreement with gold standard (+/- 1) Sows	Min–Max (%)	N pigs or groups
animal based						
groupsize	5	100–100	16–20	5	100–100	23–28
ectoparasites	5	100–100	8–9	5	100–100	23–28
body lesions	1	62,5–100	8–9	5	100–100	22–28
runts	5	100–100	16–20	5	100–100	22–28
tail lesions	5	93,8–100	16–20			
short tails	5	87,5–100	16–20			
fat sows				5	100–100	22–28
thin sows				5	100–100	23–28
vulva lesions				5	100–100	23–27
vulva deformations				5	100–100	23–27
resource scoring						
distribution of feed	5	100–100	16–20	2	0–100	5–34
ad libitium yes/no	5	100–100	16–20	5	100–100	5–34
N functional drinkers	5	75–95	16–20	0	17–65	34
type of drinker	4	69–100	16–20	1	13–78	34

3.4. Statistical analysis

Data were analysed using Microsoft Office Excel 2007 and SAS 9.2. Prevalences of animal based parameters and risk factors were first calculated on pen level and in the next step lifted up to farm level. For this purpose, data for each parameter were aggregated from pen level to farm level using the mean value per age group.

Categorical variables were controlled with regard to frequency distribution: Parameters that did not show any variation (e.g. all fattening farms provided concentrated feed in troughs) or that occurred less than five times (e.g. 4 farms had no boar, 22 kept a boar) were eliminated from further analysis. Categories of parameters that occurred three times or less were combined (e.g. water supply: 5 bowls, 1 trough combined as "bowl or trough") or eliminated (example) if a combination was not possible or didn't make sense (e.g. 1 farm provided roughage in some pens on the floor and in others in racks). If individual pens (design and resources) were completely different to the others on the same farm (e.g. one had water provided in trough and all other pens were equipped with nipple drinkers) those pens were excluded from the statistical evaluations for the concerning animal based parameter.

Firstly, all continuous variables were tested for normal distribution. In the next step univariate methods were used to select potential risk factors for the final model. For categorical parameters Wilcoxon test was used to compare two groups, for more than two groups Kruskal-Wallis test was applied. When a risk factor was significant ($p \leq 0.5$), pairwise comparison between the categories was carried out using the Wilcoxon test. For normally distributed numerical data a Pearson correlation was calculated, for not normally distributed parameters a Spearman rank correlation. Potential risk factors from univariate analysis were considered for further analysis in the final model when $p \leq 0.2$. The final model (general linear model), was calculated for all lesion types with a median prevalence of >0. The alpha level was set at $p<0.05$ and $p<0.1$ regarded as tendency. Final modelling was carried out by stepwise removing the least significant factor from the model. Due to a possible influence of the observers, differences in the husbandry systems or country-specific legislation, the factor "country" was always kept in the final model.

4. RESULTS

4.1. Prevalences of lesions

4.1.1. Weaners

In weaners, the median prevalence was 0 % for both ear (0–17.1) and tail (0–1.4) lesions (tab. 8). As prevalences were too low, it was not possible to calculate risk factors. However, as maximum values show, the range of prevalences of ear lesions was fairly wide in the assessed farms. Ear lesions were on most farms not of great importance, but 6 farms out of 30 appeared to have problems with this type of lesion as they had at least one animal with ear lesions. The mean prevalence of short tails was 1.84 % (0–12.5).

Table 8 Prevalences of different lesion types in weaners. Indicators highlighted in grey were kept for risk factor analysis (median prevalence > 0.0). Number of assessed farms (farms), number of farms where at least one animal was found to have injured skin (affected farms), Min=minimum prevalence, Q25%=lower quartile, mean prevalence, median prevalence, Q75%=upper quartile, Max=maximum prevalence.

Prevalence (%) of	Farms (N)	Affected farms (N)	Min (%)	Q25% (%)	Mean (%)	Median (%)	Q75% (%)	Max (%)
ear lesions	30	6	0.00	0.00	0.96	0.00	0.00	17.1
tail lesions	30	4	0.00	0.00	0.14	0.00	0.00	1.43
short tails	30	20	0.00	0.00	2.38	1.84	3.66	12.5

4.1.2. Fatteners

A median prevalence of 0 % was found for tail and ear lesions (tab. 9) in fattening pigs, which led to the exclusion of these lesion types from the risk factor analyses. However, the observed values on farm level varied widely from 0–16.2 % for tail lesions and from 0–30.1 % for ear lesions. The median prevalence of short tails was 5.4 % (0–46.2), so that risk factor analysis was possible. Body lesions were the most common lesion type in fatteners with a median prevalence of 15.5% (1.3–81.5).

Table 9 Prevalences of different lesion types in fatteners. Indicators highlighted in grey were kept for risk factor analysis (median prevalence > 0.0). Number of assessed farms (farms), number of farms where at least one animal was found to have injured skin (affected farms), Min=minimum prevalence, Q25%=lower quartile, mean prevalence, median prevalence, Q75%=upper quartile, Max=maximum prevalence.

Prevalence (%) of	Farms (N)	Affected farms (N)	Min (%)	Q25% (%)	Mean (%)	Median (%)	Q75% (%)	Max (%)
body lesions	39	30	1.32	9.01	20.0	15.5	22.2	81.5
tail lesions	39	19	0.00	0.00	1.79	0.00	1.39	16.2
short tails	39	35	0.00	2.10	9.35	5.36	13.0	46.2
ear lesions	39	14	0.00	0.00	1.55	0.00	0.83	30.1

4.1.3. Pregnant sows

The prevalences of body lesions, vulva lesions and deformed vulvas of pregnant sows are summarised in Table 10. Within these three lesion types, wounds or scratches on the body were the most frequently observed lesions in sows. The median prevalence of body lesions was 30.4 % (0–75). As the median prevalence of vulva lesions was 0 % (0–9.4), it was excluded from further analysis. However, for healed vulva injuries visible as deformations a median prevalence of 4.9 % (0–31.25) was found. The ranges of prevalences of body lesions and vulva deformations varied widely across the assessed farms.

Table 10 Prevalences of different lesion types in pregnant sows. Indicators highlighted in grey were kept for risk factor analysis (median prevalence > 0.0). Number of assessed farms (farms), number of farms where at least one animal was found to have injured skin (affected farms), Min=minimum prevalence, Q25%=lower quartile, mean prevalence, median prevalence, Q75%=upper quartile, Max=maximum prevalence.

Prevalence (%) of	Farms (N)	Affected farms (N)	Min (%)	Q25% (%)	Mean (%)	Median (%)	Q75% (%)	Max (%)
body lesions	26	25	0.00	16.1	35.1	30.4	54.6	75.0
vulva lesions	26	7	0.00	0.00	1.39	0.00	2.08	9.38
vulva deformations	26	17	0.00	0.00	6.52	4.86	10.6	31.3

4.2. Housing system and management

4.2.1. Weaners

A summary of all evaluated parameters can be found in table 11. The group size (average at farmlevel) varied from almost 13 to 260 weaners per pen. For space allowance (including outside run) a median value of 1.3 m² per animal (0.6–2) was calculated. On four farms, the median space allowance was below 1 m², thus violating the EU regulation on organic farming of at least 1 m² per piglet up to 30 kg (European Organic Regulation 889/2008).

In 29 of all 30 farms, the pens were littered, mostly using long straw. The median amount of of straw used was calculated to be 1.25 tons/year per livestock unit. Additional enrichment material was provided to weaners on 62 % of farms. However, there was no farm where weaners got neither litter nor enrichment material. Half of all farms that provided enrichment material offered it daily, the remaining farms at least once in a week.
For the animal: feeding place ratio the values ranged from 0.4 to 12 animals per feeding place across all types of feeding systems. The minimum and maximum numbers of animals per drinker were were 5.7 and 60 animals per drinker, respectively.
Most commonly used breeds were standard hybrids as in conventional farming (e.g. F1 Large White*Landrace) on 21 farms and other crossbreds were used on 9 farms (conventional* old/local breeds, e.g. Duroc). A detailed decription of results for all characteristics and frequencies of selected risk factors can be found in appendix 4.

Table 11 Evaluated characteristics of assessed parameters in weaners. Straw per livestock unit per year (straw/LSU), number of animals per feeding place, number of animals per drinker, weight of weaners, number of animals per group, prevalence of runts, length:width ratio inside the pen (only indoor area), area per animal. Farms=number of assessed farms, Min=minimum prevalence, Q25%=lower quartile, mean prevalence, median prevalence, Q75%=upper quartile, Max=maximum prevalence.

Potential risk factor	*Farms (N)*	*Min (%)*	*Q25% (%)*	*Mean (%)*	*Median (%)*	*Q75% (%)*	*Max (%)*
straw/LSU [t/LSU/a]	29	0.2	0.7	1.3	1.2	1.7	4.7
animals/feeding place (n)	27	0.4	1.5	3.1	2.7	4.4	12.2
animals/drinker (n)	29	5.7	10.3	17.2	13.5	20.3	60.5
weight (kg)	27	14.1	17.8	19.6	20.0	22.5	25.0
group size (n)	30	12.7	24.0	49.7	34.0	44.5	260.0
length/width ratio (inside pen)	28	1:1	1.4:1	2:1	1.6:1	2.2:1	5.2:1

Potential risk factor	Farms (N)	Min (%)	Q25% (%)	Mean (%)	Median (%)	Q75% (%)	Max (%)
area/animal [m²]	29	0.6	1.1	1.4	1.3	1.7	2.0
animal based: prevalence runts (%)	30	0.0	0.9	5.7	2.8	8.6	31.3

Table 12 shows the list of risk factors kept for further analysis after categories were combined or eliminated due to low frequencies (n≤3) in the concerning categories and lack of possibility of combination. These newly combined risk factors were used for further analysis.

