Orphaned Neonatal Kittens Suckling Behaviors and the Implications for Activity Levels and Sleeping Patterns

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Abstract

Behavioral differences between neonatal kittens (Felis catus) raised in foster homes and those receiving direct maternal care may lead to issues that jeopardize welfare and development. Maternal interactions involving nursing and weaning have far-reaching effects on behavioral and physical development of neonatal kittens. One behavior routinely observed in foster homes and shelters has been found to pose a concern to the health of kittens: non-nutritive suckling (NNS). In this observational study, video footage of 15 litters of orphaned neonatal kittens raised and bottle fed by human foster caretakers was assessed to identify if there was a relationship between the presence of NNS (oral contact to littermates' bodies that is not for the purpose of nutrient consumption) and quantified time engaged in activity throughout a typical day. This was done to assess if there is a trade-off between the motivation to engage in NNS and sleep during typical rest periods. Additionally, supplemental data from an online survey provided complementary information regarding temporal and spatial patterns associated with sucking in kittens who engage in NNS. By exploring the relationship between neonatal suckling due to a lack of a maternal presence and potential effects on activity level (and presumably, sleep), we can

determine additional ramifications that being orphaned may have on the development of abnormal behaviors, and perhaps how to better address the welfare issue NNS poses for orphaned kittens.

Introduction/Background

Feline maternal behavior and care of offspring have been extensively studied, but comparatively, fostered/hand-reared orphaned neonatal kittens are less well understood. Because of our general understanding of kitten health, the capability to address many of the physiological concerns normally managed by a mother cat has greatly improved, although successful management must consider both physical and behavioral factors involved in the care of neonates (Little, 2013). There is relatively limited research that assesses differences in behavior between neonatal kittens hand-reared by humans and those raised by a queen.

As a mammalian species, lack of maternal care prompts a need for comparative evaluation of the possible variability exhibited when kittens are orphaned. The physical needs of orphaned kittens (such as immunoprotection, adequately warm housing, and around the clock care) can be attended to given the current understanding of kitten physiology, but fulfilling the behavioral niches that a mother provides does not always prove viable (Snook & Riedesel, 1987). Evidence of the importance of this behavioral niche can be seen in the drastic developmental implications associated with the timing and nature of the weaning process a litter is subject to when kittens experience withdrawal from maternal care (Martin, 1986). The effects of premature withdrawal of maternal interaction during weaning can be physiological or behavioral but largely they are detrimental (Seitz, 1959).

Many behavioral abnormalities have been observed in human-reared kittens, including inappropriate responses to social interactions, abnormal sexual behavior, exaggerated aggressive tendencies, and evidential signs of compromised health (Hart, 1972; Ahola, et al., 2017); these abnormalities are often attributed to the lack of maternal care. Scientific consensus is that early-life maternal-offspring interactions affect the behavioral, physical and emotional development of offspring well into adulthood (Beaver, 2003; Hart, 1972). Studies in domestic cats have directly tested this, including one that recorded aberrant behaviors exhibited in high frequencies in kittens isolated from their mothers and littermates (Konrad & Bagshaw, 1970).

Behavior can indicate underlying emotional anomalies; both possibly having biologically relevant health consequences. This is evident in the population of kittens from which this project was derived (investigating the role temperature and relative humidity may play in the health of orphaned neonatal kittens). Of the 68 foster kittens, 23 were found to be impacted by NNS; 9 of 23 litters were impacted (40%); 17 kittens were "suckers"; 17 kittens were "victims"; and 11 were classified as both. Kittens engaged in up to 25-80 bouts of sucking per day, sucking for up to 56-135 minutes each day. This prompts an exploration of other risks factors involved and what may be the driving force behind the occurrence of NNS.

NNS is not exclusive to neonatal kittens in foster settings; it has been investigated in a variety of mammalian species such as pigs (Rushen & Fraser, 1989; Bøe & Jensen, 1995); horses (Tyler, 1972; Crowell-Davis, 1985); cows (Lidfors et al. 1994; Rushen & de Pasillé, 1995); and even human infants (de Carvalho et al., 1982). NNS has previously been identified in mother-reared cats (Koepke & Pribram 1971), though the behavior in that case was directed to a provided artificial nipple. For many foster caretakers, the behavior is classified as an issue to monitor for as it poses a possible risk to the litter being cared for. Many of the proposed solutions for mitigating the occurrence of NNS in other species in commercial settings involve providing alternative outlets for non-nutritive sucking and similar motor patterns, such as environmental enrichment or novel feeding methods (Widowski, et al., 2005; Horvath & Miller-Cushon, 2017; Bench & Gonyou, 2006). These interventions aim to redirect the behavior, but do not address the underlying motivation behind it, largely because nursing behaviors are not driven strictly by physical needs (such as consumption of nutrients) but also emotional and social needs (Carson & Wood-gush, 1983).

