Development of ingestive behaviour and the relationship to belly nosing in early-weaned piglets

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Abstract

Over the last 30 years, improvements in diet formulations have resulted in a steady decline in weaning age while still meeting the nutritional needs of the piglets. However, even with their dietary requirements met, many piglets still experience a number of difficulties at weaning. Piglets weaned prior to 4 weeks-of-age typically take longer to ingest solid feed, drink excessively and develop oral behaviour problems such as belly nosing and belly sucking. There is considerable variation in the amount of time individual piglets spend belly nosing, and factors such as weaning weight and suckling behaviour on the sow do not reliably predict which piglets will belly nose. However, those piglets that spend more time belly nosing also spend less time at the feeder and have poorer growth rates, and there is growing evidence that feeding, drinking and sucking motivation are linked in the early-weaned piglet. In this article, we review current knowledge on the development of feeding, drinking and belly nosing in order to illustrate the relationships among the sucking, feeding and drinking motivational systems in the early-weaned piglet. We also explore differences in the tendencies of individual piglets to develop problems at weaning and how genetic and environmental factors may play a role in these differences.

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1. Introduction

Over the last few decades, ‘early weaning’ of piglets has been a moving target in commercial pork production as weaning ages have steadily declined. Advances in our knowledge of the digestive physiology of the piglet together with the development of complex diets that meet piglets’ nutritional needs have resulted in a shift from weaning ages of about 5–7 weeks in the 1970s to as early as 1 or 2 weeks in Segregated Early Weaning (SEW) systems developed in North America in the 1990s (Robert et al., 1999). Currently, most piglets in the USA and Canada are weaned around 3 or 4 weeks-of-age. The immediate behavioural responses to artificial weaning are quite obvious regardless of weaning age, but are significantly more pronounced in younger piglets (Weary and Fraser, 1997). During the first day or two after weaning, piglets are restless, give high rates of distress calls and attempt to escape their pens, presumably in an attempt to regain contact with their sow (Weary et al., 1999; Worobec et al., 1999). Early maternal separation has been shown to have permanent effects on hypothalamic pituitary adrenal axis function, fearfulness and cognitive function in various species (see review by Latham and Mason, this volume) but any similar consequences for early-weaned piglets are just beginning to be explored (Poletto et al., 2006; Siegford et al., this volume; Souza and Zanella, this volume).

In addition to signs of emotional distress, there are other behavioural responses to weaning that reflect difficulties in adaptation to weaning. Piglets weaned at younger ages typically take longer to begin ingesting solid feed, engage in high levels of drinking and are more likely to develop belly nosing than those weaned at older ages (Fraser, 1978; Metz and Gonyou, 1990; Worobec et al., 1999). Belly nosing is the distinctive, rhythmic up-and-down movement of one piglet rubbing the belly of another with its snout (Fraser, 1978), and can result in lesions on the belly and flank of the receiver (Straw and Bartlett, 2001). Dybkjær (personal communication), observed no belly nosing in 8-week-old piglets in a semi-natural environment, whereas belly nosing commonly appears a few days after artificial weaning. Belly nosing is mechanically similar to the udder massage that occurs during the appetitive and post-consummatory phases of nursing behaviour (described by Fraser, 1980), which suggests that the behaviour arises from suckling motivation (Dybkjær, 1992; Weary et al., 1999; Worobec et al., 1999).

Belly nosing has been suggested to result from a separation problem (Gonyou, 2001) or to be a general behavioural indicator of ‘stress’ (Dybkjær, 1992). However, there is growing evidence that belly nosing is related to certain aspects of feeding and drinking in newly weaned piglets. In rodent models of ingestion, it is clearly established that feeding, drinking and sucking are distinct motivational systems, with different developmental trajectories, cues, control centers and feedback systems, and that some of these aspects overlap during the process of natural weaning (see reviews by Hall and Williams, 1983; Blass, 1995). The body of literature on newly weaned piglets suggests that soon after artificial weaning, these three motivational systems interact in ways that lead to difficulties in establishing independent ingestion and result in belly nosing. In this paper, we will synthesize current knowledge on the development of feeding, drinking, suckling and belly nosing in order to illustrate the relationships among the sucking, feeding and drinking motivational systems in the newly weaned piglet. We will explore differences in the tendencies of individual piglets to develop problems at weaning and how genetic and environmental factors may play a role in these differences.

Throughout this paper, the terms ‘sucking’, ‘suckling’ and ‘nursing’ will be used as defined by Hall et al. (1988). Suckling is the piglets’ behaviour that contributes to the attainment of milk. Sucking is a component of suckling and is the specific motor pattern involved in the creation of negative pressure on the teat or other object. Nursing refers to the activity of the dam, which aids...
the transfer of milk to her offspring. Nursing period will be used to describe the time of life when piglets are consuming the majority of their nutrients in the form of milk.

In addition, the following terms will be used frequently: ‘natural weaning’, ‘artificial weaning’ and ‘artificial rearing’. Natural weaning refers to the gradual process whereby the sow and litter remain in proximity with each other but the litter ceases to suckle and relies exclusively on the intake of solid food. Artificial weaning refers to the abrupt separation of the sow and her litter, with the litter being fed solid or liquid non-milk feed. Artificial rearing refers to the rearing of piglets without the sow, usually beginning immediately after birth or within the first few days and with the litter fed milk or a milk replacer.