Table 12 Weaners: Frequencies of risk factors kept for Global test (excluding those where no information was available, or lack of variation.

Potential risk factor	Total number of farms	Category	Frequency (n farms)	Percentage (% of farms)
straw length	30	chopped or half chopped long straw	9 21	30 70
provision of additional enrichment	29	yes no	18 11	62 38
type of enrichment	29	no enrichment 1 material mix of ≥2 materials	11 11 7	38 38 24
ad libitum feeding	30	yes no	20 10	67 33
type of drinker	29	nipple bowl or/and trough nipple and bowl	6 17 6	20 60 20
breed	30	conventional hybrids alternative cross breds (C*U)	21 9	70 30

4.2.2. Fatteners

The median group size on all assessed organic farms was 22.5 fatteners per pen (5.3–92) with a median space allowance of at least 1.2 m²/pig. As the EU regulation on organic farming prescribes a minimum area of 1.4 m² per pig up to 50 kg (European Organic Regulation 889/2008), one farm did not provide enough space for fatteners. All fatteners were offered concentrated feed in troughs, so the potential risk factor method of provision of concentrated feed was excluded from further analysis. The median animal: feeding place ratio ranged from 0.5 up to 8.7 across all feeding systems. The animal: drinker ratio ranged widely from 4 up to 39 fatteners per drinker.

95 % of all assessed fattening farms provided straw as litter whereas the others preferred a mix of two different types of materials. The majority of farms provided long straw for bedding, only one farm used chopped straw. Over 60 % of farms provided additional enrichment material, half of them on a daily basis. Most commonly silage or even a mix of at least two different materials was provided.

95 % of the farms kept fatteners in mixed-sex groups, only one farm fattened intact boars kept separately from female pigs. One third of all farms had already observed fatteners with short tails at the arrival on the fattening farm respectively when they were moved from the weaning into the fattening pens. However, the median estimated value for short tails observed at the start of the fattening period was equal to zero (0–25). All recorded frequencies of numeric and categorical parameters are presented in table 13 and 14.

Table 13 Evaluated characteristics of assessed parameters in fatteners. Straw per livestock unit per year (straw/LSU), number of animals per feeding place, number of animals per drinker, weight of fatteners, prevalence of short tails at the beginning of fattening (estimated by farmer), number of animals per group, prevalence of runts, length:width ratio inside the pen (only indoor area), area per animal. Farms=number of assessed farms, Min=minimum prevalence, Q25%=lower quartile, mean prevalence, median prevalence, Q75%=upper quartile, Max=maximum prevalence.

Potential risk factor	Farms (N)	Min (%)	Q25% (%)	Mean (%)	Median (%)	Q75% (%)	Max (%)
straw/LSU [t/LSU/a]	36	0.2	0.7	1.4	1.1	1.9	4.7
animals/feeding place (n)	37	0.5	1.2	2.8	2.7	3.8	8.7
animals/drinker (n)	38	4.4	7.5	12.3	9.8	14.5	39.0
weight (kg)	37	43.3	62.3	71.6	72.5	80.8	100.0
short tails estimated (%)	32	0.0	0.0	2.1	0.0	2.5	25.0
group size (n)	39	5.3	16.4	26.9	22.5	32.0	92.0
length/width ratio (inside pen)	37	1:1	1.2:1	2.1:1	1.7:1	2.7:1	6.2:1
area/animal [m²]	38	1.2	2.1	2.9	2.6	3.3	6.4
animal based: prevalence runts (%)	39	0.0	0.0	0.8	0.0	0.8	16.7

All parameters kept for further statistical analysis are summarised in table 14, for a complete list of all recorded frequencies see appendix 4.

Table 14 Fatteners: Frequencies of risk factors kept for Global test (excluding those where no information was available, or lack of variation).

Potential risk factor	Total number of farms	Category	Frequency (n farms)	Percentage (% of farms)
straw length	38	chopped or half chopped	11	29
		long straw	27	71
type of enrichment	38	no enrichment	14	37
		straw	4	10.5
		hay or grass	5	13
		silage	8	21
		mix of ≥2	7	18.5
provision of enrichment	38	yes	24	63
		no	14	37
frequency of enrichment provision	38	never	14	37
		daily	19	50
		weekly	4	11
ad libitum feeding	39	yes	27	69
		no	12	31
type of drinker	38	nipple	15	39
		bowl or/and trough	15	39
		nipple and bowl/trough	8	22
breed	39	conventional hybrids	28	72
		alternative cross breds (C*U)	11	28
short tails when moved into fattening pen	33	yes	12	36
		no	21	64
late mixing (>75 kg)	33	yes	12	36
		no	21	64

4.2.3. Pregnant sows

On more than half of the assessed farms a clear division between feeding place and lying area was present in the pregnant sow pens and on one farm the lying area was additionally divided into niches. The median space allowance ranged widely with a median of 3.7 m²/sow, but up to 42 m² on one farm.

Over 90 % of all assessed farms used straw as litter, with the remaining using at least two different types of materials. As already recorded in weaners and fatteners, more than half of all assessed farms used long straw as bedding and enrichment material, respectively. Almost 70 % of the farms provided additional enrichment material, which was a mix of at least two different materials in every third farm. The majority of the farms provided enrichment material daily (Table 16).

Whilst the majority of farms had low prevalences of thin and fat sows, on one farm nearly 30 % of all sows were thin whereas on another farm even half of all sows were too fat. Only on one farm pregnant sows were obviously infested with ectoparasites, so this potential risk factor was not further retained for statistical analysis (Table 15).

Table 15 Evaluated characteristics of assessed parameters in pregnant sows. Straw per livestock unit per year (straw/LSU), number of animals per drinker, number of animals per group, prevalence of thin sows, prevalence of fat sows, length:width ratio inside the pen (only indoor area), area per animal. Farms=number of assessed farms, Min=minimum prevalence, Q25%=lower quartile, mean prevalence, median prevalence, Q75%=upper quartile, Max=maximum prevalence.

Potential risk factor	Farms (N)	Min (%)	Q25% (%)	Mean (%)	Median (%)	Q75% (%)	Max (%)
straw/LSU [t/LSU/a]	24	0.2	0.5	1.3	1.2	1.6	4.7
animals/drinker (n)	25	0.5	2.4	4.5	3.8	6.0	13.8
group size (n)	26	2.0	5.5	10.5	8.8	11.0	30.5
length/width ratio (inside pen)	23	1:1	1.1:1	1.9:1	2:1	2.3:1	5.7:1
area/animal [m²]	26	3.7	6.3	10.6	7.8	11.0	42.3
animal based:							
prevalence thin sows (%)	26	0.0	0.0	5.1	2.4	8.6	29.6
prevalence fat sows (%)	26	0.0	0.0	3.3	0.0	3.8	50.0

Table 16 contains categorical risk factors that were kept for further analysis. A summary of all recorded risk factors and categories can be found in appendix 4.

Table 16 Pregnant sows: Frequencies of risk factors kept for Global test (excluding those where no information was available, or lack of variation).

Potential risk factors	Total number of farms (n)	Categories	Frequency (n farms)	Percentage (% of farms)
straw length	26	chopped or half chopped	9	35
		long straw	17	65
provision of enrichment	26	yes	18	69
		no	8	31
type of enrichment	26	no enrichment	8	31
		1 material	9	34.5
		mix of ≥2 materials	9	34.5
method of enrichment provision	15	floor	9	60
		rack or trough	6	40
lockability of feeding place (gestation stall)	22	lockable	14	64
		not lockable	8	36
type of drinker	25	nipple	15	60
		bowl or trough	6	24
		nipple and bowl	4	16
breed	23	conventional	19	83
		cross breed	4	17
integration of gilts	21	after insemination	8	38
		after first farrowing	13	62
stable groups of sows	26	yes	8	31
		no	18	69
division of feeding place and lying area	22	yes	13	59
		no	9	41

4.3. Risk factor analyses

4.3.1. Weaners

Univariate analyses were only carried out for the prevalence of 'short tails'. However, all results from univariate tests (including ear and tail lesions) are presented in appendix 4.

Table 17 Potential risk factors for 'short tails' in weaners as identified in the pre-selection step. All factors associated with the lesion type in the univariate analysis (Kruskall-Wallis/Wilcoxon test, Spearman rank correlation; p≤0.2) and thus included in the final model are listed (* significant difference between the categories)

Potential risk factors	Categories	N	Prevalence (%) / r_s	p
groupsize (n)	-	30	-0.56	0.001
weight (kg)	-	27	-0.53	0.004
type of drinker	nipple	29	1.6 ab	0.04
	bowl and/or trough*		1.9 a	
	nipple and bowl*		4.2 b	

The univariate analysis showed that the prevalence of short tails was negatively correlated with groupsize and weight. Furthermore, the prevalence of short tails was more than twice as high on farms that were equipped with both nipples and bowls than on farms solely equipped with bowls and/or troughs (tab. 17).

However, in the final **general linear model** no factors significantly influencing the prevalence of short tails were found.

4.3.2. Fatteners

Potential risk factors indentified in the pre-selection step (p≤0.2) for short tails and body lesions in organic fattening pigs are summarised in table 18. As the median prevalences of ear and tail lesions were equal to zero, no further multivariate risk factors analysis was carried out. All results from univariate tests (including ear and tail lesions) are presented in appendix 4.

Table 18 Potential risk factors for 'short tails' and ´body lesions´in fatteners as identified in the pre-selection step. All factors associated with the lesion type in the univariate analysis (Kruskall-Wallis/Wilcoxon test, Spearman rank correlation; p≤0.2) and thus included in the final model are listed.

