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Smågrisars mjölkintag vid digivning hos suggor som behandlats med oxytocin

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Examensarbete / Swedish University of Agricultural Science Department of Animal Breeding and Genetics
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Preface

This master thesis was carried out at Swedish University of Agriculture Science during autumn 2017. I would like to send my thanks to the people who helped me during the process:

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The seven visited herds, which let me be a part of the farrowing routines

Gotland Grönt centrum, how gave me the opportunity to see Gotland

Maja Forssell, who took the time to comment on my text

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Abstract

Milk ejection occurs in response to release of the hormone oxytocin from the pituitary, and this hormone is also used as treatment of milk stasis in sows in the Swedish piglet production. Today, there are few reports on the effect of oxytocin injection on sow milk let down, piglet and sow nursing behaviour or piglet milk intake. Therefore this study aims to investigate piglet's milk intake in connection to oxytocin treatment on sows in Swedish commercial piglet producing herds. The weigh-suckle-weigh method was used to asses piglet milk intake in one nursing were the sow were treated with oxytocin, the subsequent nursing after the oxytocin treatment nursing in the same sow and one nursing in a healthy control sow. Statistical analyses were performed on the variables; weight of the litter, weight spread within litter, weight change during nursing, spread in weight change within litter and percent of weight changes of live weight. In the next step of the statistical analyses, the sows treated with oxytocin were divided into two groups; sows without udder symptom and sows with udder symptom. Due to the small size of this pilot study, only numerical differences could be found. Differences of relevance were found in the variable spread in weight change within litter between sows treated with oxytocin and sows without treatment. Numerical differences were observed in all of the analysed variables between sows with- and without udder symptoms indicating that intramuscular oxytocin injection have a positive effect on sows with apparent udder symptoms. The experiences from this study indicate that the weigh-suckle-weigh method is more relevant in more controlled studies in e.g. research herd, with an equal environment and there consideration about fecal, urine, metabolic or heat losses can be taken. However, under commercial conditions, recordings about sow response to the oxytocin injection can be achieved by observation of the nursing performance in connection to the injection.

Keywords: sow, oxytocin, milk stasis, piglet, weight changes, weigh-suckle-weigh, milk ejection, milk let down

Sammanfattning

Mjölknedsläpp sker som en respons på frisättning av hormonet oxytocin från hypofysen och syntetiskt oxytocin används för att behandla mjölkstockning i svenska grisbesättningar. Idag finns det få vetenskapliga rapporter om hur intramuskulära injektioner med oxytocin påverkar suggans mjölknedsläpp och digivning, syftet med den här studien var att undersöka smågrisarnas mjölkintag hos suggor behandlade med oxytocin under svenska produktionsförhållanden. Som ett mått på smågrisarnas mjölkintag användes metoden väga-dia-väga. I studien studerades tre typer av digivningar; digivning där oxytocin injektion applicerades, den följande digivningen hos samma sugga samt digivning hos en frisk kontrollsugga i samma stall. Studien omfattade analys av kullvikt, viktspridning inom kullen, viktförändring före och efter digivning, spridning i viktförändring inom kullen och procentuell viktförändring (viktförändring/levandevikt). Förutom skillnader mellan de tre digivningstyperna så analyserades även skillnader mellan suggor som behandlas med oxytocin som antingen hade eller inte hade juversymptom. Omfattningen av den här pilotstudien gav inte utrymme för att säkerställa de numeriska skillnader som hittades med statistisk metodik. En intressant numerisk skillnad hittades i variabeln, spridning i smågrisarnas viktförändring, där digivningen i samband med oxytocin injektion återfanns ha en numerisk större spridning än digivning utan injektion. Numeriska skillnader återfanns i alla analyserade variabler mellan digivningar hos suggor utan juversymtom och suggor med juversymptom. Sammantaget tyder resultaten från denna pilotstudie på att injektioner med oxytocin har en positiv inverkan på suggor med tydliga juversymptom. Metoden väga-dia-väga är mer lämplig i studier med mer kontrollerade experimentella förhållanden, t.ex en försöksbesättning, med samma miljö för alla digivningar och en miljö där det blir enklare att ta hänsyn till urinering, fekalier, värme- och energiförluster. För att utvärdera hur suggan svarar på behandlingen med oxytocin under kommersiella produktionsförhållanden kan digivningsbeteendet i samband med behandlingen observeras för att utvärdera om suggan ger di till kullen.

Nyckelord: sugga, oxytocin, mjölkstockning, smågris, viktförändring, väga-dia-väga, digivning, mjölknedläpp

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Abbreviations

CN	Control nursing of a sow without oxytocin treatment
ID	Isotope dilution
i.m	Intramuscularly
i.v	Intravenous
NNNs	Non-nutritive nursings
NSAIDs	Non-steroid ani-inflammatory drug
NUS	Sows without udder symptom in the ON group
ON	Nursing when the sow was treated with oxytocin
SN	Subsequent nursing after oxytocin injection in the same sow
US	Sows with udder symptom in the ON group
WSW	Weigh-suckle-weigh

1 Introduction

The pre-weaning piglet mortality in Sweden was on average 17 % in 2016 (Gård&Djurhälsa 2017a) and the majority of the piglet mortality occurs during the first days postpartum (Dyck & Swierstra, 1987; Edwards & Baxter, 2014). Crushing of the piglets by the sow is the main cause of piglet mortality, and the crushing is indirectly connected to starvation (Edwards & Baxter, 2014; Quesnel *et al.*, 2014). Hungry piglets are found to spend more time close to the sow, where the risk for crushing is high (Weary *et al.*, 1996). The sow's milk production is of great importance to supply the piglets with enough energy to survive. One major factor limiting milk production is udder diseases (Gerjets, 2009), and surveillance, detection and treatment is of high importance for piglet survival in pig production. The hormone oxytocin is often used for treatment of diseases connected to disturbed milk let down in Swedish pig production (Lindahl 2015). The hormone oxytocin is known for inducing and maintaining milk ejection. There are few scientific reports on the effect of oxytocin treatment for disturbed milk ejection in sows and on more long term effects on the sow's milk production. Unnatural high dosages of oxytocin have been found to decrease milk yield in cows (Allen, 1990) and disturb milk let down in subsequent milkings (Mačuhová *et al.*, 2004). It is complicated to measure sow's milk production and an indirect method is to weight the piglets in connection to nursing and record the weight change before and after, a method called weigh-suckle-weigh (WSW) (Spinka *et al.*, 1997).

This study was a pilot study with the aim to study piglet's milk intake in connection to intramuscular oxytocin injection in sows, under commercial production conditions. A second aim was to assess the method weigh-suckle-weigh as a measurement for piglet milk intake under commercial piglet production conditions.

2 Literature review

To provide deeper understanding of the complex mechanism leading to milk let down in the sow, this literature review will begin by discussing the development in nursing behaviour from the first days postpartum to the more established nursing pattern. The literature review will also describe the physiology of the udder, the role of the hormone oxytocin in nursing mechanism and the use of oxytocin as a treatment related to disturbance in milk let down.

2.1 The nursing behaviour

Nursing in connection to parturition

The sow stays passive through parturition, by lying on the side with the udder available for the new-born piglet (Spinka & Illmann, 2014). The piglet will search for the udder soon after birth for colostrum intake (De Passille & Rushen, 1989). Increased levels of oxytocin are released in connection to parturition (Ellendorff *et al.*, 1979) and indirect initiate the ejection of colostrum for the piglets (Farmer & Quesnel, 2009). There is no need of pre-massage on the udder, performed by the piglets to initiate milk ejection at this time (Spinka & Illmann, 2014). By weighting the piglets with a 10 minute interval for two hours close after parturition, a synchronized weight gain was found 1.8 to 3.5 hours postpartum. This result suggested that colostrum is continuously available in connection to parturition but milk ejection is needed for colostrum to be available for the piglet soon after parturition (Fraser & Rushen, 1992).

Nursing

Nursing is initiated in two different ways, either by the sow calling on her piglets or by the piglets approaching the sow and at the same grunting and trying to start massaging the udder (Ellendorff *et al.*, 1982). The piglet starts to stimulate teats during nursing approximately 12 to 16 hours postpartum (Spinka & Illmann, 2014). This is in agreement with (Lewis & Hurnik, 1985) who found a changed nursing pattern 10.7 ± 4.5 hours postpartum when studying nursings of 14 Yorkshire sows. The nursing pattern went from neo-nursing with solitary continuous nursing to transition nursing identified like: half the litter performed nursing for no longer than 30 minutes with a clear break of 30 minutes between (Lewis & Hurnik, 1985). Synchronizations of nursings by the litter remain low the first day postpartum and have been found to be more pronounced after three days (Jensen *et al.*, 1991).

During the first days postpartum the sow initiates most of the nursings. This pattern will switch towards the piglets initiating an increasing portion of nursings with increasing age of the piglets (Jensen *et al.*, 1991). The piglets initiate the nursing by squealing sounds and use their snouts to pre-massage the udder. At the same time as the pre-massage is performed, the sow grunts low and rhythmically. Most of the piglets in the litter need to perform massage on the udder for milk ejection to occur (Ellendorff *et al.*, 1982). As the piglets continue to perform pre-massage on the udder, the sows grunting will increase. During the rapid grunting period the piglet will suddenly become still and quiet and begin to suckle, indicating milk let down, with duration for 6-40 seconds (Ellendorff *et al.*, 1982; Kent *et al.*, 2003).

Thereafter, the litter will start to perform post-nursing massage on the teats. Termination of the nursing either occurs when the piglets fall asleep, walk away or when the sow ends the nursing by standing up or turning to a position which the teats become unavailable (Ellendorff *et al.*, 1982; Jensen *et al.*, 1991). Up to five days postpartum, most of the nursings have been found to be terminated by the piglets, while sows have been found to terminate an increased portion of the nursings during later nursing period (Jensen *et al.*, 1991).

