Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science

Cross-suckling when sows are group housed during lactation – associations with sow productivity and behaviour

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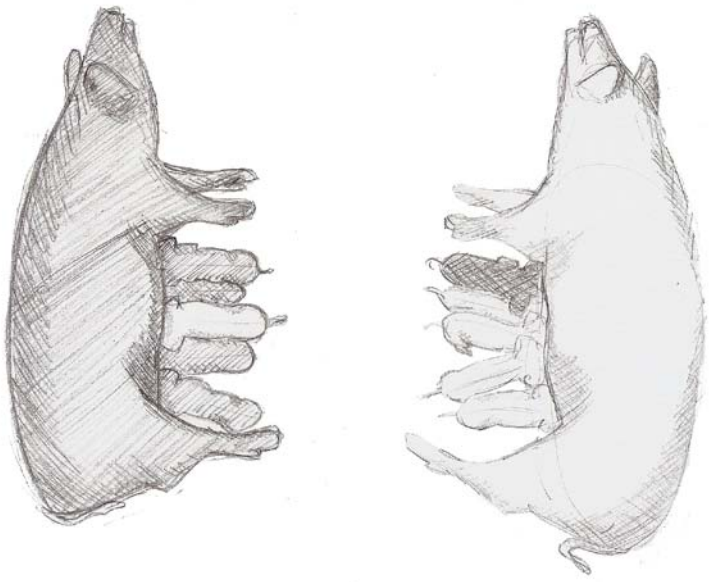

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Cross-suckling when sows are group housed during lactation - associations with sow productivity and behaviour

Korsdi vid grupphållning av suggor under laktation – samband med suggors produktivitet och beteende

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Preface

This master thesis was carried out at the Department of Animal Breeding and Genetics at the Swedish University of Agricultural Sciences (SLU) located in Uppsala. During the course in pig production at SLU my interest in pigs was awakened. After the course, I took contact with the people at the department working with pigs and asked if I could do my master thesis for them. After some discussions I decided to work with already collected data, looking more closely at the occurrence of cross-suckling. The main effort lies therefore in all the statistical analyzes done in SAS. I have enjoyed writing this thesis, even if I must admit it could be frustrating searching for missing semi-colons in the statistical programming.

Tack Anna för ditt enorma stöd och tålamod! Jag är tacksam att jag fick just dig som handledare. Du lyckades alltid peppa mig vidare när jag kände att jag hade strandat.

Tack alla underbara vänner som stöttat och hjälpt mig genom att bland annat läsa igenom arbetet. Speciellt tack till Linda, Tina och Elina, är så glad för att ni finns där. Tänk att jag lyckades hitta så fina vänner under min studietid.

Äidille ja isälle. Kiitos kaikesta.

Till Karin. Ord kan inte ens börja förklara hur jag saknar dig.

Sammanfattning

Korsdi, det vill säga när en avkomma diar någon annan hona än deras mor, förekommer bland grisar i produktionssystem där suggor hålls i grupp under diperioden. Ju vanligare dessa produktionssystem blir, desto mer ökar behovet av kunskap om korsdi. Målet med den här studien var att undersöka hur suggbeteende och produktion är kopplat till förekomsten av korsdi, och undersöka om suggans benägenhet att tillåta korsdi är upprepbart.

Studien baseras på information från de 4 första kullarna från 40 LxY suggor som hölls i både utomhus- och inomhusmiljö. Suggorna hölls i individuella grisningsboxar de två första veckorna efter grisning och flyttades sedan till en gruppbox (4 eller 5 suggor per grupp) där de stannade till avvänjningen som skedde när smågrisarna var 7 veckor gamla. Korsdi, digivningsbeteende och suggans tidsbudget observerades med direktobservationer under en dag vecka 4 och en dag vecka 6 efter grisning. Suggvikt och hull registrerades vid grisning, 2 veckor efter grisning och vid avvänjning. Smågrisarna vägdes vid dag 4 efter grisning, dag 14 efter grisning och vid avvänjningen.

Resultaten visade att suggors benägenhet att tillåta korsdi eller inte är upprepbart inom diperiod (vecka 4 till vecka 6: $r = 0,36$, $p < 0,001$) men inte mellan olika kullar. Suggor som tillät korsdi vecka 4 tappade i genomsnitt mindre fett mellan vecka två och 7 efter grisning än suggor som inte tillät korsdi ($p = 0,002$) och trenden var densamma för vecka 6 (dock icke signifikant). Dessutom hade suggor som tillät korsdi mindre kullar (vecka 4: $p = 0,01$; vecka 6: $p = 0,029$).

Sammanfattningsvis, korsdi är inte en långsiktig upprepbar individuell egenskap hos suggan utan påverkas av produktionsmiljö och hullstatus. Kullstorlek påverkar suggors benägenhet att tillåta korsdi; suggor med mindre kullar är mer benägna att tillåta korsdi.

Abstract

Cross-suckling, i.e. when an offspring nurses a female other than their own mother, occurs in pig production systems where sows are group housed during lactation. As production systems where several sows and their litters are housed together during lactation are getting more common, the need of knowledge regarding cross-suckling increases. The overall aims with this thesis was to investigate how sow behaviour and productivity are associated with the occurrence of cross-suckling, and to investigate consistency in sow nursing behaviour related to cross-suckling.

The study included information about the first 4 parities of 40 LxY sows kept in outdoor and indoor production environments. Sows were single housed the first 2 weeks after farrowing and group housed (4 or 5 sows per group) from 2 weeks after farrowing until weaning, 7 weeks after farrowing. Cross-suckling, nursing behaviour and sow time budgets were registered during 6 hours of continuous direct observation one day week 4 and one day week 6 after farrowing. Sow weight and back fat depth were recorded at farrowing, 2 weeks after farrowing and at weaning. Piglets were weighed at day 4 post partum (pp), day 14 pp and at weaning.

The results showed that sows that allowed cross-suckling week 4 lost on average less back fat between week 2 and 7 pp ($p = 0.002$). The trend was the same for week 6 (not significant). Sows that allowed cross-suckling had smaller litters (week 4: $p = 0.012$; week 6: $p = 0.029$). Sows willingness to allow cross-suckling is repeatable within lactation (between week 4 and week 6: $r = 0.36$, $p < 0.001$) but not over lactation.

In conclusion, cross-suckling is not a long term individual trait of the sow; it is affected by the environment and by body condition. Sows with smaller litters were more prone to allow cross-suckling.

Introduction

Group housing of sows during lactation is common practice in organic pig production in most European countries, and is to a small extent also practiced in conventional production in Sweden (the so called ´Västgöta pig production system´). Group housing of lactating sows is often combined with long lactation periods, making it difficult to compare productivity with conventional single housed systems. For instance, according to the Swedish animal welfare act piglets should not be weaned until they are 4 weeks old (SFS 1988:539) while piglets in herds certified by KRAV should be at least 7 weeks old at weaning (KRAV, 2010). Cross-suckling, i.e. when an offspring nurses a female other than their own mother, occurs in pig production systems where sows are group housed during lactation. Cross-suckling is believed to influence the performance of both piglets and sows, but the directions of these associations are unclear and the number of studies reported is rather low. Moreover, cross-suckling is in most cases regarded as a piglet trait and it is hard to find discussions about the influence of the sow on the occurrence of cross-suckling.

Aim of the thesis

The overall aims of this thesis were to investigate how sow behaviour and productivity are associated with the occurrence of cross-suckling, and to investigate consistency in sow nursing behaviour related to cross-suckling.