Potential risk factors	Categories	N	Short tails		Body lesions	
			p	Prevalence (%) / r_s	p	Prevalence (%) / r_s
provision of enrichment	yes no	38	0.05	8.8 10.9	-	-
straw length	half chopped/ chopped long straw	38	0.1	14.8 7	-	-
weight (kg)		37	-	-	0.003	+0.48
area/animal (m²)		38	0.18	+0.22		
type of drinker	nipple bowl or(and) trough nipple and bowl	38	0.13	12.7 6.0 10.3	0.12	12.7 21.6 32.2
animals/drinker (n)		38	0.08	-0.29	-	-
prevalence of runts (%)		39	0.08	+0.28	-	-
breed	conventional cross breed (C*U)	39	0.03	7.64 13.72	0.17	20.9 17.8
late mixing (>75 kg)	yes no	33	-	-	0.12	25.0 15.0
presence of short tails when moved into fattening pen	yes no	33	0.02	5.85 13.97	-	-
short tails when moved into the fattening pen (% estimated)	%	32	0.03	+0.37	-	-

Regarding **short tails** significant correlations/differences were found using univariate analyses for provision of enrichment, breed, short tails when moved into the fattening pen (yes/no) as well as the estimated prevalence of short tails at the beginning of the fattening period.

Short tails in fatteners were significantly less prevalent when enrichment beyond the mere provision of straw was offered (8.8 %) compared to farms, where no additional enrichment was provided (10.9 %, p=0.05). In view of straw length, prevalences of short tails were twice as high on farms where straw was cut in contrast to farms providing long straw. The median prevalence of short tails in conventional breeds (7.6 %) was almost half compared to the prevalence of short tails in cross breds (13.7 %, p=0.03). Short tails were less prevalent (5.8 %) on farms where pigs with reduced tail length had already been discovered at entering, compared to farms, which did not observe short tails at the beginning of the fattening period (14 %, p=0.02). On the other hand estimated prevalences for short tails at the arrival were found to be significantly positively correlated with the prevalence of short tails assessed during the fattening period (p=0.03). Furthermore, univariate analysis showed a tendency that short tails might be positively correlated with an increased area/animal (p=0.18) and the prevalence of runts (p=0.08).

A tendentially negative correlation was found for the prevalence of short tails and an increasing number of animals/drinker. Whilst water provided in open surfaces might have positive influence on keeping tails intact (p=0.13), the median prevalence of body lesions was lower when nipple drinkers (p=0.12) were installed in the pens in contrast to bowls or troughs.

For **body lesions,** the risk factor weight showed a positive correlation (r=0.481, p=0.003, N=37). Also the risk factors type of drinker, breed and late mixing were included in the final model as their p-values were <0.2 (results for all lesion types in fatteners see appendix 4).

The only significant risk factor for **short tails in the final model** was "presence of short tails at arrival yes/no" (p=0.048, est=-10.14, SD=4.89). The prevalence of short tails was higher when short tails were already observed at the time of moving the pigs into the fattening pen.

4.3.3. Pregnant sows

As the median prevalence of vulva lesions was 0 %, univariate analysis of risk factors was only carried out for vulva deformations and body lesions in pregnant sows (table 19, all results from univariate tests, including vulva lesions, are presented in appendix 4). Three potential risk factors of **body lesions** in pregnant sows were included in the final model as they showed a tendency to differentiate: straw length, division of lying area and feeding place and breed. In case of **vulva deformations,** the provision of enrichment, type of drinker, number of animals per drinker, time when gilts are integrated into established groups, breed and the prevalence of fat sows were included in the final model.

Table 19 Potential risk factors for 'vulva deformations' and ´body lesions´in pregnant sows as identified in the pre-selection step. All factors associated with the lesion type in the univariate analysis (Kruskall-Wallis/Wilcoxon test, Spearman rank correlation; p≤0.2) and thus included in the final model are listed.

			Vulva deformations		Body lesions	
Potential risk factors	**Categories**	**N**	**p**	**Prevalence (%) / r_s**	**p**	**Prevalence (%) / r_s**
provision of enrichment	yes no	26	0.10	11 4.7	-	-
straw length	half chopped / chopped long straw	26		-	0.07	41.3 23.3
type of drinker	nipple bowl or trough nipple and bowl	25	0.20	7.8 2.5 8.6	-	-
animals/drinker (n)	N	25	0.08	+0.36	-	-
division of lying area and feeding place	yes no	22	-	-	0.07	21.2 41.2
time when gilts are integrated into groups	after insemination after first farrowing	21	0.15	6.7 4.5	-	-
Breed	conventional cross breed (C*U)	23	-	-	0.17	34.5 51.0
prevalence fat sows (%)	-	26	0.18	-0.27	-	-

In the final **general linear model** no factors significantly influencing the prevalence of vulva deformations and body lesions were found. However, univariate analysis showed some results that should be further regarded: In this study the median prevalences of vulva deformations were more than two times higher when the sows were offered enrichment material (p=0.10). On farms where sows were kept on long straw the median prevalences of **body lesions** were much lower (23.3 %) than on farms with half chopped or chopped straw (43.3 %, p=0.07). The median prevalence of body lesions was found to be twice as high (41.2 %, p=0.07) on farms with no division of lying and feeding area in contrast to farms with division into functional areas. Futhermore, the median prevalence of body lesions was higher for cross breds (51 %) compared to conventional sows (34.5 %, p=0.17).

In univariate analysis also a tendency that an increased animal: drinker ratio increases prevalences of vulva deformations (p=0.08) was found. Moreover, the median prevalence of vulva deformations was lowest when water was provided in troughs or bowls in contrast to nipple drinkers (p=0.2). Finally, the p-level<0.2 showed that the prevalence of vulva deformations might decrease with increasing prevalence of fat sows (p=0.18).

5. Discussion

5.1. Study design

To our knowledge, there are only few on-farm studies regarding organic pig farms, and even less on risk factors for health disorders as well as more specifically focussing on skin lesions. Therefore, this study can be seen as one of the first attempts to identify risk factors, which are specifically relevant for organic farms. As within the ProPIG project farms were recruited according to their type of husbandry system, no specific selection of farms was possible regarding prevalence of lesions and/or risk factors (e.g. breed or feeding management). In contrast to an experimental setup or case-control study, data taken on the farm visit, represent only a snapshot of the current situation on farms. Moreover, data assessment respectively evaluation within an international project can hardly be repeated. Also time was limited during the farm visit, because a lot of different parameters (e.g. land use, feed composition) had to be assessed within this project.

Using the same approach and checklist across countries allows collecting data from various situations and climates and increases the number of farms within one study. However, it is definitely important to carry out inter-observer reliability testing, especially when conducting assessments in different countries using different observers with different experience levels (Dippel et al., 2014b). In this study, the inter-observer repeatability was satisfactory for all lesion types except body lesions in weaners and fatteners. In order to check agreement, the correct number of animals with lesions within one pen had to be counted. This was a challenge, especially in larger groups and small pigs, additionally when looking randomly at the left and right side of animals. When an unknown observer enters the pen the animals are stressed or excited and therefore constantly moving. It is also difficult to assess scratches or wounds that are mild or almost healed, as well as the exact number of animals. These reasons might have caused the insufficient reliability in body lesions.

Nevertheless, body lesions were kept for statistical evaluation because the median prevalence was high compared with the other lesion types and considered as relevant to the animals. In order to account for observer influence, country was kept in the final model for all lesions types. However, there was no significant effect of the country in weaners and fatteners.

Resource scoring turned out to be a challenge as well, as the observers didn´t reach sufficient reliability in case of type of drinkers, number of functional drinkers and provision of feed. This shows the high importance of carrying out IOR before on-farm assessment and training of observers. However, the observers were retrained for improving the agreement in resource scoring. This might have led to more satisfactory agreement in the following.

In this study, data were statistically evaluated using farm level prevalence, i.e. farm served as the statistical unit. However, housing systems and management were not necessarily homogenous for all pens within one farm, e.g. space allowance, animal: feeding place ratio or length: width ratio of pens differed at least in some farms. In order to calculate prevalences at farm level, many pens had to be excluded from further analysis as outliers concerning single parameters. It would be interesting to evaluate the risk factors on pen level to take this variation into account

Moreover, more conclusive results could have been obtained if prevalence data were transformed into a binary variable (i.e., "Are there animals in the pen that show ear or tail lesions?" if yes, code 1 and if no, code 0). Then it would possibly be more conclusive to compare farms that have problems with lesions to those that have none. If data were evaluated this way, the median prevalence would not be of importance and consequently less lesion types would probably have to be excluded from the modelling due to low prevalences.

5.2. Prevalences and risk factors

In the following chapter evaluated prevalences and risk factors are discussed separately for every lesion type. Although in the final model lack of significant results were found, the pre-selected parameters (p<0.2) from univariate analysis are discussed as well. They can be regarded as potential risk factors and should therefore be considered in further research on skin lesions in organic pigs.

5.2.1. Body lesions

Prevalence

Body lesions were the most common lesion type in fattening pigs and sows. The median prevalence of 15.5 % in **fatteners** was similar to the results of other studies on organic farms (Leeb et al., 2010) and much lower than studies on conventional farms (Čobanović et al., 2015: 73 %; Whay et al., 2007: 45 %). As body lesions usually happen when grouping unfamiliar pigs, the higher space allowance in organic housing might be a main factor for lower prevalences.

Regarding body lesions in **pregnant sows** the median prevalence was at a higher level (30.3 %) than it was in fatteners. Compared to other studies on both conventional and organic farms (Dippel et al., 2014b: 23.4 % in anterior and hind body parts; Leeb et al., 2010: 0,9 % in head, shoulders and flanks) this median is higher, with a wide range from 0 to 75 %. It would be thinkable that some farmers said that they kept sows in stable groups, but were in fact not quite sure about the definition of stable groups. Also the management of grouping sows could have an influence on number of lesions, which was not assessed within the interview, as well as different definitions of body regions (here: lesions on front and hint body parts were summed up).

