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The Rise and Fall of the Farrowing Sow: Does Communication Matter?

Stå eller ligge: betyr kommunikasjon noe for fødende purker?

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ACKNOWLEDGMENT

It's been a long and bumpy road finishing this master thesis, with a lot of distracting sights along the way. Still, this study has taking me places I never thought I would go, learning lots of interesting ethology about man's best friend; the pig! It is not only our friend (literally a more and more popular pet), but also historically and present day one of our most important livestock in regard to meat production. It is fascinating that we have been around this animal for thousands of years, but still have so many questions about what it does. And not the least about what it says; we don't even agree on that. The pig says 'oink' in England, 'nøff-nøff' in Norway, 'boo-boo' in Japan, and 'chrum-chrum' in Poland, but is there some meaning behind theses sound? Does for instance the mothers attempt to communicate with her piglets have any effects at all (or vice versa)…?

First of all I want to thank my supervisor Professor Inger Lise Andersen for giving me this opportunity, and for providing me with material and helping me out in the writing process. Thank you for your patience!

I also want to thank my former fellow students Ronny Steen and Karen Marie Mathisen for giving me valuable help in the final stage of this thesis. You are both dear friends and excellent academics!

Finally I want to thank my beloved wife Ragnhild who have been concerned, but supportive all the way. Especially during the hours of video analysis of farrowings with its screams and dramatic sight; not the best way to prepare for birth as she also was about to "farrow" at that time (it made the father on the other hand well prepared). Luckily our most precious Karoline does not show any sign of prenatal stress. You have both also been very patience with me!

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Anders Endrestøl

ABSTRACT

Piglet mortality is both reducing animal welfare and production yield. A large part of the piglet mortality is due to crushings by the sow, as a direct effect of the sows posture changes. Both frequencies, duration and other quality measures of the sow's posture changes (e.g. pre-lying behavior through communication with piglets) would therefore affect crushings. The purpose of this study is to investigate if and how the sow-piglet communication and the sows posture change is affected by different pen types, and if this in turn affects piglet mortality.

In this study 24 healthy Landrace × Yorkshire sows were included, 12 from a traditional pen and 12 from the UMB-pen (a prototype design-pen), with parities from 1-4 (1.8±0.20). The sows where recorded on video from prepartum and until 12 hours postpartum. The video material was analyzed for sow-piglet communication and postural changes.

A significant difference in activity level was found between comparing prepartum, farrowing and postpartum, with multiparous sows showing more posture change prepartum than primiparous sows. There were few significant differences between the pens, with only more time spend on standing to lying in the UMB-pen than in the traditional pen. The posture parameter best explaining crushings in the present study was the averages time the sow spent standing. Crushing could also be explained by an increased frequency of sitting.

Posture changes was also associated with communication. Primiparous sows communicated more, and more communication were performed in the UMB-pen. Frequency of standing to lying by the sow was positively correlated with sow-initiated communication, again positively correlated with crushings. But, when investigating communication effects on overall mortality, the best parameters to explain that was actually piglet-initiated. Increased communication by the piglets reduces mortality, which could both be due to reduced amount of crushings with increased orientation by the sow, or reduced mortality of other causes, e.g. starvation and hypothermia.

SAMMENDRAG

Spegrisdødelighet redusere både dyrevelferden og produksjonen. En stor del av spegristapet skyldes ihjelligging fra purka, en direkte effekt av purkas positurendringer. Både frekvens, varighet og andre kvalitetsmål på purkas positurendringer (f.eks. ligge-forberedende atferd som kommunikasjon med spegrisene) vil derfor påvirke ihjelliggingen. Målet med denne undersøkelsen er å finne ut av hvis og hvordan purke-spegris kommunikasjon og purkas positurendringer påvirkes av ulike bingetype, og om dette igjen påvirker spegristapet.

I denne undersøkelsen inngikk 24 friske Landrace × Yorkshire purker, 12 fra den tradisjonelle bingen og 12 fra UMB-bingen (prototype design-binge), med pariteter fra 1-4 (1.8±0.20). Purkene ble videofilmet fra før fødsel og til 12 timer etter fødsel. Videomaterialet ble analysert for purke-spegris kommunikasjon og purkas positurendringer.

Et signifikant forskjellig i aktivitetsnivå hos purka ble funnet før, under og etter fødsel, og de eldre purkene hadde mer positurendringer enn ungpurkene før fødsel. Det var få signifikante forskjeller mellom bingetypene, men varigheten av stå-posituren var lengre i UMB-bingen enn i den tradisjonelle bingen. Den positur-parameteren som best forklarte ihjelligging var varigheten av stå-posituren. Ihjelligging kunne også forklares med en økt frekvens av sitting.

Ungpurker kommuniserte mer, og mer kommunikasjon foregikk i UMB-bingen. Positurendring var også assosiert med kommunikasjon. En signifikant korrelasjon mellom frekvensen av legge-sekvensen og frekvensen av kommunikasjon initiert av purka. Purk-initiert kommunikasjon var igjen positivt korrelert med ihjelligginger. Når kommunikasjon ble undersøkt i forhold til generell dødelighet ble det best forklart med spegris-initiert kommunikasjon. Økende kommunikasjon fra spegris reduserer dødeligheten, som både kan skyldes redusert antall ihjelligginger, men og redusert mengde dødelighet av andre årsaker, f.eks sult og kulde.

INTRODUCTION

Communication in general

Communication is one of the key aspects in ethology, and important for understanding the nature of animals. In fact, communication is one of the key factors in ecosystems, or to site Hauser (1997): "nothing would work in the absences of communication". Many regard communications systems to have evolved so that an individual can maximize its decision-making based upon signals from other individuals (Endler 1993), i.e informative signals. Others conclude that deception is a "major motor" in the evolution of signs and thus communication (e.g. El-Hani et al. 2009). Some argue that communication is neither of these. Dawkins (1976) wrote in his famous book "The Selfish Gene": "*I now find myself dissatisfied with this* [his previous] *treatment of animal communication. John Krebs and I have argued in two articles that most animal signals are best seen as neither informative nor deceptive, but rather as manipulative*". The definition of communication is still disputed, and there are numerous different definition suggested (see Hauser 1997, Rendall et al. 2009). Using a broad definition we can define communication as the process where signals (behavioral, physiological, or morphological characteristics) with information expressed by an individual influence the probability of behavioral action of a second individual (Haack et al. 1983). Information is a feature of an interaction between sender and receiver, while signals transport this information (Hauser 1997).

Communication can occur among all different kinds of trophic levels. Flowers need to communicate with bees to achieve successful pollination. A moth might communicate with the bees (semiochemical) to be able to visit the hive and forage on the resources there without being attacked. A bee needs to communicate with other bees to assist efficient foraging, and the bees need to communicate with other animals (eg. birds and mammals) to avoid being eaten because they cause pain (warning signals). Animals might communicate among themselves to warn other relatives that there are dangerous bees present. The relative cost and benefit of communication will in many cases explain why communication is being used, while in some instances it is not used (Weary & Fraser 2009). Weary & Fraser (2009) uses the example of vocalizing pain. Newborns and young individuals might benefit from vocalizing pain, as they will expect attention from their parents that might relieve them from that pain, whilst an adult individual, might only attract predators if vocalizing pain.

Communication in production systems

This evolutionary socialization has led to a complicated and largely variable set of behavior and communication (including vocalization), but it has also affected how they receive the surroundings and thus interact with it. That is why this has been important factors in the domestication and breeding of livestock animals. Price (1999) defined domestication as; "*that process by which a population of animals becomes adapted to man and to the captive environment by genetic changes occurring over generations and environmentally induced developmental events reoccurring during each generation*''. Essentially all domesticated animals are descended from group-living ancestors (Weary & Fraser 2009). This has had, and still have, a potentially high impact on social aspects and animal welfare in modern production systems, at worst with lower production and increased mortality in the livestock. The field of applied ethology was expanding from the 1960's as the understanding that the study of behavior could be of great value in both animal welfare and production optimizing increased (Jensen 2009). The domestication of animals has led to some genetic difference from their wild ancestors as humans have overruled this by themselves selecting reproductive animals with desired qualities/traits (e.g. higher energy turnover, better immunity, increased food-tolerance, and temper) (Špinka 2009, Li et al. 2013). Still, the behavioral repertoire seen in wild ancestors of domesticated species might be strikingly similar which implies that apparently little of a species original behaviors have been altered by domestication (e.g. wild boar vs. domesticated pigs- Andersson et al. 2011). One of the most documented differences seen in domestic animals is the reduced sensitivity to changes in their environment (Prices 1999). This could include reduced maternal behavior, e.g. maternal responsiveness to distress calls by progeny (review by Kirkden et al. 2013), but also increased through selection for increased litter sizes and increased progeny survival. Some effects of domestication might also have led to genetic differences increasing the possibility for deleterious stereotypies (e.g. abnormal repetitive behaviors, Crib-biting) (Li et al. 2013). Other might even be an increased rate of some behaviors, e.g. as increased vocalization in sheep (Dwyer et al. 1998) or an increased rate of exploration and risk-taking in domestic guinea pigs (Zipser et al. 2014). An explanation for these examples is a "re-emergence" of some behaviors as the natural selection for suppression of such (as a prey species) are nonexistent in a domestic environment (Dwyer et al. 1998, Zipser et al. 2014). Even so, domestic animals released into more "natural" environment (enriched physically or cognitive), could also show more of the behavior repertoire shown by their wild ancestors and/or less unwanted behavior (e.g. aggression and anxiety), and by that suppress stereotypies (Jensen 2009, Špinka 2009, Li et al. 2013, Zebunke et al. 2013). These behaviors could therefore also tell us more about their ancestors "original" behavior (Illmann et al. 2002), and again be used as a measurement for an increased animal welfare (e.g. vocalization- Murphy et al. 2014).

As more attention has been given to animal welfare in livestock production systems the last decades, the more attention has also been given to interactions between individual animals, i.e. social behavior. One obvious way to alter the animal welfare and social behavior is through altering the housing arrangements or environmental factors. One example is to change from cages and stalls to free-ranging. This could lead to new welfare issues as seen in e.g. free-ranging poultry production; to meet the individuals need for movement and interactions also increases feather pecking, which is considered to be a major animal welfare problem (Miao et al. 2005). In other livestock systems, the focus on animal welfare could solve previous social behavior problems. Tail-biting in pigs, consider to be an major welfare issue, but also a production yield issue, are less a common problem in free-ranging or in an environment enriched production system (McCosker 2012).

Increasing focus on social behavior and research on alternative housing and parturition environments has given opportunities for increased maternal behaviors (including communication) from the mothers. The maternal qualities of e.g. sows may have great importance on the production (Marchant et al. 2001). Also, focusing on the farrowing environment in production systems might reduce the stress experienced by the mother and reduce the chance of prenatal stressed piglets that often have altered performance and behavior (Kranendonk 2006).

Mother-offspring communication

Mother-offspring communication have been studied and documented in a wide range of mammal species; e.g. sheep *Ovis aries* (Dwyer et al. 1998, Ramírez et al. 2011), goat *Capra hircus* (Briefer et al. 2012), pig *Sus scrofa* (Špinka 2009), horses *Equus ferus przewalskii*, *Equus caballus* (Alberghina et al. 2014), guinea pig *Cavia aperea* f. *porcellus* (Kober et al. 2008), northern fur seal *Callorhinus ursinus* (Insley 2001), mouse *Mus musculus* (Haak et al. 1983) and lesser spear-nosed bat *Phyllostomus discolor* (Esser & Schmidt 1989). This communication can be of different kind; e.g. tactile (Ramírez et al. 2011), vocal (Dwyer et al. 1998, Appleby et al. 1999, Ramírez et al. 2011), visual (De Waal 2003), and olfactory (Špinka 2009, Haak et al. 1983). These types of communication might be important for the bonding between mother and offspring (Dwyer et al. 1998, Anderssen et al. 2011) and thus crucial for the survival of the offspring (Haak et al. 1983). It could also be a source of conflict between offspring and parents ("manipulative") (Trivers 1974), even leading to abnormal maternal behavior like aggression (Chen et al. 2008). This conflict will often be a conflict between the parental investments being sufficient from the parent's point of view, than rather to get as much parental care as possible from the offspring's point of view. In an evolutionary perspective both parent and offspring will try to maximize their lifetime reproductive success (Fraser et al. 1995). In many cases (but not all), the "model of honest signaling of need" can be applied, where the progeny addresses the parents with costly signals that rise in rate and/or intensity with increasing need of the offspring (Weary & Fraser 1995, Drake et al. 2008, Illmann et al. 2013). Another evolutionary process that will affect this is also the risk of predation on both offspring and parents (as most of our livestock species originates from typical "prey" species), especially when the offspring is neonate and the communication between parents and offspring are crucial for its survival. Interestingly, such vocal communication between mother and offspring might even increase during domestication and breeding as this evolutionary selection for caution in vocalization is removed (Dwyer et al. 1998).