The specific aims of this thesis were to:

- Describe the biological background of nursing behaviour in pigs in general and cross-suckling in particular in a scientific literature survey
- Investigate associations between sows' allowance of cross-suckling and:
    - productivity of the sow and her own litter (sow body condition, litter size, piglet survival, piglet growth)
    - sow activity behaviour (nursing behaviour and time budget)
- Investigate associations between sows' ability to gather her entire litter at nursing and:
    - productivity of the sow and her own litter (sow body condition, litter size, piglet survival, piglet growth)
    - sow activity behaviour (nursing behaviour and time budget)
- Investigate repeatability within and over parities in the sow's allowance of cross-suckling and ability to gather her entire litter at nursing

Literature review

Nursing behaviour in pigs

The sow initiates each nursing by making soft grunts which the piglets respond to and gather around the udder. The sow does not necessarily wait until all her piglets are present before she starts nursing (Newberry & Wood-Gush, 1985). The piglets massage the udder intensively for 1-4 minutes, during which period the sow's grunts change in character. Just before milk letdown the grunts are loud and rhythmical and the piglets then change from massaging to suckling. The milk letdown lasts for only 10-20 seconds, this since the sow lack mammary cisterns and cannot store milk in the udder as for example cows do. Afterwards the piglets continue to massage the udder for some time. Algers & Jensen (1991) calls this the "restaurant hypothesis" where the post massage of the udder stimulates continued release of prolactin and thus increase future milk production. This means that the piglets affect how much milk the sow produces. Hungry piglets may massage more vigorously and can thus increase the milk production in their udder part to the next nursing.

Teat order is developed during the piglet's first days of life, but during the first hours after farrowing the piglet suckles on average on seven different teats. The nursings are frequent during farrowing but decrease in frequency over the first few days and thereafter become more cyclic. In commercial conditions nursing occur 20 or more times a day the first weeks post partum (pp). The anterior teats are often preferred due to higher productivity (De Passille & Rushen, 1989). Functional teats are occupied and defended by the piglets. Non-suckled teats atrophy during the first two weeks after farrowing (Fraser, 1979; Algers & Jensen, 1991).

Cross-suckling

Description

Cross-suckling, or allosuckling, is when the young nurse from females other than their mother. These individuals can be permanent or only occasional cross-sucklers. The behaviour is more common in species where litters are born compared to species that give birth to only one or two offspring. Moreover, species that live in small groups have a higher occurrence of cross-suckling compared to other species that live in large groups (Packer *et al*., 1992). Smaller than average litters may result in more cross-suckling, as seen in for example warthogs (Plesner Jensen *et al*., 1999). Cross-suckling is also more common in populations held in captivity than in the wild (Packer *et al*., 1992). Piglets mostly choose to cross-suckle from one sow rather than from many different sows (Olsen *et al.,* 1998). In captivity, cross-suckling is naturally only possible if the females and their young are group housed during lactation.

Different hypotheses

There are several hypotheses to why cross-suckling occur in different species. A review article by Roulin (2001) describes five different hypotheses. One is the misdirected

parental care hypothesis, where the female nurses alien offspring without noticing that it is not her own. Young stealing milk from other females than their mother goes under this category. Another hypothesis is the reciprocity hypothesis where a group of females that nurse other's young will have more surviving offspring. A way of raising the survival chances of the young is to provide them with immunoglobulins via the milk from different females, and hence raising their immune system (Roulin & Heeb, 1999). This means that a female will let other young nurse her in turn to keep the other females of the group nursing her offspring. There is not enough evidence of this behaviour recorded and in reality some individuals nurse more than others, and in many cases the body condition of the females differ, so it might be too costly for some to give the same amount of milk to alien offspring as the rest of the females in the group (Roulin, 2001).

A third hypothesis is the kin selection hypothesis. This means that a female will only nurse the offspring of a female she is related to. A study by König (1994) showed that female mice nesting with a sister had a higher lifetime reproduction compared to females nesting alone or with an unrelated female. Also, the spontaneous lactation in non-reproductive dwarf mongooses is another example of the kin selection hypothesis. Here the non-reproductive females nurse the young of their relatives (Rood, 1980).

In the milk evacuation hypothesis the mother nurse alien offspring as a way of getting rid of excess milk. It may be a way to maintain maximum milk production, to instantly lose body weight as for evening bats (Wilkingson, 1992), or as a way for female grey seals to lose body fat reserves after losing their own pup (important because of the effect the fat has on buoyancy) (Beck *et al*., 2000). This hypothesis is not valid if the mother's own young still are hungry and try to feed elsewhere when she nurses alien offspring.

The parenting hypothesis means that un-experienced females nurse alien young to get better maternal abilities. This might be the case when virgin females start to lactate and nurse, but there is not enough of evidence to back up this hypothesis (Roulin, 2001).

Other than these five hypotheses there is the hypothesis of the neuroendocrine function of cross-suckling by Roulin (2003). The author states that females use alien offspring to stimulate their teats in order to maximize the prolactin production, with or without milk letdown. This might apply to females with a disease since prolactin has a positive effect on immunocompetence (Yu-Lee, 1997). These different hypotheses are not mutually exclusive and one single cross-suckling event may be consistent with several of these hypotheses (Roulin, 2001).

These different hypothesis range from cross-suckling being something harmful for the female and her offspring (as in alien young stealing milk that is supposed to go to the own offspring), to actually being a benefit and increasing fitness for the female (as in giving more surviving young during her lifespan). The practical study included in this thesis investigates how cross-suckling affects sow performance and their litters, which is of interest from a production part of view. Is it a benefit, or a cost?

Housing and management influence nursing behaviour

When sows are kept in an environment where they have the possibility to restrict nursing by partly avoiding their piglets they will do so. This leads to less nursings than in intensive systems and in turn makes the piglets eat more solid feed earlier to fulfil their nutritional need. The sow and piglets also show a broader behaviour repertoire (Weary *et al*., 2002; Hötzel *et al*., 2004). If sows are individually housed before being put together with other sows and their litters, it could have an effect on the occurrence of cross-suckling. For instance, if sows have the possibility to avoid their piglets during this first period of individual housing, the occurrence of cross-suckling may be reduced later when sows and litters are kept together in a group. Since the sow is not always present, the teat order will become more rigid because of more competition between littermates. The piglets will try to keep closer to their mother whenever possible and this in turn makes it more difficult for alien piglets to cross-suckle. Also, keeping the animals so that they can get familiar with the environment in which they will be group housed may reduce suckling disruptions and cross-suckling. This can be done by keeping the sows in a system where the individual pens are a part of the communal area and are opened up for access or removed at the time of the group housing (Wattanakul *et al*., 1998).

Dybkjær *et al.* (2001) found that sows housed in small groups may have more occurrence of cross-suckling than sows housed in bigger groups. This contradicts the findings of another study where the conclusion was made that smaller groups leads to no or just a small amount of cross-suckling (Jensen, 1986).

Piglets kept in outdoor systems together with their mother grow slower compared to piglets reared inside in more intensive systems. This might be due to reduced milk intake since the sow is able to get away from her litter. Newberry & Wood-Gush (1985) saw that the time of year affects nursings as well, with higher weaning age at the beginning of the year. In their study the litters had more piglets in August compared to the ones born in February. The larger litters may have caused more uncomfortable udder stimulation compared with the smaller ones and thus the sows may have weaned the piglets earlier because of this factor.

Andersson & Andréasson (1992) reported that piglets that were 5 days old when put in group housing systems cross-suckled more than piglets that were 12 days old at the day of the grouping. This might be because the sows and the piglets did not have enough time to establish solid mother-offspring bonds, the younger piglets had difficulties to find their mother, or that the younger piglets were too light and weak to defend themselves against bigger piglets at nursings.

