COMPARISON OF MATERNAL ABILITY BETWEEN THAI AND EUROPEAN BREED SOWS IN THE FARROWING PENS

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การเปรียบเทียบความสามารถในการเป็นแม่ระหว่างสุกรพันธุ์ไทยและพันธุ์ยุโรปในคอกคลอด

นางสาวกาญจนา ปัญญาไว

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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COMPARISON OF MATERNAL ABILITY BETWEEN THAI AND EUROPEAN BREED SOWS IN THE FARROWING PENS

Suranaree University of Technology has approved this thesis submitted in partial fulfillment of the requirements for a Master's Degree.

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กาญจนา ปัญญาไว : การเปรียบเทียบความสามารถในการเป็นแม่ระหว่างสุกรพันธุ์ไทยและพันธุ์ยุโรปในคอกคลอด (COMPARISON OF MATERNAL ABILITY BETWEEN THAI AND EUROPEAN BREED SOWS IN THE FARROWING PENS) อาจารย์ที่ปรึกษา : รองศาสตราจารย์ ดร. พงษ์ชาญ ณ ลำปาง , 85 หน้า.

งานวิจัยครั้งนี้มีวัตถุประสงค์เพื่อเปรียบเทียบความสามารถในการเป็นแม่ระหว่างแม่สุกรพันธุ์ไทยและพันธุ์ยุโรปในคอกคลอด ผลการทดลองพบว่าแม่สุกรพันธุ์ไทยมีพฤติกรรมความก้าวร้าวมากกว่าแม่สุกรพันธุ์ยุโรป ($P<0.001$) พบการตายก่อนหย่านมในลูกสุกรพันธุ์ยุโรปขณะที่ไม่พบการตายก่อนหย่านมในลูกสุกรพันธุ์ไทย ($P<0.05$) สาเหตุที่พบการตายในลูกสุกรพันธุ์ยุโรปคาดว่าน่าจะเกิดจาก 1) ระยะเวลาในการคลอดของแม่สุกรพันธุ์ยุโรปนานกว่าแม่สุกรพันธุ์ไทย 2) ความก้าวร้าวในแม่สุกรพันธุ์ยุโรปมีน้อยกว่าแม่สุกรพันธุ์ไทย และ 3) แม่สุกรพันธุ์ยุโรปมีคะแนน body condition score ต่ำกว่าแม่สุกรพันธุ์ไทยตลอดช่วงระยะเวลา 8 สัปดาห์ในการเลี้ยงลูก อัตราการเจริญเติบโต (ADG) ของลูกสุกรทั้งสองสายพันธุ์ไม่แตกต่างกันทางสถิติ (274.52 vs. 195.83 g/day, $P>0.05$) พบความสัมพันธ์เชิงบวกระหว่างความถี่การให้นมลูกของแม่สุกรและอัตราการเจริญเติบโตของลูกสุกร ($r_s = 0.49$, $P< 0.05$) การให้นมลูกของแม่สุกรพันธุ์ไทยจะคงที่ตลอดระยะเวลา 8 สัปดาห์ในการการเลี้ยงลูกเมื่อเปรียบเทียบกับแม่สุกรพันธุ์ยุโรป โดยเฉพาะในสัปดาห์สุดท้ายของการสังเกตพฤติกรรม พบว่าแม่สุกรพันธุ์ไทยมีค่าเฉลี่ยจำนวนครั้งในการให้นมลูกต่อสัปดาห์, ค่าเฉลี่ยระยะเวลารวมในการให้นมลูกต่อสัปดาห์ และค่าเฉลี่ยจำนวนครั้งที่ลูกสุกรเป็นตัวเริ่มกระตุ้นในการให้นมมากกว่าแม่สุกรพันธุ์ยุโรป ($P<0.05$) และพบว่าค่าเฉลี่ยระยะเวลารวมของการดูดนมแม่ของลูกสุกรพันธุ์ไทยสูงกว่าลูกสุกรพันธุ์ยุโรป ($P<0.05$) จากสาเหตุดังกล่าวเบื้องต้นเป็นผลให้ ไม่พบความแตกต่างทางสถิติของอัตราการเจริญเติบโตลูกสุกรในทั้งสองสายพันธุ์ อย่างไรก็ตามจำนวนลูกต่อครอกอาจมีผลให้อัตราการเจริญเติบโตไม่แตกต่างกันทางสถิติได้เช่นเดียวกัน ผลจากการสังเกตพฤติกรรมแม่สุกรพบว่าแม่สุกรพันธุ์ไทยมีความคล่องตัวสูงกว่าแม่สุกรพันธุ์ยุโรปตลอดระยะเวลา 8 สัปดาห์ในการสังเกตพฤติกรรม ($P<0.05$) ผลการประเมินปริมาณน้ำนมในวันที่ 6, 9 และ 12 หลังคลอดไม่พบความแตกต่างทางสถิติ ($P>0.05$) และไม่พบการแสดงพฤติกรรมความกลัวในแม่สุกรของทั้งสองสายพันธุ์

สาขาวิชาเทคโนโลยีการผลิตสัตว์ ลายมือชื่อนักศึกษา _____

ปีการศึกษา 2550 ลายมือชื่ออาจารย์ที่ปรึกษา _____

ลายมือชื่ออาจารย์ที่ปรึกษาร่วม _____

KANCHANA PUNYAWAI : COMPARISON OF MATERNAL ABILITY BETWEEN THAI AND EUROPEAN BREED SOWS IN THE FARROWING PENS. THESIS ADVISOR : ASSOC. PROF. PONGCHAN NA-LAMPANG, Ph.D., 85 PP.

MATERNAL ABILITY/MOTHERING ABILITY/MATERNAL BEHAVIOUR

This study was aimed to gain knowledge about maternal ability of European sows when compared with Thai sows in the farrowing pens. It was found that Thai sows were more aggressive than European sows during the observation period ($P< 0.001$). The piglet mortality was found in European sows whereas no dead piglets occurred in Thai sows during preweaning period. This might have been caused by longer duration of farrowing in European sows when compared with Thai sows. Another cause could be the lower aggressiveness of European sows when compared with Thai sows. The last reason could be European sows had a lower sow body condition score than Thai sows during lactation. No significant difference in ADG between the piglets of the two breeds (274.52 vs. 195.83 g/day, $P>0.05$). A positive correlation between nursing frequency and piglet growth rate was found. Nursing frequencies of Thai sows remained relatively stable over lactation when compared with European sows, especially in the last week of observation where Thai sows had significantly higher number of nursing bouts per sow per week, total nursing time per sow per week and number of piglet initiated nursing bouts per sow per week than European sows ($P<0.05$). Moreover, Thai piglets had higher total sucking time per piglet per week than European piglets ($P<0.05$). From these results it might be the cause of the no significant difference in ADG between the two breeds. However, it is possible that litter

size at birth also affected the differences. Thai sows spent her time for active behaviour more than European sows during the observation period ($P<0.05$). Milk production on days 6, 9 and 12 of lactation was statistically similar ($P>0.05$) between the sows of the two breeds. The sows in this study did not show signs of fear to the stockperson.

School of Animal Production Technology Student's Signature_____

Academic Year 2007 Advisor's Signature_____

Co-advisor's Signature_____

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Kanchana Punyawai

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CHAPTER I

INTRODUCTION

1.1 Background and rationale

The purpose of modern pig production is to produce high quality meat at low costs. Efficient pig production depends on a number of factors such as rapid growth rate and a high reproductive rate. The number of piglets produced per sow per year is the economically most important reproductive trait for the pig production, and often the only reproductive trait included in breeding programs. Over the 10 years to 2004, litter size within the Danish breeding program has increased by 3.5 totals born/litter with Landrace herds now averaging over 15 pigs per litter (Jensen and Peet, 2006). However, there are a number of problems, including increased piglet mortality, associated with selection for increased little size at birth. A selection experiment by Johnson et al. (1999) showed that selection for increased little size at birth led to undesirable correlated responses in piglet mortality. After 14 generations of selection, the selected line had significantly larger litters at birth, but also a higher stillbirth rate and a higher mortality rate before weaning. The same results are reported from France in a recent report on the intensive selection on little size in French Large White during the last decade (Grandinson, 2003). These agree with the increase of mortality rate before weaning in Suranaree University of Technology farm. It is found that from October 2005 to September 2006 the mortality rate increased by 7.2 %. Lund et al. (2002) found a negative genetic correlation between litter size at birth and piglet survival from birth to weaning in Landrace sows. Negative genetic correlation between litter size and survival

survival rate decrease the efficiency of selection on little size at birth. Grandinson et al. (2003) reported that most mortality occurred during the first week after birth. Crushing caused about 45% of all piglet deaths, while an additional 20% are caused by inadequate nutrition. Thus, improving piglet survival is therefore highly motivated, both from an ethical and economical standpoint. Recently, there has been an increasing interest in improving piglet survival and sow maternal ability. Sow maternal ability plays a very important role in piglet survival and piglet growth, and increasing focus should be placed on the ability of sows to take care of their offspring. In the future this will become even more important because of two totally opposite development in the pig industry. Firstly, increasing unit size and more intensified production make individual care of farrowing and newly farrowed sows more difficult, because more animals are looked after by each caretaker. As human intervention decreases, it becomes increasingly important that sows have good maternal ability. Secondly, extensive production systems, in which sows are kept loosely in pens or even outdoors, demand the usage and functioning of the actual mother-young interaction. As the environment become less restrictive, the sow can perform more of their natural maternal behaviour (Valros et al., 2002).

In this thesis, focus will be on maternal behaviour traits in sows of two different genetic origins during the preweaning period and performance of their piglets.

1.2 Research objective

1.2.1 To compare the maternal ability between Thai (originated from northeast Thailand) and European sows (Landrace × Large White crossbred).

1.2.2 To investigate the indicators of maternal ability in sows.

1.3 Research hypothesis

Whether the sow's ability to take care of their own litters influence the preweaning survival and early growth rate of the piglets. Thus, in this study it is expected to find the differences in piglet preweaning survival and early growth rate resulted from the different breed of sows.

1.4 Assumption

1.4.1 Maternal ability of sows includes the number of piglets successfully weaned by the sows and their quality (Grandinson, 2003).

1.4.2 The indicators of maternal ability in the sows are as illustrated.

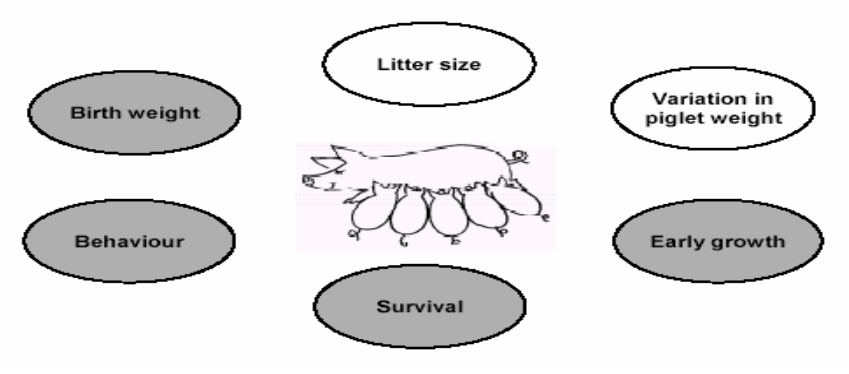

Figure 1.1 Examples of traits that can used to measure good maternal ability in the sow (Grandinson, 2003).

1.5 Scope and limitation of the study

This study will focus on comparison of the maternal ability in Thai sows (originated from northeast Thailand) when compare with that of European sows (Landrace × Large White crossbreds) under the semi-natural environments. The sows' performances of the two breeds are indicated by piglet growth and survival rates will also be studied.

1.6 Expected benefits and application

To gain knowledge about the aspects of maternal ability in Thai sows (originated from northeast Thailand). This information can be used in breeding programmes to improve piglet survival in the future.