Pigs and mother-offspring communication

Pigs *Sus scrofa* (L., 1758) belong to the mammalian family Suidae. The species is divided into numerous subspecies ranging from the wild boar, *Sus scrofa scrofa*, to the fully domesticated pig *Sus scrofa domestica*. They are native to the Old World, but both the wild boar and the domesticated pig are now found in most parts of the world due to human introductions. The wild boar live in social groups of two to five related females and their offspring, while males are solitary (reviewed by Drake et al. 2008). Wild boars are today also sometimes kept in captivity for different purposes, e.g. meat production, public display, hunting and/or training of hunting dogs (Andersson et al. 2011). Pigs have been domesticated by men on several occasions for several thousand years BC (5-9000) (Špinka 2009). Pigs have mainly been selected for energy and year-round reproduction. This has not altered its original behavioral repertoire, but it has changed quantitatively (Schmid & Hirt 1993, Špinka 2009, Li et al. 2013). As described above, a conflict exists between the sow and her piglets in the amount and duration of parental care and resources (Pajor 1998, see review in Drake et al. 2008).

The farrowing behavior in sows is in general almost similar in wild boar and domesticated pigs. Shortly before farrowing (1-3 days) the sows separate themselves from the rest of the group to find themselves a place to build a nest. The sow prepares the site by performing nest building behavior; rooting and lining the nest with different materials like branches and grass (see review in Wischner et al. 2009a). This is to keep the piglets in a controlled space protected from cold and predators, and encourage bonding between mother and offspring (Drake et al. 2008, Weary & Fraser 2009, Andersson et al. 2011). Wild boars will on average have 3.5-5 piglets while the domestic pig will have on average 12 piglets (Johnsen et al. 1982, Baber & Coblentz 1986, Fernández-Llario & Mateos-Quesada 1998, Andersen et al. 2005). Later, the sow and here piglets return to the group.

Pigs primarily communicate through olfactory and acoustic queues, but also tactile (e.g. teat massaging by piglets or nose contact) (review in Drake et al. 2008, Špinka 2009, Anderssen et al. 2011). Research on communication between the sow and her piglets has been given less attention than communications between adult individuals. When Jensen (1981) published his review, it was the first in its kind on communication between sow and piglets. Later works have focused mainly on the nursing-period (e.g. Algers 1993, Appleby et al. 1999). Systematic and detailed behavior studies of wild boar sows during farrowing are scarce (Anderssen et al. 2011). During nursing, piglets are using vocalizations to signal to the sow that they are being excluded (Appleby et al. 1999). The piglets will also call when they are isolated (called "i-calls") and call when they are returned to the sow (called "c-calls"), and these calls contains cues that are litter specific which makes the sows able to discriminate between own and foreign piglets (Illman et al. 2002). This type of communication is towards the mother, and the other piglets do not respond to this. Still, this communication will affect the whole brood as the nursing might be terminated or shortened (Appleby et al. 1999). Thus, communication between sow and piglets might be crucial for individual piglet survival, but also for the whole brood and therefore affect both animal welfare and production yields (Illmann et al. 2013). Kirkden et al. (2012) mention in their review that generations of sows restrained in crates might have lost some of their maternal behavior, e.g. the responsiveness to piglet distress calls. Piglet mortality is both an animal welfare and a production issue, and the goal in a production system is to keep the piglet mortality as low as possible.

Piglet mortality and sow posture change

Crushing piglets is a major problem in production system, and could account for more than 40% of neonatal death and up to three-quarters of early piglet mortality in open farrowing systems (Marchant et al. 2001, Andersen et al. 2005). There are indications that this piglet mortality can be partly explained by maternal characteristics rather than environmental ones (Andersen et al. 2005), even though good management procedures are important factors in increasing piglet survival (see review in Kirkden et al. 2013). The piglets are at most danger from being crushed when the sow is either 1) lying down, or 2) rolling over (Wechsler & Hegglin 1997, Damm et al. 2005). The sow individual differences might be linked to frequencies of these posture changes or how they are performed. E.g. lying down could either be done in a vertically manner or by simply "flopping straight down", where the last manner is the most dangerous from a piglets perspective (Blackshaw & Hagelsø 1990, Wechsler & Hegglin 1997). The frequency and "quality" of the sequence "lying down" is also affected by domestication, and wild boars tend to lay down more often vertically rather than flopping down compared to domesticated sows (Schmid & Hirt 1993). Melišová et al. (2011) is using the term "danger-zone" as "*the area within one piglet length of the sow on the side on which she is about to lie down*". The activity level of the sow will also affect the activity level of the piglets so that restless sows tend to have restless piglets (Van Beirendonck et al. 2014). Piglet characteristics will also affect the risk of being crushed. Weary et al. (1996b) found that piglets that had gained less weight spent more time in this risky area. Interestingly the differences in piglet weight at day 1 was largest between litters, so Weary et al. (1996b) concluded that sow milk production the first day after farrowing at some degree affects the piglets being in the risk zone the following days, implying that sow milk production indirectly affects number of crushings.

According to Marchant et al. (2001), we can also define a "danger-period" as being 24h after farrowing. The most dangerous posture change would, according to Marchant et al. (2001), be the sow lying straight down from standing. Marchant et al. (2001) found that half of the crushing incidences where done as sows were lying down from standing position and half of them within the first 24h after farrowing. Weary et al. (1996a) also found that most crushing occurring on the day of farrowing. The majority of the crushings occured during the four first days after farrowing (Marchant et al. 2000). Combining this into a "danger-index", would thus be the number of "lying down" events by the sow within the first 24h after farrowing. Increased posture changes as a result of a sows "restlessness" postpartum due to different management practices and housing arrangements could thus potentially increase piglet mortality, even though the causality is not clear (see review in Kirkden et al. 2013). Sows with high frequencies of posture changes prepartum (high restlessness) have even been found to crush less piglets (Wischner et al. 2009b), but high prepartum restlessness is also found in savaging sows (sows killing their own offspring) (Ahlström et al. 2002, Chen et al. 2008).

Housing

Different environmental conditions and housing might affect the frequency of posture changes and thus risk of potential piglet crushing as described above (Marchant et al. 2000, see reviews in Baxter et al. 2012 and Damm et al. 2005). Algers (1993) also point out that noise (due to housing arrangements) might affect the nursing process by both increasing the frequency of posture changes by the sow, but also decrease the ability for both piglets and sows to discriminate between different signals (communication), both possibly leading to increased mortality. Even the conditions a sow experience when growing up (restrained /unrestrained) will affect later postural changes (Schmid & Hirt 1993). Farrowing crates, that restrict the movements of the sow partly constructed and used because of crushing, will have reduced risk of crushing compared to pens (Weary et al. 1996a, Marchant et al. 2000). But again, the restrained movement might increase farrowing duration, and number of still born piglets (Olivier et al. 2010), and reduce the sows ability to perform nest building behavior (Jarvis et al. 2001, Wischner et al. 2009a). Crates have been banned in several countries because of animal welfare implication, e.g. in Norway (Baxter et al. 2012). Despite high research attention there is no universal acceptance of an alternative to crates at the commercial level (Baxter et al. 2012). Outdoor farrowing seems promising both in economical and animal welfare terms (e.g. piglet survival), but this production system is less appropriate in countries with less suitable climate for such, e.g. Norway (Baxter et al. 2012). Another reason for the lack of attractive pen alternatives is that posture change from standing/sitting to lying might crush piglets in both crates and traditional pens, and it is actually found to be more transition between sitting and lying in crates than in pens and more rolling in pens than in crates (Weary et al. 1996a). Also milk production and piglet weight gain will differ between crates and pens (see review in Drake et al. 2008). A number of features with the housing might thus affect the frequency (and quality, i.e. "manner") of posture changes of sows. This could be e.g. features like size and construction (width, length, flooring, shape), but also other features like draftiness and ambient temperature, their cleanliness, and the incidence of diseases (Weary et al. 1996a). This has given the inspiration to create designed pens with different areas for eating, lying, defecating, and with different features ("furniture"- Baxter et al. 2012) like rails, sloped walls, heating, flexible plastic installations on the floor etc. (Damm et al. 2005). Design pens also scores promising in the welfare design index (WDI) developed by Baxter et al. (2012) compared to crates and modifies crates. Live-born mortality in conventional crates is found to be 11.5%, in simple pens 14.2% and in design pens 11.8% (review in Baxter et al. 2012). As maternal behavior is a key factor for piglet survival, design pens tries to combine different physical features to protect piglets and other features assigned to increase better maternal behavior. A new type of designed pen ("UMB-pen") has been tested at the University of Life Science in Norway (see details in Trøen 2011), as well as in a commercial setting (Friestad 2013). This pen was designed based on the fact that the quality of the creep area in the traditional pens not increased piglet survival (Vasdal et al. 2011). Previous studies indicate that sows prefer to have access to a piglet free area, and that they prefer to defecate away from their piglets (Pajor 1998). The UMB-pen has slanted walls, padded floor with heating and two compartments (nesting area and piglet free/ defecating area). Preliminary results indicate that this pen did better than the traditional one concerning some production parameters, as well as regarding animal welfare issues like knee ulcers and shoulder wounds of the sows (Friestad 2013).

Purpose

According to Baxter et al. (2012): "*A successful housing system should attempt to reconcile the 'triangle of needs' between sow, farmer and piglets, to maximise both productivity and welfare*". Acknowledging this, design pens try to facilitate maternal behavior by presenting housing that might improves the sow's interaction with her piglets, and thus their survival. The purpose of this study is to investigate if and how the sow-piglet communication and posture change is affected by the farrowing environment, comparing a "traditional pen" vs. a newly designed pen developed at NMBU, the "UMB-pen", and if this in turn affects piglet mortality.

MATERIALS AND METHODS

Study site and subjects

The experiment took place at the Animal Production Experimental Centre at The Norwegian University of Life Sciences (NMBU, Ås). All together 24 healthy Landrace × Yorkshire sows (*Sus scrofa*) were used in this experiment, with farrowing taking place between 2009 and 2011.

Environments and routines

1) A total of 12 sows with parities 1-3 ($\bar{X}$±SE 1.6±0.2) were housed in the "traditional" pen. The traditional simple pens, as described by Andersen et al. (2011), are loose-housed with individual pens (2.2×3.0 m), with a triangular piglet creep area placed in one of the front corners of the pen. Two thirds of the sow area had a concrete floor covered with sawdust and one third was made of concrete, slatted flooring. The creep area had lamp heating (providing a stable temperature of 34°C for newborn piglets), a thick layer of sawdust and straw, and a suspended roof with a plastic cover hanging down to protect the piglets from draughts. Farrowing rails were placed along the sides of the pen to prevent the sow from crushing piglets against a wall when she was lying down.

2) A total of 12 sows with parities 1-4 (2.0±0.3) were housed in the "UMB-pen". The UMB-pen is a prototype design pen developed at NMBU to minimize piglet mortality during farrowing. The UMB-pen is described in detail by Trøen (2011) (Figur 1). The pen has two compartments, one nesting area (2.4×1.7 m) and one piglet free, activity/defecating area (2,4×1,6 m), with a total area of 7.92m^2. Between the two areas was a sill (2×15h cm) that can be doubled in height (not doubled here). This was used to keep the piglets in the nesting area while the sow could move freely between the two. In this pen the piglets stay in the nest area the first 4-5 days after birth, while the sow could leave her offspring for shorter intervals. The nesting area has an inclination of 3%, with a 3 cm thick rubber mattress covering the floor. The floor in the nesting area has heating in two different zones, where the temperature was sat at 34^{o}C from about 24 hour prepartum to 24 hours postpartum. Two of the walls in the nesting areas had additional sloping walls, and on the third was a feeding tray, water dispenser and a hay tray. Sloping walls could be an important feature for reducing crushing of piglets but investigations on this is still needed (Damm et el. 2005). In the activity area, there was a slatted concrete floor with a rubber coating. The walls of

the activity area were bar fences. This arrangement is meant to represent apparent quality differences for the sows, and at the same time meet the sow's different needs (Trøen 2011). It might also reduce crushing and savaging by sows as less restrictive environment (sow able to escape piglets) might reduce restlessness (Ahlström et al. 2002). The UMB-pen is a prototype in development, and a second edition has been tried out in commercial experiments, e.g. in Norway (Friestad 2013) and in Australia (Cronin 2014).

