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Use of a Canine Gastrointestinal Olfactory Stimulant in a Shelter Setting

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Abstract

A recent investigation linking olfactory triggers to a distinct reflex has highlighted the relationship between "sniffing" the ground and canine defecation. The work presaged the question as to whether dogs awaiting adoption would exhibit the same apparent scent mediation of final peristalsis in a kennel environment. In fact, this study has shown that olfactory gastrointestinal neurobiological pathways remained intact with rescue dogs. Further, use of an olfactory stimulant resulted in more rapid and predictable excretion behavior consistent with prototypical household routines upon adoption. In turn, the canine olfactory stimulant improved operational efficiencies in a shelter management protocol with faster, more reliable "dog walking." That is, with less time spent literally waiting for dogs to relieve themselves in often stressful, unfamiliar and densely populated shelter settings, more time would be available for interaction and exercise so as to leverage limited resources. Ultimately, this strategy may prove helpful to millions of shelter dogs, improve adoption rates and retention, and reduce relinquishments associated with home soiling.

Introduction

Dogs in the community

The bond between humans and canines has spanned centuries, and recent statistics suggest it may be stronger than ever. According to the American Pet Products Association, Inc. (APPA), 48% of American households include at least one canine member [1]. In 2017, Americans spent an estimated $69.4 billion on their pets, primarily on food, grooming, boarding during travel and veterinary care [1]. With nearly half the population owning a dog, busy and erratic schedules nonetheless can often result in prolonged "home alone" periods for domesticated canines. As such, limited or inconsistent outdoor access can lead to behavioral and indoor soiling issues. Recent APPA figures reveal that US Millennials have surpassed the baby boomer generation as the largest group of canine owners [1]. This shift has coincided with increased dog ownership in urban areas, causing other issues to arise, such as housing limitations and pet vocalization in apartment complexes [2]. This has also led to more animal-inclusive policies and ordinances, with many restaurants and stores now allowing dogs to join their owners inside. The popularity of service animals has similarly increased the incidence of dogs accompanying their owners on planes, public transportation, in retail outlets, educational settings, and entertainment venues [3].

Dogs in the shelter system

According to the American Society for the Prevention of Cruelty to Animals (ASPCA), approximately 3.3 million dogs enter US shelters every year, frequently overwhelming the infrastructure, resources and the staff working to care for them [4]. Of these, an estimated 1.6 million are adopted annually, and the cost of their supplies (i.e., food, bowls, collars, leashes, toys, etc.) to shelters often exceeds available budgets [4]. Notably, this excludes veterinary care, which can range from hundreds of thousands to millions of dollars annually depending on the size of a facility; whereas, many shelters spay and neuter animals prior to adoption, which can help prevent unwanted litters and encourage adoption [5-7]. These overarching factors culminate with euthanasia for more than one-third (38%) of total US admissions and almost half (48%) of relinquished dogs to shelters; while nearly one in five (18.8%) of rehomed dogs are returned and half of these are subsequently euthanized [8]. The interest in rescue adoptions has gradually increased, but with only 20-23% of Americans actually doing so, individual dog breeders still represent the greatest portion of new animal acquisitions at 34% [9,10]. While some shelters allow same-day adoptions, many organizations follow more rigorous procedures to ensure suitable placements; and practices can vary in relation to a given shelter's resources. With half of American households owning some 78 million dogs [11], the entire annual population of shelter dogs would nonetheless represent about 4% of the total, suggesting more potential growth for first or additional dog ownership in the US given higher rates of successful adoptions.

Canine behavior and shelter management challenges

Despite the desire of millions of pet owners to live with dogs in their homes, most owners lack the time and skills required to expertly train their dogs. Even healthy elimination routines that include walking and allowing dogs to search for the distinct aromatic amines that mediate their defecation are not always established. Notably, as with any indoor dog, shelter dogs can be equally, if not more erratic with respect to elimination. These dynamics are exacerbated when transitioning adopted pets from shelters; as the majority of animal relinquishments occur within the first year, which suggests that their owners may be unable to meet the requirements of training and caring for their adopted dogs [12-15]. Many, if not most shelters, attempt to

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pre-empt these issues by educating adoptive families to help prevent future relinquishment [13]. By necessity, shelter managers develop schedules within their operational, labor and funding framework-including routine use of cleaning agents to maintain appropriate kennel standards.

