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A survey-based assessment of risk factors for cross-sucking behaviors in neonatal kittens, *Felis catus*

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Abstract

Cross-sucking, or non-nutritive sucking on the bodies of littermates, is commonly observed in early-weaned animals. This behavior has been well-documented in production animals, which are often separated from their mothers before weaning. The behavior is less well-understood in other domestic species, such as cats (*Felis catus*), that can be orphaned due to neglect, maternal death, or accidental separation. Anecdotally, cross-sucking can cause injuries in kittens, sometimes severe enough to warrant euthanasia. To our knowledge, this is the first detailed study of this behavior in domestic cats.

We conducted a survey of caretakers ($N = 407$) of kittens (< 60 days old) with the goal of identifying characteristics of individual kittens, litters, the environment, and husbandry that might be associated with the presence of cross-sucking. The final data set, representing 1358 kittens, was comprised of 301 litters experiencing sucking and 106 litters not experiencing sucking behaviors. Almost all of the kittens represented in the survey (91%) were orphaned.

Results suggested that being orphaned ($\chi^2(1) = 42.64, p < 0.001$), bottle-fed ($\chi^2(2) = 40.32, p < 0.001$), younger ($t(405) = 3.48, p < 0.001$), separated earlier from the mother ($t(376) = 3.10, p = 0.002$), and being in an all-male litter ($\chi^2(2) = 7.13, p = 0.03$) increased the risks of cross-sucking. Male kittens also were more likely to be recipients of sucking behavior ($\chi^2(1) = 32.30, p < 0.001$). No clear associations between the environment or husbandry practices and the presence of sucking behavior were identified. Interruption and separation were the most frequently reported management strategies, but most kittens returned to sucking behavior when reunited.

Cross-sucking is a frequently reported behavior problem in orphaned kittens that may indicate distress or poor welfare. Future research should focus on a better understanding of prevention and management strategies, and determination of the effects, if any, of cross-sucking as a kitten on adult cat outcomes or behavior.

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Keywords

maternal separation; neonatal development; stereotypies; domestic cats

1 Introduction

Domestic cats spend significant amounts of time with their offspring, and kittens spend around 8 hours a day nursing and over 85% of their time in contact with their mother in the first weeks of their lives (Rheingold and Eckerman, 1971; Beaver, 2003). Rooting and suckling behavior are innate in young animals, and even when actively nursing, mammals also engage in non-nutritive sucking on their mothers (Ross et al., 1957; Cameron, 1998). A study of neonatal kittens with access to either a lactating or a non-lactating female cat demonstrated that in the first three weeks of life, acquisition of milk via sucking was not necessary to maintain high levels of sucking behavior (Koepke and Pribram, 1971).

Queens typically begin weaning their kittens when kittens are approximately one month old, but they may continue to nurse for a few months (Beaver, 2003; Bradshaw, 2012). Some kittens inadvertently become orphaned before weaning, due to neglect, maternal death, or accidental separation from the queen by humans. Orphaned kittens often are hand-raised by humans, and this practice has increased in recent years as shelters and rescue organizations improve their capacity for care via in-house nurseries or foster caretaking programs.

Little is known about the impact of early maternal separation or early weaning on kittens. One study compared kittens removed from their mothers at two weeks of age with kittens that remained with their mothers until six or twelve weeks of age. All kittens were handled minimally by humans. As adults, the kittens that were separated at two weeks were more emotionally reactive in novel or stressful situations when compared to kittens that remained with mothers for longer periods (Seitz, 1958). More recently, a survey-based study found that owners of cats that were weaned before eight weeks of age were more likely to report that those cats displayed aggressive behaviors and wool-sucking compared to later-weaned kittens (Ahola et al., 2017).

Early-weaned animals may express other abnormal or problematic behaviors in response to maternal separation. One commonly reported behavior is cross-sucking, or non-nutritive sucking on the bodies of littermates. During a recent unrelated study of 68 orphaned neonatal kittens, we observed high rates (25%) of cross-sucking behavior (Delgado et al., unpublished data). We also spoke to several rescue group members and caretakers who had experience with this behavior among kittens under their care. We learned that caretakers frequently observe cross-sucking among kittens, and struggle to manage it. We also found that sucking can lead to injuries, perineal urethrostomy surgery, or even euthanasia in recipient kittens. Additionally, kittens that cross-suck may stimulate elimination by other kittens, leading the sucker to ingest urine and feces which can cause digestive upset, decreased appetite, and failure to thrive.