Risk factors

For body lesions in fatteners and pregnant sows, the final multivariate model (GLM) did neither show significant results for the pre-selected risk factors nor an effect of the country, even though inter-observer agreement was not satisfactory (indicating that disagreement was not directional but rather random). However, during univariate analysis some potential risk factors were identified, which showed a rather close association with the outcome measure ($p \leq 0.1$) and might therefore be of interest regarding body injuries in fatteners and sows:

The weight of **fatteners** was positively correlated with the prevalence of body lesions. This outcome is in accordance with Spoolder et al. (2000) who assumed, that heavier pigs apply more force when fighting and occupy more space so that heavier pigs may block escape routes of victims.

Body lesions in **pregnant sows** are commonly observed, as sows are frequently mixed causing scratches in the front and side part of the body because of fighting. Besides fighting, also hazards in pen design such as nipple drinkers installed in narrow parts of the pen or protruding nails or sharp edges may exist and lead to deep scratches or wounds when sows pass them, especially when they try to escape from aggressors.

Univariate analysis showed that the prevalence of body lesions on farms that used long straw was half the prevalence of farms that used half chopped or chopped straw. The effect that long straw might reduce lesions due to fighting might be explained by a longer duration of explorative behaviour using long straw especially in regrouped sows, so that some distraction from fighting might happen. However, other studies found no effect of straw during mixing of unfamiliar pigs (Arey and Franklin, 1995; Arey and Edwards, 1998).

Univariate analysis also showed that division of pens into a lying area and feeding place tends to reduce the prevalence of body lesions by half compared to no separation into functional areas. Also Rodenburg and Koene (2007) recommended separate functional areas to reduce aggression, as sows are more relaxed when they can rest undisturbed.

5.2.2. Ear lesions

So far only few studies dealt with ear lesions (Petersen et al., 2008; Pejsak et al., 2011; Weißenbacher-Lang et al., 2012; Park et al., 2013) and the differentiation to ear necrotic syndrome is not always clearly described. In this study it remains unclear, if lesions were caused by ear biting or ear necrosis. Further research is needed as no other studies assessing ear lesions in organic farms were found.

Weissenbacher-Lang et al. (2012) reported prevalences of ear lesions on farms ranging from 10 to 100 % of weaned piglets kept in a conventional housing system (perforated slatted plastic floor, under pressure ventilation systems, no litter, but enrichment strategies). In the current study, the median prevalence of ear lesions in weaners and fatteners was 0 % and did not vary widely (weaners 0–17 %, fatteners 0–30 %). On one farm every sixth weaner showed lesions or missing parts of the ear. However, the prevalence was lower than on conventional fattening farms, where a median prevalence of 1.9 % was described (Petersen et al., 2008). One explanation for the reduced levels of ear lesions could be the provision of litter and enrichment in organic farms leading to satisfactory exploratory behaviour and a reduced stress level in both weaners and fatteners. Since mange mites are discussed to lead to excessive head shaking causing ear lesions, another explanation for the low prevalences of ear lesions might be that no animals were infested with mange mites. Additionally, it could be possible that organic pigs have a general good health and welfare status and are therefore less vulnerable for bacterial infections or mycotoxins that might cause ear necrosis followed by ear biting.

Risk factors

Due to a too low median prevalence of ear lesions in weaners and fatteners it was not possible to calculate a final multivariate model (GLM). However, the univariate analyses revealed some associations ($p \leq 0.1$) that could be worth considering in further studies:

In **weaners**, the prevalence of ear lesions decreased with increasing group size. This contradicts Chambers et al. (1995) who found increasing group size as a risk factor for tail lesions (which might be caused by similar risk factors as ear lesions). Perhaps it was difficult to identify animals with ear lesions in large groups, especially in smaller pigs.

In **fatteners**, a tendency was found, that additional enrichment increased the prevalence of ear lesions. In organic pigs, bedding is required anyway, additional enrichment is commonly provided in the form of e.g. hay or silage. It could be speculated, that on the six affected farms, fattening pigs had limited access leading to ear lesions due to fighting for access. However, it was not possible to take the method of provision (rack/floor; access, frequency of provision) into account. Furthermore ear lesions tended to increase with a wider animal:

feeding place ratio. However, it was not recorded if feed was provided liquid or dry, ad libitum or restricted, which is essential for a robust evaluation of this potential risk factor. This information should be included in further research.

Breed might as well have influence on ear lesions, as the prevalences were even two times higher in conventional breeds compared to cross breds (conventional x unconventional). This is in accordance with other studies (Fraser and Broom, 1990; Breuer et al., 2005) regarding increasing tail biting respectively lesion in leaner animals.

There are also tendencies that are not explainable: If finishers were mixed with 75 kg or more, the median prevalence of ear lesions was lower than on farms that did not mix finishers in the end of finishing. Another inexplicable association was found with more short tails observed by the farmers at the arrival tending to be connected with a decreased prevalence of ear lesions.

5.2.3. Tail lesions and reduced tail length

For tail lesions and short tails, comprehensive data on prevalence and risk factors were only available from conventional pig farms, where tail docking is routinely applied (even if Directive 2008/120/EG prohibits to dock them routinely). However, these data were used for comparison because tail biting may also develop when tails are docked and it is assumed to share the same potential risk factors. It should be taken into account that data based on evaluations of carcasses in the slaughterhouse (Karnholz, 2014, Čobanović et al., 2015) can be more precise than on-farm data, even if they are assessed by photos or videos, as each carcass is assessed individually. This might be a reason for higher prevalences than those that are assessed on farm, on the other hand only severe lesions can be seen.

Regarding **short tails** in **weaners,** the median prevalence of 1.8 % was only half of the value reported by Leeb et al. (2010, 3.4 %) in organic pigs. Leeb et al. (2010) found 6.9 % tail necrosis in suckling piglets. This indicates that tail loss might have already happened in the suckling period and might be, inter alia, caused by mycotoxins or bacterial infections (Jäger, 2013; Harlizius et Hennig-Pauka, 2014). In this study it is unclear if the partial tail loss was caused by necrosis in the early piglet age or if they were the result of tail biting, because the tail length in suckling piglets was not assessed. However, the median prevalence of short tails in weaners shows that necrosis in tails was at a low level on the assessed farms within this study.

The prevalence of short tails in **fatteners** ranged widely from 0 up to 46 %. On one farm nearly half of all fattening pigs had short tails. This could be caused by a severe tail biting outbreak due to change of feed or lack of enrichment. However, as the median prevalence of 5.4 % shows, short tails were not a serious health matter on most of the assessed organic fattening farms. However, the median prevalences were three times higher in fatteners compared to weaners, thus indicating a higher risk of tail damage after weaning.

The median prevalence of **tail lesions** was 0 % **in weaned pigs**. In a study conducted by Leeb et al. (2010) prevalences were nearly three times higher than on farms visited within this assessment. It has to be mentioned that the study of Leeb et al. (2010) was based on Austrian farms and assessment was carried out by solely one observer. In contrast, in this study the lower prevalence could be due to differences in the housing systems (e.g. keeping certain age groups indoor or outdoor, group suckling) or legislation (f.e. age of weaning, vaccinations related to health status, different standards of national organic farming associations) in the six participating countries. Another reason for the higher prevalence found in Austria (Leeb et al., 2010) might be, that several farms participated to improve their health and welfare status, including problems with tail biting. A further reason might be tail biting caused by mycotoxins, which is supported by the prevalence of short tails most likely caused by tail necrosis in suckling piglets.

The median prevalence of tail lesions in **fattening pigs** (0 %) was comparable to the reported prevalence on other organic finishing farms (Leeb et al., 2010: 0.5 %). There are few studies investigating tail lesions on organic farms, however, more studies exist on prevalences of tail lesions in conventionally kept fattening pigs, where pigs have their tails docked. Karnholz (2014) found a median prevalence of 22.4 % animals with injured tails in carcasses from conventional farms. Prevalences reported by Van Staaveren et al. (2015) and Sinisalo et al. (2012) were around 10 % on carcasses. Obviously, the organic farms visited within this study had considerably less problems with injured tails than it was reported in studies on conventional pig farms. However, most of the mentioned studies were based on slaughterhouse data and not on direct observations on farms. In carcass assessment often only severe lesions are taken into account, whereas on farms also scratches or healed injuries are assessed. On the other hand prevalences could be higher in the slaughterhouse because carcasses are more precisely and individually assessed than direct observations in groups of live animals.

Risk factors

Due to too low median prevalences of ear and tail lesions, it was only possible to model prevalence of short tails. Regarding **weaners**, the final model showed only a tendency for an influence of the country (confounded with the observer). Although the inter-observer repeatability regarding short tails was 100 % for all observers, other differences within the housing systems or country-specific legislation (e.g. age of weaning, at which weight fatteners are slaughtered, treatment like vaccinations influencing general health status, different standards of national organic farming associations), but also the season when data were assessed (August or October) could have been the reason.

Regarding short tail in **fatteners,** the risk factor presence of **short tails at arrival was** (slightly) **significant in the final model**, indicating more short tails when more fatteners had already arrived with reduced tail length. The most obvious explanation is that the number of fatteners that arrived with short tails in addition to the pigs which were tail bitten during the finishing period increased the prevalence of short tails in total. Despite there were animals with short tails in the very beginning of fattening, the risk might be increased that the animals are already predisposed to tail biting and therefore this abnormal behaviour is more likely to occur later on within the fattening stage.