CHAPTER II

LITERATURE REVIEW

2.1 Natural maternal behaviour of the sow

The maternal behaviour of the sow is unique, since many aspects of this are generally common in predators but not in hoofed animals. Firstly, the sow isolates herself from the group and builds an elaborated nest. The nest is built within 24 hours before farrowing. A sow can travel for distances well over 6 km to find a suitable nest-site. She then gathers bedding material such as leaves and grasses from the surrounding area. When the nest is ready, the sow covers it with branches and digs herself into the nest and lies down. The nest provides insulation and protection for the newborn piglets. It also keeps the litter close to the sow, and thus may encourage mother-offspring bonding. Location of the nest away from the family group protects the piglets from being trampled by other adults and prevents older unrelated piglets from stealing milk from the sow. Secondly, the sow gives birth to a litter, while most other hoofed animals only give birth to one or two offspring at a time (Valros, 2003). The last 24 hours before farrowing are characterised by a high level of activity in free-ranging sows. Sows housed indoors, in pens or in crates also perform nest-building behaviours, such as rooting, nosing and pawing on the floor, even when no nest building material is available (Björkner, 2003). A study from Haskell and Hutson (1996) showed that providing sows with relevant stimuli for nest building can improve maternal behaviour. Similarly, Thodberg et al. (1999) showed that the sow given access to nesting material such as straw, sawdust or sand are more active prior to farrowing. This decrease the risk

crushing newborn piglets during parturition. In addition, there are fewer intra-partum stillborn piglets, shorter parturition times higher responsiveness to piglet distress calls (Herskin et al., 1998), increased duration of suckling and decreased number of suckling sessions terminated by the sow (Herskin et al., 1999). This agrees with a study of Grandinson et al. (2003) which showed that a lower piglet death rate from birth to weaning for sows with the opportunity to build nests.

2.2 Some behaviour traits related to piglet mortality

2.2.1 Behaviour related to crushing

Grandinson (2003) and Valros (2003) found that mortality is not randomly distributed over all litters. There are many litters with a large number of deaths, many litters with no deaths, and few with a moderate number of deaths. This indicates that some litters are more likely to have high mortality than others. Large individual differences have been found in sow behaviour around and after farrowing, indicating that some sows are more likely to put their offspring at a risk of crushing and starvation.

The sows and piglets are confined in a small space during the lactation period, there is an obvious risk that even a careful sow sometimes will lie down on her piglets. When this happens, the piglet could be saved if the sow responds to vocal and tactile stimuli from the piglets by standing up. When a piglet is caught under a sow, the risk of dying increases with the time the piglet remains trapped under the sow's body (Weary et al., 1996). There are large individual differences in how strongly a sow reacts to a piglets screaming and to other stimuli from the piglets. Some sows appear to be completely unaffected by the fact that they are lying on a screaming piglets while others are very alert, reacting by sitting or standing letting the piglets escape. Sow who respond strongly to the sound of screaming piglets have a fewer crushed piglets (Wechsler and

Hegglin, 1997; Thodberg et al., 2002). Wechsler and Hegglin (1997) showed that sows that never displayed the 'flopping straight down' manoeuvre had the lowest number of piglets trapped under them, and therefore fewer piglets were at risk of being crushed.

2.2.2 Fear and aggressive behaviour

Pigs are often exposed to close interaction with the stockperson. Sometimes these interactions are of a positive nature, for example a gentle stroke, but they can also be negative such as pushing or hitting. Regular human interactions can have large effects on behaviour, physiology and production of the animal (Valros, 2003). Pigs that are exposed repeatedly to negative handling will start to avoid human contact and show increased levels of the stress hormone cortisol. These are indications of higher levels of fear. Several studies have shown that high levels of fear are related to decreased growth rates (Grandinson, 2003). A high level of fear in young gilts seems to be negatively associated with mating rates, and sows showing high levels of fear had higher stillbirth rates (Hemsworth et al., 1999). Several studies found the relationship between behaviours such as fear and aggressive of sow and mortality in piglets (Jeramy and Ford, 2002). Moreover, Grandinson et al. (2003) showed that variation in fear of humans in pigs accounted for 20% of the variation in reproductive performance across farms. Although, there are also individual variations between animals in how they respond to human interaction. Jeramy and Forde (2002) found an indirect relationship between fear-related and aggression-related behaviours. Sows that showed 'bold' behaviour when confronted with an unfamiliar person were more likely to show aggressive behaviour towards the stockperson.

Grandinson (2003) and Björkner (2003) found that aggressive behaviour towards the stockperson might be associated with a high level of maternal protectiveness that in

turn could be related to good maternal behaviour. It is a common belief among farmers that more aggressive sows are also the better mothers. However, studies on aggression towards the stockperson have shown no evidence for such an association with piglet survival. Hemsworth et al. (1990) found a moderately high heritability for the trait "fear of humans" in young gilts. This indicates that fear responses could be changed by selection, and this may have positive effects for production and reproduction traits. Hansen (1996) showed that selection for fear-related behaviour in mink markedly changed the behaviour of the animals in the selected line, so that they consistently responded aversively to human contact. However, there are very few studies of the genetic relation between fear behaviour and maternal success.

A more extreme form of behaviour that affects piglet mortality is aggressive behaviour from sows towards their own offspring. A study on piglet-directed aggressiveness in two purebred and one crossbred populations of sows found that 7-13% of the sows showed aggressive behaviour that led to wounding or death of the piglets (Grandinson et al., 2003). This problem is more common in gilts than in multiparous sows. In gilts, being kept in a barren environment possibly causes this type of behaviour. Because of lack of experience, the piglets are regarded to be unknown objects and perceived as a potential danger, triggering the aggressive behaviour. Aggression towards offspring can also be related to fear. In a study, Jeremy and Forde (2002) measured fear response of sows when confronted with an unknown human. Sows showing high levels of fear were also more likely to savage their piglets. Aggressive behaviour towards piglets is partly genetically controlled. Daughters of aggressive sows show twice the incidence of aggressive behaviour, compared to daughters of non-aggressive sows. Heritability estimates for sow aggressiveness towards piglets ranges from 0.12 to 0.9 (Grandinson et al., 2003).

2.3 Some factors affecting pre-weaning growth

2.3.1 Nursing behaviour

Nursing behaviour in the pig is fairly stereotypic. The sow can either initiate nursing by calling the litter or by piglets squealing by the sow's head or stimulating the udder. The sow has no milk cistern where milk can be stored, but milk is let down directly from the alveoli at each nursing, and a piglet cannot compensate for one missed nursing by attempting to suckle individually. Milk is only let down during one short milk ejection (lasting approx. 10-20 s) at synchronized nursings, when the majority of the litter is present and stimulating the udder. Milk ejection never occurs in the absence of udder stimulation and the need for a long duration of massage to stimulate milk letdown increases with decreasing number of piglets present. During the 1st week of lactation, the sow initiates the majority of nursings, but this rate declines with proceeding lactation (Illmann and Madlafousek, 1995). The sound of other sows and piglets nursing often stimulates nursing behaviour and sows tend to synchronize their nursing behaviour, probably to reduce cross suckling, i.e. piglets sucking sows other than their own dam (Wechsler and Brodmann, 1996). A great deal of coordinated massaging of the udder and sucking the teats is necessary before a brief period of milk flow. The whole process has been characterised as falling into five phases, i.e. gathering of piglets and finding teat position, massaging the udder, interspersed with periods of slow steady sucking which increasingly predominate, culminating in rapid suckling movements coinciding with milk ejection, and a return to alternating periods of massage and slow sucking after milk ejection (Björkner, 2003).

The piglets' behaviour to initiate a suckling is highly variable. The piglets generally assemble by the sow, sometimes grunting and squealing, frequently nosing at the udder and suckling on exposed teat. This may be done in response to movement or

grunting by the sow, or may be triggered by an external stimulus such as the sound of another litter suckling, or the behaviour may begin in apparently spontaneous manner. Before the sow start to nurse, she occasionally nudges her young, root in the bedding and gives a few soft grunts. When the sow is nursing she generally gives loud, rhythmic vocalizations related to the behaviour of the piglets and the time of milk flow.

Under commercial conditions a sow often nurse 20 or more times in a 24-hour period for several weeks after farrowing (Fraser, 1980). A wild boar sow will nurse about once per hour, a little more often short after farrowing (Jensen, 1993). Many different findings have been reported on average daily number of nursings. Barber et al. (1995) found a daily average of 28 nursings on day 6 and 24 nursings at 6 weeks after farrowing. Valros (2003) observed 26 nursings on day 3 and 24 nursings on day 30. Moreover, Björkner (2003) observed 36.3 nursings on day 4 and 5.3 nursings at 6 weeks after farrowing. Jensen et al. (1991) found in a study of sows kept in a semi-natural environment, that during the first day after farrowing, more than 85% of the nursings were initiated by the sow, while less than 5% were terminated by her. By the end of the lactation, the proportion of sow initiated nursings has gradually decreased to 55% and the sow terminated ones had gradually increased to 60%. Gustafsson et al. (1999) saw an average proportion of sow terminated nursings the first week after farrowing of 30%, which is similar to 29% found in the study of Björkner (2003). Moreover, Björkner (2003) found that sow terminated nursing were 42% on day 4 and 87% at 6 weeks after farrowing which agrees well to the finding of Jensen (1991).

Number of nursings seemed to influence piglet growth from two to seven weeks of ages in the study of Björkner (2003), which corresponds to the study of Valros (2003) on sows kept indoors. Valros et al. (2002) found that one additional successful nursing over a 24-hour period increased average daily weight gain by 5 g. Besides, Valros et al.

(2002) also showed that sows have individual nursing patterns that are repeatable within sow and lactation. These results indicate that there may be genetic differences in nursing behaviour.

2.3.2 Communication between sow and piglets during nursing

Algers et al. (1990) found that the increase in grunt rate is correlated with the time of the release of oxytocin and that there is a correlation between the sizes of the increases in the release of oxytocin and that there is a correlation between the size of the increase in grunt rate and the amount of oxytocin released. When the udder is stimulated at a lower intensity, in terms of the number of piglets stimulating, a longer stimulating period is needed to induce a milk letdown. Stimulation by fewer piglets and for longer periods changes the grunt pattern of the sow, decreasing the signal value of the increase in grunt rate, as shown in Figure 2.1.

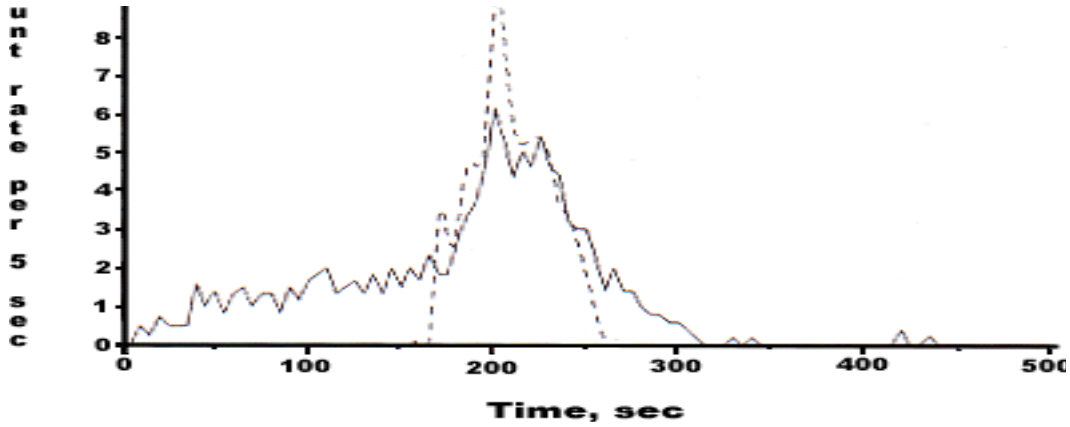

Figure 2.1 Grunt rate synchronized over the grunt rate peak. —— = the average of nursings longest pre-let massaging time, average = 199 seconds and average number of piglets massaging = 5.4. - - - = six nursings with the shortest time, average = 24 seconds and 6.8 piglets massaging (Algers et al., 1990).

