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Litter box size and litter type preference and their associated behavioral changes in cats

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ABSTRACT. House-soiling is the most common problem faced by cat owners and is the main reason for owners surrendering cats to animal shelters. Although many studies have reported on inappropriate cat excretion in relation to the toilet environment, few reports have explored the preferences of cats kept indoors when multiple litter boxes are presented. In this study, we investigated the effect of litter box size and litter types on the excretion behavior of cats and whether a litter environment that combines their preferred elements would change their excretion behavior. Our findings indicated that cats preferred litter boxes measuring ≥50 cm as well as clumping clay litter. Moreover, a comfortable litter environment combining these two elements promoted normal urination behavior while improving house-soiling (both urination and defecation) as well as three dissatisfied behaviors during excretion. The results of the present may be beneficial for cat owners and cats exhibiting house-soiling, and they could facilitate the reduction of the number of cats being abandoned owing to house-soiling.

KEYWORDS: cat, cat litter, excretion behavior, litter environment, preference

INTRODUCTION

The percentage of households in Japan that adopts cats rather than dogs has increased in recent years, and since 2014, the number of pet cats has surpassed that of dogs [12]. Cats have long been believed to choose specific places for excretion, making them easier to keep as pets because they do not need to be walked for excretion purposes, which may have contributed to their rising popularity. However, house-soiling has become the most common problematic behavior faced by cat owners, and such problems lead to cats being handed over to animal shelters [13, 14, 20].

Meanwhile, the environments in which cats are kept have also changed. The number of cats allowed to freely live indoors and outdoors has greatly decreased, with over 80% of cats currently being kept completely indoors in Japan [12]. Moreover, social media has seen an influx of posts featuring cute and funny photos and videos of cats posted by their owners. It is not easy for people to accurately perceive the communication signals of cats, and "dissatisfaction" is the most difficult behavior to identify [4]. Thus, incorrect information regarding cats may be spreading. Furthermore, many cat products sold on the market are designed with the owners in mind, rather than the cats themselves, emphasizing convenience and appearance for the owners while having little regard for ease of use by cats or their preferences. These changes in a pet's environment, along with the disparities caused by insufficient knowledge among both owners and cat product manufacturers, may contribute to house-soiling and pet abandonment.

Under normal circumstances, a cat engages in a series of behavioral patterns during excretion, wherein it approaches a specific surface or location, digs a hole in the ground with its front paws, and releases its excrement, after which it hides the excrement by covering it with sand with its front paws or by stepping on it with its hind paws [1, 9]. Behaviors exhibited by dissatisfied cats have also been discussed [3]. In addition, cats with house-soiling behavior reportedly spent significantly less time digging in the litter box than those without the behavior [21].

Causes of house-soiling include medical etiologies, feline idiopathic cystitis (FIC), aberrant marking behavior, and elimination related to primary environmental or social factors [2]. Important steps in treatment, after ruling out medical etiologies, FIC, and aberrant marking behavior, include 1) identifying and providing a comfortable litter box for the cat, 2) providing a healthy environment, and 3) making areas where the cat has inappropriately excreted unattractive or unavailable [2, 17, 18].

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Based on the results of these previous studies, we hypothesized that cat excretion behavior changes depending on the litter environment and that providing a comfortable litter environment for cats could prevent them from house-soiling. Comfortable litter conditions for cats have previously been discussed [2, 17, 18]; however, few studies have been based on actual living environments. Furthermore, in cases where cats are kept completely indoors, the litter environment may be restricted owing to the home environment, and cat products that are inconvenient for the owner may not be used by the owner. In the present survey, we investigated cats kept indoors, and based on the premise that cats have a high preference for certain things, we investigated appropriate litter boxes based the sizes that cat owners can easily place indoors and easily purchase from domestic retailers, in Japan.