Cross-sucking has been primarily reported and investigated in production animals (e.g., cows, pigs, lambs), which frequently are separated from their mothers before weaning is

complete (e.g., Weary et al., 1999; Jensen, 2003; Bodnár et al., 2006; Cantor et al., 2019). Cross-sucking impacts farm financial outcomes, and can be problematic because of the risk for injuries that become infected or require medical treatment (Lidfors and Isberg, 2003; Heinonen et al., 2010). Sucking and biting behavior can be difficult to prevent and stop once it has begun (Keil and Langhans, 2001). Furthermore, interventions may cause other problems: management techniques such as headlocks or restraint to prevent access to conspecifics limit movement and expression of normal behaviors. Separating animals from the group to prevent cross-sucking also poses problems for social species (Cantor et al., 2019).

To our knowledge, the presence of this behavior in non-production species has not yet been studied empirically. The purpose of this survey was to gain a better understanding of cross-sucking in kittens while attempting to identify risk factors that might lead to its presence among litters of kittens being cared for by humans, specifically focusing on the influence of being orphaned or experiencing early maternal separation.

2 Material and Methods

The procedures of this study were approved by the Institutional Review Board of the University of California, Davis.

2.1 Procedure

We developed the survey by first generating items that would allow us to collect detailed information about individual kittens, their early life experiences, how they were being cared for, the environment they were living in, as well as aspects of reported sucking behavior that might reveal potential risk factors. We asked an outside animal welfare/behavior expert to review the survey and made edits based on the feedback we received.

We solicited participants for the web-based survey, conducted using Qualtrics (www.qualtrics.com), from July 2018 through September 2019. There were no incentives for participation. We posted our solicitation primarily through social media outlets, newsletters, listservs and websites, such as Twitter, Facebook, and Instagram.

Participants could provide information about up to 8 kittens in a litter, including each kitten's name, estimated date of birth, weight, sex, and if the kittens were sucking or being sucked on. We asked about characteristics of the litter, such as if any kittens in the litter had died, if any were experiencing health concerns, if the kittens were related, and if they were being raised by their mother. We asked about the husbandry and care of the kittens, including questions about feeding (how, what and when kittens were fed), handling, and housing (temperature, lighting, noise exposure, objects the kittens were housed with). For litters experiencing sucking, we asked questions about the behavior, including what body areas were sucked on, behaviors exhibited during sucking bouts (such as purring and sleeping), medical concerns that were caused by the sucking behavior, and how the caretaker was managing the sucking behavior. The entire survey is included in Appendix 1.

Data were downloaded into an Excel spreadsheet and all analyses were performed using SAS 9.4 (SAS Institute, Cary NC, USA) and OpenRefine (Metaweb Technologies, Inc., San Francisco CA, USA). We conducted chi-square and t-tests to compare litters where sucking did and did not occur, and used chi-square tests to compare data from individual kittens.

2.2 Participants

In total, 1946 participants started the survey, which resulted in 407 valid surveys. Surveys were retained if they reported information on litters of at least two kittens and included the age, sex and/or weight of each kitten, as well as sucker/recipient status of each kitten in litters with sucking behavior. From July 2018 until September 2018, 257 people answered “No” to the question, “Are you currently fostering a litter/group of kittens who are sucking on other kittens and/or being sucked on by other kittens?” During that time, the Qualtrics survey was configured to automatically end the survey to prevent these participants from answering any of the survey questions. In September 2018, we invited any caretakers of kittens, to participate so that we could compare litters with sucking behavior with litters not experiencing cross-sucking.

We removed participants with incomplete surveys, who reported data for only one kitten, and for litters with kittens past weaning age (> 60 days). The final data set included surveys representing 407 litters of 1358 kittens; 301 litters experiencing sucking (1006 kittens), and 106 litters not experiencing sucking behavior (352 kittens).

3 Results

3.1 Composition of litters

Kitten ages at the time of the survey, start of caretaking, and onset of sucking behavior are presented in Table 1. The average litter size was 3.4 kittens (range 2–8 kittens). There were more orphans than would be expected by chance among sucking litters (97%), and more litters with mothers than would be expected by chance among the non-sucking litters (25%; $X^2(1) = 41.64, p < 0.001$). Most litters (88%; 270 sucking, 82 non-sucking) were composed of related kittens. Most litters included both male and female kittens and there were more all-male litters than would be expected by chance among sucking litters ($X^2(1) = 7.13, p = 0.03$). Chi-square analyses of the effects of orphan status and sex composition on the presence of sucking in litters are presented in Table 2.