2. The natural weaning process

Under semi-natural conditions, a domesticated sow and her litter will remain around the nesting site from birth until about 9 days after farrowing (Jensen, 1986). Piglets continue suckling until approximately 9–20 weeks-of-age, and to live in social contact with the sow for some time afterward (Newberry and Wood-Gush, 1985; Jensen, 1986; Jensen and Recén, 1989; Stolba and Wood-Gush, 1989). Bøe (1991) found that when sows and piglets were provided with ample bedding material in enriched pens, suckling no longer occurred after 11–12 weeks-of-age. In all of these populations, weaning was a gradual process in which it was often difficult to determine exactly when milk transfer from sow to her offspring ceased. Since not only milk transfer, but also maternal care declines gradually during the process, Martin (1984) suggested that weaning be defined as the period when drop in parental investment per unit time is the largest. Because lactation represents a significant part of the sow’s care for her offspring, the termination of such care can be expected to cause the young to make considerable efforts to obtain more resources than the parent is prepared to provide. As a result, weaning might be expected to involve overt conflicts, such as intense begging efforts or competition for remaining milk resources by the young, and aggressive rejection by the mother (as described by Trivers, 1974). However, pigs in free-range conditions show very little conflict behaviour during the weaning process (Jensen and Recén, 1989). Rather, there is a gradual decline in frequency of suckling with few attempts at rejection and little aggression shown by the sow (Jensen and Recén, 1989). Instead, she initiates fewer and terminates more nursings, and generally makes sucking more tedious for piglets (Jensen and Recén, 1989; Jensen, 1995). This is accompanied by a decrease in milk production and milk quality as lactation wanes.

3. Development and control of ingestive systems in piglets

3.1. Suckling behaviour

During parturition, milk flow is continuous as piglets use a combination of olfactory, auditory and tactile cues to initially locate a teat and begin sucking (Welch and Baxter, 1986; Morrow-Tesch and McGlone, 1990; Rohde Parfet and Gonyou, 1991). Over the next couple of days, nursing bouts become synchronous and cyclical, occurring every 30–70 min (Fraser, 1980; Lewis and Hurnik, 1985). The nursing bouts consist of five discrete phases: arrangement of the pigs on the udder, preliminary udder massage which stimulates oxytocin release for milk let-down, slow amplitude non-nutritive sucking, fast amplitude sucking which is used to withdraw milk from the teat and a final udder massage (Fraser, 1980). Primarily, it is thought that the time since the last nursing, and thereby hunger, is the major stimulus for piglets to approach the udder and resume
the nursing process (Rushen and Fraser, 1989). However, some external cues such as nursing grunts or postural changes of the sow can stimulate the onset of a nursing bout (Fraser, 1980; Rushen and Fraser, 1989), and nursing bouts are often synchronized among sows and litters in the same room, a maternal strategy to reduce cross-suckling (Špinka et al., 2004; Illmann et al., 2005). Playback of recorded nursing grunts has been used to elicit nursings (Wechsler and Brodmann, 1996) and increase piglet growth rates (Cronin et al., 2001) in farrowing rooms, but this treatment is not always reliable (Fisette et al., 2004; Špinka et al., 2004).

The final phase of piglet nursing involves massaging of the udder after milk ejection. Because this final phase is energetically expensive (Klaver et al., 1981), highly variable in duration (Bøe and Jensen, 1995), and can account for the greatest percentage of time in a nursing bout (Algers and Jensen, 1985), a number of authors have argued that it must serve an important function. Massage may play a role in milk production since it stimulates prolactin and somatostatin release, hormones involved in lactogenesis (Rushen et al., 1993). It has also been suggested to function as a form of parent–offspring communication, with pigs “ordering” up or begging for their next meal (Algers and Jensen, 1985; Špinka and Algers, 1995; Illmann et al., 1998; Jensen et al., 1998; Weary et al., 1996). Recently, Torrey and Widowski (2007) examined the relationships between the final massage and piglet birth weight and growth rates during the first 2 weeks of lactation. There was no relationship between birth weight and duration of final massage, but both individual and litter growth rates were negatively correlated with the amount of sucking and massage performed after milk ejection. Slower growing piglets were also involved in more unsuccessful nursing bouts and spent more time massaging in between bouts. Although nearly all piglets engage in final massage to some degree, it appears that the duration of final massage does indeed reflect piglets’ nutritional needs (Weary et al., 1996; Torrey and Widowski, 2007).