The sow

Natural behaviour

When sows and/or gilts are kept in small groups in a semi-natural environment they move away from the flock about 24 h before farrowing. The sow wanders around in search of a farrowing site. Once she has decided upon the place she starts to gather nest material and

builds a nest. The sow might build a mock nest before the final one. She gives birth to her litter and does not leave the nest during the first day. The sow and her piglets stay close to the nest for approximately 9 days before rejoining the family group. After this period the sow and her piglets leave the nest and do not return to it. It seems that the sows and piglets need this time to ensure colostrum intake, establish a teat order, and let unused teats to atrophy and to be able to establish mother-offspring bonds. It takes about 7 days for the sow to be able to reliably recognize the smell of her own litter, and if the piglets are washed with an agricultural deodorant solution she is able to recognize her piglets by sight alone after 14 days (Horrell & Hodgson, 1992). This implicates the importance of isolation from the other sows and their litters to allow the mother-offspring bonds to be able to be established. In some cases there are piglets left in the nest, but the mother does not go to get them after she has left. When the sow and her piglets return to the group they still keep together and the piglets are gradually mixed with the rest of the group. Piglets from the same litter prefer to rest together and piglets from different litters are rarely seen to interact with each other outside the periods in which they are active (Newberry & Wood-Gush, 1985; Jensen, 1986).

Nursing synchronisation

Nursing synchronisation could be a strategy to avoid cross-suckling. Sows nursing in close proximity of each other often synchronize their nursings (Newberry & Wood-Gush, 1985). More synchronisation gives less cross-suckling according to Maletínská & Špinka (2001); sows that nursed directly after other sows had fewer cross-sucklers at their own nursings.

Aggression

Sometimes sows show aggressive behaviour directed towards piglets. In a study by Newberry & Wood-Gush (1985) aggression towards piglets was seldom seen. The aggressive behaviour that was seen was directed at all piglets and not alien piglets as a group. Another study showed the opposite where the aggressiveness from the sow was directed more towards alien piglets (15 %) than piglets from the own litter (2 %) (Olsen *et al.*,1998).

Litter size and parity

When the sow has a large litter it is more likely that she will be a target for cross-sucklers (Maletínská & Špinka, 2001). It is also more likely that her piglets are cross-sucklers. If the parity number is high there is a higher occurrence of cross-sucklers in the sow's own piglets according to Olsen *et al. (*1998). However, Maletínská & Špinka (2001) saw no such effect of parity number.

Natural weaning

Natural weaning is a gradual and slow process and not something that occurs suddenly as is common in pig production (Newberry & Wood-Gush, 1985, Jensen & Recén, 1989; Bøe, 1993, Valros *et al.*, 2002). Bøe (1991) found that piglets that were 2 weeks old initiated about 80 % of the sucklings, and this increased to over 90 % during the following 8 weeks. The sow terminated the sucklings in 50 % of the cases in week 2 pp and this

increased to over 90 % in week 10. In a later study the amounts of sucklings initiated by the piglets were 30 % in week 0-1, 60 % in week 2 and 100% in week 5 (Bøe, 1993). Sucklings terminated by the sow were 60 % in week 2 and almost 100 % in week 4. Weaning age ranged from less than 5 weeks to over 17 weeks, with large individual differences among the sows. The different weaning ages reported are less than five weeks (Bøe, 1993), 9-14 weeks (Newberry & Wood-Gush, 1985), 11-12 weeks (Bøe, 1991), 14-17 weeks (Jensen, 1986) and 17 weeks (Jensen & Recén, 1989).

Bøe (1991) studied 22 sows and their litters and saw that the sow spent a decreasing amount of time with her litter during the 10 weeks the sows were observed, from about 54.9 % of the 24-h period at 2 weeks after farrowing to 9.9 % at 10 weeks. During the first 2 weeks she mainly left the piglets in order to feed herself. She still preferred to sleep together with her piglets during the 10 weeks. Litter size affected the weaning process, as smaller litters were weaned later and the piglets were heavier at 10 weeks pp compared to the other litters in the study. Bøe (1991) saw that the piglets' intake of solid feed increased rapidly after about 5 weeks pp and that there was no drop in the daily weight gain as is usual at abrupt weaning in commercial herds. In his later study from 1993, Bøe reported that piglets in semi-natural systems did not always compensate by eating more creep feed when they were weaned early. Algers *et al.* (1989) saw that piglets occupying teats with lower milk production ate more creep feed than their littermates. When comparing litters that were kept in a system where the sow could leave her litter with a system where the sow was confined there were no differences in piglet weight. The litters in the get-away system could participate in less nursings, but they compensated by eating more creep feed (Pajor, 1998).

The piglet

Natural behaviour

When kept in a semi-natural or natural enclosure piglets are born in a nest that the sow has built. During the first few days of life the piglets are hiders, and stay in the nest most of the time. They only leave the nest for short excursions, and do not go far away. When it is time for the sow and litter to leave the nest the piglets turn into followers. When introduced to the flock the piglets in one litter keep mostly to themselves near the sow and are rarely seen interacting with other litters other than during activity periods. When the piglets get older they move further away from the sow (Jensen, 1986).

One piglet occupies 1-2 teats, and according to Illman *et al.* (2007) 20-26 % of the piglets occupy two teats, depending on litter size and amount of functional teats. Piglets are opportunistic and will try to suckle from other teats if given the chance. It is the piglets' responsibility to defend their teats from littermates or alien piglets (Newberry & Wood-Gush, 1985).

Aggression at the udder

A piglet that at the beginning of a fight has a teat in its mouth has the highest chance of winning the conflict (De Passille & Rushen, 1989). The piglet strongly defends its teat,

and does not avoid piglets it might normally avoid when away from the udder. Fighting piglets miss more milk letdowns and the sow may interrupt the nursing if there is much fighting at the udder. This means that every piglet present will miss the nursing and not only the ones fighting (Newberry & Wood-Gush, 1985; Pedersen *et al.,* 1998). Piglets that are aggressive towards their littermates are more likely to become cross-sucklers when they join other sows and their litters in group pens. But once in the group they do not show more aggression compared with piglets that do not cross-suckle (Olsen *et al.,* 1998).

Litter size

Larger litters lead to more piglets that miss nursings and also to more cross-sucklers in the litter. If a piglet misses a nursing, its teat will be unoccupied and is therefore a possible opening for an alien piglet (Andersson & Andréasson, 1992; Maletínská & Špinka, 2001). Olsen *et al.* (1998) saw no effect of litter size on cross-suckling, but the authors pointed out that litters were all quite large in the study (9-14 piglets). Piglets born in large litters are more aggressive than those in smaller litters (D'Eath & Lawrence, 2004).

Strategies

According to Illmann *et al.* (2007) the most common way for an alien piglet to get hold of a teat is to steal it from a piglet that occupies two teats (20-26 % of piglets occupied two teats in the study). This means that the resident piglet still gets its milk supply. The other strategy is to take it from a piglet that only owns one teat. This piglet in turn searches and takes the teat from a littermate that owns two teats, or from a littermate that owns only one. It in turn had to search for a new teat, and so on. In 95 % of the cross-sucklings the piglet that lost its teat found another to suckle from before milk letdown. In the study there were no differences in weight between the permanent cross-sucklers and the rest of the piglets. Also, the teat losers did not differ in weight from their littermates, indicating that they succeeded in finding a functional teat after their own teat had been taken away.

Sows producing less milk will have more piglets that cross-suckle other sows, and they often choose a higher producing sow to suckle from (Olsen *et al.,* 1998). Piglets that only nursed their mother, occasional cross-sucklers and permanent cross-sucklers have different strategies but are in the end equally successful according to Maletínská & Špinka (2001).

