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Canine Research

The use of synthetic grass as a novel substrate within veterinary practice canine inpatient elimination enclosures

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ABSTRACT

Dogs form toileting preferences that may influence canine elimination behaviors. This study aimed to assess the effect of providing a novel substrate (synthetic grass) on indices of canine willingness to eliminate, plus associated behavioral parameters. At a veterinary hospital, an ad hoc sample of dogs (irrespective of age, sex, neuter, or fluid therapy status) were randomly allocated (based on day) to one of two treatment groups and given opportunities to eliminate off-leash (between 08:00 and 15:00 h) in an outdoor enclosure every two hours until urination occurred (or other factors prevented the dog being taken to the elimination enclosure) or data collection ended for that day. The two treatment groups were as follows: (1) synthetic grass (n = 86), and (2) concrete (n = 106), with the treatment variable being the substrate the dogs experienced in the elimination enclosure. The proportion (95% confidence interval) of dogs urinating on the first outdoors elimination opportunity was 0.77 (0.66-0.85) for synthetic grass and 0.74 (0.64-0.82) for concrete. The proportion (confidence interval) of dogs that defecated at least once was 0.19 (0.11-0.28) for synthetic grass and 0.19 (0.12-0.28) for concrete. No significant effect of substrate was identified on proportion of dogs that urinated either on the first trip to the elimination enclosure or at least once during hospitalization, proportion of dogs that defecated at least once, latency to urinate or defecate, duration of urination, locomotion, sniffing behavior, or position adopted when urinating or defecating. Locomotion predicted urination, with dogs that urinated being more active ($P < 0.001$). Sexually dimorphic effects on urination (but not defecation) were observed, with males quicker to start urinating ($P < 0.001$), more frequently ($P = 0.048$), and for a shorter duration ($P = 0.004$) than females. Finally, entire dogs of both sexes performed more sniffing behavior than neutered dogs ($P = 0.008$). It is concluded that synthetic grass does not impact on canine willingness to eliminate but further research should quantify any effect of synthetic grass on disease transmission and hygiene before adopting its use more widely in veterinary practice.

Introduction

Domestic dogs (*Canis familiaris*) hospitalized at a veterinary practice will predominantly be confined to small, one-chamber kennels (see Figure 1A and 1B for the two typical types of dog kenneling used within veterinary practice) for the duration of their period of hospitalization. Confined dogs show a strong preference for eliminating away from resting areas when provided with the opportunity (Ross, 1948; Wagner et al., 2014), which may be a behavioral adaptation to reduce disease severity (Hart, 1992). Thus, the motivation to eliminate at a distance that has been strongly selected for in the domestic dog (Wagner et al., 2014). It is clear from canine behavior outside the veterinary clinic that canines can be conditioned to form substrate preferences (Hargrave, 2012; Overall, 2013). Indeed, this behavioral phenomenon is exploited in the "toilet training" of the pet dog. However, these substrate preferences may impede willingness to eliminate in the clinical environment. This can lead to increased duration of retention of urine and/or feces or the soiling of the kennel environment both of which may be associated with discomfort and stress. Psychological distress is a negative affective state that veterinary practices should

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Figure 1. (A) A typical example of a walk-in type of dog kennel found in UK veterinary practices (source: Author's own). (B) A typical example of a shoreline-type dog cage found in UK veterinary practices (source: Haley Walters RVN).

strive to minimize in their patients (Lloyd, 2017; Ryan, 2018). Thus, the provision of adequate toileting facilities for canines may be considered an important aspect of patient care.

Substrate provided may be one component of toileting provision. From one of the author's extensive experience as a locum veterinary nurse, it is evident that many veterinary practices do not provide designated toileting facilities for canines. Thus, nurses frequently rely on exercising patients on-leash on predominantly concrete surfaces (e.g., client car parks). Where formal elimination enclosures (permitting off-leash exercise) are provided in veterinary practices, these are almost always concrete floored. This presumably reflects concerns for disease transmission and the need for ease of cleaning or lack of planning at the design stage. However, synthetic grass constructed using plastic is occasionally used, though formal quantification of its suitability as an elimination substrate from the canine perspective is very limited.

Anecdotal evidence from the veterinary profession (informal personal communications and observations) suggests that canines are more likely to urinate when grass is the available substrate; however, this has not been formally quantified. However, it is reasonable to assume that synthetic grass will be a novel substrate and, therefore, that dogs will not have developed a preference for elimination on this substrate per se. Thus, it might be expected that the provision of synthetic grass will affect either motivation or willingness to eliminate. This may occur either by increasing elimination (due to scent marking) or decreasing elimination (as dogs delay elimination until the conditioned elimination substrate is provided or until discomfort from retention overcomes substrate aversion). Teer and Buckley (2012) found that on-leash hospitalized bitches showed a preference for urinating and defecating on synthetic grass when offered a choice between this substrate and conventional concrete-floored elimination enclosures. However, a follow-up study (Straker and Buckley, 2013) that was extended to also include male dogs and with all dogs tested off-leash found that a significant preference remained only for defecation on synthetic grass, though numerically more dogs urinated on synthetic grass. Despite these findings, it is not clear whether any apparent preference for synthetic grass affects indices of willingness to eliminate (e.g., through a reduction in latency to do so) in a clinical setting and thus has any real impact on patient well-being or efficiency of nursing care provision.

The aim of this study was to explore the findings of Teer and Buckley (2012) further and identify, assuming a group-level preference existed, whether the provision of the preferred substrate had any impact on indices of elimination (primarily urination) behavior. It was hypothesized that substrate provided would have an effect on indices of willingness. Based on the previous studies (Teer and Buckley, 2012, Straker and Buckley, 2013), it was expected that, if and where any effect existed, synthetic grass would improve the willingness to eliminate and reduce latency to do so. Other behavioral observations were also undertaken to further quantify the impact of synthetic grass provision on other indices of canine behavior (including any interactions with sex and neuter status) associated with elimination during hospitalization toilet breaks. It was predicted that dogs that were reproductively entire (anecdotal observations by the authors during their veterinary nursing employment) and male dogs (based on Sprague and Anisko, 1973, Pal, 2003 and anecdotal observations) would show more investigative or scent-marking behaviors and would be less likely to show a substrate preference (due to other competing behavioral factors). The duration of the urination episode was also recorded to quantify the effect of substrate on any potential differences between scent marking and "true bladder emptying" in case some dogs had not had an opportunity to urinate for a number of hours (e.g., on intravenous fluids, not given an opportunity to eliminate by the owner before being admitted to the veterinary hospital).