Sjuth (2003) studied the grunting of nine sows at three different occasions during the lactation, but could not find an individual grunt rate pattern of these sows. Algers and Jensen (1985) showed that the grunt rate patterns of the sows are similar in a silent and noisy environment. In the silent environment, the piglets seemed to respond to the changes in the grunt pattern. During the period of initial slow grunting of the sow, the piglets were mainly concerned with massaging, although sucking did occur. When the rapid grunting period of the sow began, the piglets synchronously switched behaviour and mainly sucked for a period of approximately 40 seconds. In the silent environment a maximum value in the sucking frequency was recorded approximately 25 seconds after the grunt rate peak of the sow. Thereafter, the frequency of massaging slowly increased to a level slightly higher than during the initial massage. In the noisy environment, the frequencies of piglet behaviour were different. No distinct phases could be distinguished. The piglets exposed to noise massaged the teat significantly shorter periods in early lactation compared to the piglets in a silent environment (Algers and Jensen, 1991). The fan noise probably masked the grunt of the sows and the finding thus indicate that the grunt pattern of the sow affect the behaviour of the piglets. When the piglets were unable to perceive the signals, the phases were disrupted and the animals were probably less ready for the milk ejection. The piglet also seemed to fight more in a noisy environment than in a silent (Algers and Jensen, 1985)

2.3.3 Milk production and piglet growth.

Sow milk yield is a key limiting factor to preweaning piglet growth and consequently to postweaning growth. Piglets reared on a milk replacer diet provided for ad libitum consumption can grow at a rate substantially greater than sow-reared piglets, suggesting that sow-reared piglets are not attaining maximal preweaning growth rate

potential (Auldist and King, 1995). Furthermore, sow milk production becomes limiting to piglet growth rates by day 10 of lactation. The ability to tailor milk quantities and milk composition to optimize piglet growth rates and lean mass deposition would be of great value to the pig producer (Boyd and Kensinger, 1998). Milk production during early lactation can vary widely between sows. An inadequate production of milk can have several causes, such as various disease conditions or hormonal abnormalities, as well as environmental factors (Fraser, 1990). Disturbance of the communication between sow and piglets decreases the synchronization within the litter at nursing and decreases the amount of milk the sow produces (Algers and Jensen, 1991).

The mammary gland of sow is presented in figure 2.2.

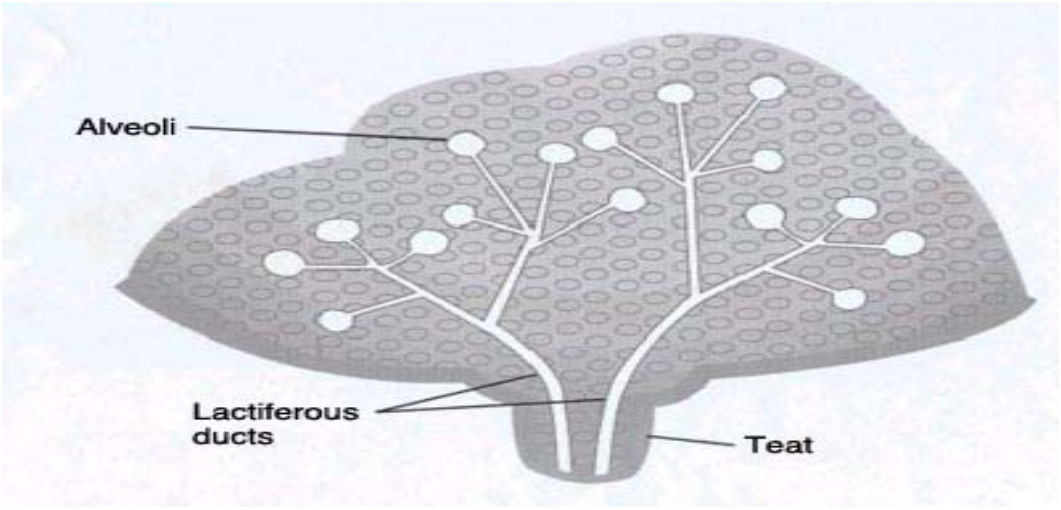

Figure 2.2 A general illustration of sow's mammary gland. Each mammary gland has lobules containing alveoli, which are the basic unit that produce milk (Cooper, 1840).

In contrast to most other mammals, the mammary gland of the sow contain no large cistern to store the milk secreted by the epithelial cells of the alveoli, therefore the sucking piglets can not passively withdraw milk. The removal of milk from the alveoli

and ductal system of the mammary glands requires a neuro-endocrine milk ejection reflex which involves a release of oxytocin and an ejection of milk (Lincoln and Pisley, 1982). Oxytocin is released from the posterior pituitary gland in response to the activation of neural receptors within the teats of the mammary gland by the massaging and sucking of piglets. An increase in the concentration of oxytocin has been observed in sows during the initial massaging phase, reaching peak values up to 30 seconds before the ejection of milk from the mammary gland (Ellendorff et al., 1982). Oxytocin stimulates the contraction of the myoepithelial cells, which surround the alveolar lumen, forcing the milk from the alveoli, through the ductal system to the teat (Hartmann and Holmes, 1989). Milk ejection in the sow, as indicated by the rise in intra mammary pressure, occurs on average 2.4 minutes after the piglets begin to suckle and is associated with the period of rapid sucking (Ellendorff et al., 1982). The duration of milk flow in the sow is very short and will last for only 10-20 second (Fraser, 1980; Hartmann et al., 1997). When individual mammary glands on a sow do not receive adequate sucking stimuli they will involute rapidly, while others that are actively sucked continue to produce milk (Martin et al., 1978).

Mackenzie and Revell (1998) show in a comparison of data from the literature that sow milk yield has clearly increased in the last 20-30 years. This improvement can be attributed to both genetic and environment factors. Since there has not been a direct selection on milk production in sows, a genetic progress has to originate from selection criteria that are indirectly related to milk yield. Mackenzie and Revell (1998) suggest that possibly correlated traits are growth rate and litter size.

It is very difficult to obtain direct measurement of sow milk production because teat stimulation and oxytocin release is necessary for milk ejection. Indirect measures are instead often used; for example, the weigh-suckle-weigh method when litter weight

is measured directly before and after each suckling. This method is not practical to use on a larger scale, where milk production instead has to be estimated from piglet growth rate form birth to start of creep feeding. Generally, milk production of the sow (in grams per day) can be approximated by multiplying litter weight gain (grams per day) by 4 (Whittemore and Morgan, 1990). The accuracy of the method differs between reported estimates (Etienne et al., 1998).

The newborn piglet has very limited body fat reserves, and early growth is mainly focused on deposition of body fat. Growth rate during the first weeks after birth is highly variable between litters. Thompson and Fraser (1988) showed that weight gain during the first couple of days after birth was not determined by birth weight but later in lactation, rate of gain became more related to body weight. Piglet that were heavier at 10 days of age, gained more weight from then on than piglet that were not as heavy at 10 days of age (Thompson and Fraser, 1988). This could be related to nursing behaviour of the piglet. Algers and Jensen (1991) showed that the intensity and duration with which a piglet stimulates a teat during massage after a nursing affects milk production of that specific teat. It is possible that heavier piglets are able to provide more effective massage. If massaging of the udder following milk letdown is prevented, average daily litter weight-gain was shown to decrease (Algers and Jensen, 1991).

2.3.4 Suckling frequencies

Suckling frequencies differ among sows and the typical suckling interval varies from 30 to 70 minutes for individual sows during the first week of lactation (Jensen et al., 1991). Suckling frequency is influenced by factors such as litter size and stage of lactation, but it may also be manipulated. Shorter intervals between nursings provide more opportunities for piglets to obtain milk (Auldist and King, 1995). Differences

between piglets sucking frequency may also influence milk production from individual glands (Auldist et al., 2000). Extending the sucking interval of piglets to longer than two hours results in a decrease in milk yield of the sow (Barber et al., 1955). Ŝpinka et al. (1999) suggested that nursing frequency is higher in sows that turn much of their body stores into milk and Ŝpinka et al. (1997) showed that manipulated shorter nursing intervals allow the piglets to receive more milk. Similarly, Sinclair et al. (1998) found that high milking Meishan sows have shorter nursing intervals than European White sows. The amount of udder massage received from the piglets (which, in turn, depends on the sow's propensity to remain long in the nursing recumbent position) may also affect future milk production, e.g. through elevated prolactin levels (Rushen et al., 1993), but the evidence is inconsistent so far (Algers and Jensen, 1991; Spinka and Algers, 1995). Also a high frequency of unsuccessful nursing (in addition to many successful nursings) will add to the total massaging time, thus increasing udder stimulation. On the other hand, much sternal recumbency by the sow limits piglet access to the udder and thus massaging time. Sternal recmbency has been found to increase with increasing lactational stage (Harris and Gonyou, 1998), possibly indication that sows use this position to limit milk production with proceeding weaning. In addition, Valros et al. (2002) showed that milk production (measured indirectly as piglet growth) is related to nursing frequency also in not manipulated sows.

2.3.5 Milk composition

The milk produced at farrowing and a couple of hours after birth contain a lot of antibodies. The first produced milk, colostrum, is vital to the piglets. Major changes in the composition of sows' milk occur during the first 72 hours after farrowing and this is characterised by a large reduction in concentration of antibodies. While the piglets

remove the first milk, they trigger an increase in fat and lactose in the milk that ensures that, after birth each piglet obtains a crucial supply of energy as it establishes itself on its preferred teat (Hartmann et al., 1997). Alston-Mills et al. (2000) investigated total protein, lactose and milk fat contents in the milk from nine crossbred sows. The results (percent ± S.E.) from gilts sampled in early lactation were; fat content, 8.91 ± 0.4; protein content, 5.41 ± 0.2 and lactose content, 4.90 ± 0.4. The same analysis was performed at weaning; fat content, 6.49 ± 0.4; protein content, 4.76 ± 0.2 and lactose content, 5.44 ± 0.4.

2.3.6 Sows' Body condition during lactation

Grandinson et al. (2005) reported about the significant genetic correlations between change in both weight and backfat and maternal genetic effects for piglet survival and growth to weaning. These results showed that sows with a genetic predisposition to use weigh and fat reserves during lactation also have a higher piglet growth rate during lactation and lower piglet mortality rates. Similarly, study by Valros et al. (2002) found that larger weight loss during the 3rd week of lactation is apparently, associated with higher piglet growth rate. Moreover, sow with low fat reserves at farrowing have a higher incidence of stillbirth. This agrees with a previous study form Knol (2001) which found that the genetic correlation between survival and fatness is 0.5, which is moderate and significant. For example the Meishan breed has strong piglets, especially considering the birth weight, and Meishan animals are very fat. Furthermore, a study of Young et al. (2004) found that poor body condition can reduce reproductive performance and result in greater sow culling and mortality.

Piglet survival is closely related to piglet birth weight and may be indirectly improved by using this trait (Roehe et al., 1999). The genetic association between direct

(genotype of the piglet) or maternal effects (genotype of the sow) of piglet survival with piglet birth weight or its variation within litter, have tremendous potential to be exploided for genetic improvement of piglet survival (Roehe, 1999; Kaufmann et al., 2000). However, genetic selection for higher birth weigh, both direct and maternal trait, might lead to a higher incidence of stillbirth in the litter and may not improve overall litter survival (McKay, 1993).