Piglet weight

Piglets that participate in more successful nursings grow faster (Valros *et al.,* 2002). Olsen *et al.* (1998) and Illmann *et al. (*2007) states that cross-suckling does not affect the weight of neither the resident piglet nor the alien piglet. Other authors claim that piglets that cross-suckle weigh less than other piglets (Andersson & Andréasson, 1992).

Material and Methods

This thesis investigates cross-suckling and the relationship to sow behaviour and piglet production in outdoor and indoor nursing environments. This was done by analyzing data already collected in the research project 'Ekogris', carried out 2003-2009.

Project 'Ekogris'

The data collected and used in this study originates from the project 'Ekogris' funded by Formas (The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning) (Høøk Presto, 2008; Wallenbeck, 2009). It was performed at the research station Funbo-Lövsta of the Swedish University of Agricultural Sciences (SLU) outside Uppsala. The sows and piglets were managed according to organic standards, but the research station was not certified as organic.

Animals

The study included 40 Yorkshire × Swedish Landrace sows and their piglets during their four first parities. All sows had litters both indoors and outdoors. The piglets were sired by AI from Hampshire boars. The sows were born and raised outdoors. As in any pig herd, some sows had to be culled because of poor fertility, injury or disease. The distribution of the sows over the parities was: 40 sows in parity 1, 36 in parity 2, 31 in parity 3 and 25 sows in parity 4. The first litters were born in April 2003 and the last in March 2005.

Housing and management

Outdoor

Sows farrowed in huts (3.9 m^2) (Salling Hytten, Henry Jörgensen, Kjeldgårdsvej 18, Selde, 7870 Roslev, Denmark) (figure 1) placed in single farrowing paddocks (2,500 m^2) to which the sows were moved approximately five days before expected farrowing. Each pen had one water nipple. When the piglets were two weeks old, the sow and her litter were moved to a family paddock (14,000 m^2) together with 3-4 other sows and their litters. The sows and their piglets were kept in the family paddock until weaning which was seven weeks post partum. In the family paddock there were two water nipples, one mud bath, one sun shed (11.0 m^2) and one hut (13.0 m^2). Both the farrowing huts and the family huts were provided with enough straw to keep the bed dry at all times. In the farrowing paddock an additional 10 kg of straw and tree-branches were added outside the hut, for the sow to use as nesting material. Two weeks before expected farrowing the outdoor sows were de-wormed.

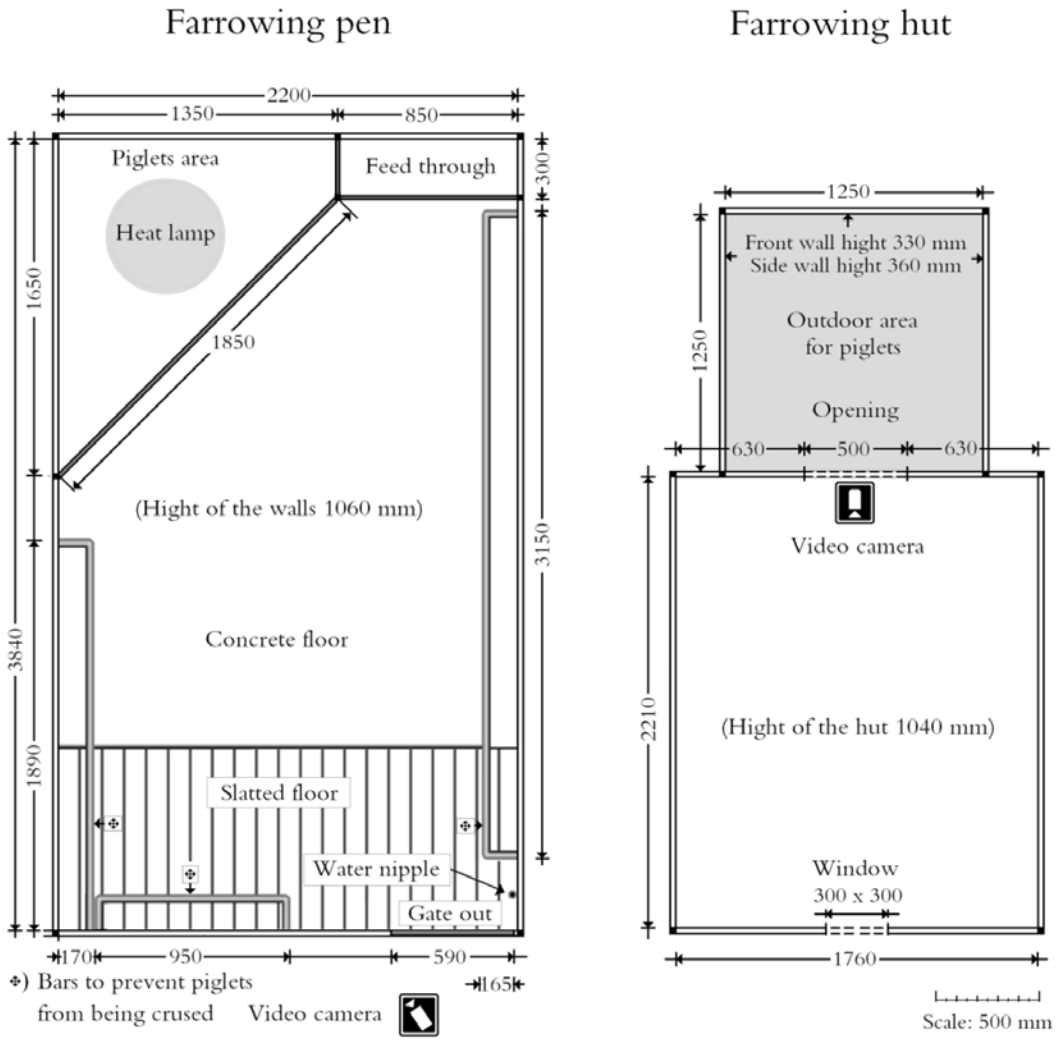

Figure 1. Design of the farrowing pen and hut (Wallenbeck, 2009).

Indoor

The farrowing pens had a solid concrete floor with slatted floor over the dunging area and a creep area for piglets with a heating lamp. A detailed description of the farrowing pen is visualised in figure 1. The pens were cleaned every day and approximately 2 kg of straw was added per farrowing pen and day. Fourteen days pp the sow and piglets were moved from the farrowing pen to an un-isolated building where they were loose housed with 1-5 other sows and their litters in a pen (52 m^2 – 114 m^2) on deep litter. Each pen had one feeder, two or three water nipples and three heat lamps in one corner for the piglets. Due to variation in birth date the sow and piglets were introduced to the new pen and other sows and litters over a six day period. At weaning, the sows were removed from the pen.

Feeding

The feed was as a typical Swedish organic pig feed composition (table 1 and 2). During week 2 to 7 pp an automatic feeder was used and the feeding was *ad libitum* during this time. The piglets had access to the feeder, but no creep feed was provided. During parity 1 and parity 3 (outdoors) the sows and piglets could root and graze whenever they wanted. When kept indoors, the sows got an addition of approximately 0.5 kg hay per sow and day.

Table 1. Feed composition

Raw material	%
Oats	40.0
Wheat	16.0
Cold-pressed rapeseed cake	15.0
Wheat bran	10.0
Triticale	6.9
Peas	5.9
Potato protein	2.5
Mono calcium phosphate	1.5
Vitamins/minerals	1.0
Calcium	0.7
Salt	0.5

Table 2. Nutrient content in the feed

Contents per kilo feed	
Energy (MJ ME)	12.2
Crude protein (g)	154.3
Digestible protein (g)	122.6
Lysine (g)	7.5

Registrations

Production traits

Each sow was weighed and the backfat depth was measured 5 days before expected farrowing and in week 2 and 7 pp. Ultrasound (Kraukrämer USK6) was used to measure the backfat at the last rib, approximately 8 cm from the midline.