Materials and methods

Subjects and hospital facility

An *ad hoc* sample of 196 (4 later excluded) canines that were admitted to the hospital facility of a charitable inner-city veterinary hospital (Royal Society for the Prevention of Cruelty to Animals Animal Hospital, Salford, Greater Manchester, UK) were used. The criteria for inclusion in this study were a temperament that enabled safe handling by the experimenter, the ability to walk without assistance, and the absence of any contraindications to exercise in the designated elimination enclosure (e.g., dogs with contagious illnesses, premedicated/sedated, or other issues that the vet indicated made the dog not suitable for use in this study). All the ambulatory dogs that otherwise met the inclusion criteria were intended to be included in this study, regardless of sex, age, breed, reproductive status, or reason for hospitalization. In practice, many otherwise suitable dogs could not be included as, in a busy veterinary hospital, the frequent failure to incorporate a T-connector or

similar device to the intravenous catheter meant that dogs could not be easily temporarily disconnected from the intravenous fluids.

The hospital facility at the RSPCA included a large hospitalization ward for housing inpatients. Patients were housed in standard hospitalization kennels that are designed for short-term housing only (i.e., they are small and elimination away from the resting area is generally not possible). A door from this room led outside into a staff car parking area (concrete floored) and there was a short walk (circa 5 meters) across this parking area to the designated elimination enclosure for canine inpatients. A section (3.3 m × 2m) of this elimination enclosure was used in the study described here (Figure 2). This secure section was bordered on one side by mesh fencing, two sides by iron railings, and one side by a solid wall. A door was set into the middle of the mesh-sided section to allow access to the run. The reason for using a section (rather than the whole elimination enclosure) was to ensure that the synthetic grass to be used in the study was easily moveable by one individual (large sections of synthetic grass are heavy to handle, particularly when wet).

Treatment groups

The patients were allocated to one of two treatment groups based on the day on which they were admitted to the veterinary hospital. These two treatment groups were as follows: (1) synthetic grass (n = 86), (2) concrete (n = 106). See Table for additional demographic details.

Experimental apparatus

This study used the elimination enclosure section described in the subjects and hospital facility section (and depicted in green in Figure 2). The concrete floor of the secure elimination enclosure alternated daily between either being covered with synthetic grass (Classic Artificial Grass, Expressgrass.com™, Sheerness, Kent) or left uncovered. The floor of the elimination enclosure was visually divided into six equal-sized rectangles (each 1 × 1.1 m) by the addition of a grid marked onto the concrete and the synthetic grass by the use of black chalk or marker pen.

Experimental design

Data collection took place over a period of 16 days during July–August with data being collected between 08:00 and 15:00 h on each day. All hospitalized patients who met the inclusion criteria were given an opportunity to eliminate within the elimination enclosure within two hours of admittance (or researcher arrival, if already hospitalized, see Table) and thereafter at approximately 2-hour intervals until urination occurred or it was no longer possible to take the dog to the elimination enclosure (discharged from the hospital, anesthetized, or outside data collection times, or miscellaneous other). Where a dog was hospitalized for more than one day, data were not collected for this dog on any subsequent days. Once urination occurred, the patient was no longer taken to the elimination

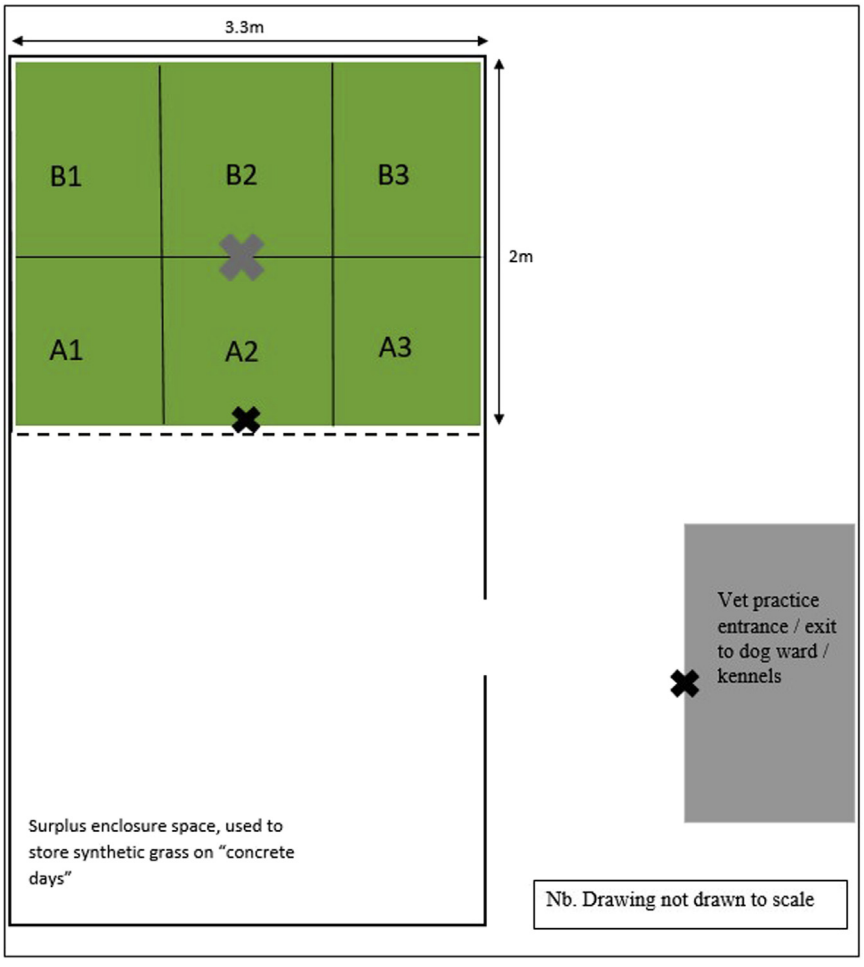

Figure 2. The layout of the elimination enclosure used in the study. Nb. The image shows the experimental setup with the synthetic grass in situ and grid lines drawn on. Each individual grid square measured 1.1 m × 1m and was chalked or drawn on (substrate dependent) to the surface of the enclosure. The dashed line shows a temporary and moveable mesh enclosure divider to section off the area used for testing. The gray cross-marks the spot at which the dog was released from the leash. The black crosses mark the points at which the dog (and experimenter) enters/exits the veterinary practice building and elimination enclosure.