2.1.1 Nursing interval

At the first day postpartum, the nursing interval is shorter than one hour and it is increased to approximately 1.4 hour at 10 days postpartum (Jensen *et al.*, 1991). Average nursing intervals for one to four weeks postpartum have been found to be 44 minutes with a wide individual variation (Ellendorff *et al.*, 1982). When investigating piglet weight gain seven and eight days postpartum in connection to nursing intervals, the intervals were found to play a central role in the regulation of milk output; intervals of 35 minutes lead to a higher weight gain at 24 hours, but the piglets received 23 % less milk at every nursing when compared to an interval of 70 minutes (Spinka *et al.*, 1997). The piglet growth is found to be positively affected by a high frequency completed nursings (Valros *et al.*, 2002). Decreasing nursing intervals is suggested to affect the frequency of non-nutritive nursings (NNNs), when there is no milk ejection during nursing. Ellendorff *et al.*, (1982) found that the NNNs were more frequently occurring when the piglets tried to initiate nursing short after previous milk ejection. This is in agreement with Spinka *et al.*, (1997) who found that decreasing nursing intervals to 35 minutes will increase the frequency of NNNs compared to nursing intervals of 70 minutes. Jensen *et al.*, (1991) found 30 % of the nursings to be NNNs day one to five postpartum.

2.1.2 Competition of teats at the udder

During the first days of life, rivalry between the piglets within litter has been found to result in the establishment of teat ownership. This means that a piglet returns to the same teat at nursing and defend it against siblings. Three days postpartum, on average 86 % of the piglets were found to be returning to the same teat and 95 % were found to return to the same teat at day 10 (De Passillé *et al.*, 1988). The litter size was found to not affect the competition between piglets at the udder (De Passillé *et al.*, 1988). However, a more recent study suggests that an increased litter size leads to higher rate of competition between the piglets (Andersen *et al.*, 2011). The higher piglet activity competition leads to losses of energy and body reserves and increases the risk for starvation and crushing by the sow. Aggressive rivalry at the udder may also lead to unsuccessful nursings due to discomfort and pain for the sow (Andersen *et al.*, 2011).

2.1.3 Milk output

The method weigh-suckle-weigh (WSW) is practiced to measure milk production in the sow indirectly by weighing of the litter before milk let down and a second weighing directly after milk let down. The weight change at one nursing when use the WSW method one to three days postpartum have been found to be between 15-25 g (Algers & Jensen, 1991; Spinka *et al.*, 1997). The first nursing have been found to result in lower piglets weight gain compared to the following eight nursings in a study using the WSW method (Speer & Cox, 1984). Speer & Cox, (1984) discuss the reason for the lower piglet weight gain during the first nursing when applied the method WSW and found that the time for the previously nursing were close to the first weighing in WSW and were suggested to be a likely explanation. Lower weight gain was also found in first parity sows compared to second parity sows when the WSW method was used on day 14 post-partum (Speer & Cox, 1984). Lower weight changes in the piglets were found when comparing the WSW with the Isotope Dilution method (ID) (Pettigrew *et al.*, 1985; Theil *et al.*, 2002). ID measures the water intake by the piglet using a hydrogen isotope. To perform ID the knowledge of the colostrum/milk composition is needed and the piglets should not have any other water source (Pettigrew *et al.*, 1985). Pettigrew *et al.*, (1985) further suggested that the WSW underestimate the milk volume and that corrections for metabolic and salivary losses need to be performed.

2.2 The udder

Purebred Swedish Yorkshire sows typically have 14 functional teats (Lundeheim *et al.*, 2013). The teats are organized in pairs, located in two parallel rows. The mammary gland is built up by milk secreting cells folded to structures called alveoli. The secretory cell is sealed tight to the neighbouring cell by a structure called the tight junction. This structure prevents the milk from leaking out to the intestinal fluid (Nguyen & Neville, 1998). The alveoli form clusters called lobuli and the lobulis form collections called lobes. The structures are connected by milk ducts, which transport the milk from the alveoli to the excretory duct ending in the teat (Sjaastad *et al.*, 2010). Each mammary gland consist of two separate mammary gland systems with two separate excretory ducts outflow in same teat (Kent *et al.*, 2003; Klopfestein *et al.*, 2006). The milk is pushed out through the ducts by contraction of the myoepithelial cells surrounding the alveoli, in response to release of the hormone oxytocin from the pituitary (Sjaastad *et al.*, 2010). Contraction of the myoepithelial cells surrounding the alveoli is caused in response to the released oxytocin and will increase the intramammary pressure. By cannulating the milk ducts in the teat, the intramammary pressure can be measured (Kent *et al.*, 2003).

2.2.1 Milk stasis

Mastitis is an inflammation in the mammary gland and result in reduced milk yield or a total lack of milk secretion. Mastitis is either caused by a non-infections inflammation or a bacterial infection (Lepori, 2015) and commonly occurs close to parturition. In human breastfeeding, inflammation starts with pain in the nipple after erosion in the breast, leading to a disturbed breastfeeding pattern and inadequate emptying of the breast which subsequently results in stasis in the alveoli. The increasing pressure in the alveoli opens the intercellular junctions and milk components moves out in the connective tissue (review by Wöckle *et al.*, 2008), leading to a sterile inflammation usually followed by a bacterial infection (review by Wöckle *et al.*, 2008; Lepori, 2015).

Clinical signs for reduced milk ejection in the sow, were explained in the review by Penny, (1970); the sow's general condition is impaired with a reduced appetite, lost mother instincts and the whole udder or some mammary glands are found to be swollen and hardened, leading to hungry piglets with poor body conditions. Milk stasis were found to be reversible after 24 hours, but may lead to decreased milk production and were found to be irreversible after 72 hours (Theil *et al.*, 2005), explaining why treatment for milk stasis need to be performed close to discovery. In Swedish piglet producing herds, oxytocin is used for treatment of milk stasis, alone or in combination with non-steroid anti-inflammatory (NSAIDs) drug and/or antibiotics depending on what clinical signs that are observed (Lindahl 2015). The use of intramuscular oxytocin injections, independent of clinical signs, was suggested by Lindberg[1] to be approximately 0-10 % of sows in a farrowing group in Swedish herds.

2.3 Oxytocin

Oxytocin is a peptide hormone produced in one part of the brain called hypothalamus. The pituitary stalk, connecting the hypothalamus and the pituitary, enable transport of secretory vesicles containing oxytocin along axons to another part of the brain called pituitary gland. The oxytocin is stored there in the nerve terminals of the axons and is secreted by exocytosis by a signal from the hypothalamus (Sjaastad *et al.,* 2010). When piglets perform massage on the mammary gland with their snouts, a neuroendocrine reflex reaches the hypothalamus through the spinal cord. The hypothalamus stimulates the pituitary to release oxytocin in the blood stream (Sjaastad *et al.,* 2010*)* and the oxytocin needs to reach a threshold level if it will result in a milk ejection (Harris *et al.*, 1969; Leng *et al.*, 2015).

When oxytocin is released in the blood stream the plasma half-life is between 2-2.7 minutes. This was shown in a study performed on cows. The cows were given three different dosages of oxytocin (0.2, 0.5 and 1 IU/cow), and no significant differences were found in the plasma half-life between the different dosages (Belo & Bruckmaier, 2010). The oxytocin reaches the udder by the blood stream and binds to receptors on the myoepithelial cells surrounding the alveoli, and the milk is pushed out through the ducts to the nipple (Sjaastad *et al.,* 2010). Oxytocin receptors have also been found on mammary epithelial cells in rats and rabbits, and oxytocin have been suggested to have a directly effect on the epithelial cell and not only bind to receptors on myoepithelial cells (Lollivier *et al.*, 2006).

1. Maria Lindberg, veterinary at Gård&Djurhälsan. Personal Communication 15 December 2017.

2.3.1 Plasma oxytocin level in sows

Oxytocin patterns in sows were investigated in two studies and it was found that milk ejection follows a pattern with a rapid increase in oxytocin concentration and a gradual decrease in the plasma oxytocin level (Ellendorff *et al.*, 1982; Algers *et al.*, 1990). Ellendorff *et al.*, (1982) collected blood samples when the sow performed low grunting and the piglets suckled the teats. Collection of 10 to 15 blood samples with 15 seconds duration were performed, and the plasma oxytocin levels were found to increase from 0.2 -6 µm/ml to 3.9 – 21.2 µm/ml. In a second study performed by Algers *et al.*, (1990) blood samples were collected over the three following nursings on day 1, 3, 7 and 14 postpartum. The samples were collected with a 10 minute interval between the three nursings, and the interval decreased to every 30 seconds when the piglets began to suckle. The basal level of oxytocin ranged from 11.2 to 28.0 fmol ml^{-1}.

2.3.2 Doses of oxytocin

Cows that repeatedly are treated with doses of oxytocin that are higher than what is found under physiological conditions have been found to have disturbed milk letdowns (Allen, 1990; Mačuhová *et al.*, 2004; Belo & Bruckmaier, 2010). Injection of oxytocin increase the time oxytocin was detected in blood plasma and prolonged contractions of the myoepithelial cells after milking (Mačuhová *et al.*, 2004). This was seen in a study by Mačuhová *et al.*, (2004) who investigated occasional injections with oxytocin, hormone pattern in blood plasma and how milk ejection was affected. Cows were observed for three consecutive days, where the cows were given one i.m dosage oxytocin (50 IU) in connection to morning milking on day two. Blood samples were collected at the beginning of milking to 120 minutes after termination. Similar milking times were achieved, but the plasma oxytocin was found to be above the basal level after 120 minutes. In a second trial the intramammary pressure was investigated by inserting a cannula in the teat canal. An extended intramammary pressure was found when 50 IU oxytocin was injected after teat stimulation, and myoepithelial and alveoli contractions were suggested to be prolonged (Mačuhová *et al.*, 2004).

Belo & Bruckmaier, (2010) investigated the minimum oxytocin dosage to cows with disturbed milk ejection. To induce disturbed milk ejection the cows were separated from the herd and moved to unknown surrounding where milking was performed. The level of oxytocin found in plasma decreased after 20 minutes when low dosage of oxytocin was injected (1 IU). The side effect of treating cows with oxytocin was suggested to be minimized when a low dosage of oxytocin was used (Belo & Bruckmaier, 2010). Occasional oxytocin injection to the sow was described in a review by Lindahl, (2015) to not disturb the milk production in most of the treatment. Nursing in connection to the injection was suggested to reduce the risk for disturbed milk ejection from further oxytocin injections. Klopfenstein *et al.*, (2006) found differences response in milk ejection when inject i.v. compared to i.m. Low dosage (10 IU) i.v were found to give good response on milk ejection and increasing dosages (50 IU) were not always found to result in milk ejection in the sow. The decreased response was suggested to depend on the injection is deposited between muscles (Klopfenstein *et al.*, 2006).