The day of farrowing the litter size was registered. When farrowing outdoors the herdsmen used a window at the back of the farrowing hut to count the piglets. Castration of the male piglets and ear-tattooing was around day 4 pp. In parities 2 and 4 when the sows were kept indoors, the ear-tattooing was carried out on day 1 pp. Weighing of the individual piglets was carried out on day 4 pp (in parities 2 and 4 the piglets were weighed on day 1 as well), 14 pp and at weaning (roughly 7 weeks pp). No iron was supplied to the piglets and their teeth were neither clipped nor grated.

Piglet mortality (cause and date) was registered from farrowing until weaning in all parities. Herdsmen judged the cause of death. Piglets judged as still-born were examined with a simple autopsy. In order to investigate if the piglet had died before it had a chance to breath, a piece of the lung was placed in water, if it did not float, the piglet was considered as still-born.

Behaviour traits

Sow behaviour was recorded with direct observations in the family paddocks between 9 am and 3 pm during one day in week 4 pp and again one day in week 6 pp. Nursing behaviour (duration, frequency and terminator) was observed continuously (table 3) and sow time budget was recorded every 10 minutes. Time budget registrations included standing/walking (all four hoofs on the ground), lying down or sitting (lateral and sternal lying and sitting with only two hoofs on the ground), eating (chewing and swallowing feed in the feeding area), drinking (sucking water nipple), rooting (snoot in contact with the ground and rooting movements of the head).

Table 3. Definitions of the nursing behaviours that were recorded continuously one day week 4 and one day week 6 pp

Behaviour parameters	Definition
Nursing	More than 50 % of the litter suckling for more than 60 seconds
Suckling terminated by sow	Sow stands up or rolls over on belly, making udder unavailable for piglets
Suckling terminated by piglets	More than 50 % of litter falls asleep or leaves the udder

Statistical analysis

Data editing and statistical analyses were performed with the SAS package (SAS institute, Inc. Cory, NC, version 9.2). Descriptive statistics (e.g. means, standard deviations and frequencies) was analysed with procedure MEANS and FREQ. Chi square (χ^2) tests were performed using procedure FREQ. Analysis of variance was performed using procedure MIXED and in these analyses, residuals of dependent variables were checked for normal distribution using procedure UNIVARIATE (all variables showed normal or approximate normal, distribution). Logistic regression was performed using procedure GLIMMIX. Based on residual variables from different measuring occasions (4 weeks, 6 weeks and between consecutive parities) estimated with logistic regression, residual correlations were estimated using procedure CORR. Predictor variables included in statistical models were set as fixed if they were considered as repeatable in new, similar studies (e.g. parity number) and as random if they were not considered as repeatable (e.g. the individual sow).

Statistical differences are indicated with n.s. = ($p > 0.10$), † = ($0.10 \geq p > 0.05$), * = ($0.05 \geq p > 0.01$), ** = ($0.01 \geq p > 0.001$), *** = ($p < 0.001$).

Analysis of variance

For each parity and observation day (week 4 and 6), sows were divided into two cross-suckling groups (from now on called the “allowing cross-suckling” variable); either they had allowed cross-suckling at least once that day, or they had not. Differences in productivity and sow behaviour variables between these groups were then analysed with analyses of variance using a mixed model (including both fixed and random predicting variables). For each sow group, corrected means (referred to as least square means (LSM)

in the SAS program) were estimated for productivity and behaviour outcome variables (y-variables) using the Model 1.

The same procedure was used to analyse associations between the sow's productivity, behaviour and ability to gather the whole litter at nursings. Sows were divided into two groups of which sows in one group always gathered the whole litter at nursings during the observation day, and sows in the other did not (from now on called the "always whole litter" variable). For each of these sow groups, LSMs were estimated for productivity and behaviour outcome variables (y-variables) using the Model 2.

Logistic regression and residual correlations

Repeatability of the traits "allowing cross-suckling" and "always whole litter" was estimated as the t-value of the random effect of the sow (the proportion of the variance for the trait that the effect of sow accounts for) using Model 3. Additionally, repeatability was estimated as the residual Pearson correlation between two measuring occasions (i.e. between week 4 and 6 within the same parity or between week 4 and week 6 in two consequent parities), where residuals were estimated using Model 4. The binary outcome (y) variables in Model 3 and 4 are "allowing cross-suckling" and "always whole litter".

Chi square tests

Association between the parameters "allowing cross-suckling" and "always whole litter" was assessed using simple χ^2-test. The same test was used to assess differences in occurrence of the two parameters between parities.

Models

Model 1: y = allowing cross-suckling + environment + parity(environment) + season + litter size + sow

Model 2: y = always whole litter + environment + parity(environment) + season + litter size + sow

Model 3: y = environment + parity(environment) + season + litter size + sow, logit link and binomial distribution

Model 4: y = season + litter size, logit link and binomial distribution

where the fixed effects allowing cross-suckling had 2 classes (did or did not allow cross-suckling at least once during the observation day), always the whole litter had 2 classes (did or did not always gather the whole litter at nursings during the observation day), environment had 2 classes (indoors or outdoors), parity had 4 classes (1 – 4) and was nested within environment, season had 4 classes (spring, summer, autumn and winter) and litter size had 3 classes (<10, 10-12, >12 piglets). The individual sow was included as a random effect.

Results

The number of sows included in the study decreased with parity due to culling (table 4). The number of live born and weaned piglets as well as piglet weight at weaning increased with parity.

Table 4. Descriptive statics (mean values and standard deviations) regarding the sow productivity and body condition over the four parities included in the study

Parity	1		2		3		4	
Number of sows (N)	40		36		31		25	
Number of live born piglets	10.7	(3.0)	12.4	(3.6)	13.4	(3.5)	13.7	(3.9)
Number of weaned piglets	8.6	(2.8)	9.5	(2.3)	10.0	(2.5)	10.3	(2.6)
Piglet weight at weaning (kg)	17.3	(3.5)	18.0	(3.9)	19.4	(2.9)	19.8	(3.9)
Sow weight at weaning (kg)	187.2	(19.1)	228.9	(24.5)	251.7	(24.6)	273.9	(22.9)
Sow back fat thickness at weaning (mm)	11.9	(3.6)	12.5	(3.0)	13.6	(3.4)	15.7	(3.4)

Nursing alien piglets

The proportion of sows allowing cross-suckling at least once during the observation day decreased from 44 % week 4 to 33 % week 6 pp.

No significant difference in the occurrence of cross-suckling was found between parities or between parities within environment. However, a tendency was found for cross-suckling to occur more often outdoors than indoors in week 4 pp (χ^2-test, p = 0.091).

Relationship with sow and piglet production

Sows that allowed cross-suckling in week 4 lost on average less body fat between week 2 and 7 pp compared to sows that did not (p = 0.002) (table 5). Although the sows that allowed cross-suckling on average gained weight and the sows that did not allow cross-suckling that on average lost almost 2 kg of weight between week 2 and 7 weeks of the lactation, the difference was not significant. Differences in sow fatness and weight between sows allowing or not allowing cross-suckling are presented in table 5 and 6.