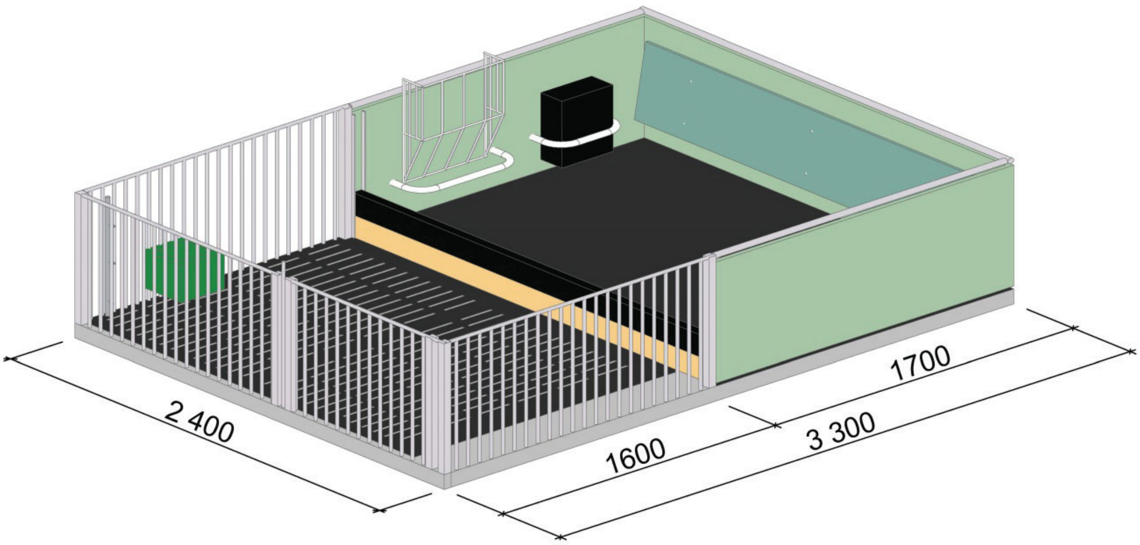

Figure 1. The UMB-pen. All numbers in millimeters. Source: Trøen (2011)

Human interference was kept to a minimum in both environments by just feeding, cleaning the pen, and providing new sawdust as bedding material twice a day (at 08:00 and 15:00), providing nest building material (i.e., straw) 1 day before expected farrowing. Some cross-fostering was done to even out some of the litters.

Video recording

All the farrowing sows were recorded on video. The cameras were placed outside the pens, recording continuously from about two meter height and tilted downwards, covering major parts of the nesting areas. In the UMB pen, only the nesting area was covered. The video material recorded from the traditional pens was all analyzed in the present study, while the analysis from the material from the UMB pen was done by Trøen (2011) (except posture changes, see below).

Video analysis

A total of 12 farrowings was recorded from the traditional pen and analyzed from the first frame and was ended 12 hours after last birth, resulting in a total material of about 260 hours. The time from the starting point of the recorded farrowings to the first birth could vary considerable. To code the behaviors, CowLog was used. This is open-source software for coding behaviors from digital video (Hänninen & Pastell 2009). The program has two main windows: a coding window, which is a graphical user interface used for choosing video files and defining output files that also has buttons for scoring behaviors, and a video window, which displays the video used for coding.

In the first behavior class, posture changes were recorded, discriminating between lying down, sitting and getting up/standing (walking). The second behavioral class was used to record three activities as nest building, birth and "others". These data were mainly used to control number of piglets (litter size), farrowing duration, pre- and postpartum duration and time spent on nest building. Nest building was here defined and recorded as a continuously rooting and pawing for more than three seconds. The last behavioral class was used to record communication between sows and piglets in the same scheme as used by Trøen (2011). In addition, aggression was recorded, but due to few observations, no further analysis was done on that parameter. The different behaviors are given in the ethogram in table 1. The CowLog output consists of three different files per behavioral class and per file.

Out of the 12 sows from the UMB-pen, only 10 of the recordings were analyzed with regards to communication during farrowing by Trøen (2011) due to technical issues. All 12 were analyzed by Trøen (2011) for postpartum communication (not discriminating between initiation from piglet or

Table 1. The behaviors recorded divided into three behavioral classes BH1-3.

BH1 - Posture	BH2 - Activity	BH3 - Communication
1: Lying down	9: Other (resting/sleeping/eating etc.)	17: Sniffing initiated by sow
2: Sitting	10: Nest building	18: Grunting initiated by sow
3: Rising/ getting up	11: Farrow	19: Sniffing and grunting initiated by sow
		20: Sniffing initiated by piglet
		21: Grunting initiated by piglet
		22: Sniffing and grunting initiated by piglet
		23: Aggression (bites/ attacks towards piglets)

sow or type of communication). Five of these recordings (a total of ca. 115 hours) where here re-analyzed to give representative data for posture changes in the UMB pen, in the same scheme as for the traditional pens. This did not include nest-building behavior, so data on that exist only from the traditional pen. The videos from the UMB-pens were analyzed using VLC (open source cross-platform multimedia player) and Microsoft Excel 2010.

Table 2. Description of the parameters used the analysis.

Code	Description
	Production parameters
ID	Used to discriminate between individual sows
Pen	The traditional farrowing pen (A), and the UMB-pen (B)
Par	Parity, here ranging from 1-4, or
(Par	parity as primiparous PP sows (parity 1) and multiparous MP sows (parity 2-4))
Birth_min	Farrowing duration
Born	Total number of piglets born
Still%	The proportion of stillborn out of total born
Live_Born	Number of piglets born subtracted still born
Litter size	Number of live born piglets (total born- still born±cross-fostering)
Crushed_M	The proportion of live born piglets crushed to death with milk in their stomach
Crushed_NM	The proportion of live born piglets crushed to death with no milk in their stomach
Crushed	The proportion of live born piglets crushed to death
Death_other	The proportion of live born piglets that died of other reasons than crushing
Mortality	The proportion of live born piglets that died
	Communication (divided into "during farrowing" CB and "postpartum" CAB)
SowSniff_CB/	Sniffing (nosing) between piglet and sow initiated by the sow
SowGrunt_CB	Grunting between piglet and sow initiated by the sow
SowSniffGrunt_CB	Sniffing (nosing) and grunting between piglet and sow initiated by the sow
SowTot_CB	Total amount of communication initiated by the sow
PiglSniff_CB	Sniffing (nosing) between piglet and sow initiated by the piglet
PiglGrunt_CB	Grunting between piglet and sow initiated by the piglet
PiglSniffGrunt_CB	Sniffing (nosing) and grunting between piglet and sow initiated by the piglet
PiglTot_CB	Total amount of communication initiated by the piglet
TotSniff_CB	Total amount of sniffing (nosing)
TotGrunt_CB	Total amount of grunting
TotSniffGrunt_CB	Total amount of sniffing (nosing) and grunting
TotSow_CAB	Communication per hour initiated by the sow postpartum
TotPigl_CAB	Communication per hour initiated by the piglets postpartum
ComTot_CB/CAB	Total amount of communication during farrowing or postpartum (CB/CAB)
ComTot	Total amount of communication
	Posture changes (PC)
PC_BB	PC per hour prepartum
PC_B	PC per hour during farrowing
PC_AB	PC per hour postpartum
Up_Down _BAB	The number of PC "standing-lying" per hour during and 12 hours after farrowing
Down _BAB	The number of lying down per hour during and 12 hours after farrowing
Sits_BAB	The number of sitting per hour during and 12 hours after farrowing
Up_BAB	The number of getting up (raising) per hour during and 12 hours after farrowing
Up_Down_min	Average time in minutes from standing to lying (include all time up, e.g. walking)
Sits_min	Average time in minutes from sitting to lying or standing
Down_min	Average time in minutes lying (including lying to sitting or standing)
PC_Tot	Total number of PC before, during and after farrowing per hour
	Other
Nestbuilding	Continuously rooting and pawing for more than three seconds
Nestb_min_BB	Nest building per min prepartum
Prop_nestb_BBB	The proportion of nest building per min before and during farrowing

Analysis and statistics

All the data registered from the video recordings were processed in Microsoft Excel 2010 and a data matrix with the different parameters was synthetized. The recorded behaviors were standardized by duration (per hour), as both time analyzed prepartum (before farrowing) and the actual farrowing time varied. For posture changes, data were presented for prepartum, farrowing and postpartum (after farrowing- 12h). On communication, data were presented as "farrowing" and "postpartum" (12h). Posture change postpartum (12h) was also calculated per hour to be able to present total amount of posture changes per hour. As the material used in this thesis is combined from own analysis and others (e.g. Trøen 2011), the number of sows that could be included in the different analysis would vary. Data on mortality existed only for 10 of the sows in the traditional pens, so a total of 20 sows were used in the mortality analysis. For analysis concerning only communication and pens, 22 sows could be included. Communication after farrowing (CAB) could, because of constrains of the data from the UMB pen, only be analyzed for three different parameter; communication initiated by the sow, and communication initiated by the piglet, and total communication (see Table 2). For posture changes 12 sows from the traditional pens could be used and only five from the UMB-pen. The sows where categorized as multiparous (MP) when having parity 2-4 (five from the traditional pen and six from the UMB pen) and as primiparous (PP) for first parity (five from the traditional pen and four from the UMB pen).

Descriptive statistics and derived parameters was calculated using Microsoft Excel 2010. When calculating average time on the different posture changes the maximum and minimum value was removed to adjust for extreme values. To analyze production parameters (born piglets and mortality) a Generalized linear model (GLM) procedure (Poisson) was performed on mortality as a response (count data, number of piglets crushed (with and without milk, and total), and the category Death-other) and pen, parity and their interaction (pen*par) as predictors, using litter size as an offset variable ($\log(y) = a + bx + E$, where E is the offset). When using still born (still) as response, total born (born) was used as offset. A GLM on litter size and mortality (and live born and still born) was performed to evaluate the offset. A manual model selection was also performed (GLM poisson, with litter size as offset) to evaluate the effect of different parameters of posture changes on crushing, as crushings are directly linked to posture changes. The communication parameters was tested for effects on overall mortality. All parameters were run separately due to low sample size and possible autocorrelation. Akaike's Information Criterion (AIC) was used to rank the best models (Burnham & Anderson 1998). The differences between the best model and the following models ($\Delta AIC = AIC_x - AIC_{min}$) can be used to evaluate support of the following models. A ΔAIC value of 0-2 gives substantial support (Burnham & Anderson 1998). To get predictions from the best (and/or second best) model a back log-transformation was done on the parameter estimates using the following equation $Y = \exp(a + bx + E)$ to calculate the regression line. To analyze the effects of pen and parity (and their interaction) on both communication and posture changes two different General linear models (GLM) with a subsequent ANOVA was performed. Generalized linear models and General linear model (GLM) were executed in SAS/STAT® and IBM SPSS 22.

To test the differences between the different communication parameters (sniff, grunt or both), one-way ANOVAs (Kruskal–Wallis) was performed on sows, piglets and total. The same was applied to posture changes per hour prepartum, during farrowing, and post-partum.

Since nest-building behavior only existed for the traditional pen, this behavior was not included in the GLMs. Two-Sample unpaired tests (t-test / Mann-Whitney) were applied to evaluate the difference between MP and PP sows in the traditional pen (N=12). This was also done for other parameters not included (or used as offset) in the GLMs. These tests were performed in SigmaPlot 12.5.

Some correlations (Pearson Product moment/ Spearman Rank order) were performed in IBM SPSS 22. To investigate the association of posture changes on communication and a possible pre-lying behavior, a correlation test was performed on the frequency of the "lying down sequence" by the sow per hour during and after farrowing and the amount of communication initiated by the same sow. Associations between parity and litter size, still born and farrowing duration, litter size and communication and posture change prepartum and nest-building were also investigated with correlation tests.

Prior to all test analysis a Shapiro-Wilk normality test was executed and based on the results the appropriate test was selected.

A significance level (P-value) between 0.1 and 0.05 was considered a trend. A significance level $P<0.05$ was considered significant (visualized with an asterisk*), and $P<0.001$ considered highly significant (visualized with two asterisk**).

Sources of errors

Some methodological sources of errors should be mentioned. First of all, there is a possibility that the communication data is subjected to observer-bias as the communications analysis from the UMB-pen was done by Trøen (2011), and the analysis from the traditional pen done by the author of the present study. The observers synchronized their scoring during common analysis, but the possibility of observer bias should be kept in mind. This could potentially have effects on between-pen analysis but less so between parities.

Posture changes were analyzed for all farrowings in the traditional pen, but only for five of the UMB-pen. This is a low sample-size, at least for the UMB-pen. In addition, the recordings from the UMB-pen covered only the nesting area and parts of the activity area. In some cases the sow could thus disappear from the view. This would potentially overestimate the time the sow was standing. That is also why the two extreme values (max, min) were removed when calculating average duration of different postures.