2.4 Lactation stage

Lactogenesis is one part of the lactation and is divided into lactogenesis 1 and lactogenesis 2 (Hartmann, 1973; Theil *et al.*, 2014). Decreasing levels of progesterone during the last days of gestation induce lactogenesis 1 (Kuhn, 1969; Foisnet *et al.*, 2010), and a rapid change to copious milk yield has been suggested to induce Lactogenesis 2 in both cows (Hartmann, 1973) and sows (Theil *et al.*, 2014). Nguyen & Neville, (1998) proposed in a review that the closure of tight junctions, is happening during the onset of enhanced milk yield. There is further a negative correlation between tight junction permeability and milk secretion. Milk composition is stabilized 10 days postpartum and is called mature milk in the sow (Klobasa *et al.*, 1987b; Theil *et al.*, 2014).

2.4.1 Permeability in the mammary gland

The milk differs from intestinal fluid in concentration of milk proteins, lactose and ion concentration. Lower concentrations of the osmotic components sodium (Na^+) and chloride (Cl^-) (Nguyen & Neville, 1998), and higher concentrations of potassium (K^+) (Sjaastad *et al.*, 2010), are found in the milk in comparison to intestinal fluid (Nguyen & Neville, 1998). Lactose and the free ions (Na^+, K^+ and Cl^-) affect the milk volume through regulation of the osmotic pressure (Sjaastad *et al.*, 2010). Lactose found in the blood plasma and the ration of the free ions can be used for investigate leakage from mammary epithelial cells. Oxytocin increases the permeability of the mammary gland in rabbits (Linzell *et al.*, 1975). The increased permeability is connected to the tight junction permeability in the cow mammary gland (Allen, 1990; Stelwagen *et al.*, 1997; Nguyen & Neville, 1998; Wall *et al.*, 2016) and in swine (Farmer *et al.*, 2017), leading to an increased transfer of molecules between the blood and milk (Wall *et al.*, 2016).

The increased tight junction permeability is suggested to be one possible reason for the decrease in milk yield found in cows given unnaturally high doses of oxytocin (Allen, 1990). Milk yield, lactose and protein declines and the milk Na:K ration increase in proportion to oxytocin injection in milk analysed 12 hours after injection with 10, 100, 1000IU (Allen, 1990). Increasing levels of Na and Cl were found in rabbit milk after oxytocin injection (Linzell *et al.*, 1975). Increasing levels of IGF-1, dry matter, protein, energy, IgA, Na:K ration were found when analysing sow milk before the 2nd treatment with oxytocin in sows within 12 hours postpartum. This difference was not found in further samples, with the exception for protein and IgA which tended to be higher (Farmer *et al.*, 2017). Low yield colostrum sows hade higher Na:K ration in comparison to high yield colostrum sows the first 24 hours postpartum. The low yield was also characterized by a low production of lactose due to late hormonal changes pre-partum (Foisnet *et al.*, 2010)

In a study aiming to explain whether the decreasing milk yield in cows either depend on increased permeability or decreasing lactose synthesis, analyses from milk and blood were performed for 24 hours after the animals had been injected with 100 IU oxytocin. The lactose level in urine only was one fifth of the total 25 % loss of lactose, and Allen, (1990) suggested that a decrease in lactose synthesis leads to a decreased milk yield when oxytocin was injected. All treated animals had recovered in milk yield and protein content within 24 hours.

3 Material and method

This study was carried out in seven commercial piglet producing herds located in middle part of Sweden from July to September 2017. The litter weight and the litter weight changes during nursing were investigated in three types of nursings; 1) when a sow was treated with oxytocin (ON), 2) the subsequent nursing after oxytocin treatment in the same sow (SN) and 3) control nursing of a sow not treated with oxytocin (CN) (figure 1). The litter weight changes during nursing were measured through the weight-suckle-weigh method at individual piglet level. Observations about the sow- litter and interaction behaviour were recorded in connection to nursing and described further in section 3.3.3. Additionally an interview with open questions about the oxytocin use in the herd was performed (appendix 1). Written and oral information about the study was given to all herdsmen before and at the herd visits.

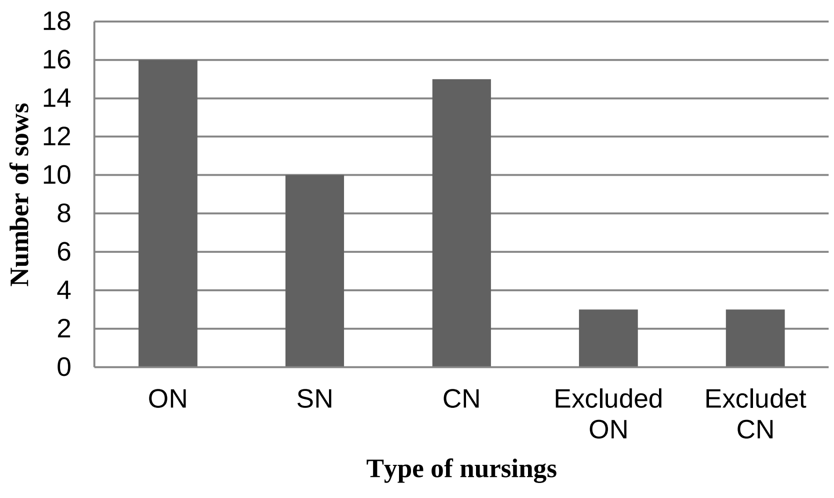

Figure 1. In total 47 nursings were observed on 37 sows; 16 where the sow was treated with oxytocin (ON), 10 after oxytocin treatment in the same sow (SN) and 15 control nursings in sows without oxytocin treatment (CN). In total three sows treated with oxytocin and three control sows were excluded from further analyses.

3.1 Animals

Observations were collected from 37 sows, where six animals were excluded from further analyses, resulted in 31 sows and 41 nursings divided in; 16 ON, 10 SN and 15 CN (figure 1). The reasons for the oxytocin treatments varied between herds since the herdsmen had different routines. Moreover the observations were performed on the animal available the day the research technician visited the herd for data collection. This leads to a large variation in reasons for oxytocin treatment, sows parity numbers, litter size and how many days postpartum the measurement took place. Each sow was only observed for one treatment with oxytocin.

The criteria for an observed nursing to be included in further analyses were that the nursing was performed within four days postpartum, that the nursing was performed within one hour after the first weighing. For an SN to be included, the nursing should be performed within two hours after second weighing in ON, with a clear nursing break between the ON and the SN nursing and no other nursing behaviour occurring between the ON and the SN nursing. The criteria for CN were that the piglets in the litter were in good body condition and the sow was in no need for oxytocin treatment at the observation day. If the visit on the herd was in early or late stage of the group farrowing the animal closest in days postpartum was observed. Some of the excluded sows are described as outliers.

The observed sows were between parity numbers one to eight (figure 2). The average parity number in the ON, SN and CN were 4.1, 3.7 and 3.3 respectively. The sows included in the study were commercial hybrids, i.e crosses between Swedish/Dutch Yorkshire and Norwegian Landrace. Five of the herds in the study bred their own recruitment gilts using criss-cross breeding resulting in a variation of portion of the two dam breeds between 33 % and 66 % of each breed. Two herds bought recruitment gilts from gilt producing herds which produce gilts with a proportion of 50 % of the two dam breeds in the gilts. Of the 31 sows included in the study 77 % were criss-cross sows and 23 % were 50 % two breed sows.

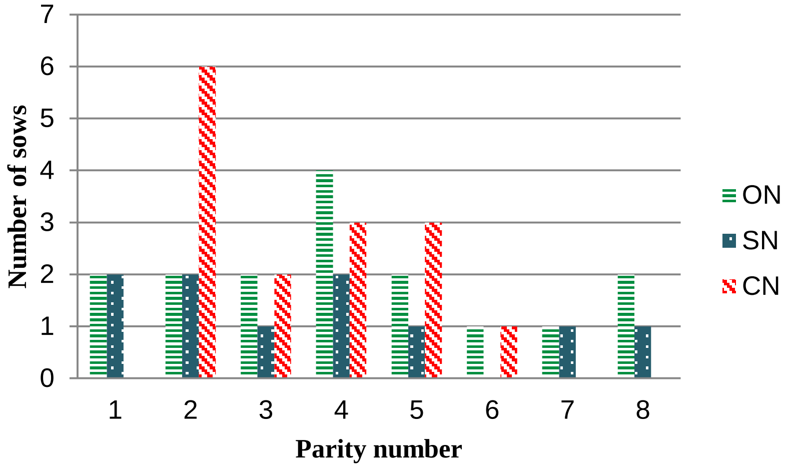

Figure 2. Distribution of parity number on observed sows, in three nursing groups; 16 nursing were the sow was treated with oxytocin (ON), 10 subsequent nursings after oxytocin treatment in the same sow (SN) and 15 control nursings in sows without oxytocin treatment (CN).

3.2 Herds and management routines

Two different herd systems were used in the seven herds studied. Five herds were integrated with farrowing-to-finish systems and with a herd size between 190 and 1200 sows. Two herds were satellite herds belonging to different "sow pools" with a common nucleus herd for dry sows. The satellite herds had room for 36 and 40 sows respectively.

The sows were feed wet-feed two or three times a day the first week postpartum. The piglets had no other feed source than milk from the sows during the period they were studied. Loose-housed individual farrowing pens were used and all pens had a corner with heat-lamp where only the piglets had access. In four of the herds the pen was designed to enable the use of crates, and these were used if needed. All herds used cross-fostering for equalisation of the litter size, where piglets from large litters are moved to a sow with smaller litters. Three herds used split-nursing one day postpartum, where half of the litter is placed under the lamp and separated from the sow while the other half of the litter has the opportunity to nurse.

3.3 Data collection

The data collection was divided into three parts; the first part were focused on collection of general information on the individual sow level, on the herd level and about the oxytocin use in the herd. The second part consisted of data collection of piglet weights for the estimation of litter weight changes, using the WSW method. The third part was to collect information about behaviours in the sow and piglets during nursing. The same research technician performed all recording in all seven herds.