The ability for piglets to alter their suckling behaviour in response to nutrient state requires that peripheral and central mechanisms involved in intake control are operative. Early work by Stephens (1975), Houpt et al. (1983) and Houpt and Houpt (1977) indicated that at least some of these regulatory mechanisms are functional in the piglet within the first week after birth since a period of fasting increases voluntary milk intake, while gastric loading with milk, glucose, and other nutritive solutions reduces it. More recently, Baranyiová and Hullinger (1999) found that administration of the peptide hormone cholecystokinin (CCK) reduced milk intake in piglets as young as 2 days old suggesting that this satiety signal is an important component of intake regulation even in the early postnatal period. This is quite different from the situation in the rat, in which nipple attachment and suckling occur almost reflexively in response to external stimuli and are not under the control of nutritional or gastric factors until much closer to natural weaning age (see reviews by Hall and Williams, 1983; Blass, 1995). However, it is important to point out that although piglets reduce milk intake after gastric loading, they continue to engage in vigorous oral activity and suckling motor patterns regardless of whether the stomach has been filled with milk (Stephens, 1975; Fry et al., 1981). Artificially reared piglets fed milk replacer are highly motivated to engage in sucking and massage and commonly develop belly nosing, navel sucking or stereotyped snout rubbing in the absence of appropriate sucking stimuli (Jeppesen, 1981; Widowski et al., 2005). This non-nutritive sucking may serve purposes not related to the attainment of milk. For example, artificially reared calves are also highly motivated to perform sucking behaviour following milk ingestion (see review by de Passillé, 2001). When calves were provided a dry teat for non-nutritive sucking following ingestion of milk from a bucket, they had higher hepatic portal concentrations of insulin and CCK compared to calves that did not suck after drinking milk (de Passillé et al., 1993). Any relationship between performance of sucking
(or suckling) behaviour and digestive hormone secretion or satiety signals as has been demonstrated in the calf has not been investigated in piglets.

The performance of suckling behaviour is also related to affective state. Non-nutritive sucking on an artificial nipple reduces heart rate and cries of human infants undergoing painful procedures (Campos, 1994; DiPietro et al., 1994; Corbo et al., 2000; Pinelli et al., 2002) and increases restfulness in human infants (Field et al., 1982; Paludetto et al., 1984), calves (Veissier et al., 2002) and piglets (Widowski et al., 2005), while non-nutritive sucking elicits an analgesic response in rat pups (Anseloni et al., 2004). Non-nutritive sucking bouts are elicited by external disturbances to sows and litters held outdoors (Castrén et al., 1989) and after handling of piglets in farrowing crates (Torrey, 2005). Therefore, sucking and massage may not only be a way for piglets to signal their need, but also a way in which pigs can soothe themselves.

3.2. Feeding behaviour

In outdoor systems, piglets are reported to begin rooting and chewing environmental substrates during the first week of life (Stolba and Wood-Gush, 1989; Petersen, 1994) and to begin grazing (biting, chewing and swallowing plant materials) during the fourth (Petersen, 1994). However in these studies it was difficult to determine how much food piglets were actually ingesting and how this changed over time. Cox and Cooper (2001) first observed piglets kept outdoors eating their sow’s food during the second week after birth.

Few studies have specifically addressed the development of eating during the natural weaning process, but the literature regarding creep feed may provide insight into factors that initiate independent ingestion in piglets. In commercial settings, suckling piglets are often provided with creep feed to supplement their nutrient intake, since there is often a gap between the piglet’s growth potential and the sow’s milk production (Pluske et al., 2005). Creep feeding is also thought to help prevent the post-weaning growth lag common in early-weaned piglets by allowing them to become familiar with eating solid food. Yet, consumption of creep feed within and between litters is highly variable and its usefulness in enhancing feed intake after weaning remains unclear (Pajor et al., 1991; Fraser et al., 1994; Delemeau and Meunier-Salaün, 1995; Bruininx et al., 2002).

Creep feed consumption of the ‘average piglet’ is usually nil until around 20 days-of-age (Pajor et al., 1991; Delemeau and Meunier-Salaün, 1995; Puppe and Tuchscherer, 2000), and increases after 28 days when suckling frequency rapidly declines (Puppe and Tuchscherer, 2000). Even at 28 days-of-age, individual intakes vary considerably (Bruininx et al., 2004). It has been proposed that heavier piglets are able to utilize ingested nutrients at an earlier age because their gastrointestinal tracts and digestive function are more mature (Bruininx et al., 2004). This agrees with the results of Pajor et al. (1991) that larger piglets consume creep feed earlier than smaller piglets and with those of de Passillé et al. (1989) who showed that heavier piglets had proportionally larger digestive tracts. However, Bruininx et al. (2004) also suggested that smaller, slow growing piglets may be more likely to eat creep feed in order to compensate for inadequate nutrition from milk, although this appears to only hold true for piglets older than 4 weeks-of-age (Appleby et al., 1992). The way in which creep feed is presented can also affect intake; piglets may eat more when the creep feed is easy to find and when social facilitation of feeding is accommodated (Keeling and Hurnik, 1996; Wattanakul et al., 2005).

While volumes have been written on development of the neonatal gut, digestive function and nutrition in piglets (for examples, Cranwell, 1995; Pluske et al., 1995; Kelly and King, 2001), one aspect that is rarely considered with regard to eating in piglets is the development of their
dentition. Piglets are not born with a full set of teeth, and develop both deciduous and permanent dentition with age (Moran, 1982). Deciduous premolars erupt by about 3 weeks (Herring, 1985). In addition, developmental changes in the musculature of the jaw, such as muscle fiber length and orientation, are necessary to permit increased muscle tension for the breaking down of solid foods (Herring and Wineski, 1986). It has been suggested that feedback from early masticatory behaviour induces anatomical changes, with neural changes occurring secondarily (Herring, 1985), since delayed solid feed intake delays jaw muscle development. As such, both the anatomical and neural systems for adult mastication are not fully developed at birth and the piglet must undergo important developmental processes before the transition to independent ingestion can occur.