Similar to the other lesion types, the results of the univariate analysis are described briefly and need to be interpreted with care, as they reflect only possible associations and cannot take other effects and interactions into account:

In the univariate analysis regarding fatteners, short tails tended to be less prevalent, when some animals had already arrived with short tails in the fattening pen. An explanation might be that when farmers had already noticed the problem of short tails they could have been more cautious in order to prevent tail biting outbreaks by providing more enrichment or different enrichment materials. There is also evidence that injured tails can heal and regrow to a certain extent, as it was reported by Herskin et al. (2015). However, formerly injured tails might only be assessed as of intact length if lesions have occurred around the tail tip. Otherwise, a full regeneration after severe damage during the fattening period is unlikely.

Three parameters were identified in univariate analysis to increase tail lesions in fatteners, which confirm already published risk factors: lack of enrichment material (Moinard et al., 2003; Zonderland et al. 2008; Tölle, 2009), cut straw (Day et al., 2008) and increasing prevalence of runts (EFSA, 2007).

Little is known about the influence of the drinker type on tail lesions in weaners and fatteners. Univariate analysis showed a tendency for nipple drinkers to increase tail lesions respectively short tails rather than bowls or water provided in troughs. Although this result was not confirmed in the final model, it supports the hypothesis based on literature review, that inadequate access to water, which could be more likely caused by insufficient nipple drinkers (e.g. insufficient flow rate) or installed in the wrong position (too high/low; in corners) may lead to stress followed by tail biting. Moreover, drinking from bowls or water in trough benefits pigs’ natural drinking behaviour.

A tendency was found that the increasing group size might decrease the number of short tails, which is contrary to other study results (Meyer-Hamme et al., 2016) and own hypothesis. On the other hand, the same effect was found in our study regarding ear lesions. One explanation might be an increased space allowance that goes along with increasing group size has a positive effect on welfare, e.g. that pigs have a larger activity area to move in order to relieve stress and to avoid confrontations with tail biters. On the other hand, it could also be the case, that in larger groups individual animals with lesions might be more easily missed by the observer than in smaller groups with better visibility of each individual.

In univariate analysis, short tails were more prevalent in alternative cross breds than in conventional hybrids, which is difficult to explain as it contradicts the assumption, that a high lean meat content and low backfat thickness is a risk factor for tail-biting (Fraser and Broom, 1990; Breuer et al., 2005).

Another interesting tendency was found for the length: width ratio of pens, with elongated, narrow pens showing a tendency to increase tail lesions compared to square pens. This is in contrast to Barnett et al. (1993), who recommended rectangular pens to minimize tail biting. Perhaps elongated pens are worse for pigs because in narrow pens the resting ones might be more frequently disturbed by active animals and might therefore get stressed or aggressive.

5.2.4. Vulva lesions and deformations

Although the median prevalence of vulva lesions was 0 %, the median prevalence of deformations was 5 %. Vulva deformations may be regarded a summarising parameter which reflects the result of lesions over a longer period. In the case of vulva deformations, the prevalences on farm varied from 0 to 31.3 %. The results again matched quite well with the median prevalences found by Leeb et al. (2010; 7.5 % vulva lesions and deformations) and Dippel et al. (2014b; 3.5 % vulva lesions) in organic farms. Obviously it is important to not just have a close look on fresh, but also on healed wounds in order to assess the real (long-term) health status of the animals.

Risk factors

It was not possible to calculate a final general model for vulva lesions, because the median prevalence was equal to zero. Thus, solely parameters for vulva deformations were taken into account for further analysis. Unfortunately, the final model did not reveal any significant results for vulva deformations.

Although for pregnant sows no significant risk factors were identified, a closer look at the results found in univariate analysis identified interesting tendencies concerning provision of enrichment and water supply: The prevalence of vulva deformations was more than two times higher when additional enrichment material was provided, similar to ear lesions in finishers in our study. This result is in contrast to other studies (Gjein and Larssen, 1995) where enrichment material significantly reduced aggression levels that might cause vulva biting in group-housed sows. It is worth emphasising, that neither the frequency nor the method of provision or the types of materials were taken into account in univariate analysis. It could be the case, that roughage was provided restrictively in a rack or spread on the ground so that sows had to fight for access to the roughage

Another finding from the univariate analysis, which cannot be explained, was that a reduced animal: drinker ratio tended to lead to more vulva lesions. There is no meaningful explanation why fewer animals per drinker should have a negative effect regarding intact vulvae. This assumption does not match with literature findings (Rizvi et al., 1998). However, again it should be emphasized that findings from preselection procedures using univariate tests are not an appropriate verification for ultimately relevant risk factors.

As vulva deformations might have originated some time before the farm visit, there might have happened changes in grouping or feeding that could have not been considered at the time of the farm visit, e.g. that the farmer did not close feed stalls (this was not directly assessed but asked in the interview), sows were not offered additional enrichment or drinkers were dysfunctional.

6. Conclusions

Organic pigs are usually provided with permanent straw bedding, at least in the lying area and commonly additional enrichment material is provided. These are important factors to ensure pig welfare such as enabling them to root, to experience environmental influences such as fresh air and sunlight, or to keep wider individual distances to unfamiliar pigs. The comparatively low median prevalences of all observed lesion types underline this assumption.

Resulting from the observed lack of significant results within our study it might be assumed, that risk factors in conventional pig husbandry are different from those in organic systems, as the minimum housing conditions (e.g. litter, provided space per animal) are significantly different to conventional farms. Perhaps straw and a higher space allowance are the two most important risk factors that help to prevent skin lesions in contrast to less space and a barren environment in conventional systems. Maybe other parameters, different from previously identified “conventional” risk factors cause injuries in organic pig husbandry, like pen equipment or specific health parameters (e.g. bacterial infections).

An analysis on pen level may have delivered more meaningful results than it did on farmlevel. It would be worth analysing risk factors on penlevel, especially for those farms where many animals were affected by lesions.

The general conclusions of this study are the following:

- On the assessed farms median prevalences of all lesion types were at a relatively low level and high prevalences of lesions appeared solely on a few farms. Attention to and improvement of those farms are necessary, using the best organic farms as benchmark.

- Some lesion types might not be relevant in organic pig farming at all, such as ear lesions in weaners and fatteners. Although the median prevalences of tail lesions and short tails were at a low level, they are a problem on individual farms.

- Risk factors that showed tendencies in univariate analysis to increase the risk of skin lesions should be considered within future case-control studies.

- Classical risk factors found for the conventional sector seem to play a less important role in organic pig farming because of different, legally regulated, minimum housing conditions (e.g. provision of straw and enrichment, space allowance).

- This study dealt with several known risk factor. However, as lesions are in most cases of multifactorial origin, there are a lot more potential hazards which were not considered within this study: e.g. the climate in pig barns, season, quality of litter and roughage, mycotoxins, diet composition, liquid or dry feed or mechanical hazards in the pens. Perhaps other parameters are of higher relevance in organic systems than those that have been assessed for this study.

  More on-farm epidemiological research including other parameters as outlined above is needed in order to find out more about risk factors of skin lesion in organic pigs. It would also be meaningful to enlarge the number of farms and animals in following studies in order to further investigate the parameters that showed associations in univariate analyses and may therefore be promising candidates for factors affecting the occurrence of skin lesions in organic pigs.

7. Abstract

Skin lesions can be used as one of many indicators to measure the welfare of animals. For this master thesis data were collected on 47 organic farms in six European countries in order to analyse potential risk factors for skin injuries in organic pigs. One objective of this study was to describe the prevalences of body lesions, vulva lesions and deformations, ear and tail lesions as well as short tails on organic pig farms. Another aim was to confirm already known risk factors or to identify additional hazards for skin lesions in organic pigs.

During the farm visits interviews and direct observations were carried out. Parameters were scored by five trained observers. Lesion scores were assessed by using a 2-category rating scale (yes/no): pigs with acute injuries (wounds or scratches)or missing parts of the body (e.g. ear or vulva deformations, reduced tail length) were counted as “1“, no lesions as “0“. Whilst the observers reached sufficient reliability in all animal based parameters (except body lesions in weaners and fatteners) resource scoring turned out to be a challenge. This points out that inter-observer repeatability testing and training is highly relevant before carrying out on-farm assessment.

The median prevalences of skin lesions were found to be on a low level on the assessed organic farms: short tails in weaners: 1.84 %, short tails in fatteners: 5.4 %, body lesions in fatteners: 15.5 %, body lesions in pregnant sows: 30.3 %, vulva deformations in pregnant sows: 4.9 %, other lesion types: 0 %.

Potential risk factors were pre-selected in univariate analysis ($p<0.2$) and further evaluated within a general linear model. The only significant final model revealed that the prevalence of short tails in fatteners increases when farmers had already observed short tails at the arrival of pigs in the fattening pen. However, univariate analysis showed tendencies for potential risk factors that should be considered in further research.

8. Zusammenfassung

Hautverletzungen können als Tierwohl-Indikator herangezogen werden. Im Rahmen dieser Masterarbeit wurden Daten auf 47 Biobetrieben in sechs europäischen Ländern gesammelt, um bereits bekannte oder zusätzliche potentielle Risikofaktoren für Hautverletzungen bei Bioschweinen zu analysieren. Die Studie sollte Aufschluss geben über die Prävalenzen von Hautverletzungen, Vulvaverletzungen und -deformationen, Ohr- und Schwanzverletzungen sowie das Vorliegen kurzer Schwänze.

Im Rahmen der Betriebsbesuche wurden Interviews und direkte Beobachtungen im Stall durchgeführt. Fünf geschulte Beobachter führten die Beobachtungen durch. Die Verletzungsgrade wurden folgendermaßen erhoben: “1” für verletzte Tiere (akute Wunden oder Kratzer oder fehlende Teile an Ohr, Schwanz und Vulva), “0” für keine Verletzungen. Während der Beobachterabgleich bei allen tierbezogenen Parametern – außer Hautverletzungen bei Absetzern und Mastschweinen – zufriedenstellend war, stellte sich der Abgleich bei Resourcen als schwierig heraus. Das zeigt, wie wichtig Beobachterabgleiche und ein dementsprechendes Beobachtertraining vor den Betriebserhebungen sind.