As such, these efforts can expose dogs to a distracting olfactory, auditory and visual environment that can hinder habituation of behaviors needed to facilitate successful adoptions, especially in circumstances of overpopulation and limited paid or volunteer staffing [16,17]. As a result, dogs generally receive less attention and exposure to the outdoor environment while housed at a shelter; in turn, many are forced to relieve themselves in their cages or kennel runs. These circumstances can eventually weaken whatever imprinting might have been achieved if previously housebroken as puppies or indoor dogs before losing former owners due to relocation, illness, death, abandonment, or behavioral reasons that resulted in their arrival at a shelter [14]. In general, the length of time dogs remain in a shelter is inversely related to their likelihood for adoption. Although many owners are keen to adopt and many shelters strive to qualify and educate potential adoptees, the obstacles associated with re-acclimating shelter dogs to a new home life too often result in relinquishment back to shelters, and chief amongst these (15-24%) is accidental house soiling [17,18-20].

Effect of shelter setting on canine elimination behavior

Multiple studies have concluded that canines defecate and urinate away from the spaces in which they sleep, drink and eat whenever possible [17,19,21]. Despite millennia of domestication, canines likewise typically defecate most readily when outside in a safe, acceptable space when given the time to do so. The sensitivity and specificity of canine olfaction have also been well-documented [22]. As such, chemosensory information exchanges from external stimuli and the canine brain appear to be linked to the physiology of the autonomic and somatic nervous systems, suggesting association with both final peristalsis (voluntarily releasing the bowel) and prompting of defecation [23]. The retention and subsequent release of gut contents following universal "sniffing"in advance of defecation yields compelling evidence of such a connection in the canine olfactory bulb; this underscores the importance of exposure to olfactory stimulants whether located successfully from a "sniff search" on open grounds or when provided to supplement the dog's natural environment. whenever shelter staff time limits the ability for systematic exercise and "outdoor" access, it would follow that reducing the time associated with routine outdoor defecation could ease the burden on shelter staff sufficiently to help establish more predictable canine elimination habits, consistent with adoption expectations. Staff working in tandem could also use the time while the dogs are walked outside for cleaning and disinfecting crates or cages to minimize the animals' exposure to cleaning agents and reduce the potential for transmission of pathogens and parasites throughout the shelter.

Canine olfaction and gastrointestinal neurobiology

Whether living as pets or awaiting adoption at a shelter, many dogs have been observed to "sniff" for extended periods and seemingly ignore competing scents throughout their "search" prior to relieving themselves. This behavior has been described as the Recto-Anal Inhibitory Reflex (RAIR) or rectal distention in the absence of specific olfactory stimulation. RAIR allows the animal to delay defecation by moving the stool inward slightly and reducing the urge to defecate [24]. Add in the vagaries of indoor disinfectants and efforts to keep outdoor kennel runs clean and the "sniff search" for specific scents could also lead to RAIR due to the scarcity of such molecules. While some pet owners may more readily indulge such delays, this aspect of canine behavior can thwart shelter efforts to maintain healthy exercise and excretion routines with limited staffing.

In turn, upon olfactory stimulation, dogs can activate voluntary muscles to initiate movement of the stool forward and outside of the body. Such behavior links the canine's "sniff search" to act as a precursor to relief and further suggests that particular organic scents induce these reflexes to facilitate elimination [25]. In turn, use of a stimulant solution formulated with such naturally occurring molecules could likewise leverage available staff time if more dogs could be "walked" and/or sequentially given "outdoor" access with the same resources due to more predictable and timely defecation by each dog.