The switch from suckling to ingestion of food requires a variety of mechanisms to be in place. In addition to the peripheral and central control systems for food intake discussed above, digestion and absorption of non-milk feedstuffs requires maturation of the gastrointestinal tract, development of various digestive enzyme systems and microbial colonization of the small intestine (see reviews by Cranwell, 1995; Kelly and King, 2001) as well as the ability to recognize, ingest and masticate food items. Most attempts to characterize the initiation of feeding on the basis of body weight alone have not been successful. It is more likely that some combination of digestive physiology maturation together with experience with food and non-food substrates and, perhaps, even inoculation of the gut with certain microflora, determine when an individual piglet is ready to consume food.

### 3.3. Drinking behaviour

Suckling piglets have the ability to drink within 3–5 h after birth but usually consume little water since most of their fluid intake comes through the sow’s milk (Nagai et al., 1994). Few studies have examined water intake in the suckling piglet, and although it is minimal, intake and drinking behaviour largely depend on environmental temperature (Nagai et al., 1994) and drinker design (Phillips and Fraser, 1991). Kinematic and electromyographic studies indicate that there are many similarities in the tongue, hyoid and jaw movements between sucking and drinking in miniature pigs; drinking involves forming a seal between the tongue and palate so as to create a negative pressure used to ingest water (Thexton et al., 1998). This is in contrast to non-ungulate mammalian species that use ‘lapping’ to ingest water (Thexton et al., 1998). This is in contrast to non-ungulate mammalian species that use ‘lapping’ to ingest water (e.g. carnivores).

For the first couple of days after artificial weaning, piglets’ feed intake is remarkably low and many piglets lose weight. However, at the same time, water intake is elevated compared to later days (Brooks et al., 1984). Time spent eating is lower on the first day after weaning compared to the second day, whereas time spent drinking is higher on the first day compared to the second (Dybkjær et al., 2006). In older pigs, most drinking is associated with feeding (Kraly, 1984; Bigelow and Houpt, 1988), but there appears to be little correspondence between drinking behaviour and feed intake during the first few days after weaning (Brooks et al., 1984). It has been suggested that young piglets ingest more water to obtain the gastrointestinal fill that they are lacking (Yang et al., 1981; Brooks et al., 2001), however it is also possible that they derive some satisfaction from drinking because of the similarities in motor patterns to suckling (Torrey, 2005).

### 4. Belly nosing and belly sucking

The time course for belly nosing after weaning is now well established, with multiple studies reporting that the behaviour usually commences 3–5 days after weaning, peaks approximately
2 weeks later, and then gradually declines (Gonyou et al., 1998; Worobec et al., 1999; Bench, 2005 and others). A similar temporal pattern for belly nosing has been observed in artificially reared piglets upon separation from their mother at 3 days-of-age (Widowski et al., 2005). In some pigs, the behaviour persists into the grower–finisher stage (Gonyou et al., 1998; Bench, 2005), and may even occasionally be observed in group-housed sows (Widowski, personal observation).

Although the majority of researchers have used averages from pens of pigs to quantify the behaviour, there are a few reports on the performance of belly nosing by individual pigs. Straw and Bartlett (2001) found that approximately 50% of piglets weaned at 18 days belly nosed. There was no difference in nosing performed between gilts and barrows, but barrows had the most lesions from being recipients of belly nosing. In a more detailed analysis, Li and Gonyou (2002) examined the variation in belly nosing among pigs weaned at 12–14 days-of-age and found that on day 7 post-weaning, 81% of piglets belly nosed. The average amount of time spent belly nosing was 2.4%, but approximately 5% of the piglets spent over 8% of their daily time budget performing the behaviour. These studies indicate that there is a high level of individual variation in belly nosing, including a significant proportion of pigs that do not engage in the behaviour.

Belly sucking is another oral behaviour pattern common in newly weaned piglets and is presumably related to belly nosing. Belly sucking occurs when one pig sucks on the teats, navel or skin on the abdominal area of another pig. Belly sucking is often not distinguished from belly nosing, perhaps because most behavioural observations are done using relatively low-resolution video recordings. Using live observations Bench (2005) found belly sucking to be distinct from belly nosing, with the two behaviour patterns following different time courses (Fig. 1). While belly nosing showed the typical peak and decline over time, the percentage of time pigs spent belly sucking rose gradually in the nursery and was highest in the grower–finisher phase. Correlations between belly nosing and belly sucking in individual pigs suggested that belly sucking replaced belly nosing and it was primarily the belly sucking that persisted beyond the first few weeks after weaning. Belly suckers tended to display a much narrower range of oral–nasal behaviour patterns such as nosing and sucking ears or tails than other pigs (Bench, 2005).

Because belly nosing is repetitive and appears to have no obvious function, it could be classified as a stereotypy (Mason, 1991; see Latham and Mason, this volume) but because of its transient

![Fig. 1. Mean percentage of daily time budget that pigs spent belly nosing and belly sucking over time. Piglets were weaned at 14 days-of-age. From Bench (2005).](image-url)
nature, most authors refer to it as simply redirected suckling. Belly sucking, on the other hand, is a more persistent behaviour pattern that seems to become fixated in a small number of individuals. It is important to note that data on belly nosing from most studies is likely to be a combination of belly nosing and belly sucking.

