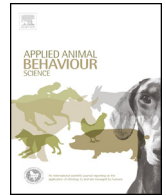




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Scent marking in shelter dogs: Effects of body size

Betty McGuire^{a,*}, Katherine E. Bemis^b

^a Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, NY 14853, USA

^b Department of Natural Resources, Cornell University, Ithaca, NY 14853, USA

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ABSTRACT

Placing scent marks in the environment allows individuals to transfer information without direct interactions. Given that body size often indicates competitive ability, small individuals may preferentially communicate via scent marking because direct social interactions are potentially costly. However, most evidence indicates a positive relationship between competitive ability and frequency of scent marking. Domestic dogs (*Canis lupus familiaris*) exhibit extreme morphological variation, which allowed us to examine whether scent-marking behavior varied with body size in shelter dogs. We observed 281 dogs on 20-min walks and recorded total urinations, urinations directed at targets in the environment, and defecations. Some dogs were walked once and others multiple times (total walks, 619). We found that size class influenced rate of urination ($P=0.002$): small dogs urinated at higher rates (0.36 urinations per min) than both medium (0.26) and large dogs (0.24). There was a tendency for size class to influence percent of directed urinations ($P=0.057$): small dogs directed more of their urinations at targets in the environment (72%) than did large dogs (60%). Consistent with previous reports, we found that males urinated at higher rates (0.41) than females (0.18; $P<0.0001$), and directed more of their urinations (males, 87%; females, 45%; $P<0.0001$). Body size and sex did not influence likelihood of defecation during a walk. Defecation is thought to play a less important role than urination in scent marking in dogs, so the absence of size and sex differences in likelihood of defecation was not surprising. Time spent at the shelter positively influenced rate of urination ($P=0.0005$), percent of directed urinations ($P=0.005$), and likelihood of defecation ($P=0.006$), which we interpret as resulting from the dogs becoming increasingly familiar and more comfortable with us. Our findings regarding body size and urinary behavior support the hypothesis that small dogs communicate more frequently via scent marking than larger dogs. Body size is known to influence visual and auditory communication in mammals, and our data show that body size also influences chemical communication. Finally, our results provide context for problematic marking behaviors in the home.

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1. Introduction

Scent marking, a common form of communication in mammals, is remarkably indirect: one individual places a mark in the environment that another individual might encounter, typically in the absence of the individual that placed the mark (Gosling and Roberts, 2001). Information gleaned from the chemical composition of scent marks may include individual identity, age, sex, reproductive state, and social status; and height of the mark may provide information on body size (Sharpe, 2015, and references therein). One advantage of this indirect transfer of information is that individuals can evaluate one another while often avoiding potentially dangerous

direct interactions (Sharpe, 2015). Given that body size usually reflects competitive ability (Huntingford and Turner, 1987), communicating via scent marks might be particularly important to small individuals, for whom direct encounters could be especially costly (e.g., fighting can cause serious injury and body size often influences the outcome of fights, with smaller individuals losing; Archer, 1988). Most evidence, however, indicates a positive relationship between competitive ability and scent marking (Gosling and Roberts, 2001; Hurst and Beynon, 2004; Johnson, 1973).

Few studies have investigated whether scent marking behavior of mammals varies in relation to body size. In dwarf mongooses (*Helogale parvula*), which use a handstand posture to deposit anogenital secretions on vertical targets in their home range, height of scent mark and body size were positively correlated for females (Sharpe et al., 2012). In contrast, smaller males marked higher on targets than did larger males of similar age, perhaps indicating an

* Corresponding author.

E-mail address: bam65@cornell.edu (B. McGuire).

effort by small males to exaggerate their size to rivals outside their group (Sharpe et al., 2012). Mice (*Mus musculus*) mark with urine and secretions from anal glands. When two male mice were housed together under laboratory conditions and briefly separated by a divider, dominant males that were smaller than their cagemate, marked more frequently and had larger preputial glands (the source of some components of the scent marks) than did dominant males that were larger than their cagemate (females were not studied; Gosling et al., 2000). These data suggest that male mice adjust their investment in scent marking based on their body size relative to that of a rival.

Scent marking has been studied in detail in several members of Canidae. Possible functions range from defending a territory (free-ranging dogs: Cafazzo et al., 2012; Pal, 2003; coyotes: Gese and Ruff, 1997; gray wolves: Peters and Mech, 1975) to providing olfactory and possibly visual landmarks, which aid in orientation and making objects within territories more familiar (free-ranging dogs: Cafazzo et al., 2012; Pal, 2003; coyotes: Gese and Ruff, 1997) to indicating characteristics of food, such as location, ownership, or that a cache is empty (free-ranging dogs: Cafazzo et al., 2012; Pal, 2003; coyotes: Harrington, 1982; gray wolves: Harrington, 1981; red foxes: Henry, 1977). With respect to social interactions, scent marking may establish or reinforce social status (companion dogs: Lisberg and Snowdon, 2011; free-ranging dogs: Cafazzo et al., 2012; coyotes: Gese and Ruff, 1997; gray wolves: Peterson et al., 2002; bush dogs (*Speothos venaticus*): Biben, 1982) and bonds between members of a breeding pair (coyotes: Gese and Ruff, 1997; gray wolves: Rothman and Mech, 1979; bush dogs: Porton, 1983). Finally, scent marks may indicate female reproductive state (companion dogs: Wirant et al., 2007; free-ranging dogs: Cafazzo et al., 2012; Pal, 2003). Comparative rates of urination and defecation by individuals of different sex, age, social status, or reproductive state typically serve as evidence for particular functions; some evidence focuses on rates of urination and defecation (or distribution of these scent marks) in different environmental contexts, such as at the boundaries versus the interior of a territory and at sites used for courtship versus raising young.