RESULTS

Production parameters

Some descriptive data for production parameters and mortality parameters are given in table 3. The results are from a GLM procedure on number of piglets in the different categories as response, and pen, parity and their interaction (pen*par) as predictors using litter size as an offset variable. When using still born (still) as response, total born (born) was used as offset. A close to significant higher number of born piglets (Born) where found in the UMB pen than in the traditional pen. There was also a trend towards more still born piglets in the UMB-pen. No difference in farrowing duration (Birth_min) was found between pens. No differences in farrowing duration, number of born, still born and live born piglets were found for MP compared to PP sows, though a trend towards more still born among MP sows where found.

A GLM was performed on total born and still born ($\chi_{1,20}^{2}$= 18.29; P>0,001**), and litter size and mortality ($\chi_{1,20}^{2}$=13.79; P>0,001**) respectively, and parameter estimates were used to calculate the predicted values (Figur 2). Since there is a clear effect of total born on still born and litter size on mortality, both total born and litter size were used as offset values in the GLM used to analyze mortality further.

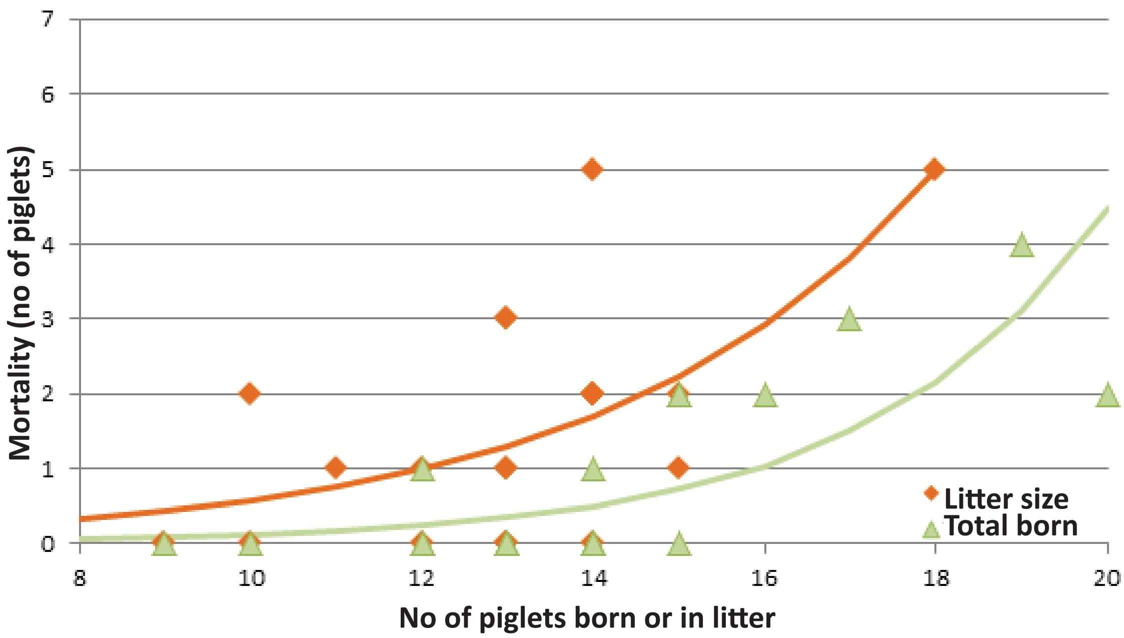

Figure 2. Litter size (red), total born (green) and mortality. Points represent raw data, while the lines are the predicted mortality (for litter size) and still born (for total born).

*Table 3. The results of separate GLMs (Poisson) testing different parameters of mortality (count data) as responses with pen, parity (par), pen*parity (pen*par) as predictors (with litter size as offset variable). A linear model with Born as offset was used for Birth_min and Born used as offset for Still (Poisson). The mortality parameters are presented as percentage of litter size. All values given as X±SE.*

	Trad. pen	UMB-pen	Statistics (pen)	Sow MP	Sows PP	Statistics (parity)	Total	Statistics (pen*par)
Birth_min	290.30±49.89	343.70±24.18	$\chi_{1,16}^2$=1.26; p=0.26	319.40±42.47	314.00±35.78	$\chi_{1,16}^2$=0.01; p=0.94	317.00±27.60	$\chi_{1,16}^2$=1.63; p=0.20
Born	12.00±1.04	14.9±0.71	$\chi_{1,18}^2$=3.78; p=0.052	14.73±0.66	12.45±1.11	$\chi_{1,18}^2$=2.72; p=0.99	13.59±0.68	$\chi_{1,18}^2$=1.39; p=0.24
Still	2.47±1.82	6.54±2.15	$\chi_{1,18}^2$=16.38; p<0.001**	4.86±6.96	4.53±2.16	$\chi_{1,18}^2$=5.45; p=0.02*	4.69±1.47	$\chi_{1,18}^2$=0.31; p=0.58
Live born	12.00±1.04	13.83±0.50	$\chi_{1,18}^2$=2.37; p=0.12	13.91±0.44	11.72±2.93	$\chi_{1,18}^2$=2.50; p=0.11	12.81±0.54	$\chi_{1,18}^2$=0.97; p=0.32
Littersize	12.10±0.56	13.8±0.50	$\chi_{1,18}^2$=1.31; p=0.25	13.80±0.44	12.30±0.63	$\chi_{1,18}^2$=1.13; p=0.29	13.10±0.41	$\chi_{1,18}^2$=0.21; p=0.65
CrushedM%	0.80±0.83	5.3±1.52	NA	3.80±1.69	2.80±1.18	NA	3.27±1.01	NA
CrushedNM%	1.60±1.07	3.3±1.51	$\chi_{1,18}^2$=1.68; p=0.20	3.70±1.63	1.40±0.92	$\chi_{1,18}^2$=1.88; p=0.17	2.50±0.95	$\chi_{1,18}^2$=0.19; p=0.66
Crushed%	2.40±1.21	8.7±2.38	$\chi_{1,18}^2$=2.38; p=0.12	7.50±2.67	4.10±1.51	$\chi_{1,18}^2$=2.66; p=0.10	5.80±1.54	$\chi_{1,18}^2$=0.19; p=0.66
Death_other%	8.60±3.74	3.4±1.83	$\chi_{1,18}^2$=35.76; p<0.001**	4.35±2.19	7.20±3.41	$\chi_{1,18}^2$=9.91; p=0.002*	5.80±2.01	$\chi_{1,18}^2$=2.16; p=0.14
Mortality%	11.00±4.02	12.1±2.95	$\chi_{1,18}^2$=37.09; p=0.001*	11.80±2.93	11.30±3.88	$\chi_{1,18}^2$=10.55; p=0.001*	11.60±2.38	$\chi_{1,18}^2$=1.92; p=0.66

No difference between pen or parity where found for the crush-parameters. For the crushed-predictor CrushedM there were too few occurrences to calculate variance in the GLM, thus NA. Applying a Rank Sum test to this parameter reveal that there is a significant difference between the pens (T_{20}=86.0; p=0.029), but not on parity (T_{20}=130.5; p=0.79). For Death_other, a significantly higher occurrence was found in the traditional pen, and for the interaction between pen and parity. The highest occurrence of Death_other was found in litters of PP sows in the traditional pen (10.15±6.45) and lowest among MP sows in the UMB-pen (2.04±1.30) (Figure 3).

Overall mortality was significantly higher in the UMB pen, and for the interaction between pen and parity. The highest occurrence of overall mortality was found in litters of MP sows in the UMB-pen (14,52± 4,11) and lowest among MP sows in the traditional pen (8,68± 4,16) (Figure 4).

There was a clear correlation between still born and total born (r=0.71; p>0.001**). A correlating trend between parity and born piglets was found (r=0.40; p=0.07). There was a correlating trend between farrowing duration and 1) total born (r=0.40; p=0.09), and 2) still born (r=0.42; p=0.07; Figure 5). Parity or mortality was not correlated with farrowing duration.

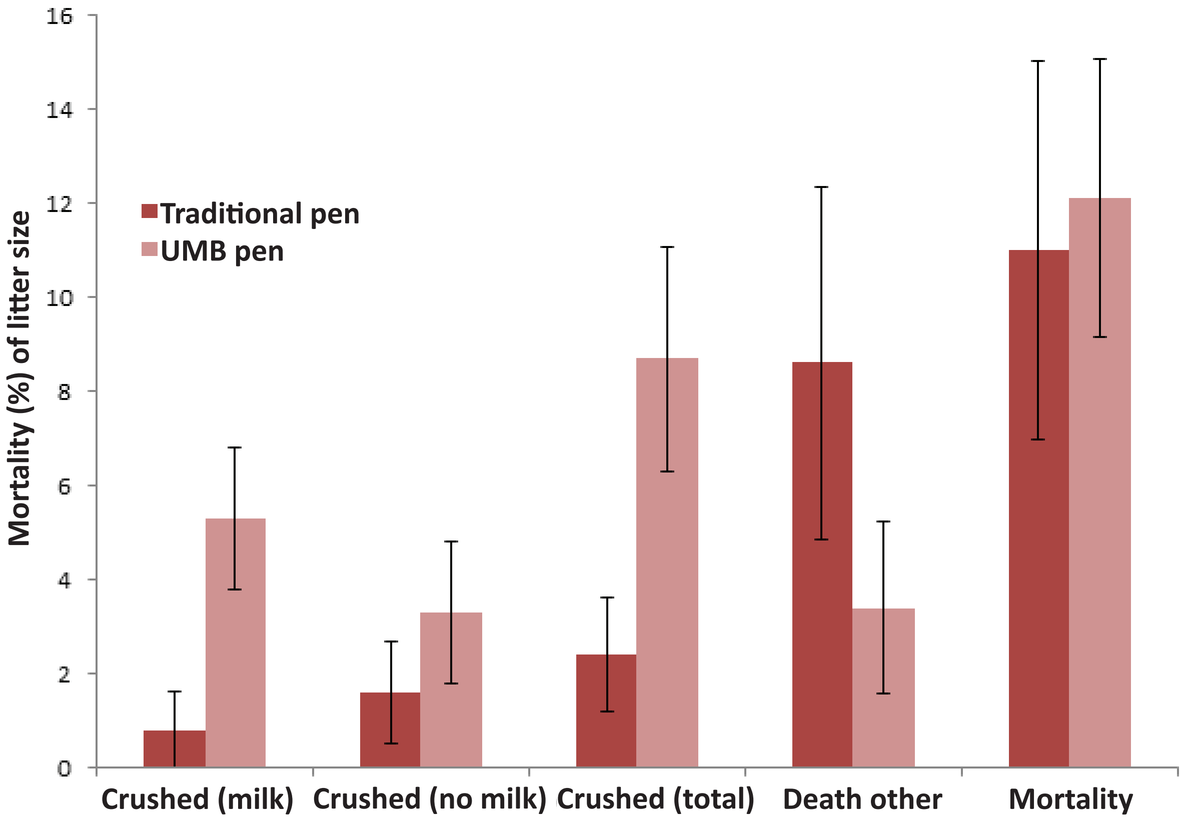

Figure 3. Mortality variables in the different pens.

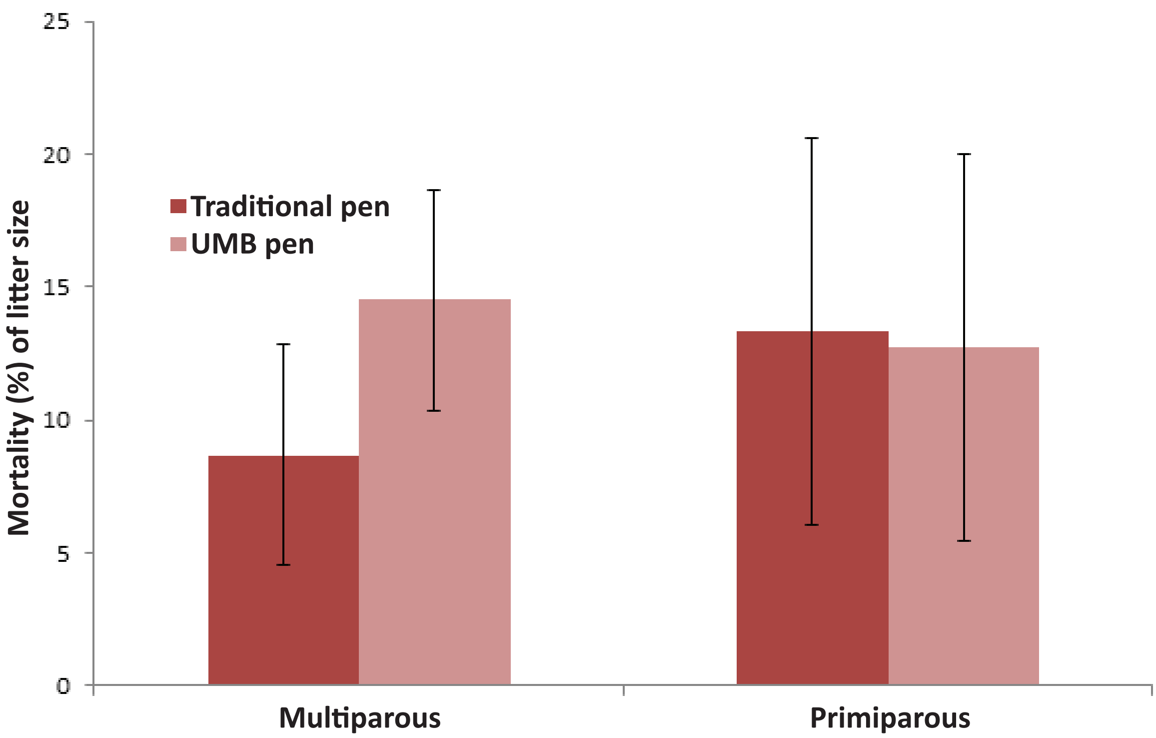

Figure 4. Overall mortality for the different pens and parity used in this analysis.