It has been suggested that there may be a link between belly nosing in the nursery and tail biting or anal massage in growing–finishing animals (Gonyou et al., 1998; Cox and Cooper, 2001). However, while some individuals are reported to have a greater tendency to perform all kinds of oral behaviour than others (Breuer et al., 2001; Bench, 2005; Torrey, 2005), Bench (2005) found a negative correlation between belly nosing in the nursery and tail biting behaviour during the grow–finish period in individual pigs.

5. Weaning age affects feeding, drinking and belly nosing

Early work comparing the effects of weaning at 3 weeks versus 6 weeks-of-age showed that piglets weaned at younger ages had lower feed intake and grew more slowly than piglets weaned later (Fraser, 1978), but the diets available for piglets were still rather crude at that time. Since then, highly palatable, complex nursery diets that are much better suited to the nutritional needs of the very young pig have been developed. Nevertheless, many early-weaned piglets still have difficulty initiating feeding behaviour and weaning age is often negatively related to time spent at the feeder during the first day or two post-weaning. For example, piglets weaned at 21 days were observed to spend about twice as much time at the feeder during the first 2 days after weaning than piglets weaned at 12 days (Gonyou et al., 1998). Similarly, piglets weaned at 7 days spent less than 1% of the time at the feeder during the first 2 days post-weaning compared to almost 3 and 4.5% for piglets weaned at 14 and 28 days-of-age, respectively (Worobec et al., 1999). While spending less time at the feeder, the younger piglets in those same studies spent significantly more time at the water nipple (Worobec et al., 1999), and these higher levels of drinking behaviour persisted throughout the nursery period (Gonyou et al., 1998; Worobec et al., 1999).

Weaning age also significantly affects the prevalence of oral behaviour directed at the bodies of pen-mates. In numerous studies, piglets weaned at younger ages spend significantly more time belly nosing than those weaned at older ages (Fraser, 1978; Metz and Gonyou, 1990; Bøe, 1993; Gonyou et al., 1998; Weary et al., 1999; Worobec et al., 1999). The relationship between weaning age and belly nosing is obvious on commercial farms as well. Data collected from short (2-h) videotaped observations in the nurseries of 11 commercial swineherds showed a significant negative correlation between belly nosing and weaning age (Widowski et al., 2003).

6. Genetic factors contribute to belly nosing

Although differences in breed or genetic line are often suggested to contribute to variation in behavioural traits, the evidence for genetic effects on oral behaviour problems is generally scarce (see review by Schröder-Petersen and Simonsen, 2001; Breuer et al., 2003). Recently, Bench and Gonyou (2007) found differences between breed lines and sire within breed in the prevalence of various types of oral behaviour patterns performed by early-weaned piglets. Yorkshire line piglets engaged in more belly sucking and belly-directed behaviour than piglets from a Duroc line. Piglets sired by Large White boars engaged in more belly nosing and belly sucking and less nosing of other parts of the body compared to piglets sired by Duroc boars, but individual sire also had a significant effect on these behaviour patterns. These data are in general agreement with
another recent study by Breuer et al. (2003) who found that Duroc pigs directed more biting at the ears and tails of pen-mates than did Landrace and Large Whites, while Landrace performed more belly nosing than Durocs.

7. Relationships among weaning weight, growth rate and belly nosing

Given that weaning age has such a profound effect on belly nosing, we might expect weaning weight to also be predictive of belly nosing. Surprisingly, data from various studies indicate no (Straw and Bartlett, 2001; Torrey and Widowski, 2006a, 15 day weaning) or very little (Torrey and Widowski, 2006a, 21 day weaning) association between weaning weight and belly nosing in individual piglets. When replicate groups of lighter weight-for-age pigs at weaning are compared to their heavier counterparts, lighter weight groups have been observed to perform more (Rau, 2002) or similar amounts of belly nosing (Gardner et al., 2001a; Bench, 2005).

Although weaning weight is not predictive of piglets that develop belly nosing, there is growing evidence that piglets who perform more belly nosing do grow more slowly after weaning (Fraser, 1978; Bøe, 1993; Straw and Bartlett, 2001; Torrey and Widowski, 2006a). The fastest growing individuals post-weaning tend to be the least active, and the least likely to nose and chew other pigs (Gonyou et al., 1998).

8. Relationships between suckling behaviour on the sow and belly nosing

Although it often suggested that belly nosing is related to suckling motivation (Dybkjær, 1992; Weary et al., 1999; Worobec et al., 1999), it does not appear that belly nosers are more highly motivated to suck on the sow or have a higher general predisposition for suckling. Torrey and Widowski (2006a) recently used principle components analysis of individual piglet behaviour to characterize belly nosers in a population with regard to their suckling behaviour and growth prior to weaning. The belly nosers only tended to be smaller at birth and weaning and their pre-weaning growth rates were not related to post-weaning behaviour. Piglets that belly nosed most after weaning were observed to perform less suckling behaviour on the sow compared to other pigs. This is in contrast to work by Nicol and Badnell-Waters (2005) who found that foals that performed the most suckling and nuzzling before weaning were most likely to develop abnormal oral behaviour over the 4 years following weaning.