Methods

Shelter description and operation

To test the potential canine behavioral and operational management impact of an olfactory stimulant to expedite defecation in a shelter setting, canine participants were selected in collaboration with a regional facility [SPCA of the Triad, Brown Summit, NC (SPCAT)]. The SPCAT maintains approximately 50 dogs of various ages and breeds at any given time and usually operates with one staff member and a volunteer at opening. These individuals are responsible for moving larger dogs to outdoor enclosures, cleaning cages, replacing bedding material and toys, taking the smaller dogs outside for walks to eliminate, and preparing food and water for each animal. The dogs are crated and secured inside the facility from 6:00PM to 6:00-7:00 AM for 12 to 13 hours, 7 days a week.

Selection of canine participants

Consent was obtained by shelter directors; the staff selected the canine participants; and field-testing was supervised by the resident kennel team. In order to be included in the study, the dogs needed to be healthy, capable of being walked with a collar and leash, in the care of the SPCAT, and estimated to be at least 6 months of age. Recruitment was ongoing, as new animals arrived at the shelter throughout the 8-week trial. The total time that each animal had been held in the shelter varied across dogs, with some new arrivals and others having been kenneled for more than two years. Dogs included in the study ranged from approximately 1 to 11 years of age, and both males and females were evaluated. In all, 25 shelter animals were selected for evaluation; however, many were adopted prior to full assessment, leaving 14 of them accessible for the entire trial. A summary of breeds is shown in Table 1.

Baseline and treatment assessment

Throughout the study, the animals were crated indoors without access to food or water each night. The minimum assessment criteria required at least four timed baseline walks, followed by at least seven timed treatment walks. The baseline average untreated defecation times (T_D) were determined without application of the olfactory stimulant. For the treated walks, a single drop of stimulant solution was placed on the front paw, a timer was started, and the dog was walked around the outdoor property (~1.2 acres). The timer was stopped at the onset of elimination. If dogs eliminated in the crate overnight, their times were not recorded, except for those of one that did so repeatedly: A 3-year old male Beagle mix nonetheless produced stool during the timed walks, which were included in the trial data. Typically, larger dogs that were located outside during operating hours were walked first, followed by the smaller dogs that were kept indoors in crates throughout the day.

Breed	Age (Yrs)	Gender	Time in the Shelter	Spayed/Neutered
Aussie mix	2	Female	<3 months	Yes
Australian cattle mix	4	Female	>18 months	Yes
Carolina dog mix	3	Female	>18 months	Yes
Chihuahua	2	Female	<3 months	Yes
Chihuahua	1	Female	<1 month	Yes
Pitbull terrier mix	3	Female	>18 months	Yes
Shih Tzu	11	Female	<3 months	Yes
Basset hound Labrador mix	2	Male	>6 months	Yes
Beagle mix	3	Male	>18 months	Yes
Flat-coated retriever mix	1	Male	<3 months	Yes
Hound mix	7.5	Male	<3 months	Yes
Labrador mix	9	Male	>18 months	Yes
Shepherd Pitbull mix	2	Male	>6 months	Yes
Spitz mix	3	Male	<3 months	Yes

Table 1: Breed, age, and gender of evaluated shelter dogs (n=14).

Each assessment began in the morning at approximately 6:30 AM and typically concluded by 8:30 AM. The canines' elimination behavior was evaluated by beginning a timer after each dog was leashed, brought outside and walked around the designated outdoor space. The timer was stopped at the onset of each defecation and the time was recorded. In addition to elimination time, stool quality, animal behavior, and other environmental observations were recorded for each test. Each dog was then additionally walked for 5 to 10 minutes for exercise before returning to their indoor or outdoor kennel for the day: Larger dogs (n=4) were maintained outside in individual cages (~6 × 10') and smaller dogs (n=10) remained indoors in crates (~2 × 3').

Results

Untreated vs. treated canine defecation times

To calculate the statistical significance of the comparative findings (using the Student's t-test), an overall mean defecation time (T_D) without treatment was established over a period of four walks on different days. Thereafter, the treatment period commenced, and the elapsed time from onset of the walk and administration of the olfactory stimulant until elimination (T_D) were recorded. A minimum of seven evaluations using the stimulant were performed. The data yielded a statistically significant effect of the stimulant on the respective defecation times (T_D) for the 13 remaining treated dogs (Student's t-test, $p<0.05$, indicated by *; shown in Figures 1-3 with aggregate mean values of 84.1 ± 49.4 seconds vs. 257.5 ± 273.8 seconds, respectively. Notably, the eldest of the 14 dogs (11-year old female Shih Tzu) was observed to have soiled the crate in at least 9 of 14 evaluation days and was excluded from the study evaluation.