Previous studies of mammals have identified suckling and other motor patterns associated with nursing behaviors as serving many purposes other than consumption of nutrients. Suckling itself is a form of social interaction between conspecifics (Robbin & Moen, 1975; McVittie, 1978; Li & Gonyou, 2002) and NNS may compensate for a lack of maternal social interaction. Two studies looked at the differences between litters of kittens raised by a mother versus a brooder (a nonsocial stimulus); littermates raised on the brooder would often nuzzle or suck one another to the point of hair loss (Schneirla, et al., 1963; Guyot, et al., 1980).

In some contexts, suckling may be a form of stereotypic behavior. Stereotypies are common in a vast number of species and are broadly defined as a repetitive, seemingly functionless, sequence of actions not commonly exhibited in wild populations (Mason, 1991a). These patterns are most prominently evident in captive settings where animals have little to no control over their environment, thus indicating a need for a sort of self-soothing mechanism (Luescher, et al., 1991). Suckling on litter mates may be adaptive by eliciting physiological changes such as decreased heart rate, or changes to digestion and activity levels. A study done on rats found sucking elicits an analgesic response (Anseloni, et al., 2004). Suckling has reduced heart rate during stressful procedures in various mammals, such as calves (Veissier, et al., 2002) and even humans (Dipietro, et al, 1994). Additionally, animals suckle when distressed or alarmed, providing further evidence that suckling may prove an outlet for stress as well as a method of nutrient consumption (Lent, 1971).

NNS may satisfy a reflexive or evolutionarily developed need considering that mammals are highly motivated to perform oral behaviors that are innate to their species (de Passillé, 2001; Widowski, et al., 2008). The feeding behaviors of neonates are largely driven by maternal initiation and innate reflexes (Snook & Riedesel, 1987). The “rooting reflex” is driven by young kittens’ inability to regulate homeostatic functions, so they huddle toward their mother or littermates for warmth; huddling continues for up to 16 days of age (Beaver, 2003). Sucking is a reflex present at birth and is initiated through a number of proposed stimuli, such as the oral-tactile stimulation of small objects or a hairless area (Ewer, 1959; Beaver 2003). Furthermore, another study established that while development of sucking from a mother’s nipple quickly follows birth, attachment and consumption from an artificial nipple requires learning, and failure to successfully feed from an artificial source can be a mortality risk (Kovach & Kling, 1967).

If orphaned kittens are spending substantial time either initiating or receiving sucking from littermates, there may be an inherent trade-off with other behaviors. Sleep is essential to the development and well-being of neonatal animals and a lack of sleep can be very detrimental to health. Increased external stimulation may decrease restful sleep for kittens; periodical incidences of suckling of littermates could disrupt quality and quantity of sleep (Sterman, et al., 1965; Beaver, 2003). When forced to stay awake for extended periods of time, cats will become increasingly irritable, even to the point of illness, but effects of sleeplessness on learning are not conclusively defined (Vogel, 1975; Beaver, 2013). The long-term effects of inadequate sleep on the growing kittens are unknown. In human infants and kittens sleeping patterns are developed in younger ages (Chase & Sterman, 1967). A major developmental period for diurnal sleep/waking rhythms in cats is between 4-6 weeks of age and begin to take on adult configurations at about 90 days (Hoppenbrouwers & Sterman, 1975). Maturation of particular brain areas (basal forebrain) that regulate sleep cycles is required for development of these rhythms, so until then their sleep pattern is plastic; compromising effects to sleep during this period could potentially be harmful later on in life (Stern, et al., 1973).

The aim of this study is to investigate the effects of NNS behavior on activity levels. We quantified the percentage of time (within total time observed) for each day that each litter engaged in activity and compared that between litters that had suckers present and litters where sucking was not observed. We hypothesized that sucking litters will have higher percentages of their daily time budget dedicated to activity because they have exhibited NNS during periods that those who don't suck might spend sleeping or resting. From our observations, NNS includes search and escape behaviors that we believe increase overall activity. Furthermore, upon assessing if activity increases as the kittens age, we hypothesized that kittens would be more active as they matured.