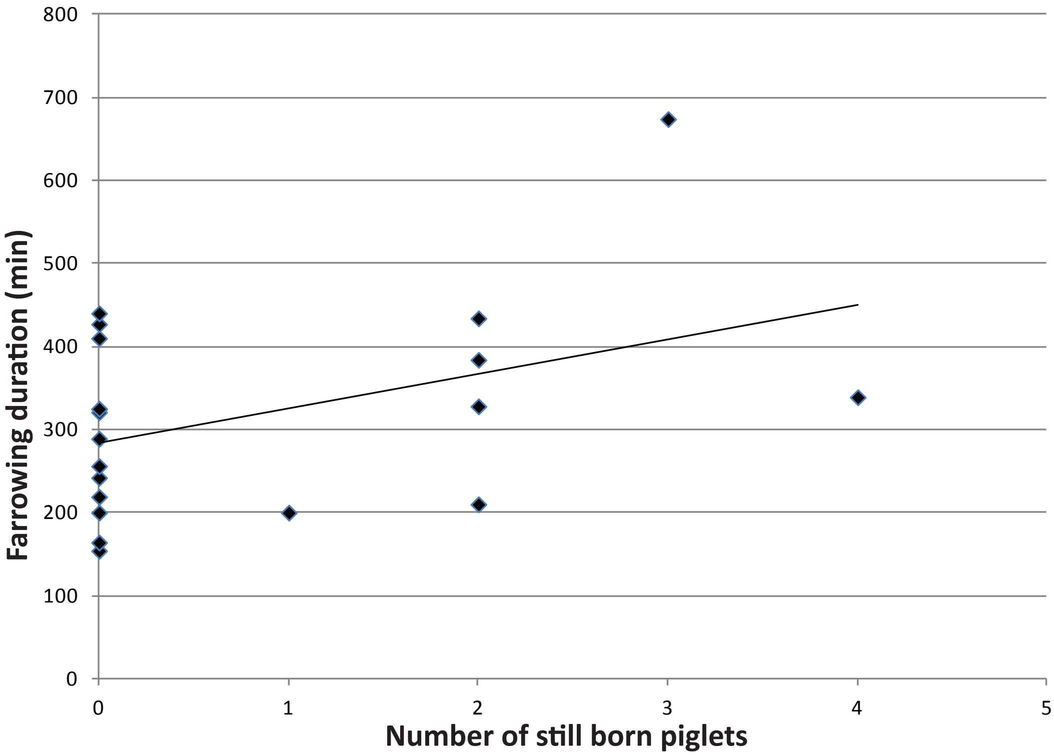

Figure 5. Number of still born piglets and farrowing duration.

Posture changes

Activity level as posture changes per hour 1) prepartum, 2) during farrowing and 3) postpartum differed significantly (Kruskal-Wallis ANOVA; H_2=12.04; p=0.002), with the post-hoc test giving a significant more posture changes prepartum than postpartum (Tukey Test; P<0.05).

No differences in any of the posture change variables could be found between the two pens. Neither could there be found any differences in postural change due to the interaction between pen and parity. The only significant difference in posture change was between MP and PP sows prepartum, with MP sows changing more posture prepartum than PP (Table 4). Available data material (length of video recordings) prepartum varied considerably (min 0.24h; max 13.6h; 4.13±0.87).

No difference between PP and MP sows regarding nest building per min prepartum was found (t_2=0.697; p=0.51). No correlations were found between posture change prepartum and amount of nest building behavior (frequency: r_s=0.21; p=0.54; duration: r_s=0.29; p=0.35).

Nest-building was not correlated with mortality variables.

A GLM model was performed on the posture parameters given in table 4. Posture changes before birth was the only dependent variable that had a tendency of being affected by the explanatory variables parity.

To investigate for any effects on posture change and crushings, a manual model selection was applied (GLM Poission with litter size as offset). The best model was the parameter Up_Down_Min, the average time in minutes a sow spends standing, including standing to lying (Table 5).

Up_Down_Min had significant effects on crushings (crush=-12.502+(-0,462*Up_Down_Min)+13); $\chi_{1,13}^{2}$=11.69; P=0,001*, Figur 6). The effect of increased Up_Down_Min is decread number of crushings

The second best model was Sits_BAB, the frequency of a sow sitting (sitting to standing, and sitting to lying). Sits_BAB had significant effects on crushings (crush=-16.708+(1,499*Sits_BAB)+13); $\chi_{1,13}^{2}$=11.12; P=0,001*). The effect of increased frequency of sitting was increased number of crushings.

Table 4. Posture changes (PC) per hour (H) before farrowing (BB), during farrowing (B), after farrowing (AB) or during and after farrowing combined (BAB), where the sow is either primiparous (PP) or multiparous (MP). All parameters are frequency per hour ($\bar{X}$±SE). The statistics are results from a subsequent ANOVA from the GLM model on posture change parameters.

	Pen A	Pen B	Statistics (Pen)	Sow MP	Sow PP	Statistics (Par)	Total	Statistics (Pen*Par)
PC_BB	9.26±1.28	10.60±2.40	$F_{1,10}$=0.00; p=0.98	11.80±1.54	5.63±0.77	$F_{1,10}$=5.64; p=0.04*	9.65±1.12	$F_{1,10}$=0.01; p=0.91
PC_B	7.41±0.97	4.65±0.98	$F_{1,10}$=1,07; p=0.32	5.14±0.76	6.46±0.70	$F_{1,10}$=0.30; p=0.60	6.60±0.79	$F_{1,10}$=0.10; p=0.76
PC_AB	4.61±0.93	6.27±2.17	$F_{1,10}$=0.19; p=0.67	4.67±1.32	5.38±1.60	$F_{1,10}$=0.00; p=0.97	5.10±0.90	$F_{1,10}$=1.31; p=0.28
Up_Down_BAB	1.23±0.26	1.14±0.37	$F_{1,10}$=0.01; p=0.92	0.97±0.22	1.15±0.31	$F_{1,10}$=0.02; p=0.89	1.20±0.21	$F_{1,10}$=1.67; p=0.22
Down_BAB	2.19±0.39	2.06±0.62	$F_{1,10}$=0.02; p=0.89	1.74±0.36	2.26±0.61	$F_{1,10}$=0.17; p=0.69	2.15±0.32	$F_{1,10}$=0.35; p=0.57
Sits_BAB	1.94±0.29	1.76±0.58	$F_{1,10}$=0,00; p=0.98	1.55±0.33	2.08±0.48	$F_{1,10}$=0.24; p=0.63	1.89±0.26	$F_{1,10}$=0.30; p=0.59
Up_BAB	1.26±0.26	1.16±0.37	$F_{1,10}$=0.03; p=0.88	1.00±0.21	1.18±0.32	$F_{1,10}$=0.03; p=0.89	1.23±0.21	$F_{1,10}$=1.75; p=0.21
Up_down_Min	3.70±0.58	7.76±2.16	$F_{1,10}$=1.71; p=0.22	5.88±1.38	3.89±1.14	$F_{1,10}$=0.87: p=0.37	4.90±0.85	$F_{1,10}$=0.91; p=0.36
Sits_Min	0.68±0.16	0.75±0.17	$F_{1,10}$=0.00; p=0.97	0.66±0.14	0.80±0.28	$F_{1,10}$=0.05; p=0.83	0.70±0.12	$F_{1,10}$=0.19; p=0.69
Down_min	10,54±1,59	8,00±1,70	$F_{1,10}$=0.09; p=0.77	9,06±1,27	10,66±2,45	$F_{1,10}$=0.63; p=0.45	9,55±1,29	$F_{1,10}$=0.88; p=0.37
PC_Tot	6.39± 0.52	7.17± 1.79	$F_{1,10}$=0.01; p=0.94	7.20± 0.96	5.82± 0.76	$F_{1,10}$=1..18; p=0.30	6.65± 0.66	$F_{1,10}$=0.48; p=0.50

Table 5. Manual model selection based on GLM (Poisson) and AIC ranking on the effect of posture change parameters on piglet crushing.

Rank	Model	Posture	AIC	ΔAIC
Rank 01	Model 08	Up_down_Min	30,21	0
Rank 02	Model 06	Sits_BAB	32,23	2,02
Rank 03	Model 09	Sits_Min	33,33	3,12
Rank 04	Model 05	Down_BAB	34,51	4,3
Rank 05	Model 04	Up_Down_BAB	34,92	4,71
Rank 06	Model 02	PC_B	34,93	4,72
Rank 07	Model 03	PC_AB	35,67	5,46
Rank 08	Model 11	PC_Tot	35,81	5,6
Rank 09	Model 01	PC_BB	37,09	6,88
Rank 10	Model 10	Down_min	38,51	8,3
Rank 11	Model 07	Up_BAB	38,79	8,58

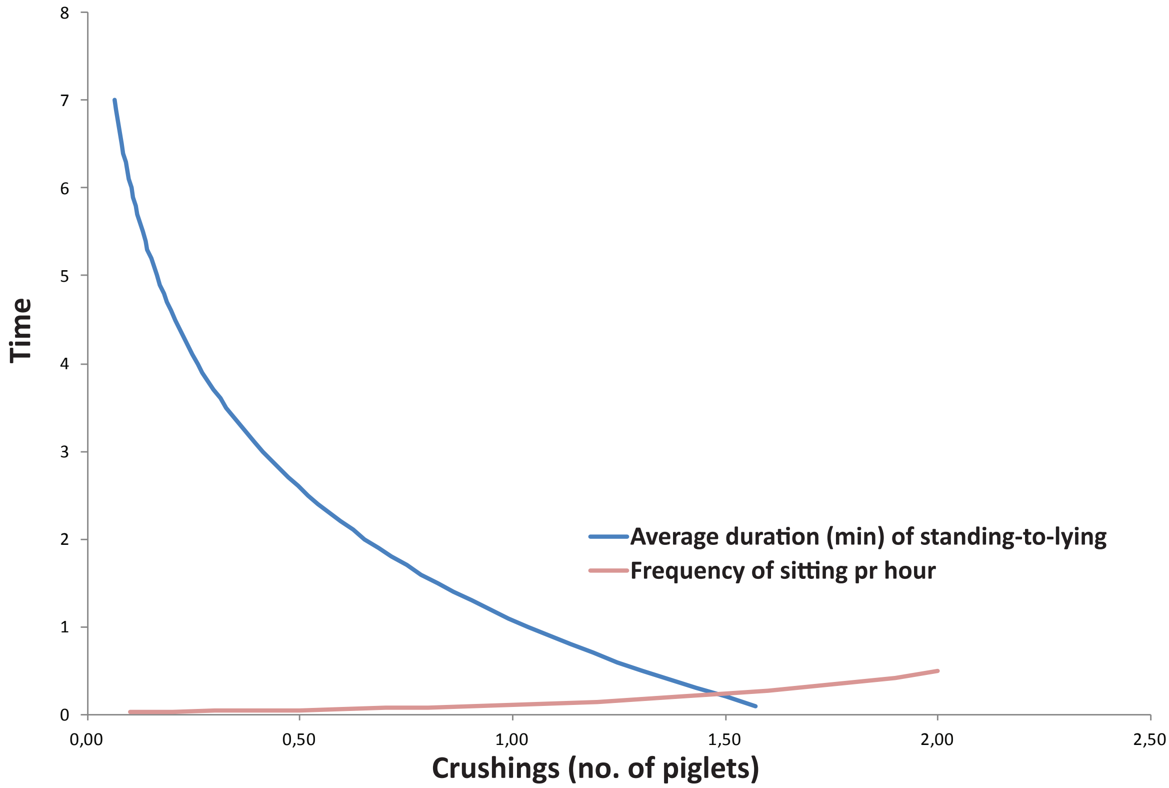

Figure 6. The regression line for the two best models of posture changes predicting crushings.