Domestic dogs (*Canis lupus familiaris*) exhibit extreme morphological variation and offer an opportunity to examine whether scent-marking behavior varies with body size. Marking with urine is sexually dimorphic in mature dogs: when compared with females, males urinate and countermark (mark on or near existing scent marks) more frequently, and direct more of their urinations at targets in the environment, typically using the raised-leg posture (females usually squat; Beach, 1974; Bekoff, 1979; Lisberg and Snowdon, 2011; Martins and Valle, 1948; McGuire, 2016; Sprague and Anisko, 1973; Wirant and McGuire, 2004). Sex differences do not characterize defecation, which is thought to play much less of a role than urination in canine scent marking (Cafazzo et al., 2012; McGuire, 2016; Sprague and Anisko, 1973). To our knowledge, only one study has examined relationships between urination, defecation, and body size in dogs. McGreevy et al. (2013) investigated correlations between 33 behavioral traits and height and body mass in 49 dog breeds. The behavioral traits included, for example, several categories pertaining to fear, aggression, separation from owner, and excitability, as well as problematic behaviors concerning urination and defecation. Behavioral scores were obtained from the Canine Behavioral Assessment and Research Questionnaire (C-BARQ), which is completed online by dog owners. McGreevy et al. (2013) found that in-home problematic behaviors, which included urination when left alone, defecation when left alone, urine marking, and emotional urination (urination when approached or handled), were more common in dogs as height decreased. Of these four behavioral characteristics, only emotional urination correlated with body mass, and this relationship was positive. We have found

no information on how body size influences behavior associated with urination or defecation when dogs are outside the home.

In this study, we tested the hypothesis that scent marking varies with body size in dogs. We also examined how scent marking varies with sex and time spent at the shelter. We recorded scent-marking behavior of 281 shelter dogs during walks in a nearby field; some dogs were walked once and others multiple times. Given that direct social interactions may be particularly costly to small individuals (Sharpe, 2015), we predicted that small dogs would be more likely to communicate via scent marking than larger dogs. Specifically, we predicted that small dogs would urinate at higher rates and direct more of their urinations at targets in the environment than would larger dogs. Based on existing information (Beach, 1974; Bekoff, 1979; McGuire 2016; Ranson and Beach, 1985), we predicted that male dogs would urinate at higher rates and direct more of their urinations at targets in the environment than would female dogs. Defecation seems to play little role in scent marking for most dogs (Cafazzo et al., 2012; McGuire, 2016; Sprague and Anisko, 1973), so we predicted that likelihood of defecation would not vary in relation to body size or sex. Time spent at this shelter did not significantly influence scent-marking behavior during first walks of dogs (McGuire, 2016); thus, we predicted that rate of urination, percent of directed urinations, and likelihood of defecation would not vary in relation to time spent at this shelter, now that some dogs had multiple walks.

2. Material and methods

2.1. Dogs and housing

We observed 281 mostly mixed breed dogs ($n=158$ males; $n=123$ females) during walks at the Tompkins County SPCA in Ithaca, NY, USA. Dogs had been surrendered by owners, picked up as strays, or transferred from other shelters. The data included here represent a subset of those presented in a previous analysis of how sex and age class (juvenile, adult, and senior) influenced scent-marking behavior during first walks of 500 dogs at two animal shelters (McGuire, 2016), plus an additional 15 dogs observed after the first study ended. Included in the subset from the first study are mature dogs (adults and seniors) from only one of the two shelters (the other shelter, the Cortland Community SPCA in Cortland NY, had too few small dogs for inclusion); we excluded juveniles because they are still growing, and differ dramatically from mature dogs in their marking behavior (McGuire, 2016; Ranson and Beach, 1985). All dogs included here were at least 1 year of age (Mean \pm SD, 4.2 ± 3.0 years; range, 1–14 years). Finally, whereas the first study included data collected during first walks of dogs, the present study includes data from first walks as well as from any subsequent walks of individual dogs.

Řezáč et al. (2011) used a system of size classes for dogs based on breed standards set forth by the Fédération Cynologique Internationale (FCI), an international federation of kennel clubs: small dog, <30 cm at withers; medium dog, 30–50 cm at withers; large dog, >50 cm at withers. Applying breed standards to the diverse population of shelter dogs is challenging because most are mixed breeds and the few apparent pure bred dogs may not meet breed standards. We used a modification of the system used by Řezáč et al. (2011) because several dogs (10 males and 6 females) were between 30 and 33 cm at withers and resembled breeds typically considered small (e.g., Chihuahua, Pug, Shih Tzu, and Pomeranian). These 16 dogs ranged in body mass from 4.3 to 9.1 kg, which was well within that of the 49 dogs <30 cm at withers (2.0–13.2 kg). Thus, we assigned size classes as follows: small dogs, ≤ 33 cm at withers (39 males and 26 females); medium dogs, 34–50 cm at withers (39 males and 52 females); and large dogs, >50 cm at

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