CHAPTER III

METERIALS AND METHODS

3.1 Animals and housing

The study was based on data from Thai sows (originated from northeast of Thailand) and European sows (Landrace × Large White crossbreds) and piglets born at the Suranaree University of Technology Farm (SUT farm), between Februarys to May 2007, winter/summer in the region. Mean temperatures at observation times ranged from 20°C to 41.5°C. The sows were studied in two groups of three animals each. The experimental farrowing unit contains six pens within the housing in outdoors environment. The sows were kept individually in farrowing pens (2×2 m^2) and the floor was filled with rice hull and then cover with fresh straw was used as nest building material.

3.2 Management

At approximately two weeks before expected parturition, sows were moved to the experimental housing and placed in individual pens. From the time sows were placed in farrowing pens until weaning, feed was allowed at a rate of 2.5 kg/head/day and after farrowing at a rate of 5 kg/head/day. The sows had ad libitum access to water offered in the nipple drinker positioned in front of the pen. The sows were weighed five days before expected parturition and weighed again on the last day of the observation. Backfat thickness measurements were taken ultrasonically, (AGROSCAN, E.C.M., An goulême, France) at the last rib on five days before expected parturition and four

and eight weeks after. On the farrowing day, the piglets got identification number (ear tattoos), tail docking and teeth clipping. The piglets were weighed on the farrowing day and once a week during experimental period.

3.3 Experimental design and statistical analysis

The experimental design was CRD with 2 treatments and 3 replications. All statistical analyses were done with SAS statistical programme (SAS Inst. Inc., Carry, NC). The distributions of all variables were examined using SAS PROC UNIVARIATE. The results from sows body condition, milk production analysis and weight observations were analysed by using PROC ANOVA. Behaviors observations, expressed as frequency of occurrence, and reproductive parameters did not show Gaussian distributions and could not be transformed into Gaussian distributions, thus required nonparametric analyses. Statistical analyses were carried out using the NPAR1WAY procedure (Wilcoxon-test) to evaluated the differences of treatments. The nonparametric Spearman rank correlations were used to find associations among behaviour, litter size, percentage of piglets mortality, birth weight, average daily gain (ADG), sows backfat loss and weight loss during lactation. Pearson correlation coefficients were used to determine the relationship between sows' body condition and litter size, piglets' survival and ADG.

3.4 Traits measured

The traits were used to measuring of maternal ability in sow are

3.4.1 Sow traits

The sow traits were measured according to the studies of Alston-Mills et al. (2000), Grandinson (2003), Grandinson et al. (2005) and Wallenbeck et al. (2005). Sow

traits measured were as fallowed.

3.4.1.1 Farrowing behaviour

At farrowing, the total duration of farrowing from the birth of the first to the last piglets and the duration of the interval between the births of each piglet were recorded. This latter measure was used to calculate the average inter-birth interval and inter-birth intervals measured as the standard deviation of inter-birth intervals within group of sows. Risk related behaviour of sows in relation to piglets was scored continuously from the birth of the first piglets until 24 h postpartum. The first category included lying on top of or crushing of a piglet. The sows' behaviour was recorded continuously. The number of live born piglets, the number of stillborn piglets, and the number of piglets dying on each day after birth were recorded. These variables were used to calculate the number of live born piglets that died between birth and 8 weeks of age. Post-mortem examinations of dead piglets were performed to assess the number of piglets that died with or without milk in their stomach, and the number of piglets killed by crushing.

3.4.1.2 Sows body condition during lactation.

Lactating sows body condition based on an estimate of weight and a measurement of thickness. Indicators of sows body condition measured were as fallowed.

1) Weight change during lactation

Thai sows' weights were obtained by direct weighing. European sows' weights were obtained by a flank-to-flank measurement using a cloth tape measure to categorise sows into weight groups. The flank-to-flank measurement is taking where the rear leg intersects with the body on one side of the sow to the same

position on the other side of the sow. Sows were weighed five days before expected parturition and again at weaning day (8^{th} week).

2) Backfat change during lactation

Backfat thickness was measured by ultrasonic (Agroscan, E.C.M., Angaulême, France) measurement at the last rib, about 8 cm from the midline of the back. Sows were measured at 5 days before parturition, again within 4^{th} week and at weaning (8^{th} week).

3.4.1.3 Milk Production.

Milk production of sows was measured on days 6, 9 and 12 of lactation. Milk production was assessed by a modification of the weigh-suckle-weigh (WSW) method of Speer and Cox (1984). Litters were separated from their dams for 1 h. Each litters then was weighed to obtain a pre-suckling weight, returned to their mother, allowed to suckle until the end of vigorous synchronize suckling, and then immediately collected and weighed to obtain a post-suckling weight. This procedure was repeated hourly for 4 times. This procedure was repeated hourly for Mean hourly milk yield multiplied by 24 was used to estimate of daily milk yield.

3.4.2 Piglet weight gain.

The piglets were weighed on the farrowing day (birth weight) and weighed once a week from birth to eight weeks of age. At weighing the piglets were moved from the farrowing pen to the outside of the pen. Here they were weighed on a scale and then put back into the pen. The scale showed the weight in kilograms with a precision of one decimal point. Piglets were weighed individually, so that no mixing with unfamiliar pigs occurred.

3.4.3 Maternal behaviour

The indicators of maternal behaviour traits measured were as fallowed.

3.4.3.1 Stockperson-directed aggression scoring

Aggression directed by the sows towards the stockperson in the farrowing pen was scored by the stockperson, on a nominal scale of 1-5 (not aggressive to very aggressive) using the sow behaviour and vocalizations as indicators, according to Marchant (2002), Grandinson (2003) and Vangen et al. (2005). The descriptions of the scores of aggression are given in Table 3.1. Scoring was performed by the same stockperson and was carried out during routine piglet handling, such as teeth clipping, ear tattooing, tail docking, castration, iron supplementation and piglet weighing. The stockperson-directed aggression scores were measured every week during lactation. An aggression scores were measured every week during lactation. From the scores, an average aggression score was calculated.

Table 3.1 Descriptions of sow behaviour for each aggression score category

Score	Aggression Score Category
1	Sow shows an obvious sign of aggression and is not bothered by presence of person during piglets handling.
2	Sow is mildly aggressive. Sow gives a few warning vocalisations and may sit or stand during piglets handling.
3	Sow is moderately aggressive, gives more warning vocalisations and may attempt to bite if approached.
4	Sow is very aggressive, vocalizing frequently and will bite if approached.
5	Sow is extremely aggressive, extremely vocalizing and will actively defend her litter, advancing on human or bite.

Merchant (2002).

3.4.3.2 Avoidance of the stockperson

Avoidance of the stockperson was used as an indicator of fear and was measured in connection with the routine piglet handling by recording how the sow position herself in relation to the person handling the litter (Grandinson et al., 2003). The avoidance of the stockperson was measured every week during lactation period. The descriptions of avoidance of the stockperson are given in Table 3.2

Table 3.2 Descriptions of sow behaviour for each avoidance of the stockperson score category.

Score	Avoidance of the stockperson score
1	Sow moves toward the handler or perceived as aggressive by the handler.
2	Sow does not move at all. A sow that does not stand up is regarded as not having moved.
3	Sow moves away from the handler.

Grandinson et al. (2003)

3.4.3.3 Nursing behaviour

Nursing behaviour was measured according to the studies of Špinka et al. (1997), Valros (2002) and Björkner (2003). A single observer performed all behavioural observations, using instantaneous scan sampling by direct visual observation. The observation of the sows started on the farrowing day. During the first three days after farrowing, nursing behaviour was observed all 24 hours, afterward it was observed daily from 8.00 to 14.00 hours. Behaviour of each sow was recorded in two scans made at 30 minutes intervals. The descriptions of nursing behaviour in sow were as fallowed.

1) Number of nursing bouts per sow per week

Number of nursing bouts per sow per week was the average number of nursing bouts of the three sows of each breed occurred in a particular week expressed as

a percentage of the average number of nursing bouts occurred in the whole 8 week study period.

2) Total nursing time per sow per week

Total nursing times per sow per week was the average nursing times of the three sows of each breed in a particular week expressed as a percentage of the average total times of all nursing times of all nursing bouts accumulate in the whole 8 week study period.

3) Weekly average nursing bout length

Weekly average nursing bout length was the average length of nursing bouts of the three sows of each breed occurred in a particular week.

4) Number of sow initiated nursing bouts per sow per week

Number of sow initiated nursing bouts per sow per week was the average number of sow initiated nursing bouts of the three sows of each breed occurred in a particular week expressed as a percentage of the average number of sow initiated nursing bouts occurred in the whole 8 week study period.

5) Total sow initiated nursing time per sow per week

Total sow initiated nursing time per sow per week was the average sow initiated nursing time of the three sows of each breed in a particular week expressed as a percentage of the average total time of all sow initiated nursing bouts accumulated in the whole 8 week study period.

6) Weekly average sow initiated nursing bout length

Weekly average sow initiated nursing bout length was the average length of sow initiated nursing bout of the three sows of each breed occurred in a particular week.

7) Number of piglet initiated nursing bouts per sow per week

Number of piglet initiated nursing bouts per sow per week was the average number of piglet initiated nursing bouts of the three sows of each breed occurred in a particular week expressed as a percentage of the average number of piglet initiated nursing bouts occurred in the whole 8 week study period.

8) Total piglet initiated nursing time per sow per week

Total piglet initiated nursing time per sow per week was the average piglet initiated nursing time of the three sows of each breed in a particular week expressed as a percentage of the average total time of all piglet initiated nursing bouts accumulate in the whole 8 week study period.

9) Weekly average piglet initiated nursing bout length

Weekly average piglet initiated nursing bout length was the average length of piglet initiated nursing bout of the three sows of each breed occurred in a particular week.

10) Number of sow terminated nursing bouts per sow per week

Number of sow terminated nursing bouts per sow per week was the average number of sow terminated nursing bouts of the three sows of each breed occurred in a particular week expressed as a percentage of the average number of sow terminated nursing bouts occurred in the whole 8 week study period.

11) Number of piglet terminated nursing bouts per sow per week

Number of piglet terminated nursing bouts per sow per week was the average number of piglet terminated nursing bouts of the three sows of each breed occurred in a particular week expressed as a percentage of the average number of piglet terminated nursing bouts occurred in the whole 8 week study period.

3.4.3.4 Sows activity

The observation was in accordance with the study of Björkner (2003). Sow activities observed were during the 8 week study period. The activity of the sows were recorded with interval sampling at 30 minute intervals and the variable used were; lying (including lateral lying and sternal recombency), sitting and standing.

3.4.4 Behaviour of piglets

The social behaviour and the activity of the piglets were observed according to the studies of Eriksson (2006) and Hessel et al. (2006). A behaviour of the piglets was scored on a group, rather than an individual basis. A behaviour was recorded as occurring when more than 75 % of the piglets were engaged in that particular behaviour. The observation of the piglets started on day four after the farrowing day from 14.00 to 16.00 hours. Behaviour of each group of piglets was recorded in two scans made at 20-minute intervals. The behaviour registered in the instantaneous scan sampling were: active, sucking and lying. The definitions of the specific behaviours are given in Table 3.3

Table 3.3 Definition of the specific piglet behaviour observed.

Category	**Definition**
Lying	Piglet's body contacted to the ground.
Suckling	Piglets massaged or suckled at the udder.
Active	Piglets in the pen performed any action in an upright position with the legs (standing or moving in the pen).

Hessel et al. (2006)

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Sows traits

4.1.1 Farrowing behaviour

The farrowing behaviour observed in Thai sows (originated from northeast of Thailand) and European sows (Landrace × Large White crossbreds) are presented in Table 4.1 The mean duration of farrowing in European sows was longer than in Thai sows (P=0.0495). This might be caused by litter size, because European sows had lager litter size than that of Thai sows (11.33 vs. 4.67, P=0.0495). Duration of inter-birth intervals and variation in inter-birth intervals were not different between sows of the two breeds. There was no stillborn piglet occurred in two breeds. However, European sows had higher piglet mortality during three days postpartum than that of Thai sows (P=0.0339). In fact, there was no dead piglets occurred in Thai sows. All of the live born deaths occurred only within three days postpartum, no further death occurred after this period. The only cause of piglet death was crushing by the sow.