Defecation times with routine use of olfactory stimulant

Defecation times (T_D) in a series of 23 sequential walks with two canines are shown in Figure 4. Individual times for a 3-year old male Beagle are shown in Figure 4A, and those of a 3-year old female Pitbull Terrier Mix are shown in Figure 4B. A significant decrease in times, reduced variability and an overall trend downward were observed (m=-1.48 seconds; R^2=0.368 and -1.34 seconds; R^2=0.301). Specifically, upon treatment, the standard deviation for both animals diminished to ± 3.4 (Beagle) and ± 3.5 seconds (Pitbull Terrier), down from ± 51.0 and ± 55.9 seconds, respectively (Figure 2B). This phenomenon is further illustrated in Figure 5, depicting the distribution of elimination times across the 13 remaining canines throughout the evaluation period.

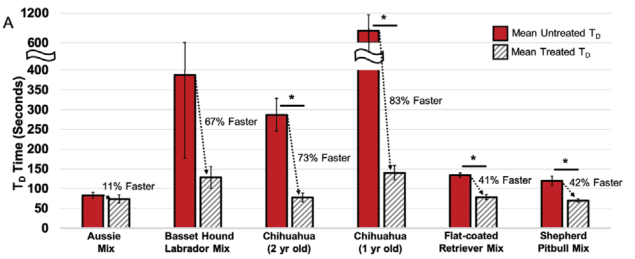
The treated times (gray diamonds), was more tightly clustered than the untreated (red circles), suggesting that consistent use of the stimulant not only shortened, but also enhanced the consistency of excretion times across all 13 dogs in the study.

Given response and initially shortened defecation times following administration of the olfactory stimulant, a faster but reproducible T_D might be expected over time. That said, efforts to explain the further acceleration and decreased variability of the defecation times tempt anthropomorphic assumptions of building canine "confidence"; these findings warrant further study as to the causality of such trends presumably toward a physical optimum with continued use of an olfactory stimulant over a longer period of time.

Impact of treatment on shelter operations

As mentioned above, shelter processes can pose logistics and time complexities. Therefore, the average T_D results across 10 representative animals with (gray bars) and without treatment (red bars) over an 8-week period (n=200 timed walks) was evaluated with respect to the potential impact on shelter operations (Figure 6). The averages for each dog (n = 10) have been combined to assess the total time required to administer an olfactory stimulant in relation to the defecation time management for a given cohort of this size. The white bars represent the amount of time required between dog walks, i.e., crating, leashing and walking outside the facility. Over the course of these studies, on average, this process would require ~60-seconds (with some larger dogs taking slightly longer than smaller ones). The aggregate results suggest that the use of an olfactory stimulant, including the time to administer it, could reduce the amount of time required to manage routine defecation by more than 50% for every 10 dogs in a kennel setting (00:53:12 minutes and seconds without treatment vs. 00:25:30 minutes and seconds with treatment).

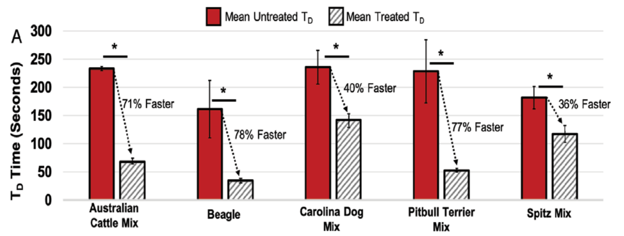
It is important to note that more predictable, rapid defecation would not only help ensure that the dogs successfully relieve themselves before being returned to their crates or enclosures when busy shelter staff members must handle a full cohort; but routine use of the olfactory stimulant can also enable the time saved to be used thereafter for socialization and more vigorous exercise, rather than spending it with characteristic stops and starts and uncertain timing for defecation. A more rapid, predictable routine could also minimize crate soiling (and consequent cleaning burdens) with a more efficient approach to more dogs in less time upon arrival in the morning, when most animals need immediate attention.