We conducted three experiments based on three hypotheses. Many studies have explored inappropriate cat excretion in relation to the toilet environment; however, few studies have explored the preferences of cats kept indoors when they are presented with multiple litter boxes. In addition, the standard size given in the documents differs, such as "1.5 times the length of the cat from the base of the tail" and "at least 1.5 times the length of their bodies" [2, 19]. Therefore, in experiment 1, we used the length of the thoracic and lumbar vertebrae, which does not vary greatly in length, as a reference, and based on previous literature, we hypothesized that cats prefer a litter box that is at least 1.5 times larger than this, which would increase the frequency of use of the litter box. Although there have been studies on the size of litter boxes in the past [8], when compared to size of houses in Canada, where the study was conducted, the size of houses in Japan is smaller, and the sizes of litter boxes actually sold in Japan are smaller than those in the results of this study. Based on personal communication with customers and the fact that all the litter boxes in the market are relatively small, it is expected that owners prefer small-sized litter boxes. Therefore, the aim of the present study was not only to verify the size of litter boxes that cats prefer, but also to promote the development of boxes based on the results of this study and their purchase by cat owners and actual use by their cats. In the present study, we researched the smallest size of litter box that cat owners could comfortably place indoors, based on the premise that cats would be able to use it with a high degree of preference. In experiment 2, we focused on litter type and tested the hypothesis that cats would prefer clumping clay litter, as it is generally considered that this type of litter is preferred and would increase the frequency of litter box use. In experiment 3, we tested the hypothesis that cat excretion behavior would change when the comfortable litter environment observed in the first and second experiments is provided by combining the preferred litter box and litter type.

MATERIALS AND METHODS

Cat café owners and cat owners were informed about the procedure for the experiment and provided informed consent before participating. All experimental procedures were approved by the Animal Ethics Committee of Lion Pet Co., Ltd. (#2018-02, #2020-03).

Experiment 1: Litter box sizes

We used 78 adult cats (ages unknown; 7 purebreds and 71 mixed breeds, comprising 43 castrated males and 35 spayed females) kept in three rooms at three cat cafés. This experiment was conducted outside business hours to avoid human influence, and test times were standardized for each room. In determining the size of the litter boxes, the length of the thoracic and lumbar vertebrae was measured in a total of 102 cats: 78 cats belonging to cat cafes and 24 cats that had visited the Tokyo Feline Medical Center. Compared to the lengths used as standards in previous studies, the thoracic and lumbar vertebrae lengths were relatively consistent and were not expected to vary greatly due to the posture of the cat at the time of measurement. To eliminate any measurement errors attributed the individual taking the measurement, the cats were measured in a standing position, with the veterinarian palpating the vertebrae and measuring with a tape measure. The average length was 35.3 cm. Based on the measurements, we used 50 cm as a reference size, which is approximately 1.5 times the average length of the thoracic and lumbar vertebrae, and prepared three types of cardboard litter boxes (height, 20 cm; depth, 35 cm; uncovered) with various widths (40, 50, and 60 cm). A cylindrical clumping clay litter was placed in the box at a height of 5 cm from the bottom. Additionally, changing the litter to a type that is not normally used can be stressful as litter has a large influence on cat preference during excretion. Thus, we avoided this effect from impacting our results by installing one litter and litter box that are normally used at each facility in the normal location. At one facility, the normally used litter was clay that resembled small pebbles and did not harden, and the litter box was 26 cm high, 40 cm wide, and 52.5 cm deep, with no cover. At the second facility, the normally used litter was cylindrical wood litter that did not harden and was in a litter box, which was 29.5 cm high, 40.5 cm wide, and 50.5 cm deep, with no cover.

The three litter boxes were installed in the center of the room, and their positions were changed each day to eliminate order effects. The experiment was conducted for 3 days in a room with 50 cats, 3 days in a room with 17 cats, and 3 days in a room with 11 cats.

The cats were recorded using a video camera (Digital high-definition camera HC-V480MS; Panasonic Corp., Tokyo, Japan), and the excretion behavior was confirmed from the recordings, with the number of excretions counted. Subsequently, the number of excretions in each room over 3 days was summed by litter box type to obtain the total number of excretions, and the total number of excretions in each room and predicted frequency of excretions were then analyzed using Fisher's exact test. The predicted frequency of excretions was calculated by first determining the area of each litter box used by the cat and then calculating the ratio of each litterbox's area to the total area of all the litter boxes, and then multiplying this by the total number of excretions.