Table 1
Demographics of the dogs included in each treatment group

Demographic	Synthetic grass treatment group	Concrete treatment group
Age (years) (mean ± standard deviation)	5.2 (±3.6)	5.7 (±4.2)
(min–max)	(0.2-14)	(0.2-15)
Sex	Male: 43	Male: 49
	Female: 43	Female: 57
Reproductive status	Entire: 37	Entire: 25
[±]The neuter status of the bitch was not always reported on the clinical records and, where this was the case, a value of unknown was returned.	Neutered: 40	Neutered: 59
	Unknown[±]: 9	Unknown[±]: 22
KC classification	Toy: 12	Toy: 24
	Gundog: 11	Gundog: 12
	Utility: 9	Utility: 8
	Working: 10	Working: 7
	Pastoral: 7	Pastoral: 9
	Terrier: 20	Terrier: 21
	Unknown/crossbreed: 17	Unknown/crossbreed: 24
Weight (kg) (mean, min–max)	20.9 (3-70)	14.1 (2-37.3)
Fluid therapy	Yes: 7	Yes: 13
	No: 79	No: 93
Already hospitalized before 08:00 h that day	Yes: 23	Yes: 19
	No: 63	No: 87

KC, kennel club breed.

enclosure by the experimenter. Any dog that urinated in its kennel before, or en route to, the elimination enclosure was excluded from the study. In practice, this meant that four dogs (two on concrete days and two on synthetic grass days) were excluded from the statistical analyses: two because they urinated in their kennel before exercise occurred and two because they urinated en route to their first trip to the elimination enclosure. The number of dogs reported in each of the treatment groups exclude these four dogs.

Immediately before any opportunity to visit the elimination enclosure occurred, any patient included who was in receipt of intravenous fluids (n = 21, eight on synthetic grass days; 13 on concrete days) was temporarily disconnected from the fluid administration set to enable free-running elimination to take place. Each patient was walked from the kennel area to the secure elimination enclosure at a brisk pace and on a tight leash to discourage sniffing or premature eliminatory behavior before entry to the elimination enclosure. Upon entry to the exercise run, the experimenter walked toward the center of the run and released the dog from its leash. The stopwatch was started at this point and the experimenter immediately vacated the elimination enclosure to record behavioral observations from a distance of approximately one meter from the run. Each patient was given five minutes within the elimination enclosure before being returned on-leash to its kennel. Five minutes was selected as the opportunity length to be practically relevant to busy veterinary clinic staff. Between each episode of elimination, the elimination enclosure was cleaned with a 1% solution of TriGene Advance Disinfectant (Medichem International (Marketing) Ltd., Sevenoaks, Kent) and rinsed with water, and any excess water was brushed away from the elimination enclosure. At the end of each data collection day, the synthetic grass (on days when used) was soaked in a 1% TriGene Advance Disinfectant solution for 20 minutes and then rinsed thoroughly and removed from the elimination enclosure to allow the concrete to be cleaned and disinfected in the same manner as the synthetic grass.

Data collection

To assess willingness to eliminate on each substrate, the following eliminative data were recorded for each patient: latency to start urinating and/or defecating, and number and duration of urination episodes (to try to identify marking and true bladder emptying activity). The start and finish of an urination and/or defecation episode was defined as the start and end of the visible voiding of the respective substance.

A number of behavioral observations were also taken to assess the impact of different substrates on other indices, or potential proxy indices, of eliminative behavior. These included the following: number of rectangles entered during the five-minute period (to evaluate locomotion), the rectangle that the dog eliminated in (to identify if dogs would preferentially choose to eliminate in the same square that previous dogs had eliminated), total number of sniffing bouts that occurred and where, and the physical position that the dog adopted to eliminate. Where the dog changed positions, the position that the dog was in at the start of the eliminative behavior was recorded. The ethogram of elimination behaviors used in this study was devised and used by Sprague and Anisko (1973) and the descriptors for each behavior can be found here. The elimination postures included the following: 1. stand, 2. lean, 3. raise, 4. elevate, 5. flex, 6. squat, 7. handstand, 8. arch, with the following combinations of postures also included: 9. lean-raise, 10. flex-raise, 11. squat-raise, 12. arch-raise.

Two additional behaviors were included: sniffing bout and elimination ground scratch. Sniffing bout was defined as follows: Period of time during which the dog's head and nose are primarily engaged in sniffing at or near a substrate. Sniffing is defined as the dog directs the head and nose toward substrate and visibly inhales with its nostrils. The substrate may be either a vertical or horizontal surface. The bout ends when the dog's head is directed away from the substrate, sniffing ceases, and the dog shows an alternative activity. This alternative activity may involve locomotion (e.g., walking) or it may involve stationary activities (e.g., looking). Elimination ground scratch was defined as follows: The dog scratches at the ground with its hind feet immediately after either urination or defecation.

Statistical analysis

All statistical analyses were performed using GenStat (version 18, VSN International Ltd., Hertfordshire, UK), with graphic presentation undertaken in Excel (Microsoft Office Professional Plus 2016, Microsoft Corporation, Washington, USA). $P < 0.05$ was considered significant for all tests. The number of squares entered, total bouts of sniffing, and latency to start urinating data were analyzed using a REML linear mixed model (LMM). The fixed effects included were substrate (synthetic grass/concrete), sex (male/female), neuter status (entire/neutered/unknown), fluid therapy (yes/no), and urinated in elimination run (yes/no), with the latter fixed effect included in the squares and sniffing analyses only. The