Methods

All animal procedures were approved by the Animal Care and Use Committee at the University of California, Davis. A survey of foster caretakers was approved by the Institutional Review Board of the University of California, Davis. The kittens in this study were part of a larger project that required they be housed in commercial incubators (Rcom MX BS600N) and continually filmed. The kittens were cared for in foster homes after being surrendered to local rescue organizations. Because of this, each of the 15 litters was cared for in adherence to guidelines and expectations set by the experimenters and the rescue organizations.

The 15 litters ranged in size from 2 to 5 kittens, and ages from 1 to 25 days at the start of the video footage. Kittens were recorded for varying amounts of time, and the footage continued until the kittens were ages 11 to 32 days. There were 33 males, and 21 females totaling to 54 kittens.

The access to 24-hour video footage allowed us to obtain an accurate representation of kittens' behavior throughout the day. Because coding of video is time-consuming, we automated the collection of data. A command-line application in Python (DVR-Scan) was used to scan all video files collected; comparing frame-by-frame it detects pixel changes above a defined threshold. A code script in R provided output of the start and end time of continuous pixel changes detected and calculated the total amount of movement (in seconds) displayed by the kittens within each video. To compare activity and inactive time, we considered activity to be any movement displayed by any kitten in the video as quantified through the software.

To ensure reliability of this automated process, we took 12 sample hours of video, ran them through the program and compared the results to hand-coded results for the same videos. Both measures provided the total number of seconds the kittens were active in a given video. From this we established a

Pearson's correlation coefficient of $r = 0.93$, proving strong evidence for the reliability of this method. To account for the fact that these kittens may be fed throughout the day and to ensure the movement detected was only movement performed by the kittens, we omitted feeding times manually, which was done by referring to records provided by foster caretakers and rendering the time in which there was feeding related movement on the footage exempt. After omitting the feeding times from the overall daily time budget, we calculated the percentage of time each litter spent engaged in activity of the total time observed.

Knowing that the amount of activity displayed within each litter was dependent on a number of different variables, for our preliminary runs we compared data from litters of similar compositions, varying only in respect to the presence of sucking behaviors; number of kittens within the litter and age at the time of footage used would be held consistent. We would then compare the percentages to see which litter exhibited heightened levels of activity and if these amounts changed with age. For further analysis we coded all available footage and conducted analyses in R 3.6.0 (Foundation for Statistical Computing, Vienna, Austria). We analyzed the effect of age, litter size (LS) and sucking (Y/N) using a linear mixed model with litter identity as a random effect to control for repeated measures.

To additionally understand NNS, a survey comprising of 60 questions was distributed online to households fostering orphaned litters exhibiting suckling behavior. We collected data from 331 litters which included 1,106 kittens. From this data, we obtained information about temporal and spatial patterns of suckling, identification of the presence of suckling behaviors, and strategies for the mitigation of NNS.

Results

The first preliminary analysis was a comparison between litter A, which composed of two kittens, 11 days of age during the 48 hours pulled and had sucking present, and litter B, same number of kittens and same age, but displaying no NNS. Litter A spent 55% of the time accounted active whereas litter B spent 38% of their time active. For the second comparison, we looked at two litters that had four kittens that were 13 days of age; litter C had sucking present and they spent 55% of their time active. Litter D did not exhibit sucking and spent 63% of their time active.

After analysis of all the video footage we found no correlation between NNS and activity. There was no significant relationship between sucking behavior and activity ($F(1, 11.2) = 1.40$, $p = 0.26$), Figure 1). There was also no relationship between litter size and the time spent active excluding the presence of sucking ($F(1, 10.5) = 1.00$, $p = .34$, Figure 2). However, analysis of the relationship between age of the kittens and activity showed that as the kittens matured, activity level appeared to decrease ($F(1, 128)=44.10$, $p < .001$, Figure 3).