Experiment 2: Litter type

We used 46 adult cats (ages unknown; all mixed breeds, comprising 23 castrated males and 23 spayed females) kept in four rooms of three cat cafés. Two of the three facilities were the same cat cafes as in experiment 1, and one was a different cat café. Similar to experiment 1, we avoided human influence by conducting the experiment outside business hours and standardized the test time for

each room. In this experiment, we used three types of commercially available litter that can be easily purchased by owners: clumping clay litter (Deodorizing Cat Litter, Lion Pet Co., Ltd.); clumping wood litter (Deodorizing Wood Cat Litter, Lion Pet Co., Ltd.; not available commercially); and clumping paper litter (Deodorizing Green tea Cat litter, Lion Pet Co., Ltd.) and inserted them in cat litter boxes up to a height of 5 cm above the bottom. The litter boxes used were based on the results of experiment 1 (height, 20 cm; width, 57.5 cm; depth, 38 cm; Cat litter box developed by a veterinarian, Lion Pet Co., Ltd.).

As in experiment 1, the three litter boxes were placed evenly in the center of the room, and their positions were swapped each day to eliminate order effects. The experiment was conducted for 3 days in 2 rooms with 7 cats, 3 days in a room with 15 cats, and 3 days in a room with 17 cats.

The cats were recorded using a video camera, and the recordings were used to confirm excretion behavior and count the number of excretions. The number of excretions in each room over the course of 3 days was then summed by litter type to obtain the total number of excretions. The total number of excretions in all rooms was summed and analyzed using the Kruskal–Wallis test, followed by a *post-hoc* Steel–Dwass multiple comparison test.

Experiment 3: The litter box environment

We used 20 adult cats (Supplementary Table 1) inhabiting ordinary households with problematic excretion behavior. Cats with a thoracic and lumbar vertebrae length of ≤34 cm or a body weight of ≤4.5 kg or less in the case of body condition score 3 were used in experiment 3. In addition, the attending veterinarian selected cats whose main cause of excretion problems was determined to be the toilet environment, based on the results of the medical history, urine test, X-ray examination, and ultrasound examination, and cats with diseases that were highly related to excretion problems and whose cause of excretion problems was not clear were excluded. Cats with diseases that were not highly related to excretion problems participated in the research while continuing their regular treatment.

The subjects were provided with a comfortable litter environment that combined a litter box developed based on the results of experiment 1 and used in experiment 2 (Cat litter box developed by a veterinarian) with clumping clay litter (Deodorizing Cat Litter) based on the results of experiment 2. The litter was placed in a litter box up to a height of 5 cm from the bottom, and the same number and position of litter boxes were used.

The experiment was divided into two patterns and conducted over the course of four weeks. Pattern I involved using the conventional litter and litter box for the first two weeks, and the provided litter and litter box for the last two weeks. Pattern II involved using the provided litter and litter box for the first two weeks and the conventional litter and litter box for the last two weeks.

During the experimental period, the owner recorded the urination and defecation frequency inside the litter box, the urination and defecation frequency outside the litter box, and the occurrence of the four types of dissatisfied behaviors on a five-point scale (0, 20, 50, 75, and 100%). All the records were checked visually by the owner, and when the owner was not present and the owner could not check visually, the urination and defecation frequency were recorded based on the number of excrement or the number of clumps of litter, and the occurrence of the four types of dissatisfied behavior were not counted. The four types of behavior during excretion indicating cat dissatisfaction are as follows: A, raising paws or placing paws on the side of the litter box while excreting; B1, scratching the air; B2, scratching the side of the litter box, floor, or wall near litter box; C, absence of digging, circling, or covering waste while using litter box. Of the four types of dissatisfied behavior, types A, B1, and C were based on Cottam *et al*. [3]. Type B2 is a behavior that is often reported by cat owners; therefore, it was considered a dissatisfied behavior derived from type B1, and it was investigated. The urination and defecation frequency inside and outside the litter box and the occurrence of the four types of dissatisfied behaviors on a five-point scale were then analyzed using the Wilcoxon signed-rank test.