Table 5. LSM (SE) for different traits between sows allowing or not allowing cross-suckling in week 4 pp

	Allowing cross-suckling week 4 pp		
	Yes, N=56	No, N= 69-71	Sign.
Sow back fat thickness at 2 weeks (mm)	15.5 (0.5)	15.4 (0.5)	n.s.
Sow weight at 2 weeks (kg)	242.9 (3.4)	238.3 (3.2)	n.s.
Change in sow fatness 2-7 weeks (mm)	-0.6 (0.4)	-2.3 (0.4)	**
Change in sow weight 2-7 weeks	0.1 (2.1)	-1.8 (2.0)	n.s.

Table 6. LSM (SE) for different traits between sows allowing or not allowing cross-suckling in week 6 pp

	Allowing cross-suckling week 6 pp		
	Yes, N=43	No, N=82-84	Sign.
Sow back fat thickness at 2 weeks (mm)	15.7 (0.5)	15.4 (0.4)	n.s.
Sow weight at 2 weeks (kg)	241.7 (3.6)	239.7 (3.2)	n.s.
Change in sow fatness 2-7 weeks (mm)	-1.1 (0.5)	-1.7 (0.4)	n.s.
Change in sow weight 2-7 weeks (kg/day)	1.4 (2.4)	-2.1 (1.8)	n.s.

Litter size at 2 weeks was significantly lower for sows that allowed cross-suckling in week 4 pp ($p = 0.011$) (table 7). Individual piglet weight did not differ between sow cross-suckling groups. Litter weight in week 2 and 7 was lower if the sow nursed alien piglets ($p = 0.019$ and $p = 0.039$ respectively) (table 7). Moreover, significant differences regarding piglet performance were found when cross-suckling occurred week 6 pp. Litter size in week 2 was smaller ($p = 0.029$), litter weight in week 7 was lower ($p = 0.033$), and higher piglet weight in week 2 ($p = 0.030$) was seen if the mother nursed alien piglets (table 7).

Table 7. LSM (SE) for differences in piglet traits between sows allowing cross-suckling or not in week 4 and 6 pp

	Allowing cross-suckling week 4 pp			Allowing cross-suckling week 6 pp		
	Yes, N= 58	No, N=70-74	Sign.	Yes, N=44	No, N=84-88	Sign.
Litter size at 2 weeks	9.4 (0.4)	10.5 (0.4)	*	9.3 (0.4)	10.3 (0.3)	*
Litter weight at 2 weeks (kg)	48.3 (1.8)	53.4 (1.7)	*	49.3 (2.0)	51.9 (1.6)	n.s.
Litter weight at 7 weeks (kg)	161.7 (5.8)	177.4 (5.7)	*	158.4 (6.7)	175.8 (5.2)	*
Piglet weight at 2 weeks (kg)	5.6 (0.1)	5.7 (0.1)	n.s.	5.9 (0.1)	5.5 (0.1)	*
Piglet weight at 7 weeks (kg)	19.6 (0.5)	19.6 (0.5)	n.s.	19.9 (0.5)	19.4 (0.4)	n.s.
Piglet growth 4 days-2 weeks (g/day)	308.2 (6.7)	310.2 (6.5)	n.s.	318.2 (7.4)	304.5 (9.0)	n.s.
Piglet growth 2-7 weeks (g/day)	397.4 (9.8)	397.2 (9.7)	n.s.	397.9 (11.2)	396.9 (9.0)	n.s.
Dead of live born 0-14 days (%)	18.8 (1.8)	14.0 (2.1)	n.s.	16.7 (2.6)	16.1 (2.0)	n.s.
Dead 2-7 weeks (%)	2.7 (0.7)	2.3 (0.6)	n.s.	3.4 (0.8)	2.0 (0.6)	n.s.

Relationship with sow behaviour

Nursing behaviour

There was a tendency ($p = 0.075$) that sows nursed more often when allowing cross-suckling in week 6 pp compared to sows that did not (6.2 ± 0.3 times and 5.6 ± 0.3 times respectively). No significance was found for week 4 pp.

Time budget

Cross-suckling was not found to be related with sow time budget (regarding proportion of time lying down, standing up, eating, drinking and rooting), neither in week 4 nor 6 pp. For example, during week 4 pp, the sows spent most of their time lying down (ranging from 51.4 % to 57.6 % of the observations) and least time drinking (1.6 % - 3.2 %).

Repeatability

Correlations between and within parities can be seen in table 8. Allowing cross-suckling is repeatable within but not over parities. No significant correlations were found in the residual correlations between subsequent parities (table 8). Variances for the random effect of sow (t-value) was not significantly different from 0 for the binary trait "allowing cross-suckling" in week 4 and 6 pp and the t-values for the random effect of sow was 0.05 (n.s.) for week 4 and 0.07 (n.s.) for week 6 pp.

Table 8. Residual Pearson correlations within and between parities. Allowing cross-suckling (1) or not (0)

	r	H0: r = 0 p
Week 4 - 6	0.37	<0.001
Week 4		
Parity 1 – 2	-0.07	n.s.
Parity 2 - 3	-0.16	n.s.
Parity 3 - 4	-0.06	n.s.
Week 6		
Parity 1 – 2	-0.19	n.s.
Parity 2 - 3	0.07	n.s.
Parity 3 - 4	0.01	n.s.

Always nursing whole litter

The proportion of sows that always had their whole litter present at every nursing decreased from 39 % in week 4 to 35 % in week 6 pp. There was a tendency that the whole litter was present more often indoors than outdoors in week 4 pp (χ^2-test, p = 0.063).

When comparing the differences within environments (i.e. indoor and outdoor), there were some differences when sows were housed outdoors. The litters were intact at nursings more often week 6 pp in parity 3 than in parity 1 (p = 0.002) (table 9). No such differences were found where sows were housed indoors (table 10).

Table 9. χ^2- test of differences in the occurrence of the sow always having the whole litter present at nursing when housed outdoors

Entire litter always present (outdoor)	Week 4				Week 6			
	N	Yes (%)	No (%)	Sign.	N	Yes (%)	No (%)	Sign.
Parity 1	37	16.7	39.4	n.s.	37	11.8	42.7	**
Parity 3	29	13.6	30.3		31	26.5	19.1	

Table 10. χ^2- test of differences in the occurrence of the sow always having the whole litter present at nursing when housed indoors

Entire litter always present (indoor)	Week 4				Week 6			
	N	Yes (%)	No (%)	Sign.	N	Yes (%)	No (%)	Sign.
Parity 2	33	25.9	31.0	n.s.	32	21.1	35.1	n.s.
Parity 4	25	20.7	22.4		25	17.5	26.3	

Relationship with sow and piglet production

Sow fatness, weight or change in fatness and weight did not differ whether or not the sow always had the whole litter present at nursings in week 4 pp (table 11).

Table 11. LSM (SE) for differences in sow traits between sows always and sows not always having the whole litter present at nursings in week 4 pp

	Entire litter always present week 4		
	Yes, N=43	No, N=75	Sign.
Sow back fat thickness at 2 weeks (mm)	15.8 (0.5)	15.0 (0.5)	n.s.
Sow weight at 2 weeks (kg)	237.9 (3.3)	239.2 (3.2)	n.s.
Change in sow fatness 2-7 weeks (mm)	-1.8 (4.5)	-1.0 (0.4)	n.s.
Change in sow weight 2-7 weeks (kg/day)	-0.7 (2.2)	-1.3 (2.0)	n.s.

Sows always having the whole litter present at nursing in week 6 pp had a tendency to lose more weight between week 2 and 7 pp (table 12).