random effect for both models was kennel club breed classification. Model assumptions were checked visually using residual plots generated by REML, with the final analysis run using the log-e transformation (number of squares and latency to start urinating data) and square root transformation (total bouts of sniffing data). Binomial data (urinated in run? Yes/no; defecated in run? Yes/no) were analyzed using a generalized linear mixed model (GLMM), with the binomial total set to 192 (to reflect the dog as the sampling unit), and the dispersion parameter set at 1. The fixed effects included substrate, sex, neuter status, and fluids, with kennel club breed classification as the random effect. Count data (number of times the dog urinated in the run during an elimination period) were analyzed using a GLMM, with a negative binomial distribution (aggregation value: 1), and a log ratio (value: 10) link function. Nonsignificant fixed effects were retained in the final model (Colegrave and Ruxton, 2017), and the hall fitting method was used for all GLMM models. For all LMM and GLMM models, interactions between substrate, sex, and neuter status were also included. All reported means (±standard error of the mean, s.e.m.) for quantitative data were directly reported from the raw data. Confidence intervals (CIs) are reported for each proportion. Duration of urination bout (first urination) was analyzed using Mann-Whitney *U* tests as transformation failed to normalize residual distribution and reported using medians (±interquartile range). Latency to urinate data is reported using box plots as, while the transformed residuals met the assumptions for a parametric analysis, the distribution of the raw data was positively skewed, and this distribution was felt to be of interest to the reader. Low sample sizes limited statistical analysis of latency to defecate data, with only substrate and sex analyzed using Mann-Whitney *U* tests and presented using box plots to aid comparison with urination data. Because of low numbers of dogs per treatment group on some days, an analysis of sniffing per rectangle was not undertaken. The daily cleaning regime meant that it was not considered meaningful to undertake an analysis without day included as a fixed effect.

Chi-square was used to determine associations between posture during elimination and substrate available. For females, all postures other than squat were combined owing to their low frequency. For males, all postures other than raise, elevate, and squat were also combined owing to their low frequency.

Results

Proportion of dogs that urinated on their first trip to the elimination enclosure

There was no effect of substrate (GLMM, $F_{1,178.0} = 0.04$, $P = 0.839$), sex (GLMM, $F_{1,178.0} = 0.48$, $P = 0.490$), reproductive status (GLMM, $F_{2,178.0} = 1.49$, $P = 0.227$), or fluid therapy (GLMM, $F_{1,178.0,} = 0.28$, $P = 0.596$) on the proportion of dogs that urinated on their first trip to the elimination enclosure during hospitalization, and no significant interactions identified. For each substrate, the proportion (±CI) of dogs that choose to urinate on the first trip was 0.77 (0.66-0.85) when the substrate was synthetic grass and 0.74 (0.64-0.82) when it was concrete.

Proportion of dogs that urinated at least once in the elimination enclosure

There was no effect of substrate (GLMM, $F_{1,178.0} = 0.13$, $P = 0.714$), sex (GLMM, $F_{1,178.0} = 0.12$, $P = 0.735$), reproductive status (GLMM, $F_{2,178.0} = 0.35$, $P = 0.706$), or fluid therapy (GLMM, $F_{1,178.0} = 0.20$, $P = 0.659$) on the proportion of dogs that urinated at least once during hospitalization, and no significant interactions were identified. For each substrate, the proportion (±CI) of dogs that choose to urinate at least once was 0.86 (0.77-0.93) when the substrate was synthetic grass and 0.81 (0.72-0.88) when it was concrete (Figure 3). These figures are limited by a ceiling effect on the potential increase in number of dogs that urinated at least once as the median (I.Q.) number of trips to the elimination enclosure of dogs that did not urinate was 1 (1-1) for both dogs in both the synthetic grass and concrete treatment groups. Where dogs were given additional opportunities to urinate, 80% of dogs given synthetic grass and 81% of dogs given concrete did so. Within subgroups of dogs that did not urinate, in the synthetic grass group, only two out of 12 dogs were given additional opportunities to eliminate (one twice, one three times). In the corresponding concrete subgroup, 2 of 19 dogs were given additional opportunities (both twice). The most common reasons for not providing additional elimination opportunities included discharged from hospital (n = 12), surgical intervention (n = 8), and medical (n = 3).

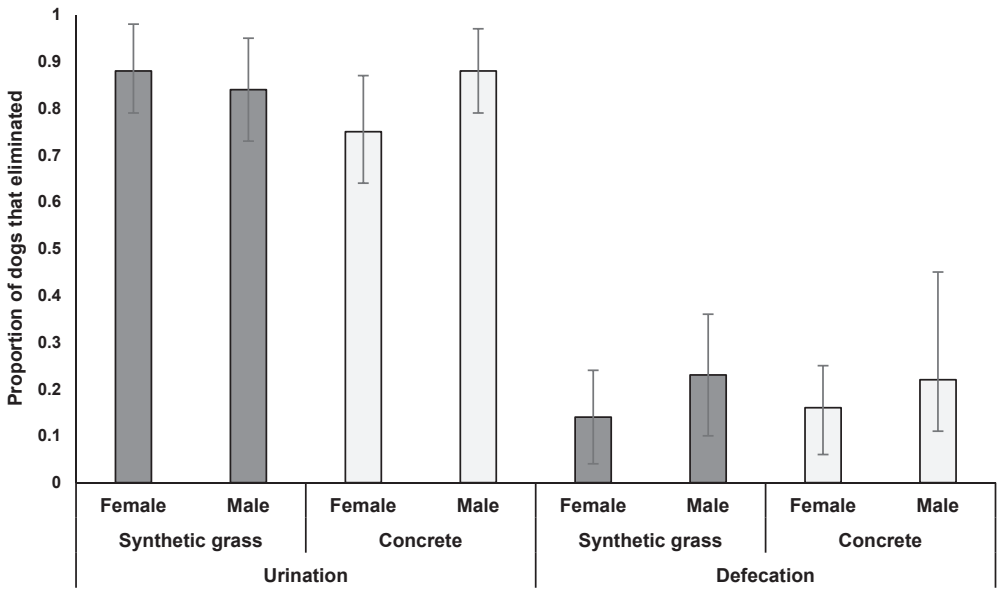

Figure 3. The proportion of dogs (split by substrate and sex) that urinated and/or defecated at least once during hospitalization. Error bars signify the confidence interval associated with each proportion.