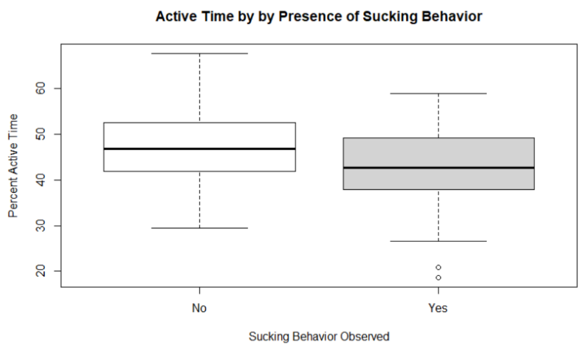

Figure 1: Active Time by Presence of Suckling Behavior

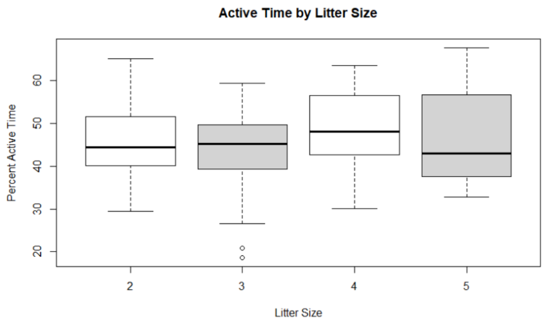

Figure 2: Active Time by Litter Size

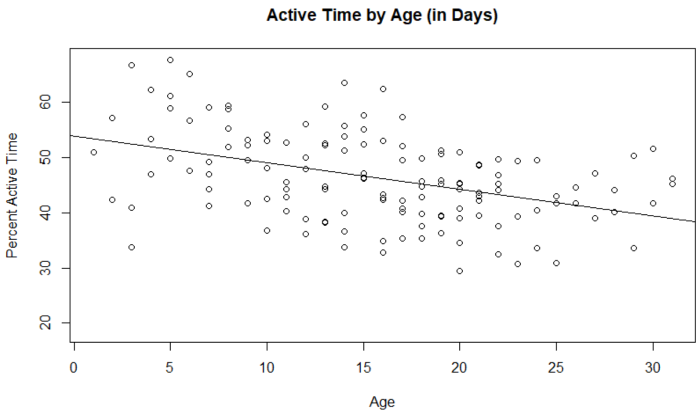

Figure 3: Active Time by Age

The survey data revealed the most commons ways that sucking was identified was direct observation as it was happening (81% of respondents) and observation of wet areas on the victim's bodies (58%). Less common ways were seeing wet areas on the sucker's face (26%), or from the presence of sores (16%).

Survey data showed 63% of victims were male, and a chi-squared test revealed that males were more likely to be a victim of sucking ($X^2(2)= 22.16$, $p < .001$). No significant effect was found of sex on initiating sucking. From data of litters where weight information was included, the largest kitten was a victim of sucking in 59.7% of litters, and in 58.4% of the litters, the smallest kitten was a victim.

To mitigate sucking behavior, many foster caretakers stated they interrupted the behavior (68%) and often separated the kittens part time (42%), but others reported using clothing or even separating the kittens full-time (20%). Participants also noted that a majority of the kittens that were separated, reinitiated sucking when brought back together. The majority of participants (76%) indicated they fed the kittens according to a set schedule. Information on when the sucking was occurring relative to sleep/wake periods suggested that suckers often slept following a bout of sucking whereas for victims sleep periods were much more variable.

Discussion

Both the preliminary results and the analysis on the entire set of video footage gathered tells us that there was no conclusive correlation between activity and the presence of sucking. Therefore, we cannot assume sucking is associated with heightened activity or reduction in the quantify of restful, non-movement periods. Regardless, in a number of instances we observed a disruption of sleep prompted by the initiation of sucking from one kitten onto another, but it is possible this trade-off is compensated for in other periods of time. Kittens could potentially be exhibiting longer periods of sleep in less frequent bouts as a result of exhaustion from sucking, therefore overall be active the same amount as non-suckers. To analyze this, we would need to examine each bout of sucking and compare it to bouts of sleeping to see if there is any relationship there.

Furthermore, we expected litter size to have a significant effect on activity, such that the more kittens there were in a litter, the more potential for interactions to be had. We did not find that to be the case. This is likely due to the method we use for data collection posing as a potential limitation to the study. The software measures activity through pixel changes between frames, meaning any movement detected counts as movement for all kittens present, not on an individual basis. Therefore, each litter is treated as a single unit and the number of kittens is unaccounted for outside of data analysis.

Because activity is quantified as movement detected through pixel changes, it is possible that pixel changes could be attributed to other things in the cameras view. We attempted to account for that limitation by using the reported feeding times to omit times where the camera would have caught other movements. Lastly, we expected that as the kittens aged, they would spend more time active. Although the video footage primarily focused on kittens who are not fully mobile, as their senses become more adept at sensing their surroundings and as motor activity and coordination increases, we would expect more movement. Our data showed the opposite to be true; across litters, as time progressed the kittens were significantly less active. This could potentially be a result of adjustment to surroundings, as kittens became more familiar with their environment, they may have been less motivated to engage in exploratory behaviors and more likely to rest. Increasing sample size and looking at a more diverse group of kittens may shed light on this finding.