Table 12. LSM (SE) for differences in sow traits between sows always and sows not always having the whole litter present at nursing in week 6 pp

	Entire litter always present week 6		
	Yes, N=44	No, N=74	Sign.
Sow back fat thickness at 2 weeks (mm)	15.3 (0.5)	15.5 (0.5)	n.s.
Sow weight at 2 weeks (kg)	239.3 (3.5)	238.1 (3.2)	n.s.
Change in sow fatness 2-7 weeks (mm)	-1.7 (0.5)	-1.1 (0.4)	n.s.
Change in sow weight 2-7 weeks (kg/day)	-4.4 (2.3)	1.0 (1.9)	†

The litter size in week 2 pp was smaller if the sow always had the whole litter present at nursing ($p = 0.002$) (table 13). No other significant differences could be found for differences in litter and piglet weight or piglet growth. For week 6 pp no significant differences between variables were found (table 13).

Table 13. LSM (SE) for differences in piglet traits between sows always and not always having the whole litter present at nursings in week 4 and 6 pp

	Entire litter always present week 4 pp			Entire litter always present week 6 pp		
	Yes, N=45	No, N=76	Sign.	Yes, N=45	No, N=76	Sign.
Litter size at 2 weeks	9.3 (0.4)	10.6 (0.3)	**	9.8 (0.4)	10.3 (0.3)	n.s.
Litter weight at 2 weeks (kg)	49.5 (1.8)	53.2 (1.7)	n.s.	51.6 (2.0)	51.5 (1.7)	n.s.
Litter weight at 7 weeks (kg)	169.4 (6.3)	171.9 (5.8)	n.s.	166.8 (6.7)	173.3 (5.5)	n.s.
Piglet weight at 2 weeks (kg)	5.7 (0.1)	5.7 (0.1)	n.s.	5.7 (0.1)	5.7 (0.1)	n.s.
Piglet weight at 7 weeks (kg)	19.8 (0.5)	19.4 (0.5)	n.s.	19.3 (0.5)	19.8 (0.4)	n.s.
Piglet growth 4 days-2 weeks (g/day)	315.3 (6.9)	310.0 (6.5)	n.s.	308.3 (7.3)	315.1 (6.2)	n.s.
Piglet growth 2-7 weeks (g/day)	406.5 (10.0)	389.2 (9.4)	n.s.	393.2 (10.7)	399.6 (9.1)	n.s.
Dead of live born 0-14 days (%)	16.9 (2.2)	13.1 (2.1)	n.s.	13.8 (2.4)	15.6 (2.0)	n.s.
Dead 2-7 weeks (%)	1.7 (0.7)	3.4 (0.7)	†	2.4 (0.8)	2.7 (0.7)	n.s.

Relationship with sow behaviour

Nursing behaviour

Sows always having the whole litter present at nursings in week 4 pp had lower nursing frequency than the ones that did not ($p = 0.001$). The nursing frequency for week 6 pp was also lower if the sow always had the whole litter present at nursing compared to sows having piglets missing, 5.3 ± 0.3 times and 6.2 ± 0.3 times during a six hour period respectively ($p = 0.007$). A tendency for longer nursing duration could be seen in week 6 pp if the whole litter was present (3.7 ± 0.3 minutes vs. 3.2 ± 0.3 minutes, $p = 0.051$).

Time budget

Sow behaviour showed no significant differences in week 4 pp whether the sow always had the whole litter present or not at nursing. In week 6 pp sows having the whole litter present at nursings ate fewer times (5.3 ± 0.4) compared to sows not having the whole litter present (6.3 ± 0.4) ($p = 0.025$). There was also a tendency that sows rooted more times (5.7 ± 0.5) if the whole litter always was present during nursing, than if the whole litter was not (4.4 ± 0.5) ($p = 0.067$).

Repeatability

Correlations between and within parities can be seen in table 14. Variances for the random effect of sow were not significantly different from 0 for the binary trait 'always whole litter' in week 6 pp. The analysis for week 4 pp did not converge, thus no correlation between week 4 and 6 pp within parity could be estimated. There was a tendency for a moderate negative correlation regarding always nursing the entire litter during week 4 pp in parity 2 and 3 (table 14). This correlation indicates that sows that always nursed their entire litter week 4 pp in parity 2 did not do so in parity 3, but also the other way around; not nursing the entire litter in parity 2 is related to always nursing the entire litter in parity 3.

Table 14. Residual Pearson correlations within and between parities. Always whole litter (1) or not (0)

	r	H0: r = 0 p
Week 4 - 6	-	-
Week 4		
Parity 1 – 2	-0.13	n.s.
Parity 2 - 3	-0.38	†
Parity 3 - 4	-0.24	n.s.
Week 6		
Parity 1 – 2	0.17	n.s.
Parity 2 - 3	0.12	n.s.
Parity 3 - 4	0.06	n.s.

Relationship between allowing cross-suckling and always nursing the whole litter

Whether or not the sow always had the whole litter present at nursing or not had no significant effect on the occurrence of cross-suckling neither in week 4 or 6 pp (figure 2). Also, no differences between the different housing systems were seen.

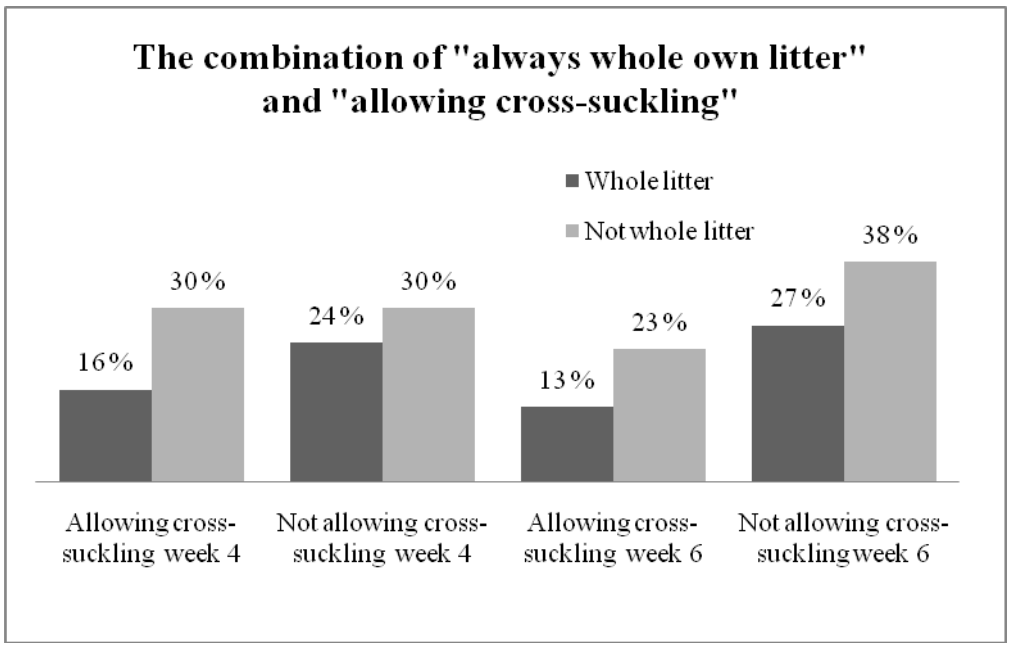

Figure 2. Relationship between the sow always having the whole litter present at nursing or not and how this affects the occurrence of cross-suckling seen over all 4 parities. No significant results were seen.

