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Applied Animal Behaviour Science 85 (2004) 335–348
APPLIED ANIMAL BEHAVIOUR SCIENCE
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Urinary behavior of female domestic dogs (*Canis familiaris*): influence of reproductive status, location, and age

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Accepted 26 September 2003

Abstract

The urinary behavior of adult domestic dogs (*Canis familiaris*) is sexually dimorphic with respect to the posture (males lift a leg and females squat), frequency of urination (males urinate more frequently than females), and tendency to direct urine at specific objects in the environment (males are more likely than females to direct their urine). Such behavioral differences have led to the belief that urination functions largely, or exclusively, in elimination in female dogs, while having the additional function of scent marking in male dogs. In this study, we observed urinary behavior of six spayed and six non-estrous intact female Jack Russell Terriers during walks on and off their home area. The females ranged in age from 0.4 to 11.2 years. Frequency of urination was positively correlated with age, and females four or more years old directed the majority of their urinations at objects in the environment. Overall, females urinated more frequently and directed more of their urinations when walked off their home area than when walked within their home area. Spayed females were more likely than non-estrous intact females to ground-scratch following defecation; we detected a similar trend for ground-scratching after urination. There was, however, considerable variation among spayed females in the tendency to display ground-scratching behavior. Overall, the most common posture displayed by females while urinating was the squat-raise. Other postures, in order of their frequency of occurrence included squat, arch-raise, combination, and handstand. Females used the squat-raise and arch-raise postures more when off their home area than when on their home area. Overall, there was substantial individual variation among females in the postures used while urinating. Our data indicate that female urinary behavior varies with location and reproductive status, and that substantial individual differences exist among females for some patterns of behavior. Additionally, the large percentages of directed urinations by spayed (60.8%) and non-estrous intact females (56.7%) in our study suggest that urination in female dogs does not function solely in

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doi:10.1016/j.applanim.2003.09.012

elimination, but that it also has a significant role in scent marking, even when females are not in estrus.

Keywords: Dog; Urine marking; Urinary postures; Scent marking; Urinary behavior

1. Introduction

Urinary behavior in domestic dogs is sexually dimorphic (Sprague and Anisko, 1973; Beach, 1974; Ranson and Beach, 1985). Adult males urinate more frequently than do females, and are more likely than females to direct their urine at specific targets (Martins and Valle, 1948; Bekoff, 1979a; Ranson and Beach, 1985). In addition, adult males typically raise a hind leg to urinate while adult females usually squat (Martins and Valle, 1948; Beach, 1974). While urination clearly functions in elimination for both sexes, its role in scent marking is thought to be larger in male dogs than in female dogs (Martins and Valle, 1948; Bekoff, 1979a; Pal, 2003). Indeed, Kleiman (1966) suggested that female dogs mark with urine only around the time they are in estrus.

A major focus of previous research has been on the development of these sex differences in canine urinary behavior. Such research has indicated that sex steroid hormones around the time of birth organize the adult male urinary posture, but are not required to activate the posture in adulthood (Berg, 1944; Martins and Valle, 1948; Beach, 1974; Ranson and Beach, 1985). These studies focused on the urinary behavior of male dogs, and typically included small numbers of females that were treated with testosterone at various times in development; even smaller numbers of untreated females served as controls (Berg, 1944; Martins and Valle, 1948; Beach, 1974; Ranson, 1981; Ranson and Beach, 1985). Few studies have investigated urinary behavior of free-ranging male and female dogs (Bekoff, 1979a; Pal, 2003). Thus, although urinary behavior has been well-studied in male dogs, relatively little is known about such behavior in female dogs.

The purpose of this study was to examine the urinary behavior of female dogs in relation to reproductive status (spayed or non-estrous intact) and location (on or off home area). With respect to reproductive status, our goal was to examine whether the simple presence of gonadal hormones influenced urinary behavior; we did not compare behavior across the estrous cycle in this study. Finally, we observed females of different ages, and thus were able to provide preliminary data on age-related patterns of urinary behavior in female dogs.