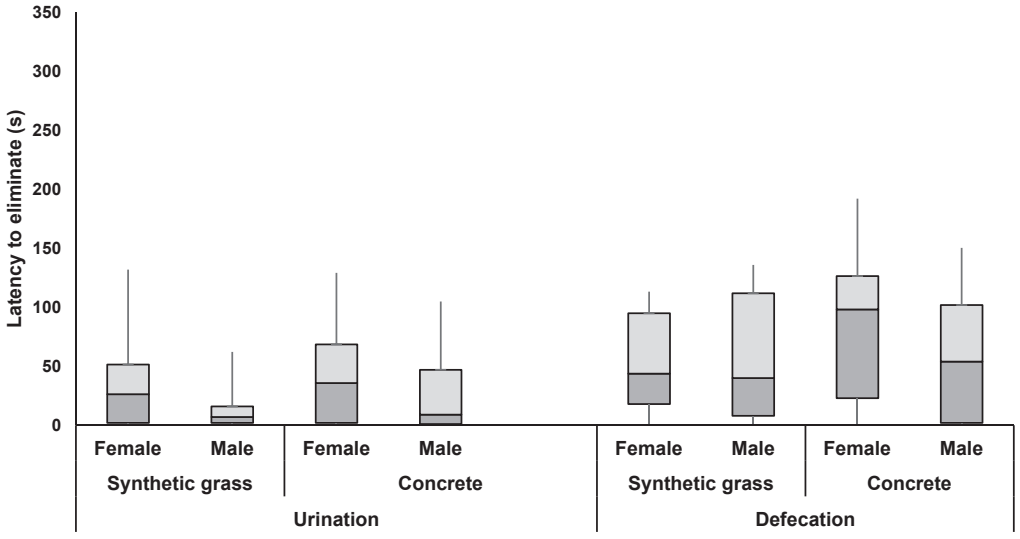

Figure 4. A box plot to show latency to start urinating and defecating in dogs (split by substrate provided and sex of the dog). The error bars signify the data range from minimum to maximum values.

Additional reasons included the following: veterinary surgeon asked researcher not to take the dog to the elimination enclosure again (reason not specified) (n = 1), overarousal during a visit to the elimination enclosure that triggered a bout of vomiting (n = 1), and escape attempts while in the run (n = 1).

Within dogs that urinated at least once, there was no overall effect of substrate on frequency of urination episodes within a five-minute elimination period (GLMM, $F_{1,146.0} = 0.33$, $P = 0.568$) or fluid therapy (GLMM, $F_{1,146.0} = 0.08$, $P = 0.782$). There was an effect of sex, with male dogs significantly more likely to urinate more than once (GLMM, $F_{1,146.0} = 3.98$, $P = 0.048$) although this was not affected by reproductive status (GLMM, $F_{2,146.0} = 0.31$, $P = 0.736$). The mean (±s.e.m.) number of times female and male dogs urinated during this elimination period was 1.1 (±0.04) and 1.7 (±0.16), respectively.

Proportion of dogs that defecated at least once in the elimination enclosure

Likelihood of defecation was not significantly affected by substrate provided (GLMM, $F_{1,.178.0} = 0.73$, $P = 0.393$), sex (GLMM, $F_{1,178} = 3.19$, $P = 0.076$), reproductive status (GLMM, $F_{1,178.0} = 0.65$, $P = 0.525$), or fluid therapy ($F_{1,178.0} = 0.83$, $P = 0.365$) and no significant interactions were observed. The proportion (CI) of dogs that defecated at least once with the provided substrate was 0.19 (0.11-0.28) for dogs exposed to synthetic grass and 0.19 (0.12-0.28) for dogs exposed to concrete.

Of the 36 dogs that defecated during the study, only three dogs (2 males, differential reproductive status and both on concrete; 1 neutered bitch, on synthetic grass) defecated more than once. Therefore, no further analysis of the impact of sex or substrate on multiple episodes of defecation was carried out.

Latency to eliminate in the elimination enclosure

Where dogs urinated at least once during a five-minute visit to the elimination enclosure, the latency to start urinating (standardized to first urination episode only) was significantly affected by the sex of the dog (LMM, $F_{1,138.7} = 11.37$, $P < 0.001$) but not by neuter status (LMM, $F_{2,145.4} = 1.12$, $P = 0.328$), substrate provided (LMM, $F_{1,147.0} = 1.10$, $P = 0.295$), or fluid therapy (LMM, $F_{1,146.6} = 0.16$, $P = 0.692$), and no significant interactions were identified. Generally, male dogs were quicker to begin urinating than female dogs with a right skew observed to both data sets (Figure 4).

Where dogs defecated at least once during a five-minute trip to the elimination enclosure, the latency to start defecating (standardized to first defecation episode only) within this period was not significantly affected by substrate (Mann-Whitney *U* test, $W_{15,21} = 126.5$, $P = 0.328$), sex (Mann-Whitney *U* test, $W_{16,20} = 152.5$, $P = 0.820$), reproductive status (Mann-Whitney *U* test, $W_{14,14} = 117.0$, $P = 0.953$), or fluid therapy (Mann-Whitney *U* test, $W_{34,2} = 33.5$, $P = 0.978$). The median (I.Q.) latency to start defecating was 101 (31-133) when on synthetic grass and 105 (65-187) when on concrete (Figure 4).

Duration of urination (first urination bout)

The median (I.Q.) duration of the first urination episode was 8 (6-16) for bitches and 5 (3-12) for male dogs. There was an effect of sex (Mann-Whitney *U* test, $W_{81,79} = 2357.0$, $P = 0.004$), but not substrate (Mann-Whitney *U* test, $W_{74,86} = 3045.0$, $P = 0.638$), reproductive status (Mann-Whitney *U* test, $W_{82,82} = 0.12$ $P = 0.901$), or fluid therapy (Mann-Whitney *U* test, $W_{145,15} = 802.5$, $P = 0.95$) on the duration of this urination episode. The median (I.Q.) time spent urinating during the first urination bout was 5 (3.25-11.75) for males and 8 (5.75-15.25) for females. Evidence of two distinct populations of urination types (scent marking and "true bladder emptying") reflected through length of the urination episode were not observed but, for both sexes, a positive skew was observed (Figure 5).