RESULTS

Experiment 1: Litter box size

The number of excretion over the course of 3 days in each room was summed by litter box type to obtain the total number of excretions, which was then summed across all rooms. The values were as follows: 40 cm litter box, 39 times (urination 37 times, defecation 2 times) (16.9%); 50 cm litter box, 82 times (urination 68 times, defecation 14 times) (35.5%); 60 cm litter box, 83 times (urination 66 times, defecation 17 times) (35.9%); and normally used litter box, 27 times (urination 20 times, defecation 7 times) (11.7%). These results demonstrated a significant bias between the predicted and measured percentages of excretion frequency ($P<0.0001$, using Fisher's exact test) (Table 1, Fig. 1). We also analyzed urination and defecation, and found significant bias between predicted and measured percentage of urination frequency ($P<0.01$, using Fisher's exact test), but not defecation frequency (using Fisher's exact test).

Table 1. Excretion counts per room and litter box size

	40 cm	50 cm	60 cm	Normally
Room A	9 (9, 0)	14 (12, 2)	21 (17, 4)	9 (6, 3)
Room B	17 (17, 0)	31 (28, 3)	36 (29, 7)	10 (8, 2)
Room C	13 (11, 2)	37 (28, 9)	26 (20, 6)	8 (6, 2)
Total	39 (37, 2)	82 (68, 14)	83 (66, 17)	27 (20, 7)
	16.9% (19.4%, 5.0%)	35.5% (35.6%, 35.0%)	35.9% (34.6%, 42.5%)	11.7% (10.5%, 17.5%)

The counts of urination and defecation were in brackets.

Experiment 2: Litter type

The number of excretions over the course of 3 days in each room was summed by litter type to obtain the total number of excretions, which was then summed across all rooms, and the values were as follows: clumping clay litter, 258 times (urination 187 times, defecation 71 times); clumping wood litter, 152 times (urination 104 times, defecation 48 times); and clumping paper litter, 66 times (urination 57 times, defecation 9 times). The results revealed a significant difference between the number of excretions for each litter type ($P<0.05$, using the Steel–Dwass multiple comparison test) (Table 2, Fig. 2). We also analyzed urination and defecation, and we observed significant difference between the number of urination and defecation for each litter type ($P<0.05$, using the Steel–Dwass multiple comparison test).

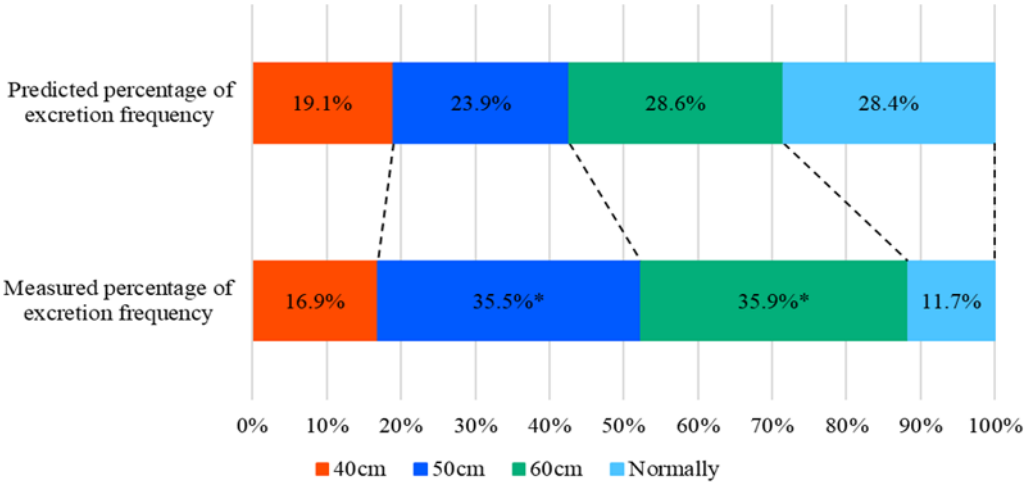

Fig. 1. Predicted and measured values of urination and defecation in each litter box size. The urination and defecation counts in each room over a 3-day period were summed for each litter box size, and the predicted and actual values were calculated by the sum of counts in all rooms. Data were analyzed using Fisher's exact test. A significant bias was observed between the predicted and measured values. *$P<0.0001$.