2. Methods

We observed urinary behavior of 12 female Jack Russell Terriers (Table 1). Females ranged in age from 0.4 to 11.2 years and were privately owned. The dogs were housed either in the homes of their owners or in kennels outside the homes. Six of the females were spayed and the other six were intact. We classified the six intact females as "non-estrous" during the period of observation. This classification was based on owner reports for each female of all available start dates of proestrus (first day of blood-tinged vaginal discharge) and estrus

Table 1
Characteristics of the 12 female Jack Russell Terriers observed for urinary behavior

Subject[a]	Age (years)	Parity	Observations[b]	Start date for last proestrus before observations[c]	Owner[d]
S1	11.2	1	18–25 March	–	A
S2	6.5	0	22 February–19 April	–	B
S3	5.6	1	18–25 March	–	C
S4	3.1	2	18–25 March	–	C
S5	2.3	0	18–25 March	–	D
S6	1.3	0	22 February–5 April	–	B
I1	7.0	2	18–25 March	20 February 2002	A
I2	4.2	1	18–25 March	16 October 2001	C
I3	4.2	2	18–25 March	16 February 2002	A
I4	1.3	0	18–25 March	18 February 2002	A
I5	1.3	0	18–25 March	30 September 2001	A
I6	0.4	0	18–25 March	–	A

[a] Reproductive status is indicated in the subject name; S = spayed, I = non-estrous intact.

[b] All testing occurred in 2002; females were observed during 14 walks within the time period shown (seven walks on their home area and seven walks off their home area).

[c] Date represents first day of blood-tinged vaginal discharge. The next period of proestrus for I2 began on 28 April 2002 and for I5 on 13 May 2002.

[d] Owners and housing of dogs: A = Farmcliff Kennels (mix of kennel housing and home of owner); B = Sharon Cudd Wirant (home of owner); C = Highwater Kennels (home of owner); D = Valerie Whiterock (home of owner).

(first day receptive to male), as well as the length of estrus (first to last day receptive to male). Owner reports indicated that none of the intact females was in proestrus at the time we observed them (Table 1) and that two females (I1 and I4) had just completed estrus a few days before observations began. More specifically, female I1 was judged nonreceptive by her owners on 12 March 2002 and female I4 on 13 March 2002; we began our observations of these females on 18 March 2002. Dogs within homes or kennels regularly interacted with one another. Outside of this study, all of the dogs participated in performance sports (e.g., conformation, hunting, agility, flyball) and thus dogs from different homes and kennels had occasionally interacted with one another at such events. Some of the dogs were also used for breeding purposes, though not during the period of this study.

All observations occurred during individual walks of the dogs between 22 February and 19 April 2002 (Table 1). Each dog was taken by the first author (SCW) for 14 walks on an 8.3 m leash (each walk was 15 min; total hours of observation across all dogs = 42). During walks, the dogs were allowed to freely investigate areas and were not pulled along by SCW; the pace of the walk was set by the dog. Seven of the 14 walks occurred within the dog’s home area (area in which the dog eliminates on a daily basis) and seven occurred outside the dog’s home area. Each walk outside the dog’s home area occurred at a different location. The latter areas were those in which the dog either had never been walked or had been walked at most two times in the preceding year. We observed each dog once or twice a day; a minimum of 4 h elapsed between walks on the same day. For 10 dogs, all observations occurred on consecutive days, and for the remaining two dogs some, but not all, observations occurred on consecutive days. This difference was due to subject availability. In all cases, the order of walks on and off home area was counterbalanced across days. For example, if a dog was walked on its home area in the a.m. and off its home area in the p.m. 1 day, then it was walked off its home area in the a.m. and on its home area in the p.m. during the next day of observation.

During each 15 min walk we recorded frequencies of occurrence for the following patterns of behavior: (1) urinating, (2) defecating, and (3) sniffing (female stopped walking and inspected the ground or an object with her nose). We also noted whether urinations or defecations were followed by ground-scratching (backward scraping of the ground with the front feet, hind feet, or both feet; Fig. 1A) and whether urinations were directed at an object in the environment (urine directed within 20 cm of an obvious target, such as a tree, fence post, or clump of grass or leaves; the criterion of 20 cm was used by Ranson and Beach, 1985). Finally, we recorded the posture(s) used by females when urinating: squat, squat-raise, handstand, and arch-raise (Fig. 1B–E; Sprague and Anisko, 1973). We