Locomotion and sniffing behavior

Locomotion was not affected by the substrate in the elimination enclosure (LMM, $F_{1,177.3} = 0.14$, $P = 0.708$), sex (LMM, $F_{1,157.6} = 0.33$, $P = 0.568$), reproductive status (LMM, $F_{2,175.6} = q.04$, $P = 0.356$), or fluid therapy (LMM, $F_{1,177.9} = 0.00$, $P = 0.974$), and there were no significant interactions. However, dogs that urinated in the elimination enclosure during the period were significantly more active (LMM, $F_{1,178} = 11.43$, $P < 0.001$). The mean (±s.e.m.) number of squares the dog entered during a five-minute period was 13.4 (±2.41) if it did not urinate during this period and 18.30 (±2.15) if it did.

Sniffing activity was also not affected by the substrate provided (LMM, $F_{1,177.3} = 0.11$, $P = 0.745$), sex (LMM, $F_{1,178.0} = 0.21$, $P = 0.651$),

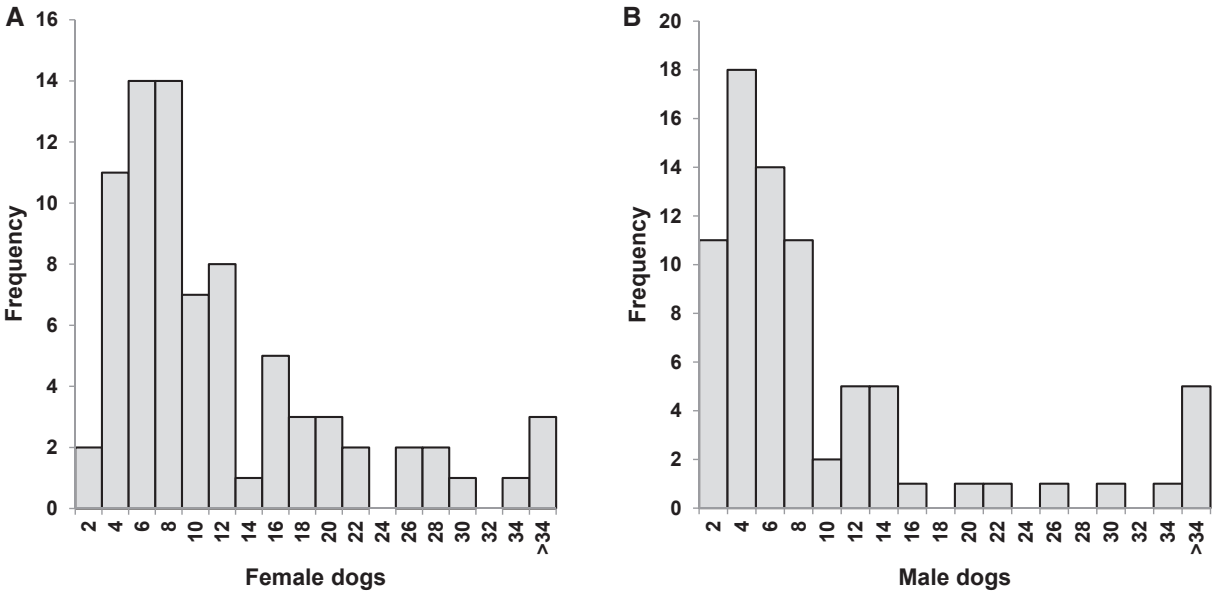

Figure 5. Frequency distribution of the duration (s) of first urination episode in (A) female and (B) male dogs.

or fluid therapy (LMM, $F_{1,177.2} = 1.06$, $P = 0.304$). However, this sniffing behavior was affected by the reproductive status of the dog (LMM, $F_{2,176.8} = 4.92$, $P = 0.008$) (but no interaction with sex). Reproductively entire dogs engaged in slightly more bouts of sniffing (mean (±s.e.m): 7.2 (±1.0)) than neutered dogs (5.8 (±1.0)).

Posture during elimination

There was no significant association between substrate and posture adopted during urination (chi-square test: bitches: $\chi^2_1 = 1.21$, $P = 0.271$; dogs: $\chi^2_1 = 0.575$, $P = 0.90$). The most common posture adopted by bitches during urination was the squat, which accounted for 87% of all postural observations. The most common postures adopted by male dogs during urination were raise (45%), elevate (22%), and squat (21%), which, when combined, accounted for 88% of all postural observations. Very few dogs scratched the ground with their back feet after urinating, with only 1.4% of synthetic grass dogs and 2.4% of concrete dogs doing so immediately after their first urination episode.

The most common posture adopted during defecation was the arch (94% of observations), with only two dogs (one per substrate provided) adopting an alternative posture during defecation. Thus, this was not formally analyzed but there was clearly no evidence that this was affected by substrate. Only one dog in each treatment group scratched the ground (6% of the 36 dogs that defecated during the study) with their back feet immediately after defecating.

Discussion

The provision of synthetic grass as an alternative to traditional concrete-floored toileting areas had no significant effect on any direct or proxy measures of canine willingness to urinate or defecate, and there were no interactions between substrate provided and sex, neuter status, or fluid therapy provision. This suggested that this lack of discernible preference was applicable to a wide range of canine inpatients. Thus, if the identified preference for synthetic grass for urination and defecation (Teer and Buckley, 2012) and defecation only (Straker and Buckley, 2013) was genuine, any population-wide preference was not strong enough to influence willingness to eliminate when the preferred substrate was unavailable. Alternatively, it is possible that the apparent preference observed in the earlier study (with 57 bitches used) was influenced by methodological limitations present in the on-leash study (Teer and Buckley, 2012) with either on-leash testing allowing the experimenter to inadvertently influence canine elimination behavior or through incomplete spot-cleaning of synthetic grass. In the case of the latter, although it is an issue for internal validity of the study, it may improve external validity in relation to the findings as, anecdotally, spot cleaning (or no cleaning) between low-risk patients is common place in clinical practice. Retention of scents that facilitated an increased canine interest and willingness to eliminate on this substrate may occur when cleaning is incomplete or scents retained (Bowen and Heath, 2005; Landsberg et al., 2013). However, both explanations were controlled for in the study by Straker and Buckley (2013), with a more rigorous between-dog cleaning regime and off-leash testing, but still a significant preference for defecation, but not urination, existed. The proportion of dogs that urinated on synthetic grass was numerically higher though, so it is possible that this study was underpowered (with 85 dogs) for the size effect that may have existed once the methodological issues with the study by Teer and Buckley (2012) were removed.