Discussion

As production systems where several sows and their litters are housed together during lactation are getting more common, the need of knowledge regarding cross-suckling increases. It is important to understand both how, when, and to what extent cross-suckling occurs and how it affects the animals and the production. In most reports, cross-suckling is considered to be a piglet trait, while the present study focuses on cross-suckling from the sow's perspective. The aim with this thesis was to investigate associations between cross-suckling, sow behaviour and productivity, and furthermore to investigate consistency in sow nursing behaviour related to cross-suckling. The following discussion will first consider the main findings regarding sows' willingness to allow cross-suckling and ability to gather the whole litter at nursing. Thereafter, the issue of whether or not cross-suckling is a sow trait will be discussed followed by a reflection about hypothesis found in the literature explaining the phenomenon cross-suckling.

Nursing own or alien piglets?

There was a higher occurrence of cross-suckling in week 4 pp than week 6 pp in this study. The lactation curve reaches its peak and starts to decline at about 21 days after farrowing (Walker & Young, 1992), and consequently the weaning process starts early during lactation (Wallenbeck *et al.*, 2008*).* This leads the piglets to search for feed elsewhere, and thus a higher occurrence of cross-suckling could be expected earlier in the lactation.

During the weaning process the sow restricts nursing by terminating nursings and decreasing the nursing frequency (Bøe, 1991). The weaning process is associated with sow body condition; sows having poor body resources start the weaning process earlier compared to sows in good body condition (Wallenbeck *et al.*, 2008*).* In the present study it was found that sows allowing cross-suckling lose less fat than sows not allowing alien piglets to nurse. Also, the nursing frequency tended to be lower in week 6 pp if the sow did not nurse alien piglets in week 6 pp. Together this suggest that sow's willingness to allow cross-suckling is related to the weaning process, and in the same way related to sow's body resources. It could be interpreted like sows that lose much weight are more careful with their resources, and do not provide milk to alien piglets.

Sows nursing alien piglets in week 4 pp had smaller litters in week 2 pp than sows that did not allow cross-suckling in week 4 pp (9.4 and 10.5 respectively). This is opposite of what other studies has shown were the litter size was larger if the sow allowed cross-suckling (Andersson & Andréasson, 1992; Maletínská & Špinka, 2001). Another study showed no difference in litter size when the sow allowed cross-suckling (Olsen *et al.*, 1998).

The percentage of piglets that died between birth and 2 weeks of age showed no difference between sows allowing and not allowing cross-suckling in week 4. This might be due to the fact that the sow and piglets were kept isolated during the first two weeks and thus the dead piglet's siblings would be the only ones that could use the unoccupied teats. If the siblings did not occupy the teat, it would dry out.

As in the study from Maletínská & Špinka (2001) no differences in the occurrence of cross-suckling was found between parities in the present study. Olsen *et al.*, (1998) on the other hand found that there was a higher occurrence of cross-suckling in later parities. In the present

study, sows were kept outdoors in parity 1 and 3 and indoors in parity 2 and 4, which could explain the present result. The results could have been different if the parities would all been in the same environment. However, no differences were found between parities when the occurrence of cross-suckling was compared between parities within environment.

The nursing environment seem to affect sows' willingness to allow cross-suckling to some extent, as a larger proportion of sows allowed cross-suckling in week 4 pp when they were housed outdoors. It could be argued that this finding is due to the fact that sows were on average younger and less experienced mothers in parity 1 and 3 in the outdoor environment compared with parity 2 and 4 in the indoor environment and did not distinguish between their own and alien piglets. The lack of differences between parities described earlier, however, indicate that this difference was indeed due to differences in nursing environment. One explanation to these results could be larger space allowances outdoors compared to the smaller indoor environment, leading to weaker mother-offspring bonds when housed outdoors.

In commercial pig production with group housed lactation systems, the common practice is mixing sows of different parities. This might affect cross-suckling if older sows wean their piglets earlier, letting younger sows nurse their piglets. Gilts that farrow for the first time might be more prone to let alien piglets nurse since they lack experience. Sows that wean their litter before the weaning conducted by the herdsmen (i.e. separation of sows and piglets) are a problem, since they sometimes come into heat too early and consequently fall out of the group production system. In this study however, there were no mixing of sows from different parities.

The group size in the present study was 4 or 5 sows per group. These are rather small groups compared to common practice in commercial conditions. It is not clear whether or not group size affects the occurrence of cross-suckling. Studies have shown different results, e.g. more cross-suckling in small groups (Dybkjær *et al.*, 2001), and Jensen (1986) stated the opposite, less cross-suckling in small groups. Large groups could affect cross-suckling simply because there are more individuals present, giving more opportunities for cross-suckling. Small groups, on the other hand, are potentially more similar to a family group, and if the kin selection hypothesis (Roulin, 2001) is valid, sows could therefore allow related piglets to suckle. The effect of group size could not be analysed in the present study due to the small variation in group size. However, results could be biased by the fact that some groups had one sow more than other groups.

Maletínská & Špinka (2001) suggests that if the sow's own piglets are missing during nursing alien piglets would fill the gap. This study did not support this as there were no significant association between sow's willingness to allow cross-suckle and her ability to always have the whole litter present at nursing.

The ability to always have the whole litter present at nursing was not affected by the sows' body condition to the same extent as the willingness to allow cross-suckling. Always having the whole litter present at nursing seemed more associated with nursing behaviour, for example a low nursing frequency. Having the whole litter present was also to some extent affected by environment, with higher occurrence of the whole litter present at nursing indoors compared to outdoors. This was possibly due to the smaller space allowance indoors, making it easier for the sow to gather her litter before each nursing. Small litters were more prone to

be intact at nursings, and a more experienced sow seemed to be better at gathering the whole litter.

Is cross-suckling a sow trait?

This study showed that cross-suckling is repeatable within but not over parities. This means that sows nursing alien piglets in week 4 pp are also more likely to do so in week 6 pp during the same parity.

The results of the present study indicate that sows willingness to allow cross-suckling is more affected by litter size, piglet mortality and sow's current body condition than a long term individual nursing strategy. Thus, it seems to be affected by the environment to a larger extent than it is affected by the genes. This emphasise the importance of keeping sows with good appetite and good ability to provide piglets with milk in group housed lactating systems.

Cross-suckling hypothesis

The initial time alone with the piglets after farrowing is needed to create the mother-offspring bond. The separation time of 2 weeks away from the rest of the sow group after farrowing should be sufficient as it takes up to 14 days for the sow to be able to recognize her own litter (Horrell & Hodgson, 1992). The misdirected parental care hypothesis (Roulin, 2001) is most likely to be the explanation for cross-suckling in pigs. Even though the sow can recognize her own litter it might not be best to always interrupt nursings when an alien piglet tries to cross-suckle as this could lead to the entire litter missing the nursing, and not only the alien piglet.

The kin selection hypothesis (König, 1994), where mothers nurse the young of relatives, might contribute to the explanation of why cross suckling occurs in piglet production, as sows within the same herd often are related, however, if this was the full explanation a higher frequency of the piglets would be assumed to cross-suckle than is seen in this and other studies.

The milk evacuation hypothesis (Wilkingson, 1992; Plesner Jensen *et al*., 1999), where the mother wants to get rid of excess milk, could be a way to maintain maximum milk production, but piglets are opportunistic and would suckle an unoccupied teat if a littermate was missing, even without the presence of an alien piglet.

Conclusion

The aim of this thesis was to investigate how sow behaviour and productivity is associated with the occurrence of cross-suckling, and to investigate consistency in sow nursing behaviour related to cross-suckling. The results of this study indicate that sows with low litter sizes and good body condition can ‘afford’ to nurse alien piglets, and will do so to a larger extent compared to sows losing more of their body reserves during the lactation period. Also, cross-suckling was found to be repeatable within but not over parities.

In conclusion, cross-suckling is not a long term individual trait of the sow as it seems to be affected by the environment and sow body condition to a large extent. Moreover, sows with small litters are more prone to allow cross-suckling.

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