Communication

Several of the communication parameters differed between pen and parities (Table 6 and Figure 7). Regarding the different pens, total amount of communication during farrowing, and especially communication initiated by the sow was significantly higher in the UMB pen. Communication postpartum was also significantly higher in the UMB pen and the overall communication during and after farrowing combined was also higher in the UMB-pen.

Regarding the parity of the sows, several of the communication parameters was also significantly different between parities (MP/PP). For all significant differences, the frequency of communication was higher in litters of PP sows, and only during farrowing. Even piglet initiated communication was higher in litters of PP sows. There was a trend towards an overall difference with more communication in litters of PP sows (during and after farrowing combined).

The interaction between pen and parity did not have any significant differences in communication.

*Table 6. The results of separate GLMs (Poission) testing different parameters of mortality as responses with pen, parity (par), pen*parity (pen*par) as predictors (with litter size as offset variable). A linear model with Born as offset was used for Birth_min and Poisson with born as offset for Still. All values given as X±SE.*

	Trad. pen	UMB-pen	Statistics (Pen)	Sow MP	Sow PP	Statistics (Par)	Total	Statistics (Pen*Par)
SowSniff CB	1.43±0.58	1.62±0.18	$F_{1,11}$= 0.11; p= 0.75	1.25±0.17	1.93±0.79	$F_{1,11}$=0.835; p=376	1.51±0.32	$F_{1,11}$=0.38; p=0.55
SowGrunt CB	0.96±0.46	2.67±1.41	$F_{1,11}$=7.90; p=0.14*	0.72±0.32	3.29±1.58	$F_{1,11}$=10.87; p=0.005*	1.72±0.69	$F_{1,11}$=4.02; p=0.65
SowSniffGrunt CB	1.92±0.68	3.95±1.74	$F_{1,11}$=7.89; p=0.14*	1.25±0.50	5.28±1.78	$F_{1,11}$=15.16; p=0.002*	2.82±0.87	$F_{1,11}$=2.14; p=0.17
SowTot CB	4.31±1.23	8.23±3.19	$F_{1,11}$=8.42; p=0.12	3.22±0.81	10.50±3.37	$F_{1,11}$=15.09; p=0.002*	6.05±1.59	$F_{1,11}$=2.34; p=0.15
PiglSniff CB	1.01±0.30	1.72±0.39	$F_{1,11}$=1.15; p=0.30	1.54±0.35	0.99±0.32	$F_{1,11}$=0.53; p=0.478	1.32±0.25	$F_{1,11}$=0.11; p=0.92
PiglGrunt CB	1.56±0.68	1.05±0.44	$F_{1,11}$=0.07; p=0.80	0.66±0.26	1.91±0.86	$F_{1,11}$=2.51; p=0.135	1.15±0.25	$F_{1,11}$=0.09; p=0.77
PiglSniffGrunt CB	0.97±0.31	1.34±0.46	$F_{1,11}$=1.65; p=0.22	0.74±0.33	1.76±0.32	$F_{1,11}$=5.14; p=0.04*	1.13±0.26	$F_{1,11}$=0.00; p=0.95
PiglTot CB	3.21±0.61	4.11±0.78	$F_{1,11}$=2.34; p=0.15	2.94±0.54	4.66±0.80	$F_{1,11}$=4.81; p=0.05*	3.60±0.48	$F_{1,11}$=0.06; p=0.82
TotSniff CB	2.44±0.78	3.26±0.45	$F_{1,11}$=0.51; p=0.49	2.78±0.50	2.93±0.83	$F_{1,11}$=0.05; p=0.82	2.85±0.45	$F_{1,11}$=0.19; p=0.67
TotGrunt CB	2.19±0.81	3.32±1.47	$F_{1,11}$=4.41; p=0.054	1.39±0.53	4.43±1.60	$F_{1,11}$=9.75; p=0.007*	2.76±0.83	$F_{1,11}$=2.43; p=0.14
TotSnifGrunt CB	2.88±0.91	7.57±2.61	$F_{1,11}$=7.75; p=0.15*	1.99±0.79	9.19±2.56	$F_{1,11}$=16.13; p=0.001*	5.23±1.45	$F_{1,11}$=1.57; p=0.23
ComTot CB	7.51±1.57	14.15±3.56	$F_{1,11}$=8.06; p=0.13*	6.16±1.26	16.55±3.48	$F_{1,11}$=14.79; p=0.002*	10.83±2.04	$F_{1,11}$=1.74; p=0.21
TotSow_CAB	2.93±0.70	8.27±2.05	$F_{1,11}$=6.97; p=0.02*	5.76±1.99	43.92±6.65	$F_{1,11}$=0.51; p=0.49	5.60±1.22	$F_{1,11}$=0.00; p=0.96
TotPigl_CAB	5.58±0.92	7.81±1.66	$F_{1,11}$=0.47; p=0.503	5.41±1.33	5.80±0.71	$F_{1,11}$=0.56; p=0.47	6.70±0.96	$F_{1,11}$=1.19; p=0.30
ComTot_CAB	8.52±1.21	15.68±3.14	$F_{1,11}$=4.59; p=0.50*	13.20±3.15	10.74±1.45	$F_{1,11}$=0.00; p=97	12.10±1.83	$F_{1,11}$=0.361; p=0.56
ComTot	9.80±2.08	14.91±2.41	$F_{1,11}$=9.17; p=0.009*	9.68±2.02	13.64±2.23	$F_{1,11}$=4.47; p=0.53	11.47±1.52	$F_{1,11}$=0.09; p=0.77

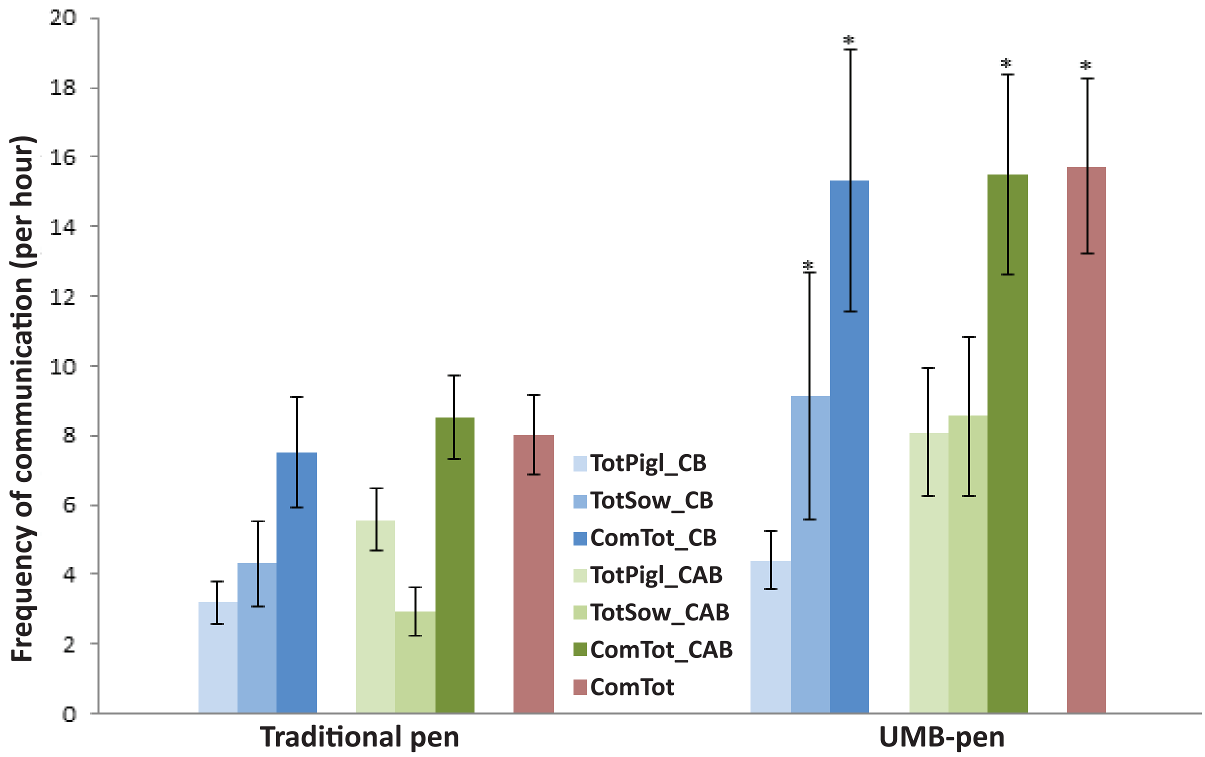

*Figure 7. Some of the differences in communication parameters between a traditional pen and the UMB-pen. Error bars with asterisk * are significantly (P>0.05) higher than the corresponding bar in the other pen.*

There were no differences in the amount of the different types of communication performed (sniff, grunt or both) within piglet (H_2=0.782; p=0.68) or sow (H_2=2.55; p=0.28) or overall (H_2=2.31; p=0.32). No difference was found between frequency piglet initiated communication (TotPigl_CAB+PiglTot_CB) or sow initiated (SowTot_CB+TotSow_CAB) communication (T=397.00;p=0.74). But a positive correlation was found between them (r_s=0.55; p=0.01*). No significant correlation was found between litter size and total amount of communication (r_s= 0.34; p=0.14).

To investigate the effects of posture changes on communication and a possible pre-lying behavior, a correlation test was performed on the frequency of the "lying down sequence" by the sow per hour during and after farrowing and the amount of communication initiated by the same sow. The correlation was positive significant (r_s=0.53; p=0.027*; Figure 8). When testing the same communication variable against the average duration of the same postural change instead of frequency, no significant effects was found (r_s=0.07; p=0.786). When testing

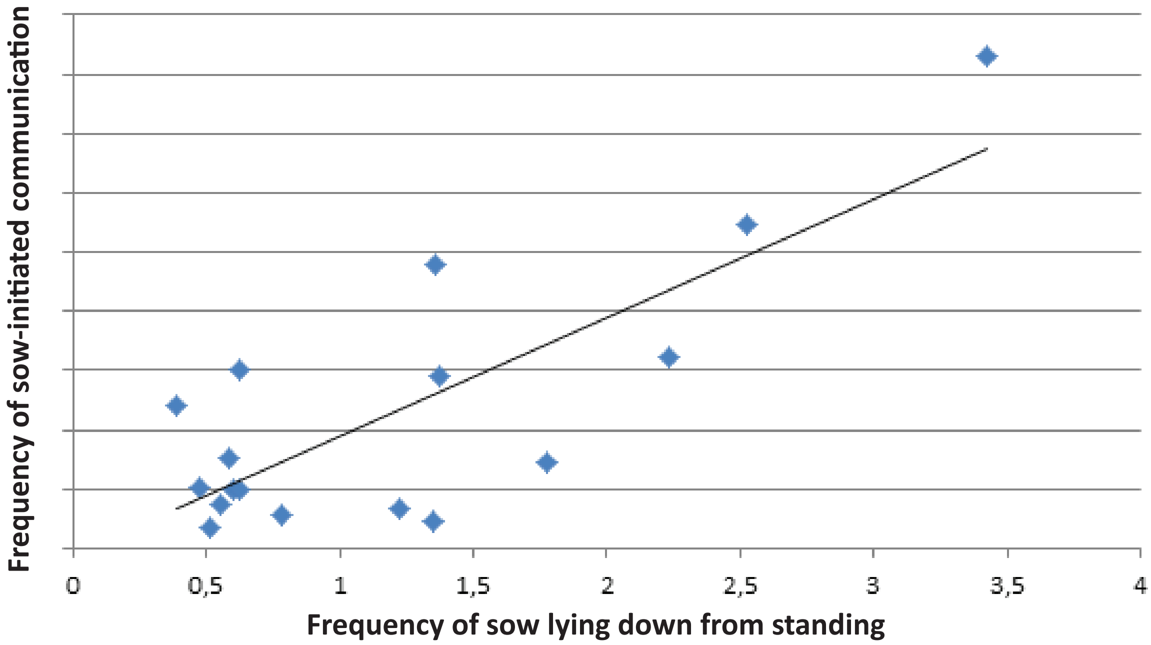

Figure 8. Correlation between posture changes and communication during and 12h after farrowing.

frequency of sow initated communication with overall mortality, no correlation was found (r_s=0.31; p=0.22). Not so with piglet communication either (r_s=0.12; p=0.64). When testing against crushing and sow initiated communication, a positive significant assosiation was found (r_s=0.48; p=0.42*), but not so for piglet initiated communication (r_s=0.26; p=0.30).