9. Relationships among ingestive systems and belly nosing in the newly weaned pig

9.1. Feeding behaviour and belly nosing

One of the more interesting aspects of belly nosing is its delay of onset. It has been suggested that belly nosing is not related to feeding or hunger because it does not appear immediately after weaning, but rather a few days after weaning, after the majority pigs have initiated feeding (Metz and Gonyou, 1990; Gonyou et al., 1998). Li and Gonyou (2002) used sequential analysis to explore the motivational context for belly nosing. They found no sequential relationships between belly nosing and feeding or drinking; rather the behaviour was usually preceded and followed by other types of nosing behaviour involved in social interactions. However, belly nosing was more prevalent in low-feed-intake piglets, and was negatively correlated with feeding and lying behaviour, and positively correlated with general activity. In fact, when the behaviour of individual piglets is considered, a significant negative correlation between time individual
piglets spend at the feeder and the time that they spend belly nosing is a consistent finding (Li and Gonyou, 2002; Torrey and Widowski, 2006a two separate experiments; Bruni, 2004).

The question arises then as to whether belly nosing develops because piglets have difficulty initiating independent ingestion or whether pigs that belly nose simply have less time available for other activities and consequently spend less time feeding. Two different approaches have been used to specifically address any causal relationship between reduced feeding or feed intake and belly nosing, with somewhat conflicting results. Gardner et al. (2001a) fed piglets diets differing in quality and palatability in order to delay onset of feed intake in some piglets and determined the subsequent effects on belly nosing behaviour. Although feed intakes and weight gains of piglets on the poor quality diet were both significantly lower than those of piglets fed high quality diets during the first week post-weaning, no treatment differences were found for belly nosing. Bruni et al. (this volume) determined the effect of restricting feed intake during the second week post-weaning on belly nosing. During the week of feed restriction, treatment piglets spent significantly more time rooting at the pen compared to controls. Variation in belly nosing among individual piglets was also significantly greater in treatment piglets during the period of restriction, but the group average for time spent belly nosing was statistically greater only after the restriction period had ended. This suggests that there are individual differences in response to reduced feed intake in weaned piglets. For most piglets, hunger immediately stimulates nosing and rooting at the floors, which might be related to foraging. For others, hunger (or at least a period of reduced growth due to feed restriction) may increase belly nosing.

9.2. Suckling cues, ingestive behaviour and belly nosing

Several researchers have explored the relationship between suckling motivation and belly nosing by exposing weaned piglets to the sensory cues with which they might associate a nursing bout. One important cue known to stimulate non-nutritive sucking and cross-sucking in calves is the taste of milk (de Passillé et al., 1997), but two lines of evidence suggest no relationship between milk-related stimuli and belly nosing. Gardner et al. (2001a) found that neither diets formulated with milk nor liquid milk replacer sprayed on and around the feeder of piglets weaned at 14 days affected belly nosing behaviour. Secondly, when examining the performance of belly nosing in artificially reared piglets fed milk replacer, belly nosing occurred at the same level preceding a milk meal as it did following one (Widowski et al., 2005).

Sow nursing vocalizations are cues for suckling pigs to begin a nursing bout and several authors have reported anecdotally that belly nosing seemed to be stimulated by the sounds of another sow and litter nursing (Fraser, 1978; Waran and Broom, 1993). However, Torrey and Widowski (2004) found no effect of broadcast sow nursing vocalizations on belly nosing during the first 3 weeks after weaning, but they did find a tendency for piglets exposed to the playback to spend less time at the feeder and more time at the drinker than controls (no sound) during the first 2 days after weaning. Earlier work by Petrie and Gonyou (1988) showed that exposing 28 day weaned piglets to sow nursing grunts during the first 2 days after weaning resulted in significantly more drinking bouts and a tendency for more feeding behaviour, but they did not measure belly nosing.

The effects of maternal olfactory cues on ingestive behaviour have also been studied. When a synthetic version of a maternal pheromone found on sows’ udders was applied to snouts and feeders, piglets weaned at 18 days spent significantly more time at the feeder and less time at the drinker during the first 2 days after weaning compared to control pigs (McGlone and Anderson, 2002). The treatment pigs also gained more weight during the first month after weaning.
However, any effect of this pheromone on belly nosing or other oral behaviour patterns has not been determined.

Although there is little direct evidence that external cues associated with suckling can stimulate belly nosing, the behaviour does appear to be closely linked to the performance of suckling behaviour. Providing young piglets with opportunities to engage in either nutritive (Jeppesen, 1981; Widowski et al., 2005) or non-nutritive sucking (Rau, 2002; Bench, 2005; Bench and Gonyou, 2006) significantly reduces the performance of belly nosing and other piglet-directed oral–nasal behaviour patterns. Rau (2002) fed piglets from feeding troughs with or without baby bottle nipples embedded in the bottom (Fig. 2). Piglets provided the nipples spent significantly less time belly nosing and nosing and sucking other body parts and they spent more time at the feeder than did piglets without them, but feed intake did not differ between the groups. Similarly, Bench and Gonyou (2007) and Bench (2005) found that providing piglets with either nipples anchored in their feed trough or on a wall or a rubber inner tube simulating the sow’s udder were effective in reducing belly-directed behaviour, but there was a significant interaction with breed line of piglet. Nipples were effective for reducing belly-directed behaviour in Yorkshire line piglets while inner tubes reduced other oral–nasal behaviour patterns in piglets from the Duroc line (Bench and Gonyou, 2006; see Section 8). Artificial udders that facilitate both massage and sucking for delivery of milk replacer have been shown to essentially eliminate belly nosing and sucking in artificially reared piglets (Jeppesen, 1981; Widowski et al., 2005).