Table 2. Excretion counts per room and litter

	Clay	Wood	Paper
Room D	19 (17, 2)	18 (14, 4)	4 (3, 1)
Room E	114 (84, 30)	55 (36, 19)	20 (17, 3)
Room F	49 (33, 16)	28 (15, 13)	15 (13, 2)
Room G	76 (53, 23)	51 (39, 12)	27 (24, 3)
Total	258 (187, 71)	152 (104, 48)	66 (57, 9)

The counts of urination and defecation were in brackets.

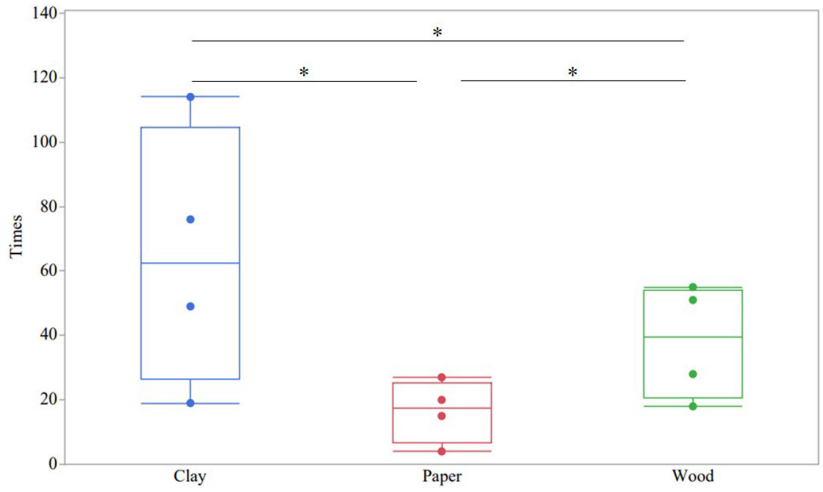

Fig. 2. Urination and defecation counts in each litter. The urination and defecation counts in each room over a 3-day period were summed for each litter in all rooms. Data were analyzed using a nonparametric multiple Kruskal–Wallis test and with *post-hoc* Steel–Dwass test. A significant difference was observed between each litter. *$P<0.05$.

Table 3. Urination and defecation frequencies of the cats inside and outside the litter box and occurrence of dissatisfied behavior types A–C

	Conventional litter box			Provided litter box		
	Q1	Median	Q3	Q1	Median	Q3
Urination frequency inside the litter box*	1	2	3	2	2	3
Defecation frequency inside the litter box	0.25	1	1	1	1	1
Urination frequency outside the litter box**	0	0	0	0	0	0
Defecation frequency outside the litter box**	0	0	0	0	0	0
Occurrence of dissatisfied behavior type A**	0	0	4	0	0	0
Occurrence of dissatisfied behavior type B1*	0	0	0	0	0	0
Occurrence of dissatisfied behavior type B2**	0	0	0	0	0	0
Occurrence of dissatisfied behavior type C	0	0	1	0	0	1

*P<0.0001, **P<0.005.

Experiment 3: The litter box environment

Compared to the conventional litter box, the urination frequency of the cat inside the provided litter box was significantly higher (P<0.0001, using the Wilcoxon signed-rank test). Furthermore, compared to the conventional litter box, the five items—number of times of urinating and defecating outside the litter box, and incidence of type A, B1, and B2—were significantly lower in the litter boxes provided (P<0.0001 and P<0.005) (Table 3) (Supplementary Fig. 1).