3.3.1 Sow,- herd level and oxytocin use

Information about the sows was collected from sow-cards that were placed outside the pen with written information about the sow and farrowing, or equivalent information from the herd monitoring software WinPig/PigWin. Subjective observation of hoof length, lameness and body condition, was performed according to standardized scales. Hoof length and lameness referred to the sows ability to move without complications. Body condition score were used for a subjective observation of the sows body condition (Lantmännen lantbruk 2011 see Gård&Djurhälsan 2017b) (appendix 2).

To gather information about the herd and management routines around farrowing, herdsmen were interviewed (appendix 1). The interview included question related to:

- The number of sows in the herd
- If the herd was integrated
- Farrowing interval
- Weaning age
- Whether recruitment animals were bought or bred in the herd
- How many times the sows were fed in connection to farrowing
- If the feed was dry or wet
- If the pen was designed to use cages or not
- Use of split nursing and cross-fostering

The herd routines for using oxytocin during disturbed milk let down were investigated. The herdsmen described the use of oxytocin during the interviews and included what clinical signs they used when treating each individual sow, how the followed up the treatment, volume of oxytocin injection and if there were any other drugs used in combination. Oxytocin injections were used in 16 nursings based on herdsmen's decisions. An examination of the udder was performed by research technician before oxytocin injection. The scale used in the study for udder health referred to earlier examinations of sows' udder by technician together with clinical signs described by Penny, (1970). The examination followed a protocol scored between 0 to 3; 0) no visible udder symptoms, 1) the whole udder was tense and hard, 2) the udder was sore and the sow was affected and, 3) the whole udder is tense and have some inflammation in one part of the udder. The four different assessments were further divided in two groups' sows with no udder symptom (NUS) and sows with udder symptom (US).

3.3.2 Weigh-suckle-weigh

Piglet milk consumption was measured by the WSW method in the three nursing groups ON, SN and CN. The recording took place between the farrowing day to four days postpartum (figure 3).

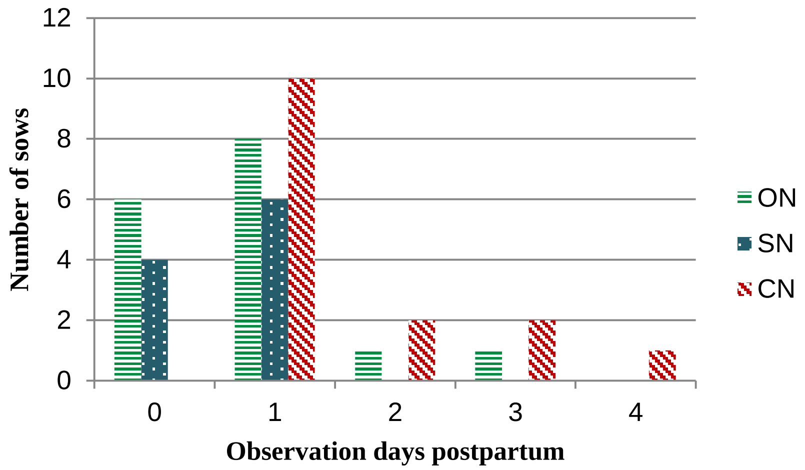

Figure 3. The observation day in relation to parturition day; 16 nursing were the sow was treated with oxytocin (ON), 10 subsequent nursings after oxytocin treatment in the same sow (SN) and 15 control nursings in sows without oxytocin treatment (CN).

Each litter observation started with separation of piglets from their mother. The separation occurred when nursing behaviour was initiated in the nursing groups SN and CN, and when the herdsmen performed oxytocin treatment in the ON group. Piglets were separated from the sow, collected and placed in a wagon or to the piglet corner. The piglets were marked with individual numbers on the back and weighed individually (appendix 3). After weighing the litter was released back to the pen and the mother sow as described in Algers & Jensen, (1991). If the sow needed treatment with oxytocin the injection was performed before the litter was released back to the pen. Recording of the weights was performed using the same type of bag with a weight of 0.07 kg and a luggage scale with two decimals specificity. The weight of the bag was included in the litter weight when analysing the data.

The litter was collected for a second weighing when nursing was performed and only small activity by less than three piglets was seen or the sow were standing up

or lying on her udder. The piglets were weight individually and released directly to the farrowing pen (Algers & Jensen, 1991; Spinka et al., 1997). If nursing was not performed within 60 minutes after the first weighing the nursing was dismissed.
If any other treatment was performed in connection with the weighing it was noted, including information on the drug for pain relief (NSAIDs). All treatment was performed based on the herdsman's decisions and directions from the herd veterinary.

The time was noted both when the piglets were collected for the first weighing, when oxytocin injection was performed, when all piglets were released back in the pen to the sow, when the nursing started and ended, when all the piglet were collected for the second weighing and when the entire litter was back in the pen (appendix 3).

3.3.3 Behaviour in connection to nursing

Observation about the sow-, litter- and interaction behaviour in the pen was recorded, using a protocol with different assessment criteria (appendix 4). The sow and litter behaviour were recorded before first weighing and nursing behaviour were recorded in connection to nursing. When subsequent nursings were observed the time between two nursings was included in the measurement

The protocol used for sow behaviour had a scale from 0 to 3 were; 0) lying on the side with the udder available for the litter and react on the moving piglets and lie down on the side, 1) lying on the stomach, the udder not available for the litter, reluctant moving to the side when entire litter is up and moving around, 2) lying on the stomach and no reaction on the piglet, 3) performed angry behaviour against the piglets. It was noted whether the sow was standing up between pre-nursing weighing and nursing.

In connection to the sow behaviour, the behaviour of the litter was observed and scored on a scale from 0 to 3 scales; 0) all piglets lie under the lamp, well spread and good body condition, 1) piglets moving around, screaming, good body condition, 2) piglets lie close to the sow or on each other, poor body condition and, 3) piglets gives up, go back under the lamp or lay down in the box. Observation of nursing behaviour started when the piglets and the sow was reunited after the first weighing. The nursing was also evaluated and scored; 0) piglet or sow induces nursing; all piglets become active and the nursing is completed, 1) piglet or sow induce nursing, the nursing is incomplete by sow laying on the udder/standing up and 2) piglet or sow induce nursing, sow stand up and start grab after piglet.

Once a nursing was initiated by the sow or the piglets, the nursing behaviour was recorded in detail. The recordings done were initiation of the nursing (piglet or sow), time of milk let down, and terminator of the nursing (sow or piglet). Piglet initiated nursings were characterised by piglets becoming active around the udder and squealing, and initiation to nursing by the sow were characterised by sow grunting, exposure the udder as described by Ellendorff et al., (1982). Increase in rhythmical grount was recorded as an indication of milk let down. The nursing was considered to be terminated when the activity at the udder had decreased and only on one to three piglets was seen active at the udder, or the sow stood up or hide the udder by lying laterally as describe in Algers & Jensen, (1991). The protocol was developed during the study and some assessments were not performed for all nursings.

3.4 Data analyses

Statistical analyses were performed on 41 nursings: 16 ON, 10 SN and 15 CN. The samples were plotted in a histogram for the variables of interest to analyse; weight of the litter, weight spread within litter, weight changes at nursing, spread in weight changes within litter and percent of weight change. All variables showed to be approximately normal distributed with approximately equal variance in the groups compared (i.e. no standard derivations more than double the size of the other groups standard derivation), and thus fulfilling the requirements of two-sample t-test analyses. Analyses were performed in two steps: first to determine if there were any pairwise differences between ON, SN and CN and secondly to analyse whether there were any differences within the ON group divided in sows with or without udder symptom (NUS and US). The recordings done for initiation of the nursing (piglet or sow), time of milk let down, and terminator of the nursing (sow or piglet) were excluded in the analyses.

Weight of the litter was calculated by summing the weights of the individual piglets' weights. This weight was divided on the litter size to determine the mean piglet weight in each litter, which were used in the statistical analyses.

Weight spread within litter was calculated using the standard deviation of piglets' weights in the litter, and the standard deviation was used in statistical analyses.

Weight changes during nursing was calculated by subtracting post-nursing weight with pre-nursing weight at individual piglet level and summarize and divide on litter size which was used in the statistical analyses.

The spread in weight changes within litter was calculated using standard deviation based on piglets weight changes between pre-nursing and post-nursing, which were used in the statistical analyses.

Percent of weight changes was calculated with the formula (mean litter weight change)/(mean litter pre-nursing weight)*100 and the present weight change was used in the statistical analyses.

The hypothesis tested using two-sample t-test between ON, SN and CN with the variables; weight of the litter, weight spread within litter, weight changes at nursing, spread in weight changes within litter and percent of weight changes, was:
H_0= There is no difference in weight between ON, SN and CN.
H_1= There is a difference in weight between ON, SN and CN.

The hypothesis tested using a two-sample t-test differences in weight of the litter, weight spread within litter, weight changes at nursing, spread in weight changes within litter and percent of weight change between NUS and US was:
H_0= There is no difference between oxytocin treated sows with NUS and US.
H_1= There is a difference between oxytocin treated sows with NUS and US.

Microsoft Office Excel 2010 was used for storage, editing, calculations of descriptive statistics and construction of diagrams. Two-sample t-test and histogram were performed in the statistical program, Minitab Statistical Software (2010).

4 Results

The analyses of the weight changes were performed in two phases. Initially a comparison was made between the three nursing types; 1) when a sow were treated with oxytocin (ON), 2) the subsequent nursing after oxytocin injection (SN) and 3) control nursing in a sow without oxytocin treatment (CN). In a second analyse were ON group divided further, sows without udder symptom (NUS) and sows with udder symptom (US).

4.1 Comparison between nursing types (ON, SN and CN)

The average number of live-born piglets was 13.9 in the ON group and 15.9 in the CN group (table 1).

Table 1. The numbers of live-born piglets in nursing were the sow was treated with oxytocin (ON), and control nursings in sows without oxytocin treatment (CN).

Nursing	Observations	≥14 piglets	<14 piglets	Average (piglets)	StDev
ON	16	62.5 %	37.5%	13.9	4.05*
CN	15	86.7%	13.3%	15.9	1.68

*One sow hade three live born piglets

Average time between weighing one and weighing two when performing WSW ranged between 19.7 minutes in the SN and 26.1 minutes in the ON (table 2). The time between the first weighing in ON and SN (between the first and the subsequent nursing) were in nine nursings on average 69.6 minutes.