Die medianen Prävalenzen von Hautverletzungen waren auf den erhobenen Biobetrieben auf niedrigem Niveau: 1.84 % kurze Schwänze bei Absetzern, 5.4 % Hautverletzungen bei Mastschweinen, 15.5 % Hautverletzungen bei tragenden Sauen, 4.9 % Vulvadeformationen bei tragenden Sauen. Die medianen Prävalenzen der übrigen Verletzungsarten waren gleich Null.

Die univariate Vorselektion ergab eine Reihe von potenziellen Risikofaktoren, die in die multifaktorielle Analyse mittels linearen Modells eingingen. Es ergab sich lediglich ein signifikantes Modell: Die Prävalenz kurzer Schwänze bei Mastschweinen war höher, wenn Landwirte bereits beim Einstallen in den Maststall Tiere mit kurzen Schwänzen beobachtet hatten. Die aus der univariaten Analyse hervorgegangenen potenziellen Risikofaktoren sollten in weiteren Forschungsarbeiten berücksichtigt werden.

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Appendix 1 – Questionnaire: Interview and Direct observations sheet

Farm ID: **Observer:** **Date:**

Direct observations: **Indoor PREGNANT SOWS**	**Explanation**			
Building ID	As used in pigsurfer			
Pen ID	As used in pigsurfer			
Service area	**Y**= Yes / **N**= No			
If single feed stall then…	**S** = self lockable by animal **F** = if lockable by farmer **SF**= both possible **No** = if not lockable			
Is there an obvious division between lying area and feeding place?	See ProPIG resource scoring sheet **Y / N**			
Is the lying area subdivided into separate lying niches?	See ProPIG resource scoring sheet **Y / N**			
If there are Electronic Sow Feeders: Can the sows leave them forwards?	**Y / N**			
Length of indoor pen:(if not rectangular or square please draw a rough draft with dimensions and pen ID on the back side)	Length (m) pen dimensions include feeding area			
Width of indoor pen:	Width (m)			
Length of outside run: (if not rectangular or square please draw a rough draft with dimensions and pen ID on the back side)	Length (m)			
Width of outside run:	Width (m)			
Length of straw provided as enrichment material (original length, not yet manipulated by animals)	**LS**=long-stemmed (>131mm) **HC**=half-chopped (40-130mm) **C**=chopped (<40mm)			

Explanation: Straw length

Long

half-chopped

chopped

Farm ID: **Observer:** **Date:**

Direct observations **Indoor WEANERS/FATTENER**	**Explanation**			
Building ID	As used in pigsurfer			
Pen ID	As used in pigsurfer			
Animal group	**W**=Weaners; **F**= Fatteners			
N of animals with ear lesions	See ProPIG animal scoring definitions			
Number of troughs/pen	Number			
Type of trough	**L**= longitudinal trough **R**= round trough			
Special type of trough	**TP**= Trough shared between two pens **RD**= Round feeders with additional drinkers			
Total trough length (long trough)	[cm]			
Diameter of round troughs	[cm]			
Length of indoor pen:	Length (m)			
Width of indoor pen:	Width (m)			
Length of outside run:	Length (m)			
Width of outside run:	Width (m)			
Length of straw provided as enrichment material	**LS**=long-stemmed (>131 mm) **HC**=half-chopped (40-130 mm) **C**=chopped (<40 mm)			

Explanation: Straw length

Long

half-chopped

chopped

Farm ID (as used in Pigsurfer):__________________ Observer: __________________Date:_____________

Additional questionnaire*– *question 1 *for* ***ALL*** *farms, other questions only for age groups kept I**NDOORS (=Indoor and partly outdoor farms)**.Please ask these questions when/after finishing the Pigsurfer Part "Interview"*

1. **Phosphorus fertilizers: Did you buy in Phosphorus fertilizer in the 1-year period before the first ProPIG farm visit?** yes❑ no❑
   If yes: Which type (trade name)? _______________________
   How much? ____________kg/year

2. **What type of litter do you provide currently?**
   Straw❑ Sawdust❑ Compost ❑ Other ❑_____________

3. **What type of additional enrichment material do you provide currently, to enable rooting and manipulation?**
   Straw(in feeding quality, daily provision)❑ Hay❑ Grass❑ Silage❑ Wood❑
   Compost❑ Soil ❑ other❑_____________

4. **How often do you provide enrichment material?**

	daily	weekly	other (f.e. seasonal,…)
Pregnant sows	❑	❑	❑_____________
Fatteners	❑	❑	❑_____________
Weaners	❑	❑	❑_____________

5. **How do you provide enrichment material?**

	On the floor	in a rack	other
Pregnant sows	❑	❑	❑_____________
Fatteners	❑	❑	❑_____________
Weaners	❑	❑	❑_____________

6. **Do you keep pregnant sows in stable groups (no regrouping or adding of new animals, except gilts, during the whole pregnancy)?** yes❑ no❑

7. Were the present gilts integrated into established groups with other gilts at the same time (not singularly)?
yes❑ no❑

8. Do you keep a boar? Yes❑ no❑
If yes: Does the boar have direct contact with the sows (e.g. kept with the sows in the service area or natural mating, except just stimulating the sows for releasing or signalizing the beginning of the oestrus period)? Yes❑ no❑

9. Were the current fatteners bought in with short tails or had short tails when they were moved into the fattening pen?
yes❑ no❑
If yes: How many %of them had short tails (estimation)? _____________%

10. Fatteners: Do you sell the whole pen at once? **yes❑** **no❑**

If no: Do you mix the remaining animals? yes❑ no❑

11. Do you fatten intact boars? yes❑ no❑

12. Do you keep fatteners in mixed-sex groups (castrates or intact boars kept with females)?

yes❑ no

Appendix 2 – Resource scoring sheet

The assessment is carried out for each pen, where animals are assessed.

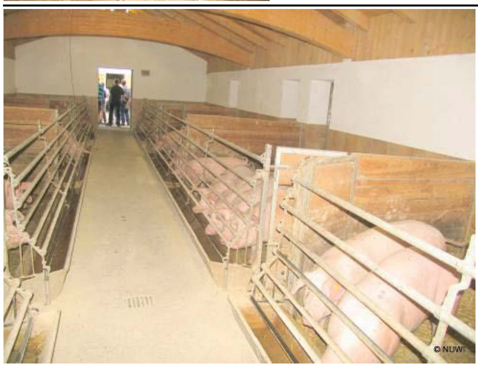
- Try to **assess all pens**, if not possible:
  - <10 pens: assess all;
  - 10-25 pens: assess 10
  - >25 pens: 15 pens (choose pens across fields/pregnancy stage etc)

How is feed being distributed?

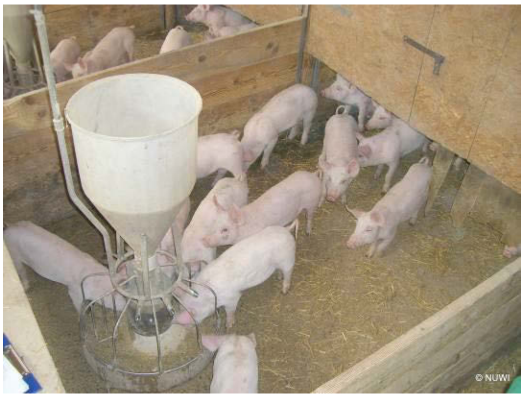
Trough: longitudinal provision of food for one or more animals, separation of feeding places max. until shoulder)

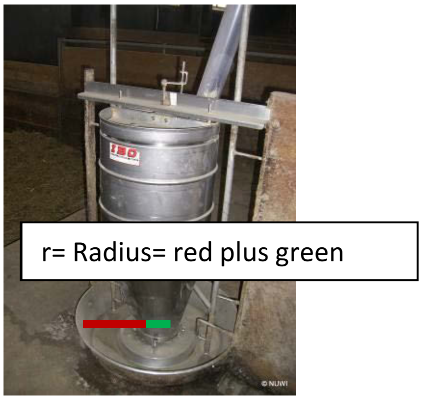
Round feeders: circular provision of food for several animals

Spread on the ground: no obvious container for food provision

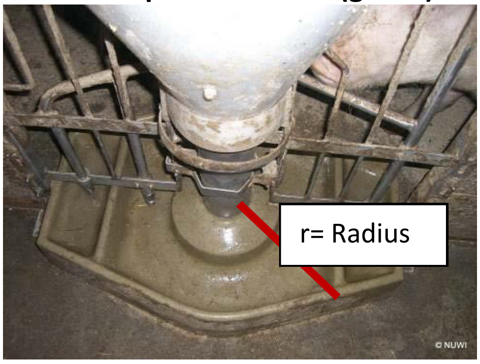


Examples of Troughs





Examples of Round Feeders; if difficult to measure radius properly estimate and add additional part in middle (green)



Red line indicates how to measure diameter (diameter = r x 2)
Round trough

Individual feeding stalls:

S= **s**elf lockable by sow: mechanism which enables animals to enter the stall individually AND protects animal during feeding (no other sow is able to enter)

F= lockable by **f**armer: mechanism in place, which allows farmer to lock sows during feeding into stalls individually or as a group (no matter, if actually done or not)

Not lockable

Not lockable (front)

Self lockable by sow

F= lockable by farmer

If there are Electronic Sow Feeders: Can the sows leave them forwards?