Of the kittens in sucking litters, 52% were suckers and 59% were recipients of sucking. Only 14% of kittens in sucking litters were not suckers or recipients and 25% were both suckers and recipients. Males ($N = 386$) were more likely than females ($N = 195$) to be a recipient of cross-sucking ($X^2(1) = 32.30, p < 0.001$), but suckers were equally likely to be male ($N = 296$) or female ($N = 223; X^2(1) = 1.69, p = 0.19$).

3.2 Feeding and husbandry

Kittens that were currently bottle-fed or weaning were more likely to be in sucking litters than kittens that were weaned ($X^2(2) = 40.32, p < 0.001$; Table 2). Miracle Nipples® were the most frequently used nipples for bottle feeding, and some caretakers used both a bottle

and syringe to feed kittens that were not yet weaned. Most kittens (74%) were fed on a schedule; younger kittens (<1 month) were fed every 3 – 4 hours, whereas older kittens (>1 month) were fed every 4 – 6 hours. Both kittens in sucking litters and younger kittens were more likely to be fed on a schedule compared to non-sucking litters and older kittens. However, no differences were found between sucking and non-sucking litters on the number of times a day they were fed (Table 3).

Because being bottle-fed, orphaned, and the age of the kitten could be dependent on one another, we conducted a binomial logistic regression including these three factors and their interactions with sucking as the outcome variable. The overall model was significant, with the likelihood ratio test (LRT) results: $X^2(8) = 59.36, p < .001$. There were no interaction effects, and so the model was re-run with only the three main effects. Being orphaned and bottle-fed were associated with sucking ($X^2(4) = 57.79, p < .001$), but age was not a significant predictor. Although being orphaned and bottle-fed were not independent, when controlling for other factors, being orphaned was still associated with a 5.87 times increase in risk of sucking behavior (95% CI for the OR: 2.50, 13.80). Being previously weaned decreased the risk of sucking by 58% (OR: 0.42, 95% CI: 0.18, 0.96).

3.3 Housing

Most kittens were housed in an open room (33%), a playpen (24%), a plastic cat carrier (15%), a crate/cage (13%), or in a plastic box (11%). Caretakers provided kittens with bedding (86%), toys (57%), stuffed animals (56%), and an added source of heat (55%). Most participants (71%) reported that their home temperature typically ranged between 70° and 80° F, and 74% indicated that their home was probably or definitely at a constant temperature throughout the day. About 6% of respondents reported that their home was maintained at less than 70° F.

Many households (70%) kept the kittens in natural lighting conditions (light during daytime, dark at night). Homes were reported as either generally quiet (42%), or of average noisiness (30%). Only five percent of homes were described as loud or very loud. Kittens were exposed to a variety of household sounds, the most common being human voices (88%), talk radio/TV (65%), household appliances (61%), and white noise (55%).

3.4 Differences between litters with and without cross-sucking

We were unable to identify many household factors that might influence sucking behavior. There were no measurable differences between sucking and non-sucking litters in lighting, night or daytime temperatures, or noise level. We also found no differences in reported litter size, time the caretaker spent handling the kittens, health conditions observed or the need for medication between litters with or without cross-sucking.

A few differences in husbandry were observed: for example, the average minimum temperature was slightly higher in households with sucking litters than without (71.8 vs 70.1° F, $t(349) = -3.00, p = 0.003$). Sucking litters and younger kittens were more likely to have a heating source and stuffed animals provided, compared to non-sucking litters and older litters. Non-sucking litters and older kittens were more likely to have toys offered.

Most of the differences in husbandry (e.g., heating source, stuffed animals, toys, frequency of travel) we found between sucking and non-sucking litters may have been related to age, as suckers were on average younger than non-suckers. Results of chi-square analyses for comparisons of husbandry between sucking and non-sucking litters, and well as younger and older kittens are presented in Table 3. Some differences between sucking and non-sucking litters also may have been influenced by the presence of the mother, since sucking litters were more likely to be orphaned. For example, non-sucking litters were less likely to be groomed ($X^2(1) = 4.97, p = 0.03$), but older kittens ($X^2(1) = 5.00, p = 0.02$) and kittens with mothers ($X^2(1) = 31.21, p < 0.001$) were also much less likely to be groomed by caretakers.

3.5 Observation and management of sucking behavior

Of the 301 caretakers of litters experiencing cross-sucking, 70% directly observed the sucking. Participants also noticed wet areas on the recipient kittens (47%), observed the wet face of sucking kittens (20%) and saw sores on the recipients (14%). The genitals (65%) and stomach (22%) were the most frequently targeted areas. Participants reported noticing kittens eating, nuzzling, and vocalizing before sucking on littermates. They also reported observing purring ($N = 127$) and kneading ($N = 167$) during sucking and sleeping ($N = 123$) after sucking among sucking kittens. In recipients, they observed vocalization ($N = 134$) or sleeping ($N = 80$) during sucking.