Table 2. The time between when litter were released back in the pen after weighing to when the litter was back to the collection space after post-nursing weighing, in nursing were the sow was treated with oxytocin (ON), subsequent nursings after oxytocin treatment in the same sow (SN) and control nursings in sows without oxytocin treatment (CN), and the time between when the litter was placed in the collection space for the first weighing in ON and SN.

Nursing	**Observations**	**Average min.**	**StDev**
ON	16.0	26.1	16.04
SN	10.0	19.7	12.61
CN	15.0	22.9	16.02
Time between ON and SN	9.0	69.6	20.16

The percent of sows standing up between the first weighing and nursing in the three nursing groups ON, SN and CN (figure 4).

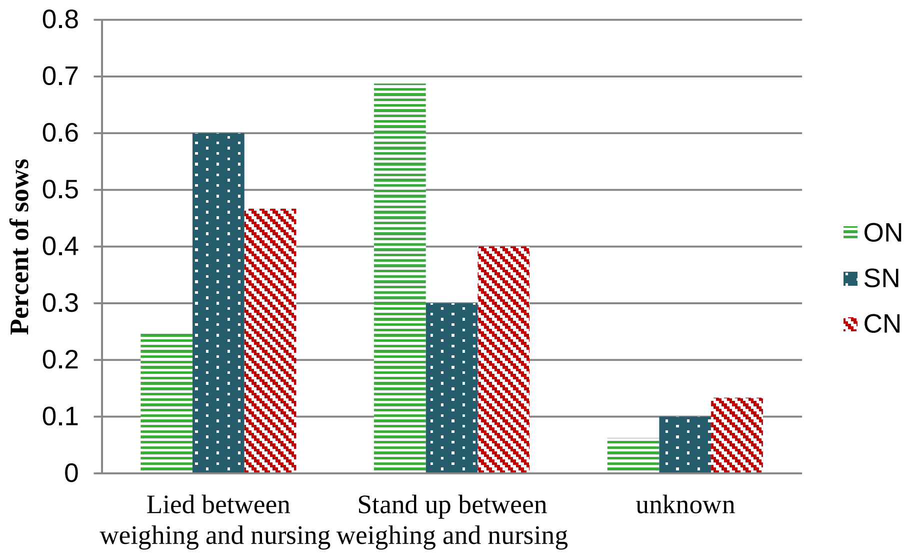

Figure 4. Percentage of sows standing up or lying down between weighing and nursing in three nursing groups; nursing were the sow was treated with oxytocin (ON), subsequent nursings after oxytocin treatment in the same sow (SN) and control nursings in sows without oxytocin treatment (CN).

4.1.1 Piglets weight and weight within litter

Comparison of the average piglet weights between the nursings groups ON, SN and CN showed equal weights in the three nursings groups. The mean weight ranged from 1711 g in SN to 1829 g in CN (figure 5 and table 3). Numerical, but not significant differences were found when weight spread within litter was compared between the three nursing groups. The ON group had least average weight spread within litter on 313 g with a StDev on 76 g (figure 5 and table 3).

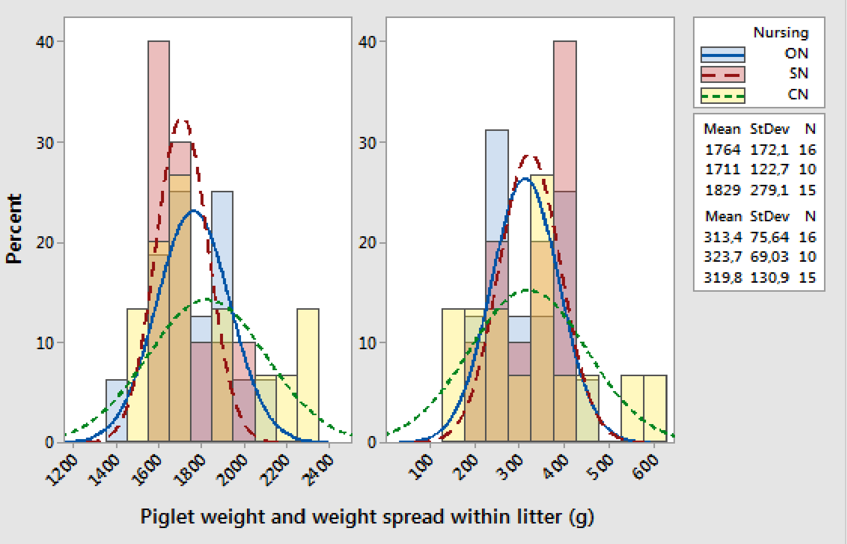

Figure 5. The left histogram show the piglet weight (g) and the right histogram show the weight spread (StDev) within litter (g) in nursing were the sow was treated with oxytocin (ON), subsequent nursings after oxytocin treatment in the same sow (SN) and control nursings in sows without oxytocin treatment (CN).

4.1.2 Weight changes during nursing and weight within litter

Mean weight changes in ON, SN and CN nursing were 13 g, 16 g and 12 g respectively. The weight spread within litter was found to have a mean value on 36 g, 29 g and 30 g respectively. Numerical differences were found, in mean weight changes and spread in mean weight changes between the three nursing groups ON, SN and CN (figure 6 and table 3).

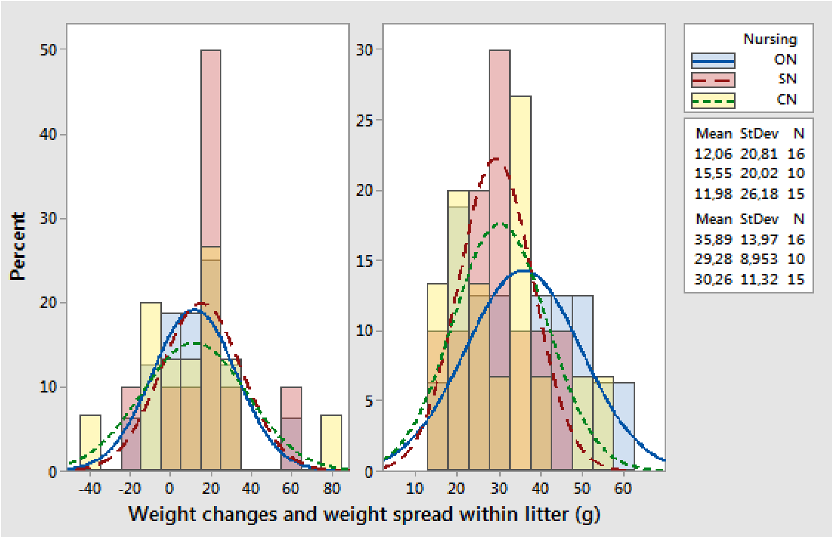

Figure 6. The left histogram show the piglet weight changes (g) and the right histogram show the spread in weight changes within litter (g) (StDev) in nursing were the sow was treated with oxytocin (ON), subsequent nursings after oxytocin treatment in the same sow (SN) and control nursings in sows without oxytocin treatment (CN).

4.1.3 Percent of weight change

Comparison in percentage of weight change of pre-nursing weight between the nursing groups ON, SN and CN showed equal changes between the three nursing groups (figure 7 and table 3).

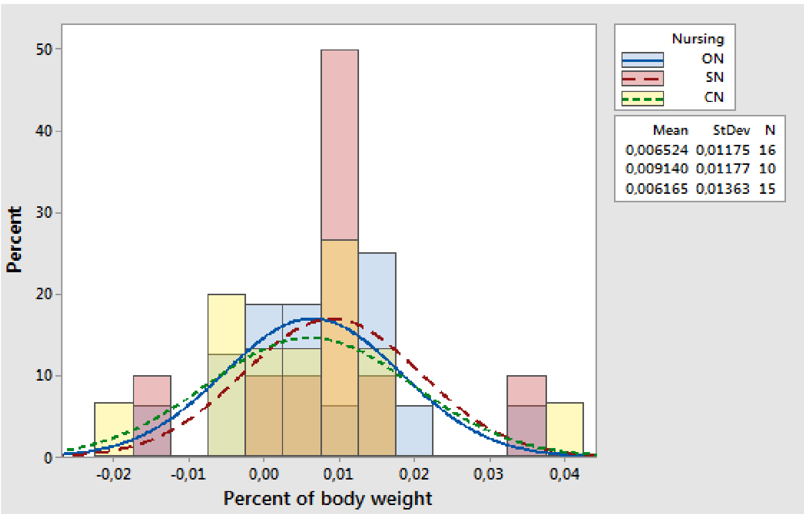

Figure 7. The average post-nursing litter weight presented as percent of litter weight changes from average pre-nursing weight in nursing were the sow was treated with oxytocin (ON), subsequent nursings after oxytocin treatment in the same sow (SN) and control nursings in sows without oxytocin treatment (CN).

Tabell 3. Mean value, 95% CI for differences and P-value for the three nursing groups in 16 nursing were the sow was treated with oxytocin (ON), 10 subsequent nursings after oxytocin treatment in the same sow (SN) 15 and control nursings in sows without oxytocin treatment (CN).

	Nursings	Mean values (g)	T-value	95 % CI	P-value
Piglet weight (g)	ON and SN	1764 and 1711	0.93	-66.1;173.7	0.363
	ON and CN	1764 and 1829	-0.77	-238.4; 108.8	0.448
	SN and CN	1711 and 1829	-1.45	-289.3; 52.1	0.163
Weight spread within litter (g)	ON and SN	313 and 324	-0.36	-70.6; 49.9	0.724
	ON and CN	313 and 320	-0.17	-86.8; 73.8	0.869
	SN and CN	324 and 320	0.10	-79.6; 87.3	0.924
Weight change (g)	ON and SN	12 and 16	0.43	-20.5; 13.7	0.675
	ON and CN	12 and 12	0.01	-17.5; 17.6	0.992
	SN and CN	16 and 12	0.39	-15.6; 22.8	0.703
Weight spread changes (g)	ON and SN	36 and 29	1.47	-2.7;15.9	0.155
	ON and CN	36 and 30	1.24	-3.7; 15.0	0.226
	SN and CN	29 and 30	-0.24	-9.4; 7.5	0.813
Percent of body weight	OT and SN	0.65 and 0.91	-0.55	-0.0125; 0.0073	0.588
	OT and CN	0.65 and 0.62	0.08	-0.0091; 0.0098	0.928
	SN and CN	0.91 and 0.62	0.58	-0.0079; 0.0136	0.568

4.2 Comparison between nursing types (NUS and US)

Observations of the sow and litters behaviour in connection to nursing were recorded in the group ON (table 4).