9.3. Drinking behaviour and belly nosing

Drinking behaviour also appears to be linked to belly nosing in the newly weaned piglet. Gonyou et al. (1998) found that drinking (from nipple drinkers) and belly nosing followed the same temporal pattern in early-weaned pigs, with a peak in the incidences of both between 2 and 4 weeks post-weaning, while Rau (2002) found that accommodating non-nutritive sucking reduced both drinking (also from nipple drinkers) and belly nosing (Fig. 2). In order to explore whether piglets were somehow accommodating their motivation for sucking by directing behaviour at nipple drinkers, Torrey and Widowski (2004) compared the behaviour of piglets provided bite-style nipple drinkers with those provided bowl drinkers (Egebjerg Drik-o-Mat).
Piglets with nipple drinkers performed twice as much belly nosing compared to piglets drinking from bowls. They also spent more time drinking, used three times more water and ate less during the first 48 h after weaning than piglets with bowl drinkers. One possible explanation for these results is that the bowl drinker is actually satisfying piglets’ motivation to suck by either permitting the more “natural” sucking motor patterns used to create the suction required for drinking (see Section 3.3) or by somehow providing other tactile feedback. The term ‘nipple’ drinker is actually misleading because pigs cannot actually form suction and still obtain water.

Several investigators have reported a relationship between diet form (liquid, mash or dry diets) and belly nosing. Piglets fed diets in liquid form engage in significantly less belly nosing (Brooks et al., 2001; Rau, 2002; Orgeur et al., 2003), spend less time at a nipple drinker (Rau, 2002) and spend more time resting or sleeping (Brooks et al., 2001; Rau, 2002) than piglets fed dry pelleted diets. It is possible that the underlying mechanism for the effect of liquid diets on belly nosing is related to the performance of drinking-like motor patterns, similar to what we have observed for ingestion of water from a bowl. However, when given the choice between a nipple drinker and a bowl for water, newly weaned piglets did not have a preference for the bowl (Torrey and Widowski, 2006b). The relationships between drinker devices and belly nosing may therefore be simply related to relative water intake and subsequent effects on the initiation of feeding. Feeding diets in liquid form often lead to improved initial dry matter intake. It may be that the onset of feeding, or level of feed intake, plays a bigger role in the development of belly nosing.

10. Environmental enrichment and the newly weaned piglet

In the absence of substrates for rooting and foraging, pigs spend more time nosing concrete and metal (Beattie et al., 1995), manipulating pen-mates (Schouten, 1991), sham chewing (Haskell et al., 1995; Petersen et al., 1995), manipulating the feeder, floor and pen fittings (Haskell et al., 1995; Petersen et al., 1995), and nudgeing and tail biting littermates (Schouten, 1991; Petersen et al., 1995). van Putten and Dammers (1976) suggested that manipulation of pen-mates may be redirected exploratory behaviour. Day et al. (1996) found that grower pigs gather nutritional information in their environment through chewing behaviour, which may explain the significant amount of time spent mouthing the pen and pen-mates, especially in more barren environments. However, it is unclear whether chewing behaviour reflects feeding motivation, exploratory motivation, or a combination of both (Day et al., 1995).

In studies conducted on pigs raised in either outdoor or enriched environments, the availability of substrates for rooting and foraging during the suckling period can have a major influence on the frequency of different behaviour patterns during lactation and after weaning (Petersen et al., 1995; Webster and Dawkins, 2000; Cox and Cooper, 2001; Hötzelt et al., 2004). Piglets from enriched or semi-natural systems are often weaned at later ages (i.e. Petersen et al., 1995 at 5 weeks) but there is also evidence for effects specific to the suckling environment on piglet behaviour. For example, Cox and Cooper (2001) found that piglets raised outdoors in a rich and complex environment fought less, were more likely to consume solid food, and spent less time belly nosing (but only observed first 2 days post-weaning) than pigs reared indoors in a barren pen environment when both groups were weaned at 3 weeks-of-age into the same environment. Similarly, Webster and Dawkins (2000) found that outdoor-bred piglets spent more time feeding and rooting after weaning compared to piglets farrowed in barren environments when both groups were weaned into straw-bedded pens. Providing straw after weaning also reduces belly nosing and other nosing, sucking and chewing on pen-mates (Petersen et al., 1995; Kelly et al., 2000; Bolhuis et al., 2005).
Bench and Gonyou (2006) recently examined the effects of providing different forms of environmental enrichment during the suckling and post-weaning period on the behaviour of piglets weaned at 14 days-of-age. Four enrichment devices were specifically designed to accommodate different oral behaviour patterns common to newly weaned piglets: foam rubber matting which simulated the udder of the sow (Nose), baby bottle nipples mounted at the back of the pen (Suck), a tray of sterilized potting soil mixed with mushroom compost (Root) and a suspended device of flexible rubber tubing (Bite, Bite-Rite™ Tail Chews, Ikadan, Denmark). Only Nose significantly reduced belly nosing when provided after weaning. There was no effect of enrichment available before weaning on behaviour after weaning.