Conclusion

The results prompt many more questions about the implications of NNS on the development and behavior of kittens. If the trade-off in time isn't with sleep, then what behaviors are occupying the time non-suckers would be using to suck? If the difference is accounted for in bout frequency what are the long-term effects of sleep deprivation on developing young from inconsistent sleep? Are there possible differences and notable outcomes expressed in adulthood as a result of NNS?

Age, litter size, individual variation, feeding amount and frequency all have effects on the amount of activity kittens might exhibit. We hope to do in depth analysis of specific trends in suckling/sleeping patterns such as sex differences, external risk factors, bout frequency, and victim vs. initiator analysis. Within the future many more orphaned kittens will be in need of homes allowing us the opportunity to increase our sample size or conduct further studies to evaluate this abnormal behavior.

References

Ahola, M. K., Vapalahti, K., & Lohi, H. (2017). Early weaning increases aggression and stereotypic behaviour in cats. *Scientific Reports*, 7, 1-9. doi:10.1038/s41598-017-11173-5

Anseloni, V., Ren, K., Dubner, R. & Ennis, M. (2004). Ontogeny of analgesia elicited by non-nutritive suckling in acute and persistent neonatal rat pain models. *Pain*, 109, 507–513.

Beaver, B. V. (2003). Feline Behavior (2nd ed.). Elsevier Saunders.

Bench, C.J. & Gonyou, H.W. (2006). Effect of environmental enrichment at two stages of development on belly nosing in piglets weaned at fourteen days. *Journal of Animal Science*, 84, 3397–3403.

Bøe, K., & Jensen, P. (1995). Individual differences is suckling and solid food intake by piglets. *Applied Animal Behaviour Science*, 42, 183-192.

Carson, K. & Wood-Gush, D. G. M. (1983). Equine behaviour: I. A Review of the literature on social and dam–foal behaviour. *Applied Animal Ethology*, 10, 165–178.

de Carvalho, M., Robertson, S., Friedman, A., & Klaus, M. (1982). Milk intake and frequency of feeding in breast fed infants. *Early Human Development*, 7, 155-163.
Chase, M. H., & Sterman, M. B. (1967). Maturation of patterns of sleep and wakefulness in the kitten. *Brain Research*, 5, 319-329. doi:10.1016/0006-8993(67)90040-6

Crowell-Davis, S. L. (1985). Nursing behaviour and maternal aggression among Welsh ponies (*Equus caballus*). *Applied Animal Behaviour Science*, 14, 11–25.

DiPietro, J.A., Cusson, R.M., O'Brien Caughy, M. & Fox, N.A. (1994). Behavioural and physiologic effects of nonnutritive sucking during gavage feeding in preterm infants. Pediatric Research, 36, 207–214.

Ewer, R. F. (1959). Suckling Behaviour in Kittens. *Behaviour*, 15(1-2), 146-162. doi:10.1163/156853960x00142

Guyot, G. W., Cross, H. A., & Bennett, T. L. (1980). Early social isolation of the domestic cat: Responses to separation from social and nonsocial rearing stimuli. *Developmental Psychobiology*, 13(3), 309-315. doi:10.1002/dev.420130306

Hart, B. L. (1972). Maternal Behavior II - The nursing sucking relationship and the effects of maternal deprivation. *Feline Practice*, 2, 6-8.

Hoppenbrouwers, T., & Sterman, M. B. (1975). Development of sleep state patterns in the kitten. *Experimental Neurology*, 49(3), 822-838.

Horvath, K. C., & Miller-Cushon, E. K. (2017). The effect of milk-feeding method and hay provision on the development of feeding behavior and non-nutritive oral behavior of dairy calves. *Journal of Dairy Science*, 100(5), 3949-3957. doi:10.3168/jds.2016-12223

Hudson, R., & Distel, H. (2013). Fighting by kittens and piglets during suckling: What does it mean? *Ethology*, 119(5), 353-359.

Koepke, J. E. & Pribram, K. H. (1971). Effect of milk on the maintenance of sucking behavior in kittens from birth to six months. *Journal of Comparative and Physiological Psychology*, 75, 363–373.