YES: door at the front, so that sow does not need to go backwards when leaving the station

NO: no door at the front, sow has to leave the station backwards

Possible to leave to the front

Are pigs being fed ad lib? (weaned piglets, fatteners, sows)

YES = ad lib = there is feed available 24h/day and it's present when you are there
NO = not available 24h, includes also, when farmer lets pig empty the trough in the night

How many functional drinkers are in the pen / paddock?

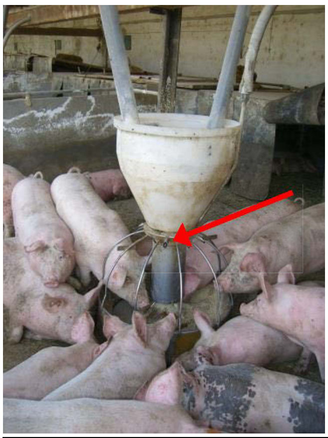
Count number of functional drinker/ing places
Functional = for age group adequate flow rate (l/min), height/position of drinker, clean;
***Trough**: e.g. count as 3 functional drinkers if 3 pigs can drink at the same time
*2 nipple drinkers on top of each other always count as 1 functional drinker, as pigs mostly cannot use both at the same time

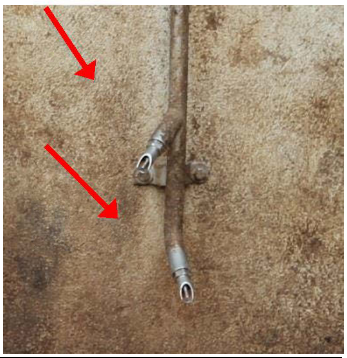
<u>Where do pigs drink from?</u>

Nipple drinker: pig has to take nipple into mouth in order to access water
Bowl drinker: metal bowl for pigs where is some standing water, pig needs to press some form of nipple to refill it
Trough: access to open water, automatic refilling
Pond/lake: natural/artificial water resource, does not include wallows
Running nat. water



Nipple **Bowl** **Trough**





Nipple drinkers on top of feeder **lateral/side**

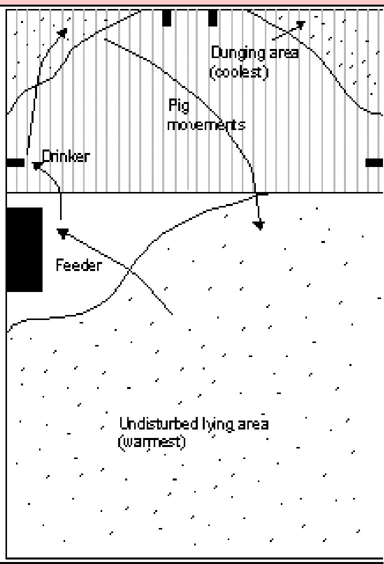
2 nipple drinkers on top of each other always count as 1 functional drinker

Do include nipples **on top**; **do not** include **lateral/side** nipple

Is there an obvious division between lying area and feeding/activity area?

YES: obvious (some structural element, which clearly separates two functional areas, animals do not need to cross lying area and disturb resting sows when moving to outside area. No drinkers/feeders (troughs or racks) in the lying area.

NO: no obvious division between lying and feeding area, resting animals are disturbed by others crossing the area for going outside, provision of drinkers/feeders in the lying area

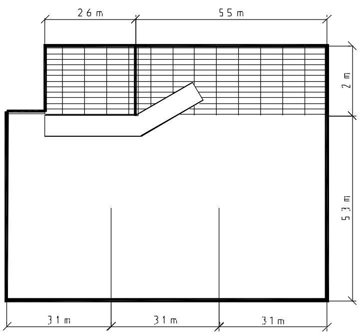


Is the lying area subdivided into separate lying niches?

YES: lying area is surrounded by three walls, max. place for 8-10 sows

NO: no subdivision of lying area into niches (no walls or other structural elements in this area)

Lying niches



Appendix 3 – Lesion scoring

The assessment is carried out from a **distance of 0.5 meter visually only**.

Assess **only one side** –half of the pigs left, half right. If you can see both sides of the animal, assess the left one.

- Try to **assess all pens**, if not possible:
  - <10 pens: assess all;
  - 10-25 pens: assess 10
  - >25 pens: 15 pens (choose pens across fields/pregnancy stage etc)
- Try to **assess all animals in pen**, if not possible:
  - <25 in pen: assess all;
  - 25-100 pigs in pen: assess 25; (randomly 5 pigs in 5 different places)
  - >100 pigs in pen: assess 50 (randomly 5 pigs in 10 different places)

If it is not possible (e.g. too dirty, too far away) to **assess at least 70% of animals**:

Exploratory behaviour (pregnant sows, weaned piglets, fatteners)

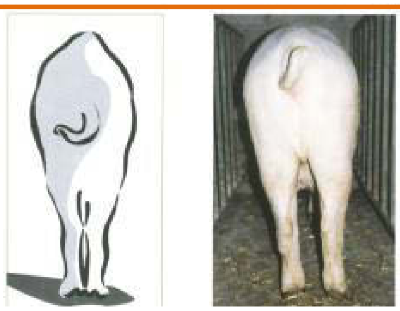
Restricted feeding: observation should not be done immediately before or after feeding.

1 = Step in front of pen, 2 minutes "adaption time"

2 = count **total number** of visible animals in pen

Body condition score (BCS; pregnant sows) (adapted from DEFRA; 1998)

To score the animals encourage them to stand up



Thin sow

visually thin, hips and backbone very prominent, no/very thin fat

Normal

hips and back well covered, rear view oval

Fat sow
very round appearance from the rear

Ectoparasites (pregnant sows, fatteners)

Count **number of animals** with obvious ectoparasites such as **mites** [Sarcoptes suis],

lice [Haematopinus suis], **ticks** [Ixodes spp] or **clinical signs** in most cases combined with **itchiness**:

- **small red dots** on whole body (fresh infections in younger animals);
- **crusts** - usually behind ear, tail base or on lower extremities in older pigs

Lice eggs (small white dots) **Lice** (black)

Mange: grey/brown crusts tail base, lower limbs and on/behind ear

<u>**Lesions** (pregnant sows, fatteners)</u>

Count **number of animals with ≥ 3 body lesion** (red scratch, wound or crust)

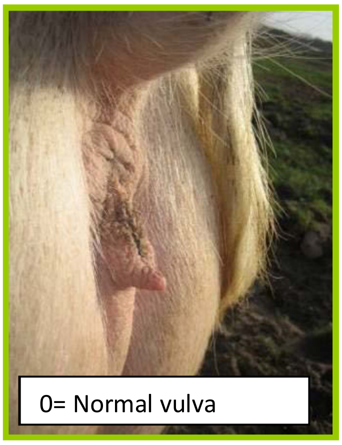
>3cm long or >1 cm diameter.

1= >=Body lesions > 3cm

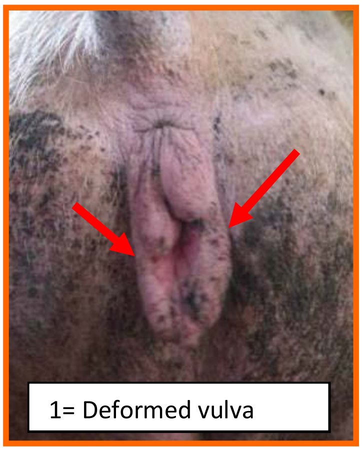
Vulva lesions (pregnant sows) **Deformed vulva** (pregnant sows)

Count **number of animals** with bleeding wounds or scabs of all sizes. (does not include discharge)

Count number of animals with vulva of abnormal shape or missing parts


0= Normal vulva


1= Vulva lesion


1= Deformed vulva

Tail lesions (weaned piglets, fatteners)

Count **number of animals** with any **scab or bleeding wound** (inspect carefully: hanging tail or swollen tails- might be early indicators of tail lesions)


0= Normal tail (no lesion, normal length as hairs on tip of tail)


1=Tail lesion (count also as "short tail" as tail is obviously shorter

Short tail (weaned piglets, fatteners)

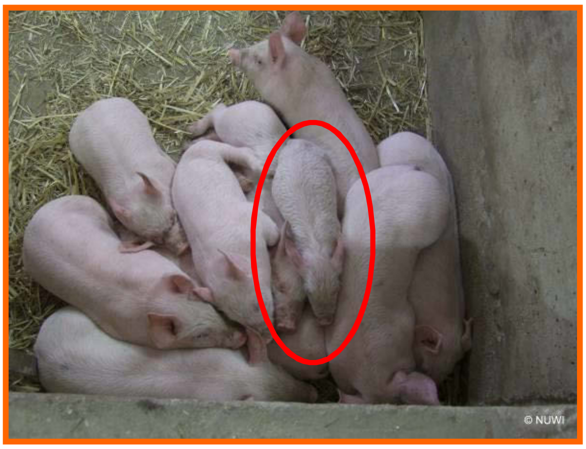
Count number of animals with tails shorter than natural length (natural length includes hairs on tip of tail)".