Table 4.2 presents Spearman rank order correlation coefficients between farrowing behaviour traits and piglet mortality measured as the number of live born piglets that died before weaning (8^{th} week). Mortality was significantly positive correlated with the duration of farrowing (r_s= 0.83, P=0.0394). There was no significant correlation between mortality and the variation in inter-birth intervals and duration of inter birth intervals. It corresponds with the result of Janczak et al. (2003), who found significant positive correlation between piglet mortality and the duration of

farrowing (r_s=0.47). The result also agrees with other reports (Klocek et al., 1992; Herpin et al., 1996; Junczak et al., 2003).

Table 4.1 Values for elements of reproduction

Variable	**Mean**		**S.D.**		**Min**		**Max**		***P*-value**
indicators of maternal behaviour traits are	**Eu**[2]	**Na**[2]	**Eu**	**Na**	**Eu**	**Na**	**Eu**	**Na**	
Duration of farrowing (hours)	3.95*	1.55	1.29	1.19	2.56	0.09	5.10	2.46	0.0495
Duration of inter-birth intervals (minutes)	24.18	12.82	16.34	9.65	13.55	3.20	43.00	22.50	0.2752
Variation in inter-birth intervals (minutes)	49.86	13.08	73.12	11.02	0.15	6.00	186.00	28.00	0.8099
Number of live born piglets	11.33*	4.67	4.04	1.53	7.00	3.00	15.00	6.00	0.0495
Number of stillborn piglets	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Percentage of piglets stillborn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Number of live born dead by crushing.	0.66	0.00	0.58	0.00	0.00	0.00	1.00	0.00	0.1138
Number of live born dead by crushing	1.67*	0.00	0.58	0.00	1.00	0.00	2.00	0.00	0.0339
Percentage of live born dead by crushing	14.76*	0.00	1.72	0.00	13.33	0.00	16.67	0.00	0.0339
Number of live born dead within 3 days postpartum	1.67*	0.00	0.58	0.00	1.00	0.00	2.00	0.00	0.0339
Percentage of mortality[1] ≤ 24 h postpartum	7.54	0.00	7.18	0.00	0.00	0.00	14.29	0.00	0.1138
Percentage of mortality ≤ 3 days postpartum	14.76*	0.00	1.72	0.00	13.33	0.00	16.67	0.00	0.0339

[1] Percentage of mortality refers to the percentage of live born piglets that died, [2] Eu = European sows; Na = Thai sows.

* Significantly differs ($P < 0.05$).

Table 4.2 Spearman rank order correlation coefficients between the number of live born piglets that died within three days of age (mortality) and farrowing behaviour.

farrowing parameters	**Mortality**	
	r_s	***P*-value**
Duration of farrowing (hours)	0.83	0.0394
Variation in inter-birth intervals (minutes)	0.64	0.1694
Duration of inter-birth intervals (minutes)	0.14	0.7849

4.1.2 Sow body condition during lactation.

The results of sow body condition score are presented in Table 4.3 At five days before parturition, European sows and Thai sows did not significantly differ in backfat thickness (P=0.1225). However, at 4th and 8th week of lactation, backfat of Thai sows was thicker than that of European sows (P=0.0018, P=0.0417, respectively). Moreover, European sows' backfat thickness decreased during the period from 5 days before parturition to 4th week of lactation more than Thai sows (P=0.0069). In fact, European sows lost backfat thickness whereas Thai sows gained backfat thickness. The significant difference in backfat thickness losses between sows of the two breeds might be caused by the difference in litter size. Mean values of litter size in European sows were larger than that in Thai sows (11.33 vs. 4.67, P=0.0495). Grandinson (2005) and Wallenbeck (2005) found that sows with large litters lost more backfat thickness than sows with small litters (r=-0.30). In this study, negative correlations between backfat loss and litter size was found but this correlations was not significant (r=-0.76, P=0.0793). There were significant differences in weight between sows of the two breeds before parturition and at weaning day (P=0.0005, P=0.0001, respectively). During lactation European sows lost weight while Thai sows gained weight. However, the differences was not

Table 4.3 Mean, standard deviation, minimum and maximum values of sow body condition traits.

Sow body condition during lactation (Backfat, mm; Weight, kg)	**Mean**		**SD**		**Min.**		**Max.**		***P*-value**
	Eu[1]	**Na[1]**	**Eu**	**Na**	**Eu**	**Na**	**Eu**	**Na**	
Sows backfat at 5 days before parturition	20.03	15.37	3.61	2.03	17.90	13.10	24.20	17.00	0.1225
Sows backfat at 4th week of lactation	12.43	21.57**	0.76	2.01	11.60	19.70	13.10	23.70	0.0018
Sows backfat at 8th week of lactation	16.80	22.47*	1.97	2.67	15.00	19.40	18.90	24.30	0.0417
Backfat change during 5th d before parturition to 4th w of lactation	-7.60	6.20**	4.33	2.03	-12.60	13.10	-4.90	17.00	0.0069
Backfat change during 4thw -8th w of lactation	4.37	0.90	2.73	1.37	1.90	-0.30	7.30	2.40	0.1209
Sows weight at 5 days before parturition	179.67**	54.67	17.16	11.93	164.00	41.00	198.00	63.00	0.0005
Sows weight at 8th week of lactation	172.00***	66.67	7.00	6.35	164.00	63.00	177.00	74.00	0.0001
Weight change during lactation	-7.67	12.00	11.59	9.53	-21.00	3.00	0.00	22.00	0.0858

*, **, *** Significantly differs, P<0.05, P<0.01 and P<0.0001, respectively.

[1]Eu = European sows; Na = Native sows.

Table 4.4 Correlation between sow backfat thickness loss and weight loss during lactation period and litter size.

	Litter size	
	R	***P*-value**
Sow backfat thickness loss	-0.76	0.0793
Sow weight loss.	-0.75	0.0831

Table 4.5 Correlation between sow backfat thickness loss and weight loss during lactation period and piglets' survival.

	Piglets survival	
	r	***P*-value**
Sow backfat thickness loss	0.97	0.0016
Sow's weight loss.	0.70	0.1223

Table 4.6 Correlation between sow backfat thickness loss and weight loss during lactation period and average daily gain (ADG).

	ADG	
	R	***P*-value**
Sow backfat loss.	-0.68	0.1367
Sow weigh loss.	-0.11	0.8413

significant (P=0.0858). Weight loss during lactation and litter size was negatively correlated (r=-0.75, P=0.0831).

A positive significant association between backfat thickness lost and piglets' survival during lactation (r=0.97, P=0.0016) was found, but not between weight loss and piglets' survival (r=0.70, P=0.1223). The finding of Grandinson (2003) on positive correlation of maternal effect and mortality of liveborn piglets indicated that a large loss of weight and backfat thickness associated with a higher survival rate. Sows with greater body weight at farrowing tend to lose more weight during lactation, and this weight loss can be utilised by the sow to support milk production especially if her food intake is low (Mullan and Williams, 1989). Grandinson (2005) found a negative genetic correlation between the direct effect for piglet birth weight and backfat at farrowing (r_g =-0.31), and between the maternal effect for stillbirth rate and backfat at farrowing (r_g=-0.23). This indicates that piglets with a genetic capacity for a high birth weight will have lower fat reserves when they later farrow. Sow with low fat reserves at farrowing have a higher incidence of stillbirth. Moreover, Knol (2001) found that selection for the direct effect of survival is likely to result in an increase in backfat. Valros et al. (2003) found that larger weight loss during 3rd week of lactation is apparently, associated with higher piglet growth rate. Similarly, this study found the negative correlation between backfat loss, weight loss and average daily gain (ADG), but not significant associations between these traits (r=-0.68, P=0.1367, r=-0.11, P=0.8413, respectively).

The results form this study show that Thai sows have higher fat reserve during lactation than European sows, and the fat reserve during lactation associated with piglets' survival during preweaning. Mersmann et al. (1984) suggests that an increase in body fat reserve will help to increase survival, through improved thermoregulation and through availability of direct usable energy. These agree with Lee and Haley (1995),

who showed that piglets from full Meishan litter survive almost as well as from full Large White litters, and the Meishan breed is considered to have a high body fat. Indeed, Meishan sows have a greater capacity to catabolise body fat in support of lactation and synthesise milk that is richer in lipids, an added benefit for newborn piglets. Leenhouwers (2002) also found a higher percentage of body fat, a somewhat higher relative weight of the stomach, and higher relative weight of the small intestine in 111 day pig foetuses with a higher genetic merit for survival. This is in line with the results of McKay (1993) which reported that index selection for reduced backfat thickness and increased growth rate increased preweaning losses, for a large part through a decrease in mothering ability.

4.1.3 Milk Production Analysis

Milk production on days 6, 9 and 12 of lactation was statistically similar ($P>0.05$) between European sows and Thai sows. Milk production in this study was approximately the same as in the previous studies of Noble et al. (2002) and Marshall et al. (2006). The results of milk production analysis are presented in Table 4.7

Table 4.7 Milk production determined by modified weight-sucking-weight (WSW) method.

Milk production analysis, kg/d[1,2]	**Day of lactation**		
	6	**9**	**12**
European sows	5.28 (0.23)	5.20 (0.09)	6.50 (0.94)
Thai sows	4.44 (0.23)	4.90 (0.09)	5.36 (0.94)
Nobel et al. (2002)	4.52 (0.32)	5.02 (0.24)	5.42 (0.37)
Marshall et al. (2006)	5.8 (0.6)	6.5 (0.6)	6.6 (0.6)

[1] Means (SD).

[2] Mean hourly milk yield was used to determine daily milk yield, assuming 24 sucking bouts per day.

4.2 Piglet weight gain

Table 4.8 shows the mean value of the weekly ADG in piglets from two breeds of sows. At one week of age, there was a significant difference in ADG of piglets of the two breed types. European piglets had a higher ADG than Thai piglets (511.90 vs. 227.62) ($P<0.05$)**.** However, there was no significant difference in ADG between the piglets of the two breed types from two up to eight weeks of age. In the last week of the lactation period average ADG of European piglets was 274.52 g/day, and Thai piglets was 195.83 g/day. In general, the observed pattern of piglets weight gain agrees well with Valros et al. (2002). ADG increased during the beginning of lactation, while it seemed to stabilise after day 15 postpartum. This is in accordance with the fact that milk output usually peaks during the third week of lactation (Toner et al., 1996).

Table 4.8 Mean, standard deviations, minimum and maximum values of ADG of European and Thai piglets.

Average daily gain (g/day)	Mean		S.D.		Min.		Max.		*P*-value
	Eu[1]	Na[1]	Eu	Na	Eu	Na	Eu	Na	
One week of age	511.90*	227.62	115.55	21.40	424.29	210.00	642.86	251.43	0.0138
Two weeks of age	355.95	202.86	96.49	7.73	270.71	194.29	460.71	209.29	0.0519
Three weeks of age	276.03	197.94	73.54	45.09	207.62	163.81	353.81	249.05	0.1919
Four weeks of age	227.62	177.74	46.13	45.04	182.86	148.93	275.00	229.64	0.2513
Five weeks of age	220.95	183.14	37.29	40.70	183.71	140.00	258.29	220.86	0.3011
Six weeks of age	268.65	187.62	64.30	32.88	200.71	156.67	328.57	222.14	0.1239
Seven weeks of age	270.41	195.92	72.31	27.81	190.82	166.53	332.04	221.84	0.1712
Eight weeks of age	274.52	195.83	73.47	16.73	193.57	178.57	336.96	211.96	0.1447

* Significantly differs ($P< 0.05$).