It might be argued that this study (with treatment group sample sizes of 86 and 106) was also underpowered with respect to detecting small differences between treatment groups. However, biological significance is not the same as statistical significance, and to be a key determinant of practice design and purchasing decisions, it would be necessary to demonstrate a pronounced substrate effect at the group level. In this study, willingness to urinate was high, with 74%-77% of dogs choosing to urinate on their first trip to the elimination enclosure. Willingness to eliminate per se (80%-81% urinated at least once in the elimination enclosure) may have been underestimated because of restriction on repeat exercising as, when dogs were given additional opportunities to urinate, most did so. This suggested that either substrate would be acceptable as a toileting substrate for most dogs. Fewer dogs defecated but, with a maximum 7-hour data collection period, this is not surprising, as bowel movements are less frequent than urination episodes in most dogs. The design of the study does not allow the authors to separate scent-marking behavior from genuine bladder emptying. However, Yang et al. (2014) found that

mammalian urination duration is predicted to take 21 seconds (±13 seconds) and that this prediction holds true across the range of bodyweights included in the present study. This might suggest that, in our study, the predominance of shorter durations reflected scent marking rather than genuine need to empty the bladder. The lack of bimodal distribution to urination length does not support two populations of urination "types" in the present study; however, it is assumed that if a dog is willing to eliminate on a substrate for one of these purposes, it will be willing to do so for the other. This is an untested assumption.

To the authors' knowledge, this is the first study to examine the effects of substrate provision on canine willingness to eliminate in any captive housed environment and certainly the first published in relation to veterinary hospitalization facilities. This is surprising given that expert opinion suggests that dogs form strong substrate preferences for elimination purposes from an early age (Houpt, 2009; Hargrave, 2012; Tomlinson, 2016) and that preventing an animal from being able to meet a strong preference is likely to cause stress (Wagner et al., 2014). In the present study, it is possible that neither option (concrete vs. synthetic grass) allowed the dog to eliminate on its preferred substrate if that preference was for a third, unoffered substrate (e.g., grass). However, the use of real grass enclosures poses disease transmission and maintenance challenges, which may make its provision inappropriate in many hospital facilities. Locational preferences were identified by Wagner et al. (2014), who found that rescue kennel dogs provided with a two-chamber kennel preferentially choose to eliminate away from the chamber containing their bed, food, and water. This is unlikely to be practical in most veterinary practices for both logistical and patient health/condition status reasons, so provision of adequate toileting areas away from kennel areas remains essential to allow elimination away from resting and feeding areas. Wagner et al. (2014) report that dogs still eliminated within their kennel 58.1% of the time. In the present study, only 2 dogs (out of 196) were removed from the study for soiling their kennel. Logistical differences (size of kennel, frequency of dog walking, length of stay, etc.) make comparisons difficult. However, it seems reasonable to assume that dogs preferred to eliminate away from their hospital kennel, perhaps because eliminating in the confines of a small kennel is aversive, perhaps because scents in the run act as elimination attractants, or perhaps a combination of these factors. Thus, given the challenges of staff time, it is essential to provide dogs with opportunities to eliminate in areas they find acceptable.

In keeping with the wider literature in relation to canine urination behavior, significant effects of sex were identified in this study, with male dogs urinating more frequently than female dogs, having shorter urination episode durations and showing shorter latencies to start urinating. In general, male dogs are quicker to start urinating (Sprague and Anisko, 1973) and urinate more frequently (Sprague and Anisko, 1973; Pal, 2003; Lisberg and Snowdon, 2011; McGuire, 2016; Fattah et al. 2017). Frequency is increased with sexual development/maturity (Ranson and Beach, 1985), or if castration is delayed until sexually mature (Beach, 1974, but see Lisberg and Snowdon, 2011), in small dogs (McGuire and Gough, 2017), being in estrus (Kleiman, 1966; Bowen and Heath, 2005) and being off home territory (female dogs: Wirant and McGuire, 2004, but see Cafazzo et al., 2012) or on the territorial boundary (male dogs: Pal, 2003; Cafazzo et al., 2012). Interestingly, owners report problem urine-marking to decrease at home, but not outside, when dogs are castrated (Maarschalkerweerd et al. 1997; Yeon et al. 1999), which might suggest that neutered dogs mark as frequently as entire dogs in external, less familiar environments. A recent study (McGuire, 2019) found that, in a shelter environment, castrated male dogs urinated less frequently than entire males (or after castration where a within-subject analysis was undertaken). While time effects (e.g., since entering the shelter, increased familiarity, etc.) might potentially explain this novel finding where neutering of the dog was undertaken by postadmission to the shelter, McGuire and Bemis (2017) found that the longer a dog was at a shelter the more frequently it urinated suggesting this explanation would be erroneous. The multifactorial nature of the purpose of canine urinations, with marking associated with a range of social and nonsocial directed outcomes (Lisberg and Snowdon, 2009; McGuire, 2016), may explain the variation in elimination-related behaviors observed. These latter effects could not be explored using the current data set but may have represented nuisance effects that masked any effect of substrate on canine urination preferences, and, where feasible, could be controlled for in any subsequent study. However, latency to urinate was less than 3 minutes (five minutes opportunity per elimination session was permitted, so if urination did not occur within 3 minutes, it was not going to happen within that elimination session) for all dogs that urinated. Furthermore, repeated scent-marking opportunities is not the primary goal when exercising canine inpatients, so the practical effect in terms of nursing efficiency (time saving) and patients having sufficient time to urinate before return to the kennel is likely to be negligible. Interestingly, Sprague and Anisko (1973) in their study of urination behavior in laboratory-housed beagles found that latency to urinate reduced with increased familiarity with the elimination enclosure. The authors do not report whether the crushed rock substrate used in the test elimination arena was a novel substrate to the dogs, but by trip 2 and 3 latencies were lower than that in trip 1. This was particularly pronounced for female dogs. This might suggest that getting dogs to urinate quickly while hospitalized will get easier as dogs habituate to the new environment. An alternative explanation though may be that the test arena became more odorous by trials 2 and 3 and so facilitated more rapid scent marking as dogs' over-, or adjacent-marked in response to preexisting odors. As veterinary practice elimination enclosures are likely to include a wider range of canine odors than was present (and exposed to the study dogs) on the first trial of the study by Sprague and Anisko (1973), it is possible that no effect of trial would be seen in clinical practice. By contrast, no effect of sex on defecation frequency has been observed in dogs (McGuire, 2016), and the same was observed in the present study. What was noticeable was that dogs showed a longer latency to defecation than urination, thus a practical implication of this was that, if a dog defecated without urinating first, it was probably not going to urinate during that elimination opportunity. This may have practical implications for veterinary nursing decision-making when deciding when to terminate an elimination opportunity but should be weighed against other clinical factors and welfare considerations.