Table 4. Observation of the behaviour before nursing in the ON group and in the NUS and US groups.

	Score*	ON (%)	NUS (%)	US (%)
Piglet behaviour (%)	0	43.8	75.0	12.5
	1	25	0	50
	2	31.2	25.0	37.5
Sow behaviour (%)	0	37.5	62.5	12.5
	1	18.8	25.0	12.5
	2	43.8	12.5	75.0

*The different score in piglet behaviour; 0) lay under the lamp, well spread and in good body condition, 1) piglets moving around in the pen, screaming and in good body condition and, 2) the litter were found to lie close to the sow in the pen or close to each other with bad body condition. The sow behaviours were; 0) sow lied on the side with the udder available for the piglet, 1) sow lying on the udder and reluctant moving to the side when piglets were active around her in the pen and, 2) sow lied on the udder without reaction on the active piglets in the pen.

Six herdsmen used oxytocin to treat disturbed milk let down on routine and one herdsman were not using oxytocin to treat udder diseases. Routines to follow up the oxytocin treatment were performed next time someone passed the pen with the sow in three herds or the next day in three herds. The quantity of oxytocin injection was 2 ml on two herds, 2 ml to small sows and higher quantity oxytocin (2.5 to 3 ml) to larger sows in three herds and 1 ml oxytocin were given in one herd. In connection with the intramuscular oxytocin injection were NSAIDs given to 75 % of the oxytocin treated sows. Criteria for treating the sow with oxytocin differed between the herdsmen (figure 8). Different combinations of symptoms were used for treatment at the herds, three different combinations found were; 1) hard and swollen udder together with weak piglets, 2) reduced general condition without fever and 3) weak piglets and loosed appetite with a body temperature over 38.8°C.

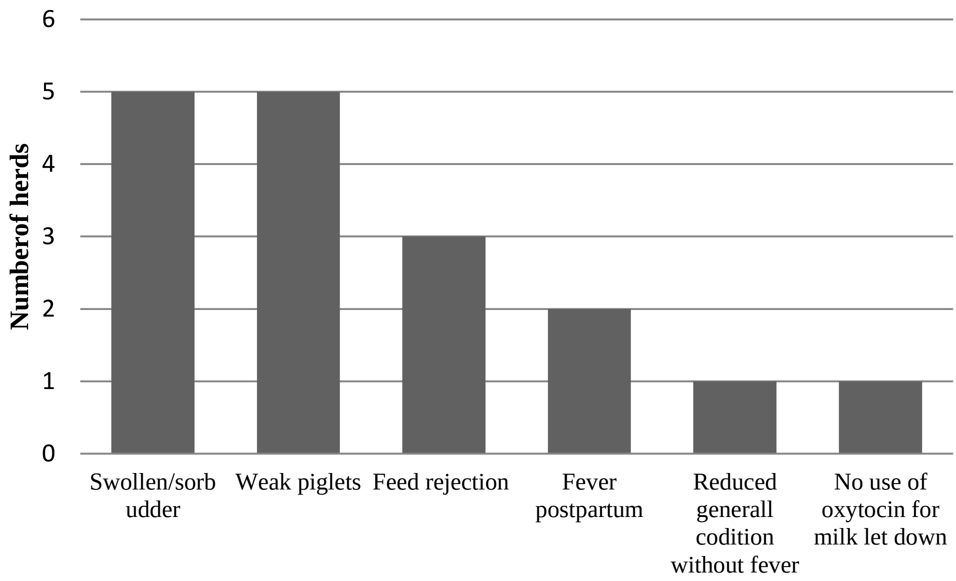

Figure 8. The criteria for treatment of sows the herdsmen used when treated sows in the herd. Some symptoms appeared together, and some did not.

Examination of the udder before oxytocin treatment in 16 sows by the research technician, resulted in 50 % with no udder symptom, 32 % were the whole udder was tense and hard, 13 % where the sow clearly was affected with a sore udder and 6.3 % where the whole udder was tense and some udder part had signs of inflammation:, red, heat, hard and swollen. The different assessments were divided in eight sows with NUS and eight sows with US. Observation day in relation to birth day in the two groups were recorded (table 5).

Table 5. Observation day in relation to parturition day in the groups; 8 nursing without udder symptom (NUS) and 8 nursing with udder symptom (US).

Observation day postpartum	**NUS (%)**	**US (%)**
0	25.0	50
1	62.5	37.5
2	0.0	12.5
3	12.5	0.0

4.2.1 Litter weight and weight within litter

Comparison of piglet pre-nursing weights between NUS and US showed insignificant, but numerical differences between the two groups. The mean values were found to be 1716 g in the group NUS with eight nursings and in the group US

1813 g with eight nursings (figure 9 and table 6). Comparison of the spread in the pre-nursing weights in the two nursing groups NUS and US are present in figure 10 and table 6. No significant differences between the two groups were evident but the graph indicates a wider spread in US group. Eight nursings were recorded in each group with an average spread in weight within litter on 285 g in NUS and 342 g in US (figure 9 and table 6).

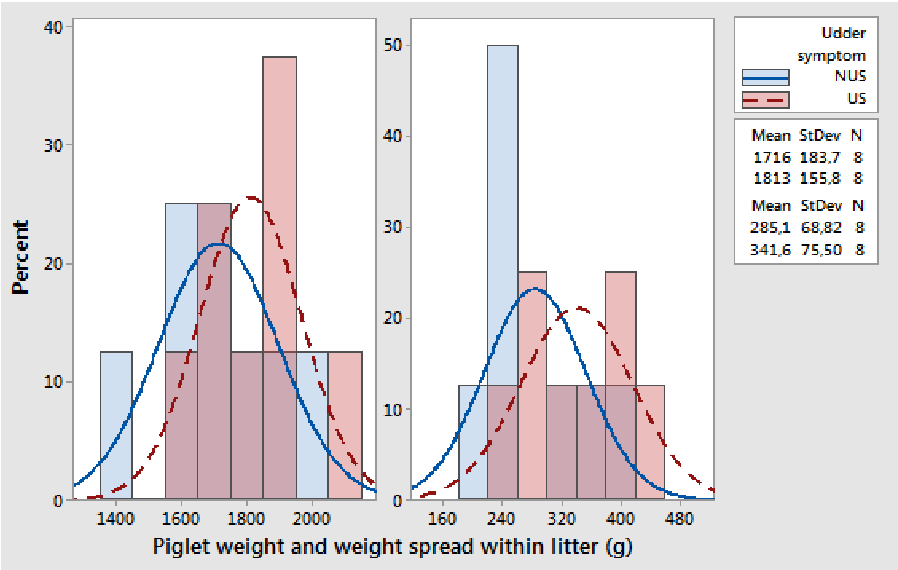

Figure 9. The left histogram show average pre-nursing piglet weights (g) in the two groups nursing without udder symptom (NUS) and nursing with udder symptom (US). The right histogram show spread in pre-nursing weight (g) within litter for the two groups NUS and US.

4.2.2 Weight changes and weight within litter

A comparison of mean litter weight change, expressed as difference in weight before and after nursing between the two groups NUS and US shoved numerical differences between the two nursings. The mean weight change is in the NUS group which included eight nursings was 7 g and in the US group which included eight nursings were 17 g. The spread in weight changes within litter at nursings were compared between the two groups NUS and US and numerical but not significant differences in weight changes between the two groups were found, with a mean value on 32 g and 40 g respectively (figure 10 and table 6).

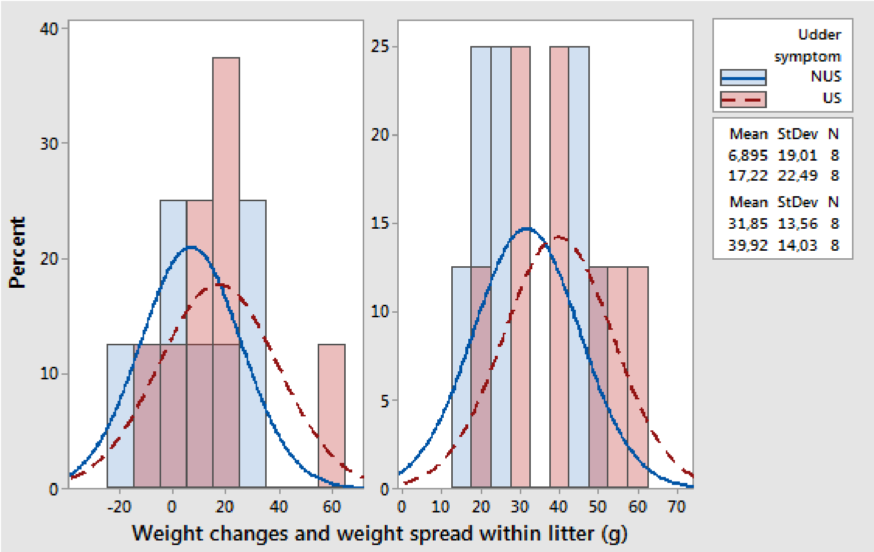

Figure 10. The left histogram show average piglet weights change (g) in the two groups nursing without udder symptom (NUS) and nursing with udder symptom (US). The right histogram shows weight spread (g) within litter for the two groups NUS and US.

4.2.3 Percent of weight change

Comparison of piglet weight changes in percent between the two groups NUS and US did show numerical but not significant differences between the two groups (figure 11 and table 6).

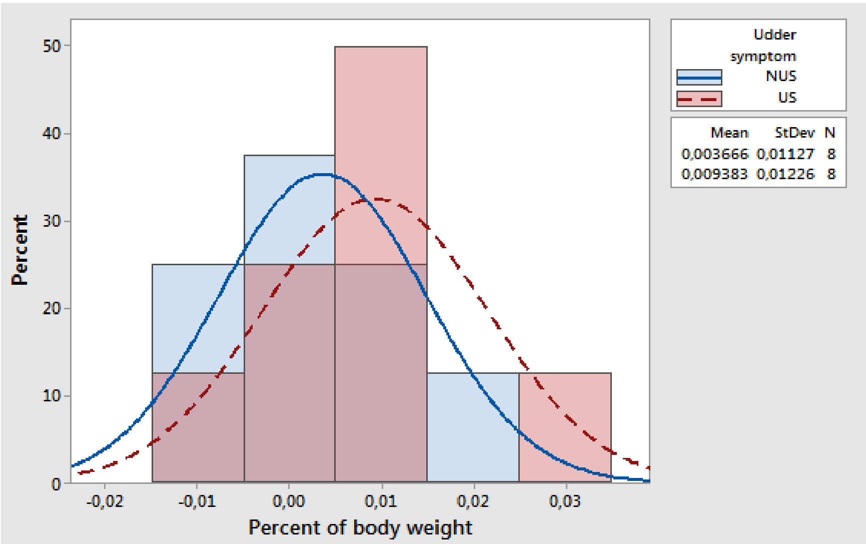

Figure 11. The average post-nursing litter weight present as percent of litter weight changes from average pre-nursing weight in the two groups nursing without udder symptom (NUS) and nursing with udder symptom (US).