[1] EU = European sows; Na = Native sows.

4.3 Maternal behaviour

4.3.1 Stockperson-directed aggression scores

Thai sows were given higher scores of aggression toward stockperson than European sows during lactation period (1st to 8th week) (P= 0.0001). The mean aggression scores of each breed of sows are presented in Table 4.9. All Thai sows were given aggression score between 4 and 5 during experimental period (1st week to 8th week). An aggression score of 3 or above places the stockperson at risk of injury (Marchant, 2002). There was difficult to handle with routine management of piglets and thus present management problem. On the contrary, aggression score of European sows were between 1 and 2 and easier to handle her piglets than Thai sows.

Table 4.9 The score of aggression towards the stockperson in two breed types of sows.

Aggression score[1]	**Mean**	**S.D.**	**Min.**	**Max.**
European sows	1.208	0.389	1.000	2.000
Thai sows	4.625***	0.389	4.000	5.000

*** Significantly differs (P= 0.0001)

[1] Weekly average aggression score from week 1st to week 8th of lactation**.**

4.3.2 Aggression and production performance

There were significant differences between highly aggressive sows and none or low aggressive sows in the term of production performance (Table 4.10). Sows that were dangerously aggressive in the farrowing house (i.e. scored 3 or more) had lower piglet percentage mortality during preweaning than sow that none or low aggressive. This agrees with previous study of Merchant (2002). The relationship between aggression towards the stockperson and piglet growth rate is not clear from this study.

There was no significant association between sow aggression and ADG. Contrary to the previous study by Marchant (2002), who showed that highly aggressive sows had better piglet growth rates than non/low aggressive sows. However, the work of Merchant (2002) concerned only Large White × Landrace crossbreeds, did not compare between two breeds like this study. It is possible that growth rate of piglets are affected several factors such as genetic and not only aggressive of sows.

Table 4.10 Mean (S.D.) Mortality and ADG of piglets of high and low/non-aggressive sows.

	Highly aggressive sows (score 3-5)	**Low/non-aggressive sows (score 1-2)**	r_s[1]	***P*-value**
Mortality	0.00 (0.00)	14.76 (1.72)*	-0.95	0.0033
ADG	195.83 (16.73)	274.52 (73.47)	-0.26	0.6175

r_s[1] Sperman rank order correlation coefficients.

* Significantly differs (P<0.05).

4.3.3 Avoidance of the stockperson

European sows were given higher score of avoidance of the stockperson than Thai sows during lactation period (1st to 8th week) (P= 0.0001). The mean avoidance of the stockperson scores of sows of the two breeds are presented in Table 4.11. There was a significant different in avoidance score between breeds of sows. European sows had higher mean of avoidance score than Thai sows (2.00 vs. 1.12, P= 0.0001). However, the sows in this study were given avoidance of the stockperson scores between 1 and 2 only. The sows that were given score 1 are the same sows that perceived as aggressive by the stockperson. The sows that were given avoidance of the stockperson score 1 to 2 had low levels of fear and the sows that were given avoidance of the stockperson score 3

had high level of fear (Grandinson, 2003). Thus, the result in this study indicates that there was no difference in levels of fear between European sows and Thai sows.

Table 4.11 The score of avoidance of the stockperson in two breed types of sows.

Avoidance of the stock person score[1]	**Mean**	**S.D.**	**Min.**	**Max.**
European sows	2.000***	0.000	2.000	2.000
Thai sows	1.125	0.389	1.000	2.000

*** Significantly differs $P = 0.0001$

[1] Weekly average aggression score from 1st to 8th week of lactation**.**

4.3.4 Nursing behaviour

Nursing behaviour of sows of the two breeds were not different in number of nursing bouts per sow per week, total nursing time per sow per week, number of sow initiated nursing bouts per sow per week, total sow initiated nursing time per sow per week, number of piglet initiated nursing bouts per sow per week and total piglet initiated nursing time per sow per week ($P>0.05$) (Table 4.12). However, weekly average nursing bout length, weekly average sow initiated nursing bout length and weekly average piglet initiated nursing bout length were longer in European sows than Thai sows ($P<0.05$). Moreover, there was found a significant positive correlation between nursing bout length and litter size of sows ($r_s=0.88$, $P=0.0188$). This indicates that the sows that had larger litter sizes had longer nursing bout length than the sows that had small litter size. It is corresponding with the study of Valros et al., (2002) who found that nursing bout length was affected by litter size. Nursing bout length being longer in larger litters, possibly because of more stimulation of the udder. A significant positive correlation was found between nursing bout length and number of piglet terminated

nursing bouts per sow per week (r_s=0.64, P= 0.0076) and negative correlation between nursing bout length and number of sow terminated nursing bouts per sow per week (r_s=-0.99, P=0.0001). These agree with the results from Björknor (2003), who found that the positive correlation between nursing bout length and the rate of number of piglet terminated nursing bouts per sow per week and the negative correlation between nursing bout length and the rate of number of piglet terminated nursing bouts per sow per week. Thus, a result from this study indicates that European sows had longer nursing bouts length than Thai sows and those European piglets often terminated nursing bouts. On the contrary, Thai sows had shorter nursing bout length than European sows and that Thai sows often terminated nursing bouts.

Various aspects of nursing behaviour changed throughout lactation. All nursing behaviour in European sows were declined towards the end of lactation, agrees with the previous reports on sows which had the possibility to move away from their piglets (get-away-system) (Bøe, 1991) and free ranging sows (Jensen, 1988). This could indicate that the weaning process of the sows. However, the number of nursing bout per sow per week, total nursing time per sow per week, number of piglet initiated nursing bouts per sow per week and total piglet initiated nursing time per sow per week in Thai sows remained relatively stable over the lactation period, especially in the last observation week (8^{th} week) where Thai sows were significantly higher than European sows ($P<$ 0.05). Similarly to what was reported for pure-breed Yorkshire sows that had the successful nursing remained relatively stable over lactation period (Valros et al., 2002). However, the studied of Valros et al. (2002) was for the entire lactation period (5 weeks) and the weaning process had not started in the last observation day. In addition, Gotz (1991) reported that nursing bout length decreased with proceeding lactation showing that the sows allow less massage at later stages of lactation. It is probable that also the

latter is a sign of weaning (thus the sow is reducing the possibility for massaging by the piglets). The same author also did not find a decrease in nursing frequency toward the end of 4 week lactation, when studying sow in farrowing crates. It is possible that lowering of nursing frequency as a method of weaning is only used by sows that able to walk away from their piglets. Crated or penned sows that cannot move away from the nursing stimulus provided by their litters might be use sternal recumbency and shorter allowance of udder massage. The differences of nursing patterns between European sows and Thai sows might be caused by the sows allow massaging from the piglets and Thai sows are allow more massage at later stages of lactation than European sows.

Table 4.12 Means (SD) for nursing traits recorded during experimental period (1st week to 8th week postpartum).

Nursing parameters	**Total 1st week to 8th week**		***P*-value**
	European sows	**Thai sows**	
Number of nursing bouts per sow per week (6 hours/day, %).	33.33 (2.85)	33.33 (11.85)	Ns
Total nursing time per sow per week (6 hours/day, %).	33.33 (5.55)	33.33 (13.55)	Ns
Weekly average nursing bout length (6 hours/day, minutes).	7.74 (0.85)*	3.81 (0.33)	0.0495
Number of sow initiated nursing bouts per sow per week (6 hours/day, %).	8.86 (1.26)	9.56 (6.51)	Ns
Total sow initiated nursing time per sow per week (6 hours/day, %).	11.87 (2.60)	11.06 (6.89)	Ns
Weekly average sow initiated nursing bout length (6 hours/day, minutes).	9.61 (1.04)*	5.01 (0.66)	0.0495
Number of piglet initiated nursing bouts per sow per week (6 hours/day, %).	24.47 (2.55)	23.77 (5.35)	Ns
Total piglet initiated nursing time per sow per week (6 hours/day, %).	22.27 (2.94)	21.46 (7.10)	Ns
Weekly average piglet initiated nursing bout length (6 hours/day, minutes).	7.08 (0.86)*	3.43 (0.54)	0.0495
Number of sow terminated nursing bouts per sow per week (6 hours/day, %).	11.11 (2.96)	26.47 (2.37)*	0.0495
Number of piglet terminated nursing bouts per sow per week (6 hours/day, %).	22.22 (8.96)*	6.86 (0.48)	0.0495

Nursing records was analyzed using NPAR1WAY procedure (Wilcoxon test).

Results are presented as means, *$P<0.05$ and ns = not significant ($P>0.05$)

Table 4.13 Means (SD) for number of nursing bouts per sow per week during experimental period (1st to 8th week postpartum).

	Piglet age								
Nursing records	**3 days Postpartum (24 hours)**	**week 1**	**week 2**	**week 3**	**week 4**	**Week 5**	**week 6**	**week 7**	**week 8**
Number of nursing bouts per sow per week (6 hours/ day, %).									
- European sows.	11.49 (1.19)	15.29 (0.79)	5.38 (1.58)	2.32 (0.65)	2.53 (0.63)	2.00 (0.48)	2.10 (0.48)	1.90 (0.69)	1.79 (1.83)
- Thai sows.	10.40 (5.62)	13.76 (8.83)	4.26 (3.02)	2.97 (1.28)	2.58 (0.48)	2.19 (0.40)	2.13 (0.51)	2.33 (0.72)	3.10* (1.53)

* Significantly different ($P<0.05$), using NPAR1WAY procedure (Wilcoxon test).

Table 4.14 Means (SD) for total nursing time per sow per week during experimental period (1st to 8th week postpartum).

	Piglet age								
Nursing records	**3 days Postpartum (24 hours)**	**week 1**	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Total nursing time per sow per week (6 hours/day, %)									
- European sows.	19.66 (2.78)	23.27 (3.12)	4.08 (1.45)	2.41 (0.34)	2.02 (0.69)	1.03 (0.49)	1.16 (0.93)	0.90 (0.43)	0.56 (0.15)
- Thai sows.	14.67 (4.23)	17.98 (8.08)	2.74 (3.64)	1.62 (1.39)	1.78 (0.63)	1.47 (0.50)	1.73 (0.73)	1.65 (0.65)	2.23* (1.09)

*Significantly different (P<0.05), using NPAR1WAY procedure (Wilcoxon test).

Table 4.15 Means (SD) for weekly average nursing bout length during experimental period (1st to 8th week postpartum).

	Piglet age								
Nursing records	**3 days Postpartum (24 hours)**	**week 1**	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Weekly average nursing bout length, (6 hours/day, minutes).									
- European sows.	13.41*	11.87*	3.77	5.64*	6.09*	3.98	6.06	14.64*	11.72
	(2.73)	(7.73)	(1.48)	(0.31)	(2.54)	(5.05)	(3.05)	(4.38)	(3.95)
- Thai sows.	5.91	5.49	3.37	3.00	2.60	2.59	4.67	5.89	7.17
	(1.48)	(0.67)	(2.14)	(2.16)	(1.84)	(2.05)	(0.41)	(0.94)	(2.09)

*Significantly different ($P<0.05$), using NPAR1WAY procedure (Wilcoxon test).

Table 4.16 Means (SD) for number of sow initiated nursing bouts per sow per week during experimental period (1st to 8th week postpartum).

	Piglet age								
Nursing records	**3 days Postpartum (24 hours)**	**week 1**	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Number of sow initiated nursing bouts per sow per week (6 hours/day, %).									
- European sows.	3.79	4.53	0.63	0.42	0.42	0.95*	0.84	0.21	0.84
	(0.83)	(0.48)	(0.00)	(0.36)	(0.48)	(0.31)	(0.48)	(0.37)	(0.18)
- Thai sows.	5.23	6.40	1.03	0.58	0.25	0.25	0.13	0.52	0.39
	(0.83)	(5.91)	(1.12)	(0.34)	(0.22)	(0.29)	(0.22)	(0.40)	(0.51)

*Significantly different (P<0.05), using NPAR1WAY procedure (Wilcoxon test).