There was no effect of sex or neuter status on proportion of dogs that urinated either on the first trip to the elimination enclosure, or at least once during their hospital stay. This mirrored the findings of Lisberg and Snowdon (2011) who found that the percentage of pet dogs urinating on arrival at a park entrance was unaffected by sex. In that study, the differences observed were related to the type of urine-marking performed (over- or adjacent-marking), with sexual dimorphic effects in marking style and whether urine was directed at a stimulus (marking) or not (genuine urination) (distinction as defined by Kleiman, 1966) observed in multiple studies (Sprague and Anisko, 1973; Pal, 2003; Wirant et al., 2007; Lisberg and Snowdon, 2011; Cafazzo et al., 2012; Gough and McGuire, 2015; Fattah et al., 2017). Perhaps controversially, relative social status of the dog has also been reported to play a role in subsequent canine urination-associated behaviors triggered by unfamiliar dog urine (Lisberg and Snowdon, 2009, 2011; Cafazzo et al., 2012). Lisberg and Snowdon (2009, 2011) found that tail base position was associated with both frequency of urination (high tail base dogs

urinated more, Lisberg and Snowdon, 2011) and duration of sniffing when unfamiliar urine (low tail base dogs sniffed for longer, Lisberg and Snowdon, 2009) is encountered. Tail base position was associated with resource-holding potential of dogs in an experimental social situation, with high tail base associated with being more obtaining and maintaining hold of a toy in a social test, and low with least success. Other dimensions to canine personality (confidence per se), motivation, or arousal may provide alternative explanations to this behavior. Finally, McGuire et al. (2018) suggest that urination may function as a way in which little dogs may dishonestly signal body size to exaggerate potential competitiveness. The present study was not designed to explore the type of marking behavior observed or provide explanations for these differences, which reflects the difference in study focus. In a busy veterinary practice, the veterinary professional is more concerned with providing opportunities for patients to eliminate at regular intervals to minimize patient discomfort and maintain kennel cleanliness, while balancing other nursing activities. Willingness to eliminate and latency to do so is therefore the key measure of interest. However, additional factors shown or proposed to explain differences in urination-associated behavior do suggest that trips to the elimination enclosure will represent a rich tapestry of olfactory experiences for hospitalized dogs. These may be either enriching or stressful depending on the individual dog. It is noted that the percentage of dogs that ground-scratched with their hind feet after urination (1.4%-2.4% of dogs) or defecation (6% of dogs) was lower than has been reported in the wider literature. McGuire (2016) found that 28%-50% of adult/senior dogs in a dog shelter displayed ground scratching after elimination, though this behavior was rarely performed by juvenile dogs. The lower incidence of this behavior may reflect differences in the substrate provided (McGuire's dogs were walked on a variety of substrates, including grass, dirt, and gravel). Alternatively, it may reflect differences in the dogs' motivational or affective state at the time of exercising that may have inhibited this aspect of the normal eliminative behavioral repertoire of the domestic dog. Further research could focus on the effect of dog temperament or stressors on willingness to eliminate or perform aspects of the normal eliminative behavioral sequence in a shared veterinary practice elimination enclosure.

Lisberg and Snowdon (2009) did not find an effect of neuter status on overall time spent sniffing, though there were some effects of neuter status, with neutered males and entire bitches spending more time sniffing the urine of entire dogs than either entire females or neutered males, respectively. Riach et al. (2017) and Wirant and McGuire (2004) also did not find an effect of reproductive status on either male or female dogs, respectively. In the present study, entire dogs of both sex engaged in more sniffing bouts than neutered dogs; however, this did not translate into increased willingness to urinate. By contrast, in the present study, locomotion was significantly associated with willingness to urinate, with dogs that traversed more squares significantly more likely to urinate than dogs that traversed less squares. This suggests that canine activity levels may be a useful predictor of whether a canine inpatient is likely to urinate when released into the elimination enclosure, as it was unaffected by sex or fluid therapy status. However, although significant, a marked difference between two groups was not observed, and a perceptive veterinary nurse may find other behavioral indicators (not measured in this study) to be a more robust and reliable indicator on impending elimination.

Conclusions

It is concluded that there is no evidence that providing synthetic grass as an elimination substrate instead of the conventional concrete-floored toileting facilities primarily available at UK veterinary practices has any effect on canine willingness to urinate or defecate, or on any behaviors associated with the act of elimination. Thus, from a behavioral perspective, the provision of synthetic grass does not provide any additional welfare concerns or benefits. However, before synthetic grass can be recommended as an alternative toileting substrate, further research should be undertaken to identify whether there are any disease transmission or hygiene implications associated with this substrate and its relative ease to clean and disinfect in comparison with concrete. Contact with urine or fecal material from an infected dog is a recognized route of transmission for a number of bacterial and viral diseases associated with high morbidity and mortality (see Tennant and Ramsey, 2001), including some with zoonotic potential (Ghazemzadeh and Namazi, 2015), and by the very nature of a veterinary practice, even with adequate isolation facilities, the risk of infection may be higher without adequate disease transmission measures.

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Ethical considerations

This study was approved in accordance with the Harper Adams University College Ethics Committee's protocols at the time the study was carried out. The study was noninvasive with the only additional procedure being the potential opportunity for additional exercise and elimination away from the kennel facility. Therefore, the welfare of the dogs included in this study was potentially enhanced by the presence of the experimenter. The dogs remained in the care of the veterinary practice throughout the study and thus all dogs were alive and expected to be returned to their owners at the point of discharge from data collection.

Conflict of interest

The authors declare no conflict of interest.

Authorship

The idea for the paper was conceived by both authors. The experiments were designed by Louise Buckley. The experiments were performed by Clare Whalley. The data were analyzed by Louise Buckley. The paper was written by Louise Buckley, with input and final approval by Clare Whalley.

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