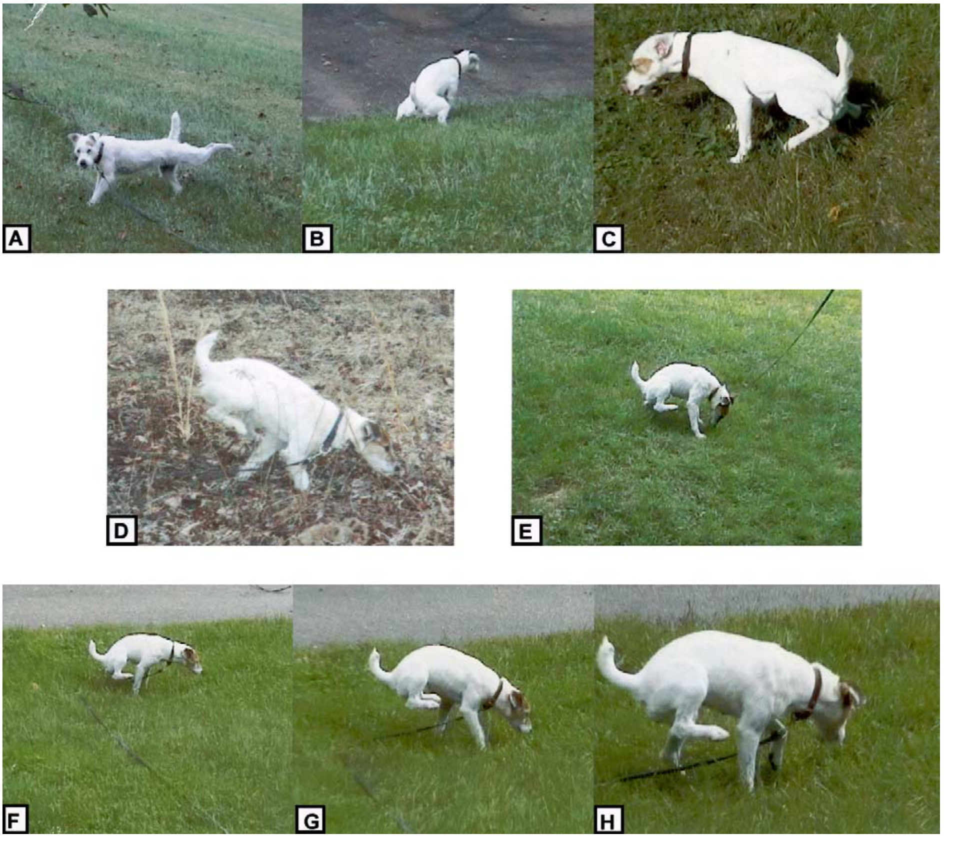


Fig. 1. Urinary behavior and postures of female Jack Russell Terriers: (A) ground-scratching; (B) squat; (C) squat-raise; (D) handstand; (E) arch-raise; and (F through H) the combination posture squat-raise into handstand into squat-raise.

occasionally observed females using two or three postures in sequence during a single urination. For example, some females would begin urinating in the squat-raise posture and then move into a handstand and then back into the squat-raise with no pause in urinating (Fig. 1F–H). We described these occurrences collectively as "combination postures", after Ranson's (1981) classification of serial combinations of postures in beagles as the "combo."

For each female, we calculated a mean frequency of urinating, defecating, and sniffing over the seven trials on home area and the seven trials off home area, and used these means in statistical analyses. We analyzed the mean frequencies of urinating, defecating, and sniffing with a two-way mixed ANOVA with reproductive status (spayed or non-estrous intact) as the between-subjects variable and location (on home area or off home area) as the within-subjects variable. We plotted several of our dependent variables against age and ran either linear or nonlinear regression. For the variables measured (in percentage) as proportions (directed urinations, urinations followed by ground-scratching, defecations followed by ground-scratching, and urinations using specific postures), we plotted on home area values against off home area values for each dog to examine patterns with respect to location. In many cases, we calculated for each female a new variable "difference", where difference = her value for a particular behavior off home area (e.g., average number of urinations or percentage directed urinations) minus her value for that behavior on home area. Using "difference" as our dependent variable, we then ran ANCOVA with age, reproductive status, and the interaction between age and reproductive status as explanatory variables. We first examined models with all three explanatory variables, then models with age and reproductive status, and finally models with either age or reproductive status. For subsequent comparisons of spayed and non-estrous intact females we used the Mann–Whitney *U*-test and for subsequent comparisons of behavior off and on home area we used Wilcoxon's Signed-Ranks Test (one-sample, paired observations). We used either BMDP 7.0 (BMDP Statistical Software, Inc., Los Angeles, CA, USA) or Minitab 13.32 (Minitab, Inc., State College, PA, USA) for statistical analyses.