Table 4.17 Means (SD) for total sow initiated nursing time per sow per week during experimental period (1st to 8th week postpartum).

	Piglet age								
Nursing records	**3 days Postpartum (24 hours)**	**week 1**	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Total sows initiated nursing time per sow per week (6 hours/day, %).									
- European sows.	7.96	8.77	0.29	0.39	0.52	0.29	0.40	0.06	0.31
	(0.86)	(1.13)	(0.07)	(0.37)	(0.48)	(0.10)	(0.44)	(0.11)	(0.19)
- Thai sows.	7.71	8.82	0.94	0.58	0.31	0.30	0.14	0.36	0.41
	(4.87)	(6.22)	(1.00)	(0.61)	(0.28)	(0.43)	(0.24)	(0.28)	(0.45)

*Significantly different ($P<0.05$), using NPAR1WAY procedure (Wilcoxon test).

Table 4.18 Means (SD) for weekly average sow initiated nursing bout length during experimental period (1st to 8th week postpartum).

	Piglet age								
Nursing records	**3 days Postpartum (24 hours)**	**week 1**	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Weekly average sow initiated nursing bout length (6 hours /day, minutes).									
- European sows.	16.76*	15.09*	3.63	4.78	7.61	2.63	3.22	0.80	1.68
	(4.09)	(2.37)	(0.88)	(4.57)	(7.50)	(1.51)	(2.06)	(1.39)	(0.64)
- Thai sows.	6.46	9.38	3.54	3.32	3.10	2.46	1.39	2.89	3.54
	(1.44)	(6.36)	(0.98)	(1.67)	(2.80)	(2.64)	(2.41)	(1.14)	(3.50)

*Significantly different (P<0.05), using NPAR1WAY procedure (Wilcoxon test).

Table 4.19 Means (SD) for number of piglet initiated nursing bouts per sow per week during experimental period (1st to 8th week postpartum).

	Piglet age								
Nursing records	**3 days Postpartum (24 hours)**	**week 1**	**week 2**	**Week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Number of piglet initiated nursing bouts per sow per week (6 hours/day, %).									
- European sows.	7.70*	10.76	7.74	1.89	2.10	1.05	1.26	1.69	0.94
	(0.79)	(0.54)	(1.58)	(0.32)	(0.91)	(0.73)	(0.63)	(0.48)	(0.31)
- Thai sows.	5.16	7.36	3.23	2.39	2.39	1.94	2.00	1.81	2.71*
	(1.06)	(2.93)	(1.91)	(0.95)	(0.29)	(0.19)	(0.29)	(0.29)	(1.02)

*Significantly different ($P<0.05$), using NPAR1WAY procedure (Wilcoxon test).

Table 4.20 Means (SD) for total piglet initiated nursing time per sow per week during experimental period (1st to 8th week postpartum).

	Piglet age								
Nursing records	**3 days Postpartum (24 hours)**	**week 1**	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Total piglet initiated nursing time per sow per week (6 hours/day, %).									
- European sows.	11.70 (3.27)	14.49 (2.82)	2.44 (1.37)	1.23 (0.16)	1.49 (1.06)	0.74 (0.49)	0.75 (0.57)	0.84 (0.32)	0.25 (0.09)
- Thai sows.	6.97 (1.70)	9.17 (2.33)	3.14 (2.64)	1.83 (0.79)	1.47 (0.50)	1.17 (0.17)	1.59 (0.57)	1.29 (0.37)	1.81* (0.74)

*Significantly different ($P<0.05$), using NPAR1WAY procedure (Wilcoxon test).

Table 4.21 Means (SD) for weekly average piglet initiated nursing bout length during experimental period (1st to 8th week postpartum).

	Piglet age								
Nursing records	**3 days Postpartum (24 hours)**	**week 1**	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Weekly average piglet initiated nursing bout length (6 hours/ day, minutes).									
- European sows.	11.75*	10.49*	3.78	5.20	5.13	5.85	4.34	3.79	2.12
	(2.78)	(2.22)	(0.93)	(1.53)	(1.60)	(3.77)	(3.17)	(0.38)	(0.41)
- Thai sows.	5.40	5.10	3.40	2.92	2.34	2.36	3.01	2.72	2.55
	(2.02)	(1.69)	(0.88)	(0.38)	(0.51)	(0.56)	(0.88)	(0.54)	(0.39)

*Significantly different (P<0.05), using NPAR1WAY procedure (Wilcoxon test).

Table 4.22 Means (SD) for number of sow terminated nursing bouts per sow per week during experimental period (1st to 8th week postpartum).

Nursing records	Piglet age								
	3 days Postpartum (24 hours)	**week 1**	**week 2**	**week 3**	**week 4**	**week 5**	**Week 6**	**week 7**	**week 8**
Number of sow terminated nursing bouts per sow per week (6 hours/day, %).									
- European sows.	2.23	4.65	1.29	0.97	0.97	0.58	0.71	0.84	1.09
	(1.29)	(2.85)	(0.73)	(0.58)	(0.33)	(0.38)	(0.11)	(0.48)	(0.73)
- Thai sows.	4.61	10.34*	4.55*	2.00	2.00	1.79*	2.11*	1.90	1.79
	(4.50)	(0.96)	(0.79)	(0.79)	(0.65)	(0.48)	(0.48)	(0.83)	(0.18)

*Significantly different (P<0.05), using NPAR1WAY procedure (Wilcoxon test).

Table 4.23 Means (SD) for number of piglet terminated nursing bouts per sow per week during experimental period (1st to 8th week postpartum).

	Piglet age								
Nursing records	**3 days Postpartum (24 hours)**	**week 1**	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Number of piglet terminated nursing bouts per sow per week (6 hours/day, %).									
- European sows.	7.17 (5.06)	9.11 (6.05)	2.97 (2.29)	2.00* (0.80)	1.61* (0.62)	1.61* (0.11)	1.42* (0.44)	1.48* (0.22)	2.00* (0.78)
- Thai sows.	5.48 (3.00)	4.96 (0.65)	0.84 (0.79)	0.31 (0.31)	0.52 (0.18)	0.21 (0.18)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)

*Significantly different (P<0.05), using NPAR1WAY procedure (Wilcoxon test).

4.3.5 Effects of nursing behaviour on ADG

ADG was found to be significantly association with number of sow initiated nursing bouts per sow per week, number of piglet initiated nursing bouts per sow per week, weekly average nursing bout length and weekly average piglet initiated nursing bout length (Table 4.24). However, it was found in this study that total nursing time per sow per week had no effect on piglets' growth, similarly to the previous study of Valros et al., (2002). It is likely that the positive effect of nursing frequency on piglets' growth is mainly caused by the high frequency of milk ejection per second, not by a longer total duration of udder massage (Valros et al., 2002). Moreover, the data on individual milk intake collected by Špinka et al. (1997) suggested that alveoli could fill-up with milk quickly after each successful nursing. Hence, the authors hypothesised milk yield to mainly be determined by the frequency of emptying of alveoli and by the completeness of the emptying. In addition, Auldist et al. (2000) found a positive correlation between milk yield and gland weight and a higher individual gland weight in more frequently nursed sows. This indicates that milk production is strongly influenced by behavioural aspects affecting the frequency of milk-let-down.

Table 4.24 Sperman rank order correlation coefficients between nursing behaviour traits and ADG.

Nursing behaviour	**ADG**	
	r_s	***P*-value**
Number of sow initiated nursing bouts per sow per week.	0.49	0.0500
Number of piglet initiated nursing bouts per sow per week.	0.70	0.0022
Weekly average nursing bout length.	0.63	0.0093
Weekly average piglet initiated nursing bouts length.	0.60	0.0142

4.3.6 Sows activity.

Sows of the two breeds spent a majority of the time lying during observation periods (Table 4.25 and 4.26). However, European sows spent more time lying than Thai sows in all of the observation periods ($P<0.05$). From first to last weeks of observation, Thai sows spent more time standing than European sows ($P<0.05$). Moreover, during 3 days postpartum Thai sows spent more time standing than European sows ($P<0.05$). Thus, Thai sows were more active than European sows during observation period. No correlation was found between the number of nursing bouts and the time of the sows stood up ($r_s= 0.77$, $P= 0.07$). Contrary to the previous report by Björkner (2003), that sows spent more time standing up and nursed their piglets more often. In addition, no correlation was found between the time when the sow was active and total number of dead and crushed piglets.

Table 4.25 Sow activities during lactation period (6 sows).

Duration (%) of observation period.	**Mean (SD)** **3 days postpartum**	**Mean (SD)** **Weeks 1-8**
Lying (not nursing)		
European sows	5.27 (0.18)	82.83* (1.23)
Thai sows	5.12 (0.19)	77.60 (0.73)
Standing		
European sows	0.75 (0.53)	8.62 (0.67)
Thai sows	1.10* (0.08)	16.50* (0.75)
Sitting		
European sows	0.49 (0.13)	7.67 (1.20)
Thai sows	0.40 (0.12)	6.26 (0.17)

*Significantly different ($P<0.05$).

Table 4.26 Means (SD) for sow activity during lactation period (in each observation week).

Duration (%) of observation period.	**W eek 1**	**W eek 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Week 8**
Lying (not nursing)								
European sows	20.88 (3.60)	11.08 (2.11)	7.52 (0.37)	8.83* (0.61)	8.62 (0.49)	8.35 (0.58)	8.82 (0.48)	8.73 (0.62)
Thai sows	19.96 (1.79)	10.11 (0.62)	7.27 (0.28)	7.73 (0.40)	8.30 (0.08)	8.30 (0.24)	8.01 (0.89)	7.92 (0.74)
Standing								
European sows	2.42 (1.57)	2.69 (1.84)	1.10 (0.75)	0.55 (0.56)	0.05 (0.41)	0.43 (0.24)	0.69 (0.54)	0.69 (0.44)
Thai sows	5.41* (1.24)	2.87 (0.13)	2.05 (0.32)	1.58 (0.52)	1.01 (0.13)	1.17* (0.09)	1.18 (0.89)	1.23 (0.67)
Sitting								
European sows	3.78 (0.75)	0.81 (0.40)	1.10 (0.81)	0.33 (0.07)	0.60 (0.07)	0.45 (0.16)	0.21 (0.06)	0.39 (0.18)
Thai sows	1.71 (0.56)	1.60 (0.49)	0.41 (0.15)	0.40 (0.11)	0.41 (0.19)	0.63 (0.27)	0.53* (0.22)	0.57 (0.12)

*Significantly different ($P<0.05$).

4.4 Behaviour of piglets.

Piglets' behaviour observation was started at 3 days postpartum. The time of the day for the observation was selected on the thought of recording both an active and a calm period of the pigs. According to Bøe (1993) and Eriksson (2006) one of the most active periods of the day are from 08.30 to 10.30 hours. In my study the piglets seemed to be more active in the morning, around 8.00 to 10.00 hours and again, around 14.00 to 16.00 hours. Around 10.00 to 14.00 hours the piglets seemed to rest more. In this study the time around 14.00 to 16.00 hours was chosen for observing behaviors of the piglets.

The parameters used in piglets' behavior observation are presented in Table 4.27 to 4.36 The results showed that Thai piglets token longer times for sucking than European piglets ($P<0.05$). Number of sucking bouts in Thai piglets increased from the first observation week to the last observation week, whereas that of European piglets decreased. However, weekly average sucking bout length was higher in European piglets ($P<0.05$). It corresponds with the nursing behaviour of sows, nursing bouts length was affected by the litter size, i.e. nursing bout length being longer in larger litter size**.** In addition, there was found a significant positive association between total nursing time in sow and the weekly average sucking length in piglet ($r_s=0.52$, $P=0.0374$). This result indicates that both of total nursing time in sow and total sucking time in piglet were effect by the litter size, i.e. longer in larger litter size.