1= Short tail, no lesion	**1= Short tails** (count also as "tail lesion" as tails are swollen/with crusts)

Runts (weaned piglets, fatteners)

Count number of animals with **at least two of the following indicators** present:

obviously smaller than the other animals,



1= Runt: Long face, large ears, sunken flank	**1= Runt:** Visible spine, hairy coat, obviously smaller

Appendix 4 – Frequencies of all recorded parameters and potential risk factors evaluated in the pre-selection step

Table 20 Frequencies of all recorded risk factors in weaners

Risk factor	N farms	Category	Frequency	Percentage
type of litter	30	no litter	1	3
		straw	26	87
		sawdust	1	3
		mix of ≥2	2	7
straw length	30	chopped	3	10
		half chopped	6	20
		long straw	21	70
provision of enrichment	29	yes	18	62
		no	11	38
type of enrichment	29	no enrichment	11	38
		straw	2	7
		grass	1	3
		silage	8	28
		mix of ≥2 materials	7	24
frequency of enrichment provision	29	never	11	38
		weekly	3	10
		daily	15	52
type of enrichment provision	29	no enrichment	11	38
		floor	14	48
		rack	3	10
		mix (floor, rack)	1	4
provision of concentrated feed	30	trough	30	100
ad libitum feeding	30	yes	20	67
		no	10	33
type of drinker	29	nipple	6	21
		bowl	11	38
		trough	2	7
		nipple and bowl	6	21
		bowl and trough	4	14
breed	30	conventional	21	70
		cross breed (C*U)	9	30

Table 21 Frequencies of all recorded risk factors in fatteners

Risk factor	N farms	Category	Frequency	Percentage
litter	39	Straw	37	95
		mix of ≥2	2	5
straw length	38	Chopped	1	3
		half chopped	10	26
		long straw	27	71
provision of enrichment	38	yes	24	63
		no	14	37
type of enrichment	38	no enrichment	14	37
		Straw	4	11
		hay	4	11
		grass	1	3
		silage	8	21
		mix of ≥2	7	18
frequency of enrichment provision	38	never	14	37
		weekly	4	11
		daily	19	50
		last 4 weeks of fattening	1	3
type of enrichment provision	38	no enrichment	14	37
		floor	18	47
		rack	4	11
		mix(floor, rack, trough)	2	5
provision of concentrated feed	39	trough	39	100
ad libitum feeding	39	yes	27	69
		no	12	31
type of drinker	38	nipple	15	40
		bowl	13	34
		trough	1	2.5
		nipple and bowl	6	16
		bowl and trough	1	2.5
		nipple and trough	2	5
breed	39	conventional	28	72
		cross breed (C*U)	11	28
fatteners with short tails when moved into fattening pen	33	yes	12	36
		no	21	64

Risk factor	N farms	Category	Frequency	Percentage
whole pen sold at once	38	yes	2	5
		no	36	95
late mixing (>75 kg)	33	yes	12	36
		no	21	64
fattening of intact boars	38	yes	1	3
		no	37	97
mixed-sex groups	38	yes	36	95
		no	2	5

Table 22 Frequencies of all recorded risk factors in pregnant sows

Risk factor	N farms	Category	Frequency	Percentage
litter	26	straw	24	92
		mix of ≥2	2	8
straw length	26	chopped	1	4
		half chopped	8	31
		long straw	17	65
provision of enrichment	26	yes	18	69
		no	8	31
type of enrichment	26	no enrichment	8	31
		straw	2	8
		grass	1	4
		silage	6	23
		mix of ≥2	9	35
frequency of enrichment provision	26	no enrichment	8	31
		weekly	3	12
		daily	15	58
method of enrichment provision	26	no enrichment	8	31
		floor	9	35
		rack	3	12
		trough	3	12
		mix (floor, rack, trough)	3	12
provision of concentrated feed	23	trough	5	22
		spread on the ground	1	4.2
		single feed stalls (SFS)	10	43.5
		ESF	1	4.2
		trough and SFS	4	17.5
		trough and ESF	1	4.2
		ESF ad SFS	1	4.2
ad libitum feeding	26	yes	1	4
		no	25	96

Risk factor	N farms	Category	Frequency	Percentage
lockability of single feed stalls	16	not lockable	1	6
		by farmer	4	25
		by sow	2	13
		by sow and farmer	9	56
lockability of feeding place (gestation stall)	22	lockable	14	64
		not lockable	8	36
ESF	5	front exit	4	80
		rear exit	1	20
type of drinker	25	nipple	15	60
		bowl	5	20
		trough	1	4
		nipple and bowl	4	16
breed	25	conventional	19	76
		unconventional	1	4
		cross breed (C*U)	4	16
		conventional and unconventional on farm	1	4
integration of gilts	24	immediately after arrival	1	4
		after insemination	8	33
		after first farrowing	13	54
		after second farrowing	1	4
		at beginning of oestrus period	1	4
stable groups	26	yes	8	31
		no	18	69
boar on farm	26	yes	22	85
		no	4	15
direct contact boar-sow	22	yes	18	82
		no	4	18
division of feeding place and lying area	22	yes	13	59
		No	9	41
lying niches	22	yes	1	5
		no	21	95

Table 23 Weaners: Potential risk factors considered in the pre-selection step (p≤0.2) x…p≤0.2 in multivariate analysis, x*…p≤0.05 in univariate analysis

Risk factor	Category	N	Ear Lesions p	Preva-lence / r	Tail Lesions p	Preva-lence/ r	Short tails p	Preva-lence/ r
ad libitum feeding	yes no	26	-	-	-	-	-	-
provision of enrichment	yes no	29	-	-	-	-	-	-
enrichment type	1 material mix of ≥2 materials	29	-	-	-	-	-	-
straw length	half chopped / chopped long straw	30	0.16	2.7 0.2	-	-	-	-
straw/LSU	[t/LSU/a]	29	0.19	+0.25	0.11	-0.30	-	-
Groupsize	N	30	0.05	-0.36	0.12	-0.29	0.001	-0.56
Weight	[kg]	27	-	-	-	-	0.004	-0.53
area/animal	m²	29	-	-	0.11	+0.30	-	-
Length:width ratio (inside pen)		28	-	-	0.09	+0.32	-	-
type of drinker	nipple bowl and/or trough* nipple and bowl*	29	-	-	0.01	0.2 ab 0.0 a 0.5 b	0.04	1.6 ab 1.9 a 4.2 b
animals/drinker	N	29	-	-	0.12	-0.30	-	-
animal:feeding place ratio		27	-	-	-	-	-	-
prevalence of runts	%	30	-	-	-	-	-	-
Breed	conventional cross breed (C*U)	30	-	-	-	-	-	-

Tab. 24 Fatteners: Potential risk factors considered in the pre-selection step (p≤0.2)

x…p≤0.2 in multivariate analysis, x*…p≤0.05 in Univariate analysis

Risk factor	Category	N	Ear lesions p	Preva-lence/ r	Tail lesions p	Preva-lence / r	Short tails p	Preva-lence/ r	Body lesions p	Preva-lence/ r
ad libitum feeding	yes no	39	-	-	-	-	-	-	-	-
provision of enrichment	yes no	38	0.04	2.4 0.2	-	-	0.05	8.8 10.9	-	-
enrichment type	1 material mix of ≥2 materials	24	0.17	3.3 0.2	-	-	-	-	-	-
straw length	half chopped/chopped long straw	38	-	-	-	-	0.10	14.8 7	-	-
straw/LSU	[t/LSU/a]	36	-	-	-	-	-	-	-	-
groupsize	N	39	-	-	-	-	-	-	-	-
weight	[kg]	37	-	-	-	-	-	-	0.18	+0.48
area/animal	m²	38	0.11	-0.26			0.18	+0.22		
length:width ratio (inside pen)		37	-	-	0.04	+0.34	-	-	-	-
type of drinker	Nipple bowl or(and) trough nipple and bowl	38	-	-	-	-	0.13	12.7 6.0 10.3	0.12	12.7 21.6 32.2
animals/drinker	N	38	-	-	-	-	0.08	-0.29	-	-
animal:feeding place ratio		37	0.06	+0.23	-	-	-	-	-	-
prevalence of runts	%	39	-	-	-	-	0.08	+0.28	-	-
breed	conventional cross breed (C*U)	39	0.009	1.8 1.0	-	-	0.03	7.6 13.7	0.17	20.9 17.8
late mixing (>75 kg)	yes no	33	0.02	0.1 0.6	0.2	2.4 1.7	-	-	0.12	25.0 15.0
short tails when moved into fattening pen	yes no	33	0.10	0.3 2.7	0.04	0.6 3.1	0.02	5.8 14.0	-	-
short tails estimated	%	32	0.02	-0.40	-	-	0.03	+0.38	-	-

Table 25 Pregnant sows: Potential risk factors considered in the pre-selection step (P≤0.2)

x…p≤0.2 in multivariate analysis, x*…p≤0.05 in univariate analysis

Risk factor	Category	N	Vulva lesions	Preva-lence	Vulva defor-mations	Preva-lence	Body lesions	Preva-lence
provision of enrichment	yes no	26	-	-	0.10	11 4.7	-	-
enrichment type	1 material* mix of ≥2 materials*	18	0.05	0.2 3.3	-	-	-	-
method of enrichment provision	floor rack or trough	15	-	-	-	-	-	-
straw length	half chopped / chopped long straw	26	-	-	-	-	0.07	41.3 23.3
straw/LSU	[t/LSU/a]	24	-	-	-	-	-	-
groupsize	N	26	0.19	+0.260	-	-	-	-
area/animal	m²	26	-	-	-	-	-	-
length:width ratio (inside pen)		23	-	-	-	-	-	-
type of drinker	nipple bowl or trough nipple and bowl	25	-	-	0.2	7.8 2.5 8.6	-	-
animals/drinker	N	25	0.02	+0.456	0.08	+0.357	-	-
division of lying area and feeding place	yes no	22	-	-	-	-	0.07	21.2 41.2
lockability of feeding place (gestation stall)	lockable not lockable	22	-	-	-	-	-	-
stable groups	Yes no	26	-	-	-	-	-	-
time when gilts are integrated into groups	after insemination after first farrowing	21	-	-	0.15	6.7 4.5	-	-
breed	conventional cross breed (C*U)	23	0.16	1.9 0.0	-	-	0.17	34.5 51.0
prevalence of fat sows	%	26	-	-	x	-0.270	-	-
prevalence of thin sows	%	26	-	-	-	-	-	-