A manual model selection was performed on the different communication parameters and overall mortality (table 7). The very best model was the parameter PiglSniffGrunt_CB, communication (sniff and grunt) initiated by the piglet during farrowing. The variable PiglSniffGrunt_CB had significant effect on mortality (mortality=-12.58+(-0.896*PiglSniffGrunt_CB)+13); $\chi_{1,16}^{2}$=56.94; P>0,001**). The nest best model was TotPigl_CAB, piglet initiated communication postpartum. The variable TotPigl_CAB had significant effect on mortality (mortality=-18.804+(-0.3*TotPigl_CAB)+13); $\chi_{1,16}^{2}$=49.58; P>0,001**). Both are presented though the second best has quite high ΔAIC (Figure 9)

Table 7. Manual model selection based on GLM (Poisson) and AIC ranking on the effect of communication parameters on piglet overall mortality.

Rank	Model	Communication	AIC	ΔAIC
Rank 1	Model 7	PiglSniffGrunt CB	77,06	0
Rank 2	Model 14	TotPigl_CAB	85,44	8,38
Rank 3	Model 15	ComTot_CAB	88,79	11,73
Rank 4	Model 13	TotSow_CAB	93,453	16,393
Rank 5	Model 16	ComTot	94,51	17,45
Rank 6	Model 8	PiglTot CB	97,89	20,83
Rank 7	Model 11	TotSnifGrunt CB	107,001	29,941
Rank 8	Model 12	ComTot CB	115,043	37,983
Rank 9	Model 10	TotGrunt CB	117,53	40,47
Rank 10	Model 2	SowGrunt CB	117,6	40,54
Rank 11	Model 6	PiglGrunt CB	120	42,94
Rank 12	Model 9	TotSniff CB	124,16	47,1
Rank 13	Model 3	SowSniffGrunt CB	124,38	47,32
Rank 14	Model 4	SowTot CB	125,14	48,08
Rank 15	Model 5	PiglSniff CB	126,6	49,54
Rank 16	Model 1	SowSniff CB	128,74	51,68

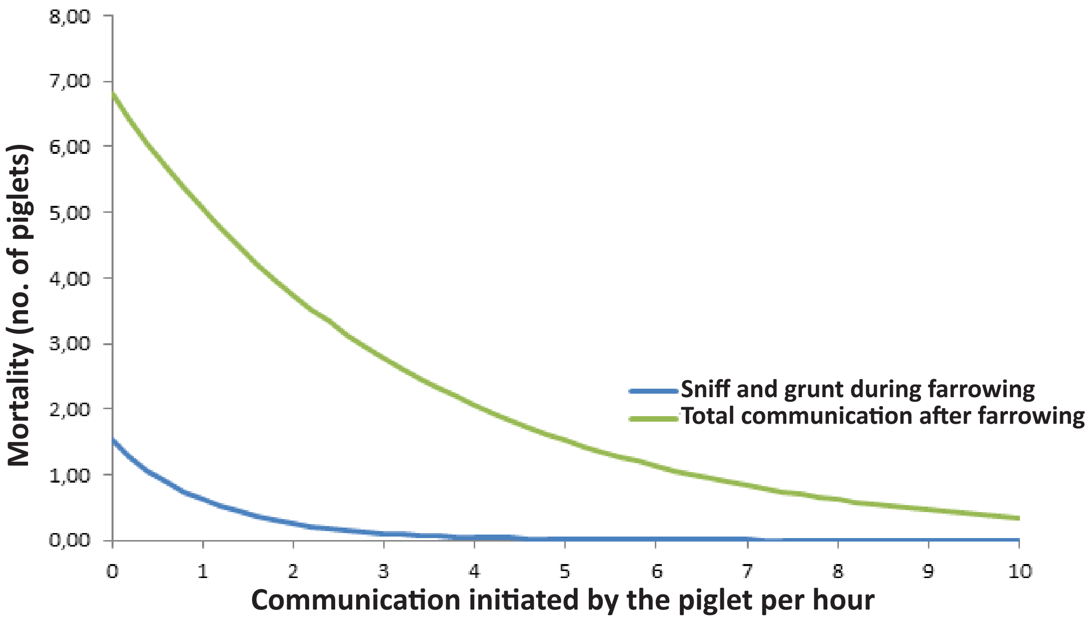

Figure 9. The regression line for the two best model of communication predicting mortality.

DISCUSSION

There is a lot going on when a sow is about to farrow, both in the pen and inside the different sows. It is not possible to comprehend it all, but by narrowing down the universe and systemize some observation, we might be able to solve som of the puzzle. One of the pieces in that puzzel is communication and what it does and where, i.e. will communication differ in different pens and will it affect mortality of piglets in any way? Another piceis in the puzzel we can ask the same question about is posture changes. And finally, do they interact?

Production parameters

To be able to evaluate this we first have to discuss the production parameters, i.e. number of piglets, farrowing duration, and different types of mortality, and how they vary between sows and environment. The results presented here show that the number of total born piglets was close to significantly higher in the UMB pen than in the traditional pen. No difference was found in litter size, which is expected as cross-fostering (applied in this experiment to a small extent) tends to equalize such differences (Lammers et al. 2007). Friestad (2013) found no difference between the two housings regarding litter size (possibly also because of cross-fostering), but Cronin (2014) found a tendency towards more "live born" piglets in the UMB pen, with fewer still born. It has to be emphasized that these studies compared the UMB-pen with other pens than used in the present study. A tendency of more still born in the UMB pen was found in the present study, as opposite to the findings reported by Cronin (2014). Total born and number of still born was in the present study found to be highly significantly correlated. Housing arrangements have previously been found to affect number of live born piglets (Lammers et al. 2007).

The only significant difference found between multiparous (MP) sows and primiparous (PP) sows in regard to production parameters was a higher number of still born by MP sows. MP sows have been reported to get larger litters, which is often explained by previous farrowing experience, but could also be a result of the sow's age at farrowing time (French et al. 1979). In the present study the MP sows got on average 2.28 piglets more than PP sows, but the difference was not significant. The relationship between parity and litter size is previously described as curvilinear (Dewey et al. 1995). Dewey et al. (1995) found the litter size to level out around parity 7. The data presented here only included parities from 1 to 4, so assumptions about the shape of the trend-line is not possible to evaluate, but a trend towards a positive correlation between parity and litter size was found. Several authors have not found any effects of parity on litter size (e.g. Fahmy & Friend 1981, Andersen et al. 2011), and parity is generally found to explain little of the variation in litter sizes (Dewey et al. 1995) and other factors might be more important in controlling this. Farrowing duration did not vary between pen and parities. There was a correlating trend between farrowing duration and both total born and still born. One should expect this correlations to be significant, but other have also reported not to find any clear association between farrowing duration and born piglets, e.g. Friend et al. (1962). Several authors have though found a positive linear correlation for farrowing duration and litter size (Deroth & Downie 1976, Fahmy & Friend 1981, van Rens & van der Lende 2004). Fahmy & Friend (1981) estimated that every additional piglet required 10.4 min. extra in farrowing duration. The reason that Fahmy & Friend (1981) found a positive correlation was according to them that they used a much larger data set than previous studies (e.g. Friend et al. 1962). Holm et al. (2004) also found a genetic correlation between litter size and farrowing duration. Farrowing duration is a complicated trait influenced by several environmental factors (e.g. temperature, housing), including sow characteristics (e.g. placental thickness- van Rens & van der Lende 2004, back-fat- Oliviero et al. 2010). Another factor might be the number of still born piglets, also reported by Oliviero et al. (2010). Holm et al. (2004) found a genetic correlation between farrowing duration and number of still born piglets. This supports the results found here with a positive correlating trend between farrowing duration and number of still born. Yet another factor might be housing. The sows in the UMB-pen used on average 50.4 min longer farrowing than sows in the traditional pen, but the differences was not significant. This could be due to the fact that sows in UMB-pen got more still born that again is correlated with farrowing duration. Oliviero et al. (2010) reported effects of housing on farrowing duration, and concluded that the ability of the sow to move freely reduced constipation states and excessive fattening, which in turn reduced farrowing duration. Farrowing duration reported here (317 min) was in the higher end of the scale compared to what has been reported previously (e.g.

130 min; van Rens & van der Lende 2004, 186 min; Deroth & Downie (1976), 234 min; Fahmy & Friend 1981; 272 min; Oliviero et al. 2010). If correcting these number for mean litter size, they become more even (with a normal range of birth per min around 21-23).

The present study found a significant higher frequency of mortality (except for crushing with milk and overall crushings) between pens. The UMB pen had a higher overall mortality, while the traditional pen had a more piglets dying of starvation/hypothermia ("Death_other"). The reason for the last finding is not clear and could be due to several environmental factor, e.g. temperature. Cronin (2014) found no difference between crates and (a modified) UMB pen, but reported more still born in crates than in the UMB-pen, opposite to what is reported here. After Cronin (2014) correcting still born for parity, the differences was not obvious. From present data still born was indeed affected by parity, with more still born among MP sows. MP had litters with overall higher mortality, while PP sows had more mortality in the Death_other category. The interaction between parity and pen did not show any significant interaction. Some of the differences in mortality found in the present study is supported by the findings of Friestad (2013), who found a higher mortality in the UMB pen than in a traditional pen, and a higher mortality in litters of MP sows. For crushings, a significant higher number of crushed piglets (with milk) were found in the UMB pen, which also is supported by the findings of Friestad (2013). For crushed piglets (without milk), and total, the average number where higher in the UMB-pen, but the differences were not significant.

Andersen et al. (2011) found that piglet mortality increased with increasing litter size, both as a result of crushings, but also due to starvation, and increasing with parity. This is in contrast with the results presented here where PP sows had a higher amount of mortality assign starvation/hypothermia than MP sows. Marchant et al. (2000) also found a significant positive association between mortality and both litter size and the sows parity. They explained their findings by the fact that increased litter sizes increases the birth weight variations of the piglets (were lighter piglets have a higher risk of dying), and that increased size (as a result of increased parity an thus age) of the sow reduces its ability to express good maternal behavior and control its posture changes (Marchant et al. 2000). Higher mortality with increasing parity is reported by several authors (Marchant et al. 2000, Andersen et al. 2011, Friestad 2013), which is also supported by the findings in the preset study.

Posture changes

The activity level of the sow will vary according to what part of the gestation or lactation period she is in, and both during and after farrowing. In the present study a significant difference in activity level measured as posture changes before, during and after farrowing was found, with higher activity level prepartum. That is also reported by several author (e.g. Hartsock & Barczewski 1997, Harris & Gonyou 1998), and Hartsock & Barczewski (1997) found activity level of the sow to peak 6h prepartum, with increased level of several behaviors like rooting, urinating, pawing and general posture changes (lying, sitting and standing up). Pedersen et al. (2003) reported different frequencies of posture changes in time interval from the birth of the first piglet until 24h after. They found that the activity was high in the beginning of the farrowing, but that it dropped rapidly after 2 hours and stayed low 2-8 hours postpartum before increasing again (Pedersen et al. 2003). Posture changes here was more frequent prepartum by MP sows than for PP sows. Posture changes prepartum have been demonstrated to characterize maternal abilities (crushing vs. no-crushing- Wischner et al. 2009b, Wischner et al. 2010, savaging- Ahlström et al. 2002, Chen et al. 2008). In opposite to the findings presented here, Wischner et al. (2009b) reported more posture changes prepartum by PP sows than MP sows. A higher frequency of posture changes prepartum, i.e. restlessness, are found among savaging sows (S) than no-savaging sows (NS), which in turn are more often PP sows (by some referred to as “Gilt Hysteria”) (Ahlström et al. 2002, Chen et al. 2008). Wischner et al. (2009b) also reported a higher frequency of nest-building behavior prepartum by PP non-crushers (NS) than those crushing piglets (C), and later Wischner et al. (2010) also reported a higher frequency of posture changes (restlessness) by PP no-crushers. Andersen et al. (2005) also reported more nest-building ny NS sows. behaviour It seems that the prepartum behavior (posture changes and nest building) vary according to different characteristics of the sow (PP/MP, C/NC, S/NS), but not consistent. Generally high activity level prepartum is considered to characterize good maternal behavior that in the end increases piglet survival (Valros et al. 2003, review by Wischner et al. 2009a), even though a lot of authors previously reported an increased activity by the sows prior to the farrowing as "restlessness and agitation" (e.g. in review by Jensen 1981, Harris & Gonyou 1998,). Jarvis et al. (2001) found that nest building behavior is modified over parities due to previous experiences in different farrowing crates, and that older sows had adapted to their farrowing environment. No difference in nest-building behavior was found between PP and MP sows in the present study and no association between posture changes and nest-building, indicating that the elevated activity level prepartum found here was due to other types of behaviors than nest-building (as reported by Hartsock & Barczewski 1997). Valros et al. (2003) concluded that activity level is an individual characteristic of the different sows.