Total of lying behaviour in piglets (1^{st} to 8^{th} weeks) was not different in number of lying bouts per piglet per week and total lying time per piglet per week between the two breeds. However, The number of lying bouts per piglet per week and total lying time per piglet per week in Thai piglets increased from the first observation week to the last observation week. Whereas in European piglets decreased, in 6^{th} week and 7^{th} week Thai piglets were higher in number of lying bouts per piglet per week and total lying

time per piglet per week than European piglets. Lying bout length was higher in European piglets than in Thai piglets ($P<0.05$).

European piglets were active than Thai piglets from the first observation week to the last observation week ($P<0.05$). There were significant higher in number of active bouts per piglet per week, total active time per piglet per week and weekly average active length in European piglets than Thai piglets. It is possible that Thai piglets were taken the large times for sucking and lying behaviours, whereas European piglets were taken the large times for active behaviour.

Table 4.27 Means (SD) for piglets' behaviour during observation period.

Piglets' behaviour traits.	**Mean (SD) weeks 1-8 postpartum**		***P*-value**
	Europea	**Thai**	
Number of sucking bouts per piglet per week (%).	15.50 (1.99)	21.92 (2.66)	0.2752
Total sucking time per piglet per week (%).	23.36 (1.89)	31.82* (0.89)	0.0495
Weekly average sucking length (minutes).	5.63* (0.85)	3.75 (0.48)	0.0495
Number of lying bouts per piglet per week (%).	30.22 (186)	40.83 (1.34)	0.5127
Total lying time per piglet per week (%).	30.18 (1.36)	33.60 (3.51)	0.2752
Weekly average lying length (minutes).	8.75* (0.73)	6.42 (0.94)	0.0495
Number of active bouts per piglet per week (%).	54.28* (0.91)	37.25 (0.93)	0.0431
Total active time per piglet per week (%).	46.46* (1.41)	34.57 (3.12)	0.0495
Weekly average active length (minutes).	10.14* (0.26)	5.72 (1.08)	0.0495

*Significantly different ($P<0.05$).

Table 4.28 Means (SD) for number of sucking bouts per piglet per week during observation period in each week.

Piglets' behaviors	**Piglet age**							
	week 1	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Number of sucking bouts per piglet per week (%).								
- European piglets.	2.62	4.72	3.41	3.41	2.89	2.36	1.57	2.36
	(0.90)	(0.79)	(1.20)	(1.20)	(1.63)	(0.78)	(0.78)	(0.78)
- Thai piglets.	2.91	4.36	4.84	2.75	3.55	3.87*	3.39	6.14*
	(1.74)	(0.48)	(1.28)	(0.56)	(1.96)	(0.48)	(2.11)	(0.55)

*Significantly different ($P<0.05$), using NPAR1WAY procedure (Wilcoxon test).

Table 4.29 Means (SD) for sucking time per piglet per week during observation period in each week.

Piglets' behaviors	**Piglet age**							
	week 1	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Sucking time per piglet per week (%)								
- European piglets.	1.87	3.14	2.33	2.21	1.60	1.68	1.05	1.58
	(0.44)	(1.71)	(1.22)	(1.24)	(1.10)	(1.91)	(0.81)	(0.99)
- Thai piglets.	1.97	3.22	3.90	2.58	2.47	2.40	2.17	3.19
	(0.55)	(0.15)	(0.45)	(0.22)	(0.80)	(0.51)	(0.46)	(0.55)

*Significantly different ($P<0.05$), using NPAR1WAY procedure (Wilcoxon test).

Table 4.30 Means (SD) for weekly average sucking length during observation period in each week.

Piglets' behaviors	**Piglet age**							
	week 1	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Weekly average sucking length (minutes).								
- European piglets.	6.41*	5.58	5.73	5.35	4.55	5.79	5.78	5.53*
	(0.95)	(2.74)	(0.99)	(1.95)	(0.92)	(3.91)	(2.41)	(1.72)
- Thai piglets.	4.11	3.99	4.44	5.09	4.00	3.28	5.05	2.79
	(1.24)	(0.63)	(0.98)	(0.62)	(0.85)	(0.29)	(3.98)	(0.56)

*Significantly different ($P<0.05$), using NPAR1WAY procedure (Wilcoxon test).

Table 4.31 Means (SD) for number of lying bouts per piglets per week during observation period in each week.

Piglets' behaviors	**Piglet age**							
	week 1	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Number of lying bout per piglets per week (%).								
- European piglets.	5.25	8.40*	3.94*	3.15	2.36	1.84	2.10	3.41
	(1.98)	(2.53)	(0.78)	(1.36)	(0.78)	(0.45)	(0.45)	(1.64)
- Thai piglets.	3.23	2.91	2.58	3.55	4.04	5.82*	6.14*	5.33
	(1.11)	(0.96)	(0.28)	(1.22)	(1.22)	(2.11)	(1.01)	(0.84)

*Significantly different ($P<0.05$), using NPAR1WAY procedure (Wilcoxon test).

Table 4.32 Means (SD) for total lying time per piglet per week during observation period in each week.

Piglets' behaviors	**Piglet age**							
	week 1	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Total lying time per piglet per week (%).								
- European piglets.	5.84	5.32*	3.56	2.82	2.96	2.54	2.90	4.26
	(2.71)	(1.52)	(0.65)	(2.02)	(0.99)	(0.42)	(0.31)	(1.93)
- Thai piglets.	5.12	3.33	2.55	4.45	4.91	6.62*	6.83*	6.99
	(1.96)	(0.95)	(0.84)	(2.80)	(2.85)	(2.54)	(1.88)	(1.61)

*Significantly different ($P<0.05$), using NPAR1WAY procedure (Wilcoxon test).

Table 4.33 Means (SD) for weekly average lying length during observation period in each week.

Piglets' behaviors	Piglet age							
	week 1	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Weekly average lying length (%).								
- European piglets.	11.08	5.69	7.88	7.25	11.81	12.22*	12.55*	11.72
	(7.73)	(1.48)	(0.31)	(2.54)	(5.05)	(2.02)	(3.97)	(3.94)
- Thai piglets.	8.39	6.43	5.41	6.31	6.12	6.02	5.89	7.17
	(0.66)	(2.14)	(2.17)	(1.84)	(2.05)	(0.41)	(0.94)	(2.09)

*Significantly different ($P<0.05$), using NPAR1WAY procedure (Wilcoxon test).

Table 4.34 Means (SD) for number of active bouts per piglet per week during observation period in each week.

Piglets' behaviors	**Piglet age**							
	week 1	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Number of active bouts per piglet per week (%).								
- European piglets.	3.94*	8.14*	6.04*	6.07	6.30	6.30	4.99	4.72
	(0.78)	(1.82)	(0.45)	(1.20)	(2.08)	(0.78)	(1.20)	(0.78)
- Thai piglets.	2.42	4.85	4.68	5.65	4.68	4.20	4.04	4.36
	(0.48)	(0.48)	(0.74)	(1.00)	(0.56)	(0.56)	(0.56)	(0.48)

*Significantly different ($P<0.05$), using NPAR1WAY procedure (Wilcoxon test).

Table 4.35 Means (SD) for total active time per piglet per week during observation period in each week.

Piglets' behaviors	**Piglet age**							
	week 1	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Total active time per piglet per week (%).								
- European piglets.	3.20	4.23	6.91	7.66	8.14*	10.57*	6.74	6.82*
	(0.37)	(0.29)	(0.74)	(0.74)	(1.52)	(1.38)	(2.65)	(1.89)
- Thai piglets.	2.56	6.88*	6.21	5.95	5.28	3.65	3.66	3.07
	(1.28)	(0.41)	(1.15)	(2.09)	(2.11)	(2.04)	(1.41)	(1.01)

*Significantly different ($P<0.05$), using NPAR1WAY procedure (Wilcoxon test).

Table 4.36 Means (SD) for weekly average active length during observation period in each week.

Piglets' behaviors	Piglet age							
	week 1	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**
Weekly average active length (%).								
- European piglets.	7.32	4.63	10.01*	11.39*	12.06*	14.57*	11.46*	12.42*
	(2.11)	(0.79)	(1.71)	(3.13)	(4.29)	(0.79)	(2.49)	(1.56)
- Thai piglets.	5.76	7.61*	7.12	5.65	5.93	4.74	4.87	3.88
	(2.96)	(0.58)	(1.10)	(1.94)	(1.94)	(2.95)	(1.76)	(1.71)

*Significantly different (P<0.05), using NPAR1WAY procedure (Wilcoxon test).

CHAPTER V

CONCLUSION

The present study demonstrated that sow nursing behaviour changes during the lactation period in a way that indicates a continuous weaning process starting already in the early weeks of lactation. However, there was found a difference in nursing pattern between the two breeds of sows. Nursing behaviour in European sows was declined towards the end of lactation whereas that in Thai sows remained relatively stable over lactation. Moreover, weekly average nursing bout length, weekly average sow initiated nursing bout length and weekly average piglet initiated nursing bout length were longer in European sows than in Thai sows. That nursing bout length being longer in larger litters, it is possible because of more stimulation of the udder. This study found a significant positive correlation between weekly average nursing bout length and number of piglet terminated nursing bouts per piglet per week (r_s=0.64, P= 0.0076) and negative correlation between weekly average nursing bout length and number of piglet terminated nursing bouts per piglet per week (r_s=-0.99, P=0.0001). This means that if the sows were to terminated a nursing, the nursing would be short and if the piglets were to terminated a nursing, the nursing would be long. The results in this study show that European sows had longer nursing duration than Thai sows.

The piglets of European sows have been selected for increasing in both litter size at birth and growth rates. On the contrary, the piglets of Thai sows have not been selected through the process of domestication. Hence, this study hypothesized that these European piglets should have higher growth rate than Thai piglets. Nevertheless, study

showed that no significant different in ADG between two breeds (274.52 vs.195.83 g/day, P=0.1447). It was found a positive effect of nursing frequency on piglets' growth. Nursing parameters of Thai sows remained relatively stable over lactation whereas those of European sows declined, especially in the last week of observation where Thai sows were significantly higher in number of nursing bouts per sow per week, total nursing time per sow per week and number of piglet initiated nursing bouts per sow per week than European sows (P<0.05). Moreover, Thai piglets were higher in total sucking time per piglet per week than European piglets (P<0.05). From these results it might be the cause of the no significant different in ADG between piglets of the two breeds. However, it is possible that litter size at birth also affected the differences.

The results in this study showed that European sows had higher piglets' mortality than Thai sows (P=0.0339) during lactation period. One reason can be the duration of farrowing. A significant positively correlation between the duration of farrowing and piglets' mortality (r_s=0.83, P=0.0394) was found. Moreover, European sows were higher in duration of farrowing than Thai sows (P=0.0495). Another reason can be the aggression in sows. A negative correlation between mortality in piglets and aggression in sows (r_s=-0.95, P=0.0001) was found. Thai sows were highly aggressive whereas European sows were no or low aggressive. The last reason can be that sows body condition during lactation. Thai sows had higher fat reserve during lactation than European sows and fat reserve during lactation associated with piglets' survival during pre-weaning.

Thai sows spent her time for active behaviour more than European sows during the observation period. However, the relation between the frequency of nursing and the times of sows stood up is not clear in this study, i. e. no correlation was found. Contrary

to the previous reported from Björkner (2003).

Milk production was statistically similar between European sows and Thai sows on day 6, 9, 12 of lactation. In addition, the sows of both breeds in this study did not show signs of fear of the stockperson.

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