To manage the behavior, more than half of the participants (57%) interrupted sucking when they observed it. Eight percent noted that the behavior was still occurring or was unmanaged at the time they completed the survey. Many chose part-time (34%) or full-time (19%) separation of kittens to prevent sucking. Ten percent placed clothing on recipient kittens, and 5% used bitter apple spray on recipient kittens to deter sucking. Of kittens that were separated and then reunited ($N = 128$), 73% returned to sucking. No statistical differences were found between kittens that resumed sucking and those that did not on any measured aspects of husbandry (all Chi-square analyses, $p > .05$). Ten percent of participants caring for sucking litters reported that the sucking led to a medical concern, such as genital injuries, sores on skin, weight loss or digestive problems. Other participants noted problems such as infections from kittens getting feces in their eyes and aspiration pneumonia. Antibiotics (both oral and ointment) and regular bathing were the most common treatments. Cross-sucking led to euthanasia in two kittens, and one kitten needed perineal urethrostomy surgery.

4 Discussion

From this survey, we have identified risk factors associated with the presence of cross-sucking in neonatal kittens. Being orphaned was the most important contributor, with orphaned litters being 5.87 times more likely to be impacted by cross-sucking than were litters raised by their mothers. However, maternal separation appears to be necessary, but not sufficient, for this behavior to occur. Being part of a male-only litter, being male and being in younger litters also occurred more commonly in sucking than in non-sucking litters. Kittens in sucking litters also were younger when caretaking began, suggesting they were likely separated from their mothers at a younger age.

Cross-sucking was also statistically related to current bottle-feeding. Kittens that were already weaned were 58% less likely to be in cross-sucking litters. One potential explanation for this association and the younger age of sucking kittens is that kittens may cease cross-sucking when weaning begins. However, over 75% of non-sucking litters entered caretaker homes before they were 21 days old, which is earlier than weaning typically begins. Although kittens may stop cross-sucking when they start weaning, it cannot be the only explanation for the age differences between suckers and non-suckers. Because we did not directly test the hypothesis that weaning leads to a cessation of cross-sucking, future studies should investigate the effects of weaning and aging on sucking behavior.

We did not find any discernable relationship between the environment and husbandry with sucking behavior. This included feeding schedules, lighting and most measures of temperature. Differences in husbandry, such as provision of toys and heating sources, and grooming practices could instead have been driven by the age of kittens or the absence of the mother, each of which was also related to the presence of cross-sucking behavior.

Aside from being orphaned at a young age, the cause of sucking behavior may be related to an individual kittens' stress responses or other biological factors that we did not measure in this study. This could explain why not all kittens that were orphaned began sucking, and why not all kittens in sucking litters were affected by sucking behavior, either as a sucker or a recipient. Although this study did not attempt to quantify the prevalence of sucking behavior in the general population of kittens, our ongoing research suggests that up to 40% of litters may be impacted by sucking behavior (Delgado et al., unpublished data). From this study, we determined that the majority of kittens in a cross-sucking litter (86%) will be affected by this behavior.

Searching is part of the innate appetitive response behavior of newborn kittens (Ewer, 1961), but stress responses may increase search behavior. Increased locomotion in the absence of the mother has been theorized as a mechanism that may increase the likelihood of a reunion (Hudson et al., 2017). Search behavior also may increase the probability that a kitten will experience tactile stimulation or other cues that attract them to a littermates' genitalia or other body parts. Locating a mother's nipple by kittens is highly guided by tactile cues (Larson and Stein, 1984), but they also use olfactory cues to learn and return to the same nipple location (Ewer, 1961; Raihani et al., 2009). These same types of cues could lead a kitten to search for and return to any stimulus that resembles a nipple (e.g., a male kitten's penis).

Unfortunately, once sucking behavior begins, it appears to be difficult to stop. We did not explore the natural progression of this behavior and how or whether it ceases with aging and weaning in this survey, but caretakers reported difficulty with controlling cross-sucking. In some kittens, cross-sucking leads to injury, illness and even death. The most common strategies for managing cross-sucking behavior all pose potential welfare concerns, and there is a need for better solutions. Separating orphaned kittens from littermates deprives them of social contact, which may be especially important for kittens that have also experienced maternal separation (Guyot et al., 1980; Bateson and Young, 1981). Placing clothing on kittens to prevent sucking may present a strangulation hazard, be uncomfortable, or restrict

normal movements. Most importantly, the management techniques described by caretakers do not address the underlying motivation for the behavior, which is the innate need of kittens to suck (Beaver, 2003).