B

	Aussie Mix	Basset Hound Labrador Mix	Chihuahua	Chihuahua	Flat-coated Retriever Mix	Shepherd Pitbull Mix
Age [years]	2	2	2	1	1	2
Sex	Female	Male	Female	Female	Male	Male
Untreated T_D [sec]	(82.8 ± 7.4)	(387.5 ± 211.1)	(287.0 ± 41.3)	(848.8 ± 317.8)	(134.0 ± 6.2)	120.0 (± 12.2)
Treated T_D [sec]	(73.8 ± 10.2)	(128.3 ± 27.7)	(77.7 ± 11.2)	(140.5 ± 18.1)	(78.5 ± 6.2)	69.9 (± 4.6)
Evaluations (n)	10	9	7	14	26	13
% Decrease T_D	11%	67%	73%	83%	41%	42%

Figure 1: Field Trials with 1 to 2 Year-old Shelter Canines: Aussie Mix, Basset Hound Labrador Mix, Chihuahuas (2), Flat-coated Retriever Mix, and Shepherd Pitbull Mix. A) The average untreated defecation time (T_D; red bars) for each dog was established individually with at least 4 observations over a 1-week period. Gray "striped" bars represent the average treated T_D using an olfactory scent stimulant with >7 evaluations. B) Indicates details, average untreated/treated defecation times, total treatment evaluations, and percent change from untreated vs. treated T_D of each dog. Significant differences ($p<0.05$; Student's t-test) between treated and untreated T_D indicated by (*).



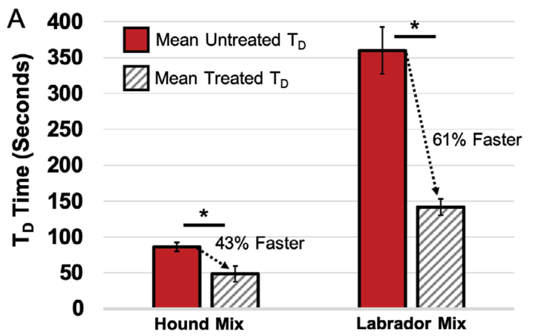
B

	Australian Cattle Mix	Beagle	Carolina Dog Mix	Pitbull Terrier Mix	Spitz Mix
Age [years]	4	3	3	3	3
Sex	Female	Male	Female	Female	Male
Untreated T_D [sec]	(233.8 ± 3.8)	(161.3 ± 51.0)	(236.0 ± 29.9)	228.8 (± 55.9)	(182.0 ± 20.1)
Treated T_D [sec]	(68.1 ± 6.6)	(34.8 ± 3.4)	(141.8 ± 11.6)	52.7 (± 3.5)	(117.1 ± 15.2)
Evaluations (n)	29	28	16	27	11
% Decrease T_D	71%	78%	40%	77%	36%

Figure 2: Field Trials with 3 to 4 Year-old Shelter Canines: Australian Cattle Mix, Beagle, Carolina Dog Mix, Pitbull Terrier Mix, and Spitz Mix. A) The average untreated defecation time (T_D; red bars) for each dog was established individually with at least 4 observations over a 1-week period. Gray "striped" bars represent the average treated T_D using an olfactory scent stimulant with >7 evaluations. B) Indicates details, average untreated/treated defecation times, total treatment evaluations, and percent change from untreated vs. treated T_D of each dog. Significant differences ($p<0.05$; Student's t-test) between treated and untreated T_D indicated by (*).