Konrad, K. W. & Bagshaw, M. (1970). Effect of novel stimuli on cats reared in a restricted environment. *Journal of Comparative and Physiological Psychology*, 70(1), 157-164.

Kovach, J.K. & Kling, A. (1967). Mechanisms of neonate sucking behavior in the kitten, *Animal Behaviour*, 15(1), 91–101.

Lent, P. C. (1971). Mother-infant relationships in ungulates. In The Behaviour of Ungulates and its Relation to Management (Vol. 1, pp. 14-45). Morges: IUCN Publications.

Lidfors, L. M., Jensen, P. & Algers, B. (1994). Suckling in free-ranging beef cattle: temporal patterning of suckling bouts and effects of age and sex. *Ethology*, 98, 321–332.

Little, S. (2013). Playing Mum: Successful management of orphaned kittens. *Journal of Feline Medicine and Surgery*, 15(3), 201-210

Li, Y.Z. & Gonyou, H.W. (2002). Analysis of belly nosing and associated behaviour among pigs weaned at 12–14 days-of-age. *Applied Animal Behavior Science*, 77, 285–294.

Luescher, U.A., McKeown, D.B. & Halip, J. (1991). Stereotypic or obsessive-compulsive disorders in dogs and cats, Veterinary Clinics of North America: Small Animal Practice, 21(2), 401–413.

Martin, P. (1986). An experimental study of weaning in the domestic cat. *Behaviour*, 99(3), 221-29.

Mason, G.J., (1991a). Stereotypies: A critical review. *Animal Behaviour* 41, 1015-1037.

McVittie, R. (1978). Nursing behavior of snow leopard cubs. *Applied Animal Ethology*, 4, 159–168.

de Passillé, A. M. (2001). Sucking motivation and related problems in calves. *Applied Animal Behavior Science*, 72, 175–187

Robbins, C. T. & Moen, A. N. (1975). Milk consumption and weight. gain of white-tailed deer. *Journal of Wildlife Management*, 39, 355–360.

Rushen, J. & Fraser, D. (1989). Nutritive and non-nutritive sucking and the temporal organization of the suckling behaviour of domestic piglets. *Developmental Psychobiology*, 22, 789–801.

Rushen, J. & de Pasillé, A. M. (1995). The motivation of non-nutritive sucking in calves, *Bos taurus. Animal Behaviour*, 49, 1503–1510.

Schneirla, T. C., Rosenblatt, J.S., & Tobach, E. (1963). Maternal behavior in the cat. In H. L. Rheingold, Maternal Behavior in Mammals. New York: Wiley. Pp. 122-168.

Seitz, P. F. D. (1959). Infantile experience and adult behavior in animal subjects. *Psychosomatic Medicine*, 21(5), 353–378. doi: 10.1097/00006842-195909000-00002

Snook, S. S., & Riedesel, E. A. (1987). Feline Neonatal Medicine. *Iowa State University Veterinarian*, 49(2), 106-111.

Sterman, M.B., Knauss, T., Lehmann, D. & Clemente, C.D. (1965). Circadian sleep and waking patterns in the laboratory cat. *Electroencephalography Clinical Neurophysiology,* 19, 509–517.

Stern, E., Parmelee, A.H. & Harris, M.A. (1973). Sleep state periodicity in prematures and young infants. *Developmental Psychobiology,* 6(4), 357-65.

Tyler, S. J. (1972). The behaviour and social organisation of the New Forest ponies. *Animal Behaviour Monographs,* 5, 85–344.

Veissier, I., de Passillé, A.M., Després, G., Rushen, G., Charpentier, I., Ramirez de la Fe, A.R. & Pradel, P. (2002). Does Nutritive and non-nutritive sucking reduce other oral behaviors and stimulate rest in calves?, *Journal of Animal Science*, 80, 2574–2587.

Vogel, G.W. (1975). A review of REM sleep deprivation. *Archives of General Psychiatry*, 32(6), 749–761.

Widowski, T. M., Torrey, S., Bench, C. J., & Gonyou, H.W. (2008). Development of ingestive behaviour and the relationship to belly nosing in early-weaned piglets. *Applied Animal Behaviour Science*, 110(1-2), 109-127. doi:10.1016/j.applanim. 2007.04.010

Widowski, T.M., Yuan, Y., Gardner, J.M. (2005). Effect of accommodating sucking and nosing on the behaviour of artificially reared piglets. *Laboratory Animals*, 39, 240–250.