DISCUSSION

In the experiments in the present study, we provided cats with multiple litter boxes and studied their preferences from an ethological perspective. Few previous studies have examined this type of choice behavior, and we obtained new insights. The findings revealed that cats use litter boxes of an appropriate size based on their body length and that they prefer distinct materials, and satisfying such preferences could reduce problem behavior.

Experiment 1: Litter box size

Regarding litter box size, we confirmed that cats have a high preference for litter boxes that are larger than 50 cm in size, if they are general litter box for urination and defecation. Fifty centimeters is approximately 1.5 times the average length of the thoracic and lumbar vertebrae, and this was consistent with our hypothesis. In addition, we confirmed that cats have a high preference for litter boxes that are larger than 40 cm in size, if they are litter boxes for urination only. The litter box size that cats are most comfortable with has been discussed in many studies and explained in terms of various indicators, such as 1.5 times the length from the nose to the base of the tail [2] or large enough to allow the cat to fully enter, circle, dig, eliminate, circle, and cover without touching the sides of the box [11]. Guy *et al*. conducted a study using actual ecological conditions and compared cat preference using litter boxes with a length, width, and height of 56 × 38 × 14 cm and 86 × 39 × 14 cm. Their results indicated that cats preferred the larger litter box [8]; however, the larger litter box was difficult to install indoors, inconveniencing owners. A highlight of the present study is that we investigated the smallest possible litter box size that maintains the comfort of cats while ensuring owner convenience. We also used the length of the thoracic and lumbar vertebrae, which has been discussed in previous studies and is consistent with results indicating that cats prefer a litter box length that is 1.5 times the length of the body. This may be due to cats having a series of behavioral patterns during excretion, including hiding the excrement by covering it with sand with their front paws or stepping on it with their hind paws [1]. In addition, cats prefer to defecate and urinate in locations with the necessary space as they turn their torso after excretion. Furthermore, for the ancestors of solitary domestic cats, excretion was a time when they were most vulnerable to danger. Consequently, cats are believed to have evolved to prefer locations where they have a wide view of their surroundings during excretion. However, most of the cats that participated in this study were medium-sized mixed-breed, and larger sizes are expected to be required for large cats. Therefore, further research is required to confirm the preferences of all domestic cats.

Additionally, changing the litter to a type that is not normally used can be stressful as litter has a large influence on cat preference during excretion. Thus, we prevented this factor from impacting our results by installing one type of litter and a litter box that are normally used at each facility in the normal location. Previous research has reported that cats prefer clumping-type litter, and the litter used in the litter boxes they normally use were all non-clumping types [16]. The size of litter box they normally use was larger than the 50 cm that was confirmed to be highly preferred, and we think that this difference in litter could have affected preference.

Experiment 2: Litter type

Regarding litter, in all cases, whether for excretion, urination only, or defecation only, we confirmed that cats preferred clumping clay litter, followed by wood and paper litter, which confirmed our hypothesis. Many studies have discussed the most comfortable litter environment for cats, with most reporting that the litter features that create a comfortable litter environment are litters that are fine and sand-like, have a loose texture, are unscented, and scoopable [2, 9, 11], whereas large gravel- or pellet-like materials are

disliked by cats. This is consistent with the results of our study. These results are believed to be related to the evolutionary process of domestic cats. *Felis lybica*, the ancestor of domestic cats, lives widely across deserts and savannas. The excrement of carnivorous cats, including *F. lybica*, has a strong odor, and eliminating the odor was important for cats to hide their presence from other predators or prey. Therefore, domestic cats likely inherited the behavior of hiding their excrement by covering it with sand using their front paws or stepping on it using their hind paws, and the preference for excretion in fine sand particles, as it hides excrement more effectively.