Posture change of the sows during and after farrowing is the direct cause for crushings of piglets (Damm et al. 2005), both an animal welfare problem and a production problem. There is some discrepancy in the literature what actual postural change that causes most crushings, but the lying down behavior by the sow is consider to be one of the major causes (Marchant et al. 2001, see review in Damm et al. 2005). The best model to explain number of crushings in the present study was the average time the sow uses from standing to lying, with an increased duration reducing the number of crushings. This postural change includes the time the sow is up, so it must not be compared directly to the duration of a strict standing-to-lying sequence. Still, if the duration of the up-down sequence measured here is reduced, the more it will reflect the actual duration of the lying down sequence. From the prediction presented here, number of crushings will reach zero as the duration of the up-down sequence reaches about 10 minutes. Investigating only the duration of the lying down sequence, Marchant et al. (2001) did not find any effects on its duration and the risk of being crushed, even though Burri et al. (2009) did. Damm et al. (2005) suggest that despite this, the duration of the last stage of the lying down sequence (dropping of the hindquarters, "flopping") might still influence on risk of crushing. Wechler & Hegglin (1997) found an increased risk of crushings if the sow flopped straight down in contrast to lying down vertically. Flopping straight down is also reported to be higher in crates than in pens (Andersen et al. 2014). The second best model to explain crushings in the present study was increased number of crushings with increased frequency of sitting. This includes both sitting-lying and sitting-standing. Since the average frequency of lying is higher than standing in the present study, it is reason to believe that the sittings counted here for a large part was sitting to lying. The amount of time spent sitting was found to be higher among crushers (C), than no-crushers (NS) by Wischner et al. (2009b), but they also reported that 70% of the crushed piglets where crushed while the sow performed descending from standing to lying. The lying down sequence is described in Baxter & Schwaller (1983), and normally includes kneeling before bringing down the hind part, but a lying down sequence could also be done after sitting (Marchant et al. 2001), especially in the order lying – sitting – lying. If the actual frequency of the lying down sequence are higher among crushers is not unambiguously from the literature. Wischner et al. (2009b) found no difference in the frequency of the lying down sequence in crushers and no-crushers. Some estimates of numbers of lying down 24h postpartum for 11 different publications are given in Damm et al. (2005). The values range from 3 to 15 incidences. Pokorná et al. (2008) reported 19.9±2.78 incidences of lying down 24h after the first piglet was born. These numbers are still low compared to what was found here (27.1±5.4 after first piglet is born and 24h). The reason for this is not quite clear, but the values from the different sows ranged from 6 to 76, so the variation is substantial.

It might be that the frequency of lying down behavior is less important that it's "quality" or associated behaviors, i.e. duration (as found here), pre-laying behavior, piglet communication, position etc. Damm et al. (2005) also suggest that pre-laying behavior (including communication) towards the piglets would have effects on risk of crushing, which is also consistent with Marchant et al. (2001) who found that dangerous lying down behavior increased with decreasing pre-lying behavior. Neither Melišová et al. (2011) nor Pokorná et al (2008) found any effects on pre-lying communication on risk of crushing, but Pokorná et al (2008) found that the sows "carefulness" (based on a set of behaviors) had effects on risk of crushing. Valros et al. (2003) stated that rooting the nest as a pre-lying behavior could be considered a good maternal behavior, reducing the risk of crushings. In the present study a significant correlation was found between the frequency of lying down sequences (from standing) and the frequency of communication initiated by the sow. That could indicate that the sows would communication when lying down, which would be a pre-lying behavior. Since the registration of communication was not linked to pre-lying, this could also e.g. be a result of higher frequency of communication when the sow was up and mobile. Andersen et al. (2005) found NS sows to lie down more slowly and nose piglets more often when canging posture. Finally, post-laying behavior, i.e. response to stimuli (either acoustic or tactile) from the piglet being crushed, would also effect sows posture change and thus potential on piglet survival (Wechler & Hegglin 1997).

Housing could also affect postural changes although no difference on posture change between the two types of pen was found here, except an average more time spend on standing to lying in the UMB-pen than in the traditional pen. The possible overestimation of the standing to lying duration mentioned in the methodology section is less likely as no difference was found between the two pens regarding this parameter. That supports the fact that the individual share of posture change is significant (Wechler & Hegglin 1997). (Harris & Gonyou (1998) also reported difference in time spent on lying down from different pen types, where sows in wide pens used more time in lying down. In the present study a trend towards more postural changes during farrowing in the traditional pen was also found. Cronin (2014) found significantly differences in posture change between the UMB-pen and farrowing crates. Sows in crates lied down more often to the side versus more on the belly in the UMB-pen (Cronin 2014). There was also more sits in the UMB-pen, but no difference between the two pens in standing by the sow (Cronin 2014). Jarvis et al. (2001) found a higher frequency of posture changes among sows from crates than from pens. Housing will also affect piglet behavior and posture changes and whether they spread out or clustered together (Marchant et al. 2001). This might also explain the higher number of crushed piglets found in the UMB-pen here. This pen is design to give the sow control over the suckling in that she can leave the piglets. An option that has been thought to increase the sows comfort by providing her udder stimulation control (Valros et al. 2003). According to Marchant et al. (2001), this option might increase the risk of crushing as piglets might get hungry and have less coordinated behavior when the sow returns. Even so, Melišová et al. (2011) did not find any effects on piglet clustering on the risk of being crushed.

Interpretations of posture change should therefore be done with caution, and in the right context. Posture change prepartum might be a sign of discomfort or restlessness, but it might also be due to high nest-building activity or responsiveness to piglets (Ahlström et al. 2002). During farrowing and lactation, posture changes might be due to distress or due to different responsiveness of the sows towards the piglets (e.g. excessive piglet attention, Valros et al. 2003). It might also be due to high nest building activity, increasing the risk of crushings (Burri et al. 2009). Pedersen et al. (2003) suggest that low frequency of postural change and low maternal responsiveness during farrowing and to some extent after (postpartum) probably constitutes good maternal behavior as it reduces the risk of crushing. That is in accordance with Ahlström et al. (2002) who found abnormal maternal responses (savaging) associated with restlessness and responsiveness, and they suggested that this could be as a result of restrictive farrowing environment.

Communication

As discussed above, communication between piglet and sows might affect piglet behavior and thus affect the risk of crushings. It might also be a measure of the sow's maternal abilities, e.g. in orienting her on the locations of the piglets in a pre-lying behavior also affecting the number of crushings.

Overall there were no difference found in the different types of communication (sniff, grunt or both) performed by either piglets or sows, or combined. There were either no difference between the amount of communication initiated by the sow or the piglet as reported by Trøen (2011). The result from Trøen (2011) is not independent from the analysis presented here as her data also is a part of this analysis. The addition of the data from the traditional pen could still result in different conclusions. From the present study a positive correlation between sow and piglets frequency of communication was found. So in litters with a high frequency communicating sow, the piglets will also communicates more than in a litter with a sow communicating little. From the analysis performed here, the communication initiated by the sows (grunt and sniffgrunt) during farrowing was affected by both pen and parity (but not their interaction). PP sows performed more of these communications in general and more of these communications were performed in the UMB pen. Melišová et al. (2011) found that sow vocalization decreases with increasing parity. That is supportive of the results found here, where PP sows vocalized more (grunt) than MP sows. Friestad (2013) also investigated the amount of communication between the sow and piglets in the traditional versus the UMB pen, and found that parity did not affect communication. She also found that sow-piglet communication (and communication initiated by the sow) was more frequent in a conventional pen (not the same pen as in the present study) than in the UMB-pen, both contrary to the findings here. Friestad (2013) is though somewhat inconsistent in her conclusion on communication between the two pen-types as the results are not reflected in the discussion. Trøen (2011) found PP sows to communicate more during farrowing than MP sow (not correcting for farrowing duration), and the same is reflected in the present study. In addition, both total amount of communication during farrowing and after (and thus overall) where found to be significant higher in the UMB-pen, than in the traditional pen in the present study.

As previously stated, the communication data presented here could not be assigned to a pre-lying behavior, as postural changes was registered only as changes in the states from standing, sitting and lying. The frequencies and durations of e.g. the standing-to-lying sequence in the present study would thus include all the time from the sow got up till she was down again (thus including activities like walking, easting, defecating etc.). Still, the positive correlation found between sow-initiated communication and her posture changes from standing to lying should be noted. This could indicate that the sow increased her communication with the piglets when she was up standing or walking around, or that she increased her communication pre-lying (in the process of lying down), or both. The duration of the lying down sequence found here would for a large part be affected by activities in addition to the actual duration of the lying down sequence. If the sow communicated more doing other activities than lying down, a correlation between average duration and communication should be found. Since no such correlation was found here, it could be argued that the communication was actually connected to the lying down sequence. In addition to that, a positive correlation was found between crushings and sow-initiated communication. Several papers on communication and crushing evaluate pre-lying behavior. According to Wischner et al. (2010), the frequency of “nosing” activity will vary with period, an increase after nearly half a day postpartum. According to Andersson et al. (2011) nosing is peaking 2-3 days postpartum (with around 13 sow initiated nosing per hour). If evaluating the frequencies given by Andersson et al. (2011) the first day after farrowing with the sow initiated communication found here, they are roughly in same range there (about 3 per hour). Andersson et al. (2011) found more nosing by no-crushers (especially PP sows). They emphasized the importance of nosing for social bonding and as a precautionary measure before changing position, demanding higher responsiveness. Blackshaw & Hagelsø (1990) on the other hand found no association with nose contact and the frequency of the sow lying down, and they concluded that this behavior was not an action by the sow to localize the piglets.

Melišová et al. (2011) found that more pre-lying communication affected piglet clustering, but could not find evidence that this would affect risk of crushing. What they did report was that increased communication increased the risk of piglets being in the “danger zone”, i.e. communication attracts piglets closer to the sow (Melišová et al. 2011). They speculated that this could potentially increase the piglets risk of being crushed, but concluded that the benefits of being close to the sow outweighs the risks of being crushed (Melišová et al. 2011). The findings in the present study could support this as crushings was positively associated with sow-initiated communication. In regard to overall mortality, the best explanatory effect on mortality by communication found here was actually piglet initiated. With increased piglet-initiated communication the mortality is reduced. This is somewhat in contrast to the findings of Melišová et al. (2011). The findings here could be supportive of the good maternal pre-lying behavior hypothesis. It is not directly a maternal behavior, since it is piglet-initiated, but this communication might help the sow in have her piglets localized and therefore avoid them when lying down. Since the present results analyzed the effect of communication on overall mortality, it will not only be effects on crushings but also other causes of death like starvation and hypothermia. It could reflect the fact that piglet-initiated communication might help prevent these causes of death.

CONCLUSION

There was only small differences in the production parameters in regard to pen and parity. Some trends could be found, like more piglets born (and also more still born) in the UMB-pen. Also a higher number of still born was found in MP litters, with a trend towards higher litters for higher parities.

Regarding mortality, the overall mortality was higher in the UMB-pen (partly probably due to more crushings), and the traditional pen had a higher frequency of starvation and hypothermia. MP had litters with overall higher mortality than PP sows, with PP sows had litters where more piglets died of starvation and hypothermia. Parity is known to affect mortality, but it is not consensus in the literature regarding this.

Posture changes are complex behaviors that are affected by several factor, both internal and external. The interpretation of the causes of posture changes should be done by care. A significant difference in activity level was found between comparing prepartum, farrowing and postpartum, with MP sows showing more posture change prepartum than PP sows. There were few significant differences between the pens, with only more time spend on standing to lying in the UMB-pen than in the traditional pen.

The postural parameter best explaining crushings in the present study was the averages time the sows spends standing. With short duration this parameter will equal the actual lying-down sequence, and with shorter durations the predicted crushings increases. Crushing could also be explained by an increased frequency of sitting, possibly for a large part sitting to lying.

Posture changes are also associated with communication. A significant correlation was found between the frequency of lying down sequences and the frequency of communication initiated by the sow. No differences in frequency were found in the different types of communication. or who initiated it. There was also no differences in frequency of communication initiated by the sow or the piglet, but they were positively correlated. PP sows communicated more, and more communication were performed in the UMB-pen. Sow-initiated communication was poestively correlated with crushings. But, when investigating communication-effects on overall mortality, the best parameters to explain that was actually piglet-initiated. Increased communication by the piglets reduces mortality, which could both be due to reduced amount of crushings with increased orientation by the sow, or reduced mortality of other causes, e.g. starvation and hypothermia.

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