Discussion

In an earlier study using an olfactory stimulant with domestic dogs in residential settings, approximately 75% of them demonstrated more rapid and consistent defecation; whereas, each of the participating dogs evaluated in the shelter setting (100%) responded with decreased defecation times in this study [23-25]. These findings suggest that the organic amines required to mediate canine gastrointestinal neurobiology may be literally harder to find in the relatively sterile and continually disinfected environment required to maintain a clean and safe shelter. Whereas, more of the previously evaluated pets had presumably acclimated to more fruitful "sniff searching" in their back yards or familiar grounds, where such naturally occurring organic



B

	Hound Mix	Labrador Mix
Age [years]	7.5	9
Sex	Male	Male
Untreated T_D [sec]	(86.3 ± 6.3)	(360.0 ± 32.4)
Treated T_D [sec]	(48.8 ± 11.1)	(141.8 ± 11.3)
Evaluations (n)	16	25
% Decrease T_D	43%	61%

Figure 3: Field Trials with >4 Year-old Shelter Canines: Hound Mix and Labrador Mix. A) The average untreated defecation time (T_D; red bars) for each dog was established individually with at least 4 observations over a 1-week period. Gray "striped" bars represent the average treated T_D using an olfactory scent stimulant with >7 evaluations. B) Indicates details, average untreated/treated defecation times, total treatment evaluations, and percent change from untreated vs. treated T_D of each dog. Significant differences ($p<0.05$; Student's t-test) between treated and untreated T_D indicated by (*).

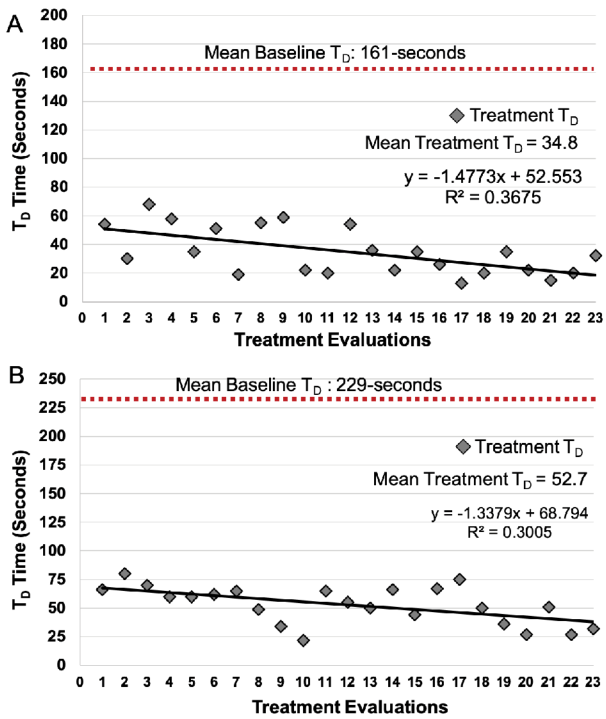


Figure 4: Individual Field Trial Time Measurements with Two Shelter Canines: A) Average treatment TD using an olfactory scent stimulant (red circles) for 3-year old, male; Beagle over 4-week period (n=23). Dashed red line=average untreated T_D (161.3 ± 51 seconds) prior to treatment evaluations. B) Average treatment T_D using an olfactory scent stimulant (red circles) for 3-year old, female; Pitbull Terrier Mix over 4-week period (n=23). Dashed red line=average untreated T_D (228.3 ± 55.9 seconds) prior to treatment evaluations.

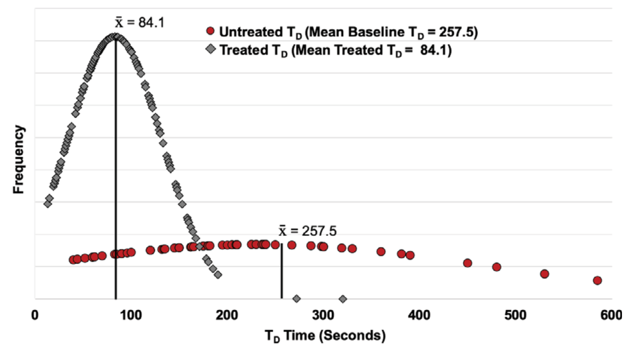


Figure 5: Distribution of Shelter Canine Defecation Times (n=13): The gray diamonds represent distribution of treated T_D (using an olfactory stimulant; n=185). The solid red circles represent the distribution of baseline values T_D (without treatment; n=52 baselines). The mean treated time (84.1 seconds) and the mean untreated time (257.5) are represented by the solid black line.