In the present study, we did not investigate the texture, scent, and coagulation properties of litter, which are features of litter that determine the comfortability of the litter environment. Although numerous previous studies have reported that cats prefer unscented litter, a retrospective study by Horwitz demonstrated that cats using scented litter were significantly more likely to exhibit house-soiling [3]. Conversely, according to McGlone *et al*. [15], cats prefer to excrete in sand, to which 2M2B, a maternal-neonatal pheromone of rabbits, has been added. Furthermore, other studies have reported a preference for urination in litter containing attractants [6]. In experiment 2, we used unscented litter to standardize the conditions of the toilet sand used; however, based on the results, we can infer that scent has a significant effect on excretion behavior; thus, further research focusing on scent is necessary for a more in-depth analysis of cat preferences.

In addition, in Japan today, from an owner convenience perspective, there are many non-clumping litter products in the market that are similar to the type of litter used in experiment 1. As mentioned above, the non-clumping litter used in this study is expected to have low preference, but the clumping clay litter, wood litter, and paper litter used as comparison products all have finer litter grains than the non-clumping litter. We believe that this is not simply due to difference in clumping properties. In particular, when we consider the excretion behavior of cats, which dig a depression in the ground with their paws before excreting, we think that the texture that is transmitted to their paws at that time and the weight of the litter are critical. In future, we would like to continue our research by focusing on such aspects.

Experiment 3: The litter box environment

We confirmed that a comfortable litter environment promoted normal urination behavior, improved house-soiling (both urination and defecation), and improved the types of dissatisfied behaviors displayed during excretion, specifically types A (raising paws or placing paws on the side of the litter box while excreting), B1 (scratching the side of the litter box, floor, or wall near litter box), and B2 (scratching the air). Therefore, our results confirm the hypothesis that a cat's excretion behavior changes when exposed to a comfortable litter environment compared to an uncomfortable environment, which is consistent with previous studies demonstrating that providing a comfortable litter environment for cats is important for treating house-soiling [2, 17, 18].

No changes in normal defecation behavior were observed, and the frequency of type C dissatisfied behavior was not different (absence of digging, circling, or covering waste while using the litter box). Many studies have discussed the conditions of a comfortable litter environment for cats in terms of litter and litter box size, shape and number of litter boxes, and location. However, in the present study, we compared only the litter and litter box size, maintaining the standard for the other conditions. The impact of these other conditions may have been more significant on normal defecation behavior and type C dissatisfied behavior, which could be the reason these behaviors did not change in the present study.

Regarding litter box shape, Grigg *et al*. reported no differences in cat preferences between litter boxes with and without covers [7]. However, they used a large covered litter box (82.5 × 50.2 × 47.3 cm); therefore, further confirmation is required for whether this would apply to the litter box size used in the present study (height, 20 cm; width, 57.5 cm; depth, 38 cm). Furthermore, regarding the number of litter boxes and their locations, owners should place one more litter box than the number of cats in quiet, accessible locations away from food and water [2], out of sight, and easy for cats to access [10, 11]. Feldman reported that wild domestic cats choose an excretion location with at least a 10-m radius buffer from their feeding area [5]. Thus, in the case of domestic cats kept in homes, further research considering factors other than distance, such as home layout, and obstacles, such as furniture, must be conducted to evaluate the buffer radius.

In conclusion, the present study clarified the litter box size and litter type preferred by cats and confirmed that a comfortable litter environment that combined a litter box and litter of a comfortable size changed the excretion behavior of cats. Our findings could benefit cats and cat owners who are troubled by house-soiling, and the findings could facilitate the reduction of the rate of pet abandonment due to house-soiling.

CONFLICT OF INTEREST. Yumi IWABUCHI-INOUE is an employee of Lion Pet Co., Ltd.