Tabell 6. Mean value, 95% CI for difference and P-value in comparison between the two groups nursing without udder symptom (NUS) and nursing with udder symptom (US) with eight nursing in each group.

Variable	**Mean values NUS and US**	**T-value**	**95 % CI NUS and US**	**P-value**
Piglet weight (g)	1716 and 1813	-1.15	-281.7; 86.3	0.272
Spread in weight (g)	285 and 342	-1.56	-134.5;21.6	0.142
Weight change (g)	7 and 17	-0.99	-32.8;12.2	0.339
Spread in weight changes (g)	32 and 40	-1.17	-23.0; 6.8	0.263
Percent of body weight	0.0037 and 0.0094	-0.97	-0.0184;0.007	0.349

4.3 Special cases

In this section, the cases of four outlier sows that were excluded from the data statistically will be described.

Case 1

The sow was treated because the staff found the piglets to be in bad body condition, and because piglets were lying close and on top of each other under the heat-lamp and the sow was lying on the udder without reaction when the piglet were active around her. Treatment used was oxytocin in combination with NSAIDs. The sow was standing up after treatment and did not perform any nursing. The herdsman repeated the treatment after 20 minutes. Milk dropped from the udder on to the floor, but the sow was not lying down to expose the udder for the litter and did not perform nursing standing up. The piglets were weak and spent most of the time under the heat-lamp in piglet corner

Case 2

The sow was treated because the piglets had poor body condition, and were lying close and on top of each other under the heat-lamp and the sow was laying on the udder without reaction when the piglet were active around her. Treatment used was oxytocin in combination with NSAIDs. The injection was performed when the sow was standing up, and she did not lay down the following two hours, and no nursings were achieved. Milk was found when palpating the udder 10 minutes after oxytocin injection. The piglets repeated their attempts to initiate nursing but the sow did not respond.

Case 3

The sow was treated because one part of the udder was hard. Drugs used were NSAIDs and after half an hour oxytocin was injected. This treatment was repeated for two following days and both treatments were observed. The observation day two to was excluded from the statistical analysis, to avoid the impact which the first treatment may have.

Case 4

The sow was treated because the piglets were in poor body conditions, were lying close and on top of each other under the heat-lamp and the sow was lying on the udder without reaction when the piglet were active around her. Oxytocin and NSAIDs were the drugs used for treatment. Only one nursing was observed because the time to initiation the subsequent nursing was exceeded.

5 Discussion

The aim of the study was to map piglet's milk intake in connection to intramuscular (i.m) oxytocin injection in sows. The milk intake was measured using the method weight-suckle-weight (WSW), and a second aim was to assess this method of measuring piglet milk intake under commercial piglet production conditions. Piglet's weight and weight changes were investigated in three different nursing types; 1) when a sow was treated with oxytocin (ON), 2) the subsequent nursing after oxytocin injection (SN) and 3) control nursing in a sow without oxytocin treatment (CN). In a second analysis the ON group was divided further, into either sows without udder symptom (NUS) or sows with udder symptom (US). A relatively low number, 31 sows, from seven different herds were included in the study. The unequal production environment, management and symptom for treatment of sow's influence the results and consequently the results from this pilot-study should mainly be considered as descriptive and a first indication of how oxytocin treatment affect piglet milk intake.

5.1 Comparison between nursing groups (ON, SN and CN)

The piglet weight and weight spread within litter were numerically different between CN and the other nursing types (ON and SN) (figure 5). Numerical differences were also found between the ON group and the other two groups (SN and CN) when comparing the spread in weight change within litter, and the ON had the numerical higher mean value and variation (StDev) (figure 6). Altogether, the piglet weight and the weight spread were lower in the ON compared to CN, and the weight change and spread in weight change were higher in ON group compared to the CN group. This may indicate that weight spread was not found to have the main influence on the spread in weight change. The number of sows standing up (figure 4) when preforming the method weight-suckle-weight and time between weighing's (table 2) were found to be higher in the ON group compared to the other groups. The longer time between weightings in the ON group was either an effect of increased nursing time or an increased time before nursing was induced after the first weighing.

Piglet weight and weight within litter

No significant differences were found between the three groups ON, SN and CN in piglet weights and weight spread within litter (figure 5). The variation (StDev) was found to be numerically higher in CN compared to ON and SN. This could be interpreted as higher difference within the CN group and also higher within litter variation. Observation day postpartum differed between the three groups; ON was observed at farrowing day to three days postpartum, SN group were observed at the farrowing day to one day postpartum and CN group were observed between one day to four day postpartum (figure 3). The difference in observation day in relation to parturition day between the groups is one possible reason for the wider spread in piglet weight and weight spread within litter in the CN group.

Differences between the nursing groups ON and CN in distribution of the average live-born piglets were found be 13.9 and 15.9 piglets respectively (table 1). The Swedish average 2016 were 14.0 piglets (Gård&Djurhälsa 2017a) which is compatibility with the ON group while the CN hade 1.9 live-born piglets higher than average. Increased litter size has been found to increase the competition at the udder (Andersen *et al.*, 2011), which may think affect the milk consumption and weight gain. The numerically higher live-born piglets in the CN group are suggested to be another reason for the difference in weight variation between the three groups in that larger litters often are associated with increased variation within litter (Quiniou *et al.*, 2002).

Weight changes during nursing

The mean weight changes were found to be 12 g, 16 g and 12 g in the three nursing groups ON, SN and CN, respectively (figure 6). This is low compared with earlier studies, in which the method WSW was used, an where weight gain the first three days postpartum ranged between 15 to 25 g (Algers & Jensen, 1991; Spinka *et al.*, 1997). Consideration about the environment and the health status of the sow need to be taken when compared the weight changes. These previously mention studies were performed under experimented conditions, and on healthy sows (Algers & Jensen, 1991; Spinka *et al.*, 1997), and the weight change in this study were collected in commercial piglet production and on both healthy sows and sows treated for udder diseases. Speer & Cox, (1984) found lower piglet weight gains when using the method WSW in the first nursing, compared to the following eight, and suggested that collection of the piglet close to previously nursing could be the reason. Considering that the weight is slightly higher in the SN group, the group weight for the second nursing, this may be one explanation.

Spread in weight changes

Numerical indications of differences were found when the weight spread within litter between the ON group and the two groups SN and CN was compared, with higher mean weight gain and variation (StDev) (figure 6). The teat order is established during the first days postpartum (De Passille & Rushen, 1989) and fight over teats increase the activity and the energy losses (Andersen *et al.*, 2011). Assuming that the higher weight spread within litter is connected to the quantity of milk consumption for each piglet, the milk let down or piglet consumption rate, or a combination of both, is one possible reason. Increasing litter size in relationship with available functional teats may be a limiting factor for all piglets to increase in weight and could also be one reason for the variation in weight spread within litter.

The sows in the ON group were considered by the herdsmen to have disturbed milk let down and were treated with oxytocin. Oxytocin have been found to affect the milk let down in cows by enhancing the contraction of the myoepithelial cells (Mačuhová *et al.*, 2004). Sows lack milk cisterns and contractions of myoepithelial cells may lead to available milk for the piglets without initiation of nursing by the sow. Hungry piglets were in a higher rate found close to the sow (Weary *et al.*, 1996) and these piglets would in that case have an advantage and increases its milk consumption and contribute to the numerical higher variation (StDev) in weight change (figure 6). The variation within litter may also case a variation in the weight change at nursing, litter size and birth weight is mention in a review by Farmer, (2006) to be the main factors for the colostrum intake over 24 hours postpartum. Further were heavier piglets explained to be able to extracting more milk compared to lighter siblings this period.

Time and behaviour recordings

Sows activity and the time were recorded between the weightings when the WSW method was performed. The ON group had a higher average time between the weightings compared to the other two nursing groups (SN and CN), and the SN group had the shortest average time (table 2). The sows in the ON group were also found to stand up a larger portion of times compared to the other two nursing groups (SN and CN) (figure 4). The increased time found in the ON group between weightings may be explained by; 1) an increased time before the sow laid down and performed nursing, 2) an increased nursing time including pre-massage, milk let down and post-massage, 3) or a combination of both. Considering that a higher percent of the sows were found to stand up between weightings in the ON group, this probably influenced the increased time between weighing and nursing found in the group. Injection of oxytocin was performed after the weighing and some sows reacted by standing up.

Excluded measurements

The changes in nursing behaviour were hard to distinguish from pre- and-post nursing behaviour, as nursing patterns had not been completely established when WSW was performed, and those results were therefore dismissed from further analysis. Piglets start to initiate teat stimulation approximately after 5.5 to 16.0 hours (Lewis & Hurnik, 1985; Spinka & Illmann, 2014) and synchronization of the nursing by litter remain low the first day postpartum (Jensen *et al.*, 1991). The development of the nursing pattern may be one reason for problem to distinguish when the sow performed milk let down. The natural milk let down have duration between 6 to 40 seconds (Ellendorff *et al.*, 1982; Kent *et al.*, 2003). Cows treated with oxytocin have been found to have a prolonged contraction of their myoepithelial cells (Mačuhová *et al.*, 2004). The sow lacks a milk cistern and treatment with oxytocin may increase the time for milk let down. Registration of the initiation of nursing was excluded because of the use of split nursing on some farms. Some sows were in cages and some lose in the pen which may have affected whether the sow or piglet terminated the nursing.