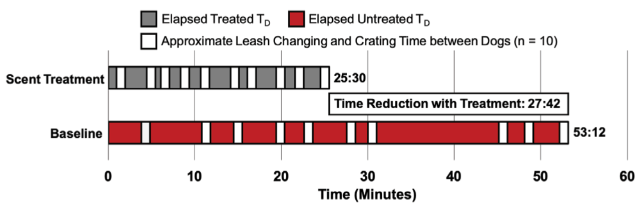


Figure 6: Representative Time Savings with Administration of Stimulant in Shelter Setting: The total time savings associated with shelter canine elimination (n=10 dogs). The average treated (gray bars) and untreated T_D (red bars) of 10 representative dogs. The approximate time required to change leashes and crate dogs between walking is indicated by white bars. The established untreated (baseline) time required for 10 successive dogs was 00:53:12. The use of olfactory stimulant treatment resulted in >50% faster handling with a reduction of 27:42 (minutes:seconds) vs. baseline. Each red block represents averages for one dog, evaluated > 7x.

compounds may have been more prevalent. In fact, the defecation response to botanical scents in both cohorts has further refuted the common misperception that dogs seek prior fecal deposits to stimulate defecation; this is distinctly different behavior than repetitive urination associated with competitive "marking" of a given territorial perimeter, as in one common example [26].

Epidemiologically, once impounded in a shelter, dogs face nearly a 50% probability of euthanasia; if adopted and returned to a shelter for house soiling, the odds may double. Simply put, shelters represent the front line of homeless dog and cat survival, where staff and volunteers might be compared to "first responders" that perform heroics, much as firefighters and police officers. If routine use of an olfactory stimulant can help sheltered dogs establish predictable and more rapid defecation behaviors, it would follow that administering precisely the same olfactory stimulant to which they responded in the shelter would likewise help orient them to unfamiliar household circumstances upon adoption. In turn, continued home use would enable new owners to help prompt appropriate defecation when let outside to a yard or taken for a walk with far greater probability of the same response in keeping with busy human schedules; thereby, reduce the risk of home soiling and the attendant consequences of one or more failed adoptions for any given animal.

Conclusion

Whether acquired from shelters or breeders, such human routines have also continued to shape canine daily life with more owners dependent on increasingly accessible, organized dog walking services; as apps and providers merge the virtual and real resources to address the exercise and elimination needs of the "home alone" pet. The business model often requires a dog walker to manage multiple canines simultaneously. Thus, the "sniff search" can be complicated by numerous distractions and represents the next exploration of canine olfactory mediation of gastrointestinal neurobiology, or the use of such a stimulant, in complex circumstances.

Authorship Statement

The canine "sniff search" target molecule research hypothesis was conceived by TEB. AAW coordinated field studies with regional shelter affiliates. ALD, AAW designed field research methods with the participating shelter. ALD, KD and AAW conducted field trials and data collection. AAW and IC prepared the first draft of the manuscript. MKMG refined and elucidated the thesis of this work. ALD, RTK, LR, and KD prepared olfactory formulations for canine trials. SKA provided DVM experience and gastric expertise. ALD supervised the findings of this work.

Conflict of Interest

The lead authors AAW and IC have no conflict of interest disclosures. TEB and ALD are founding members of Kepley BioSystems, Inc. (kepleybiosystems.com) RTK, KD, MKMG and LR is also members of Kepley BioSystems. SKA is an Assistant Professor of Clinical Nutrition at the Ontario Veterinary College, University of Guelph, and Owner of Sit, Stay, Speak Nutrition, LLC. Specializing in nutritional coaching. The group has developed unmatched expertise with respect to identification, selection and synthesis of specific, naturally occurring molecules that demonstrate olfactory behavioral properties. Their work in designing delivery matrices for crustacean attractants has further provided a framework for formulating a canine olfactory stimulant.

Ethics Statement

The animals included in this field assessment were evaluated by the research team with the express permission and supervision of the shelter staff at the SPCA of the Triad.

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