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REFERENCES

1. Borchelt PL, Voith VL. 1986. Elimination behavior problems in cats. *Compend Contin Educ Pract Vet* **8** 197–207.
2. Carney HC, Sadek TP, Curtis TM, Halls V, Heath S, Hutchison P, Mundschenk K, Westropp JL. American Association of Feline Practitioners International Society of Feline Medicine. 2014. AAFP and ISFM Guidelines for diagnosing and solving house-soiling behavior in cats. *J Feline Med Surg* **16**: 579–598. [Medline]
3. Cottam N, Dodman NH. 2007. Effect of an odor eliminator on feline litter box behavior. *J Feline Med Surg* **9**: 44–50. [Medline] [CrossRef]
4. de Mouzon C, Di-Stasi R, Leboucher G. 2024. Human perception of cats' communicative cues: human-cat communication goes multimodal. *Appl Anim Behav Sci* **270**: 106137.
5. Feldman HN. 1994. Methods of scent marking in the domestic cat. *Can J Zool* **72**: 1093–1099. [CrossRef]

6. Frayne J, Murray SM, Croney C, Flickinger E, Edwards M, Shoveller AK. 2019. The behavioural effects of innovative litter developed to attract cats. *Animals (Basel)* **9**: 683 (MDPI). [Medline] [CrossRef]
7. Grigg EK, Pick L, Nibblett B. 2013. Litter box preference in domestic cats: covered versus uncovered. *J Feline Med Surg* **15**: 280–284. [Medline] [CrossRef]
8. Guy NC, Hopson M, Vanderstichel R. 2014. Litterbox size preference in domestic cats (*Felis catus*). *J Vet Behav* **9**: 78–82. [CrossRef]
9. Hart BL. 1974. Normal behavior and behavioral problems associated with sexual function, urination, an defecation. *Vet Clin North Am* **4**: 589–606. [Medline] [CrossRef]
10. Heath S. 2019. Common feline problem behaviours: unacceptable indoor elimination. *J Feline Med Surg* **21**: 199–208. [Medline] [CrossRef]
11. Herron ME. 2010. Advances in understanding and treatment of feline inappropriate elimination. *Top Companion Anim Med* **25**: 195–202. [Medline] [CrossRef]
12. Japan Pet Food Association (JPFA). 2023. Research for the number of household dog and cats in Japan. https://petfood.or.jp/pdf/data/2023/3.pdf [accessed on November 15, 2024].
13. Jensen JBH, Sandøe P, Nielsen SS. 2020. Owner-related reasons matter more than behavioural problems-A study of why owners relinquished dogs and cats to a Danish animal shelter from 1996 to 2017. *Animals (Basel)* **10**: 1064. [Medline] [CrossRef]
14. Marston LC, Bennett PC. 2009. Admissions of cats to animal welfare shelters in Melbourne, Australia. *J Appl Anim Welf Sci* **12**: 189–213. [Medline] [CrossRef]
15. McGlone JJ, Garcia A, Thompson WG, Pirner GM. 2019. Maternal-neonatal pheromone/interomone added to cat litter improves litter box use and reduces aggression in pair-housed cats. *J Appl Anim Welf Sci* **22**: 127–138. [Medline] [CrossRef]
16. Neilson JC. 2001. Pearl vs. clumping: litter preference in a population of shelter cats. *Proc Am Vet Soc Anim Behav Sympos* **4**.
17. Neilson JC. 2003. Feline house soiling: elimination and marking behaviors. *Vet Clin North Am Small Anim Pract* **33**: 287–301. [Medline] [CrossRef]
18. Neilson J. 2004. Thinking outside the box: feline elimination. *J Feline Med Surg* **6**: 5–11. [Medline] [CrossRef]
19. Overall KL, Rodan I, Beaver BV, Carney H, Crowell-Davis S, Hird N, Kudrak S, Wexler-Mitchel E. Panel on Feline Behavior Guidelines American Association of Feline Practitioners. 2005. Feline behavior guidelines from the American Association of Feline Practitioners. *J Am Vet Med Assoc* **227**: 70–84. [Medline] [CrossRef]
20. Salman MD, Hutchison J, Ruch-Gallie R, Kogan L, New JC, Kass PH, Scarlett JM. 2000. Behavioral reasons for relinquishment of dogs and cats to 12 shelters. *J Appl Anim Welf Sci* **3**: 93–106. [CrossRef]
21. Sung W, Crowell-Davis SL. 2006. Elimination behavior patterns of domestic cats (*Felis catus*) with and without elimination behavior problems. *Am J Vet Res* **67**: 1500–1504. [Medline] [CrossRef]