One possible solution is oral enrichment, which has proven effective in reducing cross-sucking in early-weaned calves and piglets (Oostindjer et al., 2011; Ude et al., 2011). Sucking behavior is not strictly motivated by hunger, and most mammals, including cats, engage in significant amounts of non-nutritive sucking (Ross et al., 1957; Koepke and Pribram, 1971; Cameron, 1998). In piglets, when a rubber mat affixed to a wall offered nosing opportunities, belly-nosing was reduced (Bench and Gonyou, 2006). Both being fed from a teat and given access to the teat outside of feeding time reduced cross-sucking among calves (Jensen, 2003). Therefore, the provision of an object that allows kittens to safely suck outside of the times they are bottle-fed may be an effective strategy for reducing cross-sucking; we are currently investigating this possibility. In addition to determining whether oral enrichment could reduce sucking in neonatal orphaned kittens, future research also could assess the trajectory of cross-sucking behavior. It is currently unknown whether oral behaviors in adult cats, such as pica or excessive grooming, are influenced by early-life cross-sucking.

In sum, we have identified some important factors associated with the presence of cross-sucking in domestic kittens. To our knowledge, this is the first study and detailed documentation of specific features of this behavior in cats. Because sucking can lead to sickness and injury, and because it may be an indicator of distress or poor welfare, more research is necessary to determine how to best prevent and treat cross-sucking behaviors in kittens.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Cross-sucking is commonly observed in neonatal animals who are prematurely weaned
- Being orphaned, male, and younger increase the risk of cross-sucking in kittens
- Caretakers report challenges in managing cross-sucking behavior in kittens

Table 1.

Kitten ages at the time of the survey, start of foster, and onset of sucking behavior.

Variable	Average	Sucking Litters	Non-sucking Litters	<i>t</i>	<i>p</i> -value
Age	31.7 days <i>SD</i> : 14.8 days range 2–60 days	30.3 days <i>SD</i> : 14.2 days	35.4 days <i>SD</i> : 15.6 days	<i>t</i> (405) = 3.48	< 0.001
Age at foster start	14 days <i>SD</i> : 11.4 days	12.9 days <i>SD</i> : 10.8 days	17 days <i>SD</i> : 12.5days	<i>t</i> (377) = 3.10	0.002
Age at sucking onset		17.3 days <i>SD</i> : 11.8 days range 2–56 days			

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Table 2.

Chi-square analyses of the effects of orphan status, litter sex composition and weaning status on the presence of sucking in litters.

Variable	Total (N)	Sucking Litters (N)	Non-sucking Litters (N)	X ² statistic	p-value
Orphan status					
Orphaned	353	276	77	42.64	< 0.001
Mother-reared	36	10	26		
Litter composition					
Male only	66	56	10	7.13	0.03
Female only	33	20	13		
Mixed	298	221	77		
Unknown	10	4	6		
Weaning status					
Currently bottle-fed	152	123	23	40.32	< 0.001
Weaning	87	74	13		
Weaned	152	85	67		

Table 3.

The relationship between husbandry, sucking/non-sucking litters, and kitten litter age group.

Husbandry	Sucking Litters	Non-sucking Litters	<1 MO	>1 MO
Fed on schedule	More likely, $X^2 = 7.76, p = 0.005$	Less likely	More likely, $X^2 = 13.41, p < 0.001$	Less likely
Feeding frequency	No differences	No differences	No differences	No difference
Feeding schedule	Every 3–4 hours	Every 6 hours $X^2(4) = 20.91, p < 0.001$	Every 3–4 hours	Every 5–6 hours $X^2(4) = 72.08, p < 0.001$
Average home temperature	No differences	No differences	No differences	No differences
Noises	No differences	No differences	No differences	No differences
Heating source	More likely, $X^2(1) = 8.08, p = 0.004$	Less likely	More likely, $X^2(1) = 32.38, p < 0.001$	Less likely
Stuffed animals	More likely, $X^2(1) = 5.87, p = 0.02$	Less likely	More likely, $X^2(1) = 4.67, p = 0.03$	Less likely
Toys	Less likely	More likely, $X^2(1) = 11.06, p = 0.001$	Less likely	More likely, $X^2(1) = 130.28, p < 0.001$
Travel	More likely	Less likely, $X^2(1) = 4.59, p = 0.03$	More likely	Less likely, $X^2(1) = 6.15, p = 0.01$