Although straw or other rooting substrates do not specifically accommodate suckling behaviour they do effectively reduce belly nosing, but perhaps by a different mechanism than do artificial nipples or udders (Rau, 2002). It could be that provision of rooting substrates stimulates foraging. Bench and Gonyou (2006) found that pigs provided rooting substrate after weaning also spent less time with their heads in the feeder. Horrell and A’Ness (1996) suggested that the final massage might be a pre-cursor or juvenile form of foraging behaviour. They observed suckling piglets in crates furnished with trays of peat moss and found that the time spent rooting increased as time spent massaging the udder decreased. Alternatively, rooting substrates may simply serve as a distraction and indirectly reduce belly nosing by taking up time.

11. Belly nosing as a response to stress

Although belly nosing has been suggested to be a general behavioural indicator of stress (Schouten, 1986; Dybkjær, 1992; McKinnon et al., 1989) any direct relationship between belly nosing and the stress response has not been determined. Intracerebroventricular (ICV) administration of corticotropin releasing factor (CRF) rapidly stimulates snout rubbing and other oral behaviour patterns in young pigs (Salak-Johnson et al., 2004), and handling or other disturbances stimulate non-nutritive nursing bouts in piglets with sows (see Section 3.1), but the behavioural signs of acute post-weaning stress such as vocalizations and attempts to escape the pen occur in the days prior to the development of belly nosing (Weary et al., 1999; Worobec et al., 1999). When the effects of specific environmental stressors such as mixing (Gardner et al., 2001b), ‘crowding’ (Gardner et al., 2001b) or exposure to cold drafty environments (Bruni, 2004) were examined in environments where there was no straw or other foraging material available, the environmental stressors did not increase belly nosing compared to “less stressful” conditions. In fact, cold drafty environments caused piglets to spend significantly more time at the feeder (but not increase feed intake) and significantly less time belly nosing. Any relationship among response to acute or chronic stress and belly nosing remains to be determined.

12. Summary and conclusions

Belly nosing was first described nearly 30 years ago (Fraser, 1978), but only recently have researchers tried to determine the causation of, and find ways to prevent, the behaviour. Repeatedly, age at weaning has been shown to be the strongest predictor of belly nosing, but it is becoming apparent that there is a complex relationship among feeding, drinking, sucking and belly nosing in the young pig (Fig. 3). Prior to weaning, piglets’ are highly motivated to perform suckling behaviour, but the strength of motivation to suck and especially to perform the final massage is dependent, in part, on their nutritional status (see Section 3.1). During artificial weaning, piglets are at a developmental transition when their motivation to perform suckling and...
independent ingestion may overlap. The stage of ‘ingestive’ development for individual piglets likely depends on a combination of their age, maturity of the digestive system and experience (see Section 3.2). Although other factors are involved in appetitive behaviour after weaning, hunger or a discrepancy between nutrient intake and growth potential may be a causal factor for belly nosing (Sections 7 and 9.1), which suggests that the behaviour is analogous to the final massage. If a piglet is weaned at an early stage in its ingestive development, it will still be motivated to suckle (Fig. 3A). This suckling motivation, if not accommodated through the provision of teats or other non-nutritive devices (Section 9.2), will lead to belly nosing. Excessive drinking may also result because, in the absence of appropriate suckling stimuli, piglets adopt the next most familiar ingestive system, and begin drinking. This may temporarily satisfy the pig, although done excessively, it will inhibit feeding. Piglets weaned later in development will experience feeding motivation with increasing hunger (Fig. 3B). As a result, they will be more likely to perform feeding behaviour and drinking associated with feeding. After some time, piglets that are less developed at weaning undergo maturation and experience a reduction of suckling motivation (Fig. 3C). At such time, the incidence of belly nosing and excessive drinking will decline, and these piglets will be more motivated to feed rather than to perform suckling behaviour when hungry.

The tendency for an individual piglet to develop belly nosing may depend, in part, on how easily it makes the transition from suckling to independent feeding. A piglets’ nutritional status can change dramatically at weaning. Mason et al. (2003) suggested that it is the heavier piglets at
weaning that suffer the most nutritionally, and perhaps, even some heavier pigs at weaning may develop belly nosing if they have difficulty adapting to feeding. In other cases the most "nutritionally needy" piglets pre-weaning may make this transition more easily than some larger piglets at weaning if they readily adopt feeding and are better able to grow to their full potential when not limited by the sow’s milk production.

Other factors such as genetics (see Section 6) and environmental context, either by affecting availability of recipients or through provision of substrates that elicit other types of oral behaviour (see Section 10) also determine whether and how much belly nosing a piglet will perform. For some pigs, belly nosing may progress into belly sucking (Section 5) and this behaviour pattern can continue into later stages of life, but it is not known whether the triggers for the more permanent form of the behaviour are the same as those that cause it to develop initially. Whether there is some functional consequence of belly nosing (and belly sucking) to the individual pig performing the behaviour is also still unknown. Pigs may derive some comfort from performing the behaviour (see Section 3.1) or it may provide a form of social contact that is important to the young pig (Li and Gonyou, 2002).

References