5.2 Comparison between nursing groups (NUS and US)

Only numerical differences were found when comparing the NUS and US group, when the following five different variables were analysed; weight of the litter, weight spread within litter, weight changes at nursing, spread in weight changes within litter and percent of weight changes. The NUS group had a numerical lower number in the all the analyses compared to the US group, which indicate a lower and more even litter size and also lower and more even weight change at nursing in this group. The US group had numerical heavier piglets, a wider weight spread within litter, and a higher and more uneven weight change at nursing. The criteria for treatment of sows were found to differ between the herds in the study and this affect the cause of treatment for the observed sows and influence the results of the study. It would be interesting to further investigate the oxytocin use on Swedish herds, and to also include criteria used for treatment.

Litter weight and weight within litter

When the litter weight between the two nursing groups NUS and US were compared, no significant differences were found (figure 9). Although insignificant, the numerical differences that were found indicate that piglets in the NUS litters had lower weights before the nursing and lower variation in piglet weight within the litter compared to the US litter. All observations were performed within three days from parturition and the numeric differences in litter weight between the two groups can be suggested to depend mainly on differences in birth weight. The more even litter weight found in the NUS group, can be suggested to affect the lower weigh spread within litter size.

Weight change and weight within litter

When the weight change and the weight spread in the two nursing groups were compared, NUS and US showed no significant differences between the two groups. However, numerical differences were found, which may indicate that piglets in the NUS group gained less weight and had lower spread within litter (figure 10).

The lactation stage lactogenesis is separated in two stages lactogensis 1 and lactogenesis 2 (Hartmann, 1973; Theil *et al.*, 2014). Induction of lactogenesis 2 have been suggested to be recognised like a rapid change in the milk yield (Theil *et al.*, 2014) and is further linked to the closure of the dynamic structures between the secretory cells, called tight junctions (Nguyen & Neville, 1998). All observations were performed on the parturition day to three days postpartum, and 25 % of the NUS and 50 % of the US observation were performed on the parturition day (table 5). A higher portion of sows in the NUS group were observed later in relation to parturition day compared to the US group where half of the sows were observed on the parturition day. This indicate that higher portion of the sows in NUS group would be in lactogenesis 2 with an increased milk yield, compared to the US group. The statistical analyses found numerical higher weight changes in the US group and not in the NUS group.

The nursing interval has been found to affect piglets' weight gain; piglets gain less weigh at every nursing on shorter intervals (every 35 minutes) compared to long intervals (every 70 minutes). Weighing after 24 hours with short intervals showed a total higher weight gain compared to long nursing intervals (Spinka *et al.*, 1997). Analyses were performed on only one nursing in this study and long term effects of the oxytocin treatment were not recorded. Recording of the sow behaviour showed that 44 % of the sows in the ON group lied on the udder in the pen without reaction on the active piglets around them. This group was further divided into; the NUS group with 6 % and the US group with 38 % with the sows lying on the udder. The litter behaviour was observed and 13 % of the sows in the NUS group were found to have a litter in bad body condition lying close to the sow, and the same condition was found in 75 % of the litters in the US group (table 4). The sows in the NUS group were probably carrying out a more regular nursing pattern compared to the US group. One reason for the slightly higher weight gain in the US group can be an increased nursing interval.

Percent of weight changes

No significant differences were found between the two groups in change in percent of body weight. Same pattern were found as described in previously results on weight change and spread within litters, with numerically lower percentage of weight change in the NUS group compared to the US group (Figure 11).

Special cases

Two sows treated with oxytocin did not nurse during the observation time and were excluded from statistical analyses. Both sows were treated with NSAIDs in combination with oxytocin, and one sow was given a second dosage of oxytocin 20 minutes after the first injection. The sows were standing up when injections were deposited. Differences between the litters were observed; one litter was weak and the piglets were lying under the heat lamp, and the piglets of the other litter were attempting to perform nursing. Andersen *et al.*, (2011) concluded that the aggressive rivalry performed by the piglet over the teat ownership, may lead to pain for the sow and unsuccessful nursings. Injections with oxytocin and NSAIDs were not always found to lead to nursing. Further research is needed about the treatment with oxytocin for better understanding how the sow best deposit oxytocin for a successful nursing.

5.3 Weigh-suckle-weigh method

The litter weight change in connection to nursing is an indirect method to measure the sow milk production. WSW was used in this study on Swedish conventional piglet producing herds for one or two subsequent nursings. Analyses of the data were performed without considerations taken to fecal, urine, metabolic or heat losses. The method have been found to underestimate the sows milk production when corrections for fecal and urine losses were made but not for metabolic and heat losses (Pettigrew *et al.*, 1985). The first nursing was found to have significant lower weight change when the WSW was used (Speer & Cox, 1984). For more precise estimation of sow milk production, a more developed WSW method should be implemented in an equal environment. Long term effect of oxytocin treatment, piglet survival and daily weight gain, would be interesting aspect to study further to increase the knowledge about the use of oxytocin.

6 Conclusion

Numerical, but not significant, differences in the spread in weight change were found between sows treated with intramuscular oxytocin injections and sows not treated with oxytocin in commercial piglet production herds. Numerical differences were further found between sows without udder symptoms and sows with udder symptoms, for the following variables; weight of the litter, weight spread within litter, weight changes at nursing, spread in weight changes within litter and percent of weight changes. Due to the field conditions and relatively low number of observations in this pilot study, there were no statistical significant differences found between the nursing groups. However, the results of this pilot study indicate that intramuscular oxytocin injection may have a positive effect on the sows milk production in sows with clear udder symptom, but not in sows without udder symptoms.

Intramuscular oxytocin injections did not always result in nursing. The injection should be applied when clear symptoms are recognized and should be followed up shortly after the injection to ensure successful nursing.

The experiences from this master thesis study suggest that the effects of intramuscular oxytocin injections in commercial production can be investigated by observing the sows nursing behaviour in connection to the treatment. To obtain information about the sow milk production more in detail, the method weigh-suckle-weigh should be performed under more experimental conditions, and also include long term effects of the treatment.

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Appendix 1

To gather information about the herd and management routines around farrowing, herdsmen were interviewed. Additionally an interview with open questions about the oxytocin use in the herd was performed.

Herd:

Datum	
Owner	
Number of sows	
Integrated	
Farrowing interval	
Nursing time	
Recruitment gilts	
Wet or dry feed	
Number of feedings/day	
Cage	
Split nursing	
Cross-fostering	

Oxytocin use in the herd

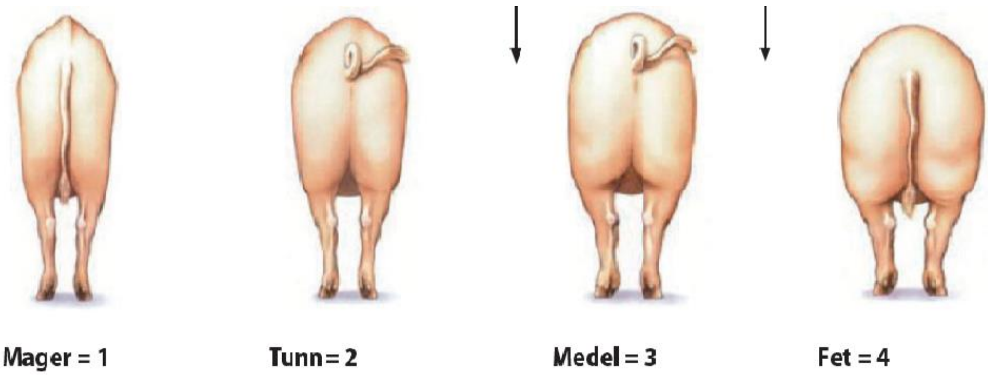
Used as treatment for udder diseases	
Symptom	
Number of injections	
In combination with other drugs	
Follow up the injection	
Dosage	

Appendix 2

The different assessment used when score the sow performance

Body condition:

1. Visually thin: with prominent hips and back bone, back fat thickness <10mm
2. Thin: hipbones and backbones are felt whit the hands, back fat thickness, 14mm
3. Middle: Hard pressure is needed to feel the hipbones and backbones, back fat thickness, 17mm
4. Fat: cannot feel the bones, back fat thikness, >20 mm



From: (Lantmännen lantbruk 2011 see Gård&Djurhälsan 2017b).

Hoof length

0. The hoof length do not disturb the sows movements
1. The hoof length disturb the sows movements
2. The hoof length is obvious disturb the sows movements

Lameness

0. No lamensess
1. Lamensess
2. Clear lamensess

Udder health

0. No visible symptom
1. The hole udder was tens and hard
2. The udder was sore and the sow was affected
3. The hole udder is tens and have some inflammation in one pert of the udder

Appendix 3

The piglets were numerated on the back and weighed individually and the weight was recorded and the time recording when WSW were performed.

Sow:						Sow:			
Nursing 1 injection			Nursing 2			Nursing 3 Control			
	Before nursing	After nursing	Before nursing	After nursing	D		Before nursing	After nursing	D
1						1			
2						2			
3						3			
4						4			
5						5			
6						6			
7						7			
8						8			
9						9			
10						10			
11						11			
12						12			
∑		∑	∑	∑		∑		∑	

Time recordings

	Nursing 1	Nursing 2	Nursing 3
1.Collected in cage	start	start	Start
2.Back in pen			
3.Injection			
4.Milk let down			
5.Collected in cage			
6.Back in pen			

Appendix 4

The behaviour recordings and nursing performance.

Behavior	Score	Parameters
Piglet behavior	0	All piglet laying under the lamp, well spread and good body condition
	1	>1 piglet moving around, screaming, good body condition
	2	Piglet laying close to the sow or on each other, poor body condition > Piglets moving around in the box
	3	Piglet gives up, go back under the lamp or laying down in the box
Sow behavior	0	Laying on the side with the udder available for the piglet and react on the moving piglet and lay down on the side
	1	Laying on the stomach, the udder not available for the piglet, reluctant moving to the side when all piglet is up and moving around
	2	Laying on the stomach and no reaction on the piglet
	3	Become angry when the piglet is moving around in the box
Nursing	0	Piglet or sow induce nursing, all piglets get active and the nursing is complete
	1	Piglet or sow induce nursing, the nursing is incomplete by sow lay over on the stomach/standing up
	2	Piglet or sow induce nursing, sow stand up and start grab after piglet

Initiated nursing			
Terminated nursing			
Clear grunting			
Clear increase			
Post-massage time			
Milk when palpating			

Where the sow lie when injection were performed	
Were the sow standing up any time	
Palpating after injection	
Palpating when terminated nursing	