3. Results

Overall, females urinated more frequently when off their home area than when on their home area (Table 2; $F = 8.54$, d.f. = 1, 10, $P = 0.02$); we did not detect an effect of reproductive status ($F = 0.37$, d.f. = 1, 10, $P = 0.55$) or a reproductive status by location interaction for this behavior ($F = 2.17$, d.f. = 1, 10, $P = 0.17$). We ran ANCOVA with mean frequency of urination as our dependent variable and age, reproductive status, and the interaction between age and reproductive status as explanatory variables; neither the interaction nor reproductive status was a significant predictor of mean frequency of urination. However, age was a significant predictor of mean frequency of urination ($F = 12.45$, d.f. = 1, 10, $P = 0.005$, $R^2 = 0.54$; Fig. 2A). We explored the possibility that age should be used as a covariate in the ANOVA by calculating the variable "difference" for each female, where difference = average number of urinations off home area minus the average number of urinations on home area. Using "difference" as our dependent variable, we then ran ANCOVA with the variables age, reproductive status, and the interaction between age and reproductive status. In no model was age a significant predictor of the dependent variable "difference."

Table 2
Frequency of urinating, defecating, and sniffing in 12 female Jack Russell Terriers in relation to reproductive status and location walked ($n = 6$ spayed females; $n = 6$ non-estrous intact females)

Reproductive status	Location walked	Urinate[a]	Defecate[b]	Sniff[c]
Spayed	On home area	3.60 ± 1.19	0.60 ± 0.14	20.74 ± 1.47
	Off home area	5.70 ± 1.47	0.76 ± 0.14	23.64 ± 1.93
Non-estrous intact	On home area	3.36 ± 0.90	0.36 ± 0.09	19.67 ± 2.19
	Off home area	4.05 ± 0.91	0.52 ± 0.09	20.95 ± 1.77

Values represent mean frequency of occurrence per 15 min walk ± S.E.M.
[a] Significant effect of location ($P = 0.02$).
[b] No significant effects.
[c] No significant effects.

We found no significant effects for defecating or sniffing. The frequency of defecating did not vary with respect to reproductive status ($F = 3.60$, d.f. = 1, 10, $P = 0.09$) or location ($F = 2.39$, d.f. = 1, 10, $P = 0.15$), and we did not detect a reproductive status by location interaction for this behavior ($F = 0.00$, d.f. = 1, 10, $P = 0.99$; Table 2). The frequency of sniffing did not vary with respect to reproductive status ($F = 0.78$, d.f. = 1, 10, $P = 0.40$) or location ($F = 1.87$, d.f. = 1, 10, $P = 0.20$), and we did not detect a reproductive status by location interaction ($F = 0.28$, d.f. = 1, 10, $P = 0.61$; Table 2). Age was not a significant predictor of either mean frequency of defecating ($F = 0.09$, d.f. = 1, 10, $P = 0.77$, $R^2 = 0.01$) or mean frequency of sniffing ($F = 3.17$, d.f. = 1, 10, $P = 0.11$, $R^2 = 0.24$).

Of the 390 urinations by spayed females, 237 (60.8%) were directed at objects in the environment. Similarly, of the 312 urinations by non-estrous intact females, 177 (56.7%) were directed at objects. The overall relationship between percentage of total directed urinations and age was nonlinear (Fig. 2B). In general, females four or more years old directed the majority (70–80%) of their urinations while younger females did not. We fit the following exponential model to the data: $C_o(1 - \exp(-at))$ where the asymptote $C_o = 92.43$, $a = 0.22$, and $t =$ age; $R^2 = 0.77$. With the exception of the youngest female (I6) who did not direct any of her urinations, all other females directed more of their urinations when off their home area than when on their home area (Fig. 2C). We examined whether this pattern was significant by first calculating “difference” for each female, where difference = percentage directed urinations off home area minus percentage directed urinations on home area. We then used Wilcoxon’s Signed-Ranks Test to test the null hypothesis that the median “difference” = 0.00. We were able to reject the null hypothesis ($P = 0.004$). Finally, using “difference” as our dependent variable, we then ran ANCOVA with the variables age, reproductive status, and the interaction between age and reproductive status. None of the explanatory variables was a significant predictor of “difference.”

We analyzed ground-scratching after urinating and after defecating separately. No clear pattern with respect to location emerged from our plot of percentage urinations followed by ground-scratching on home area against percentage urinations followed by ground-scratching off home area. We calculated “difference”, where difference = percentage urinations off home area followed by ground-scratching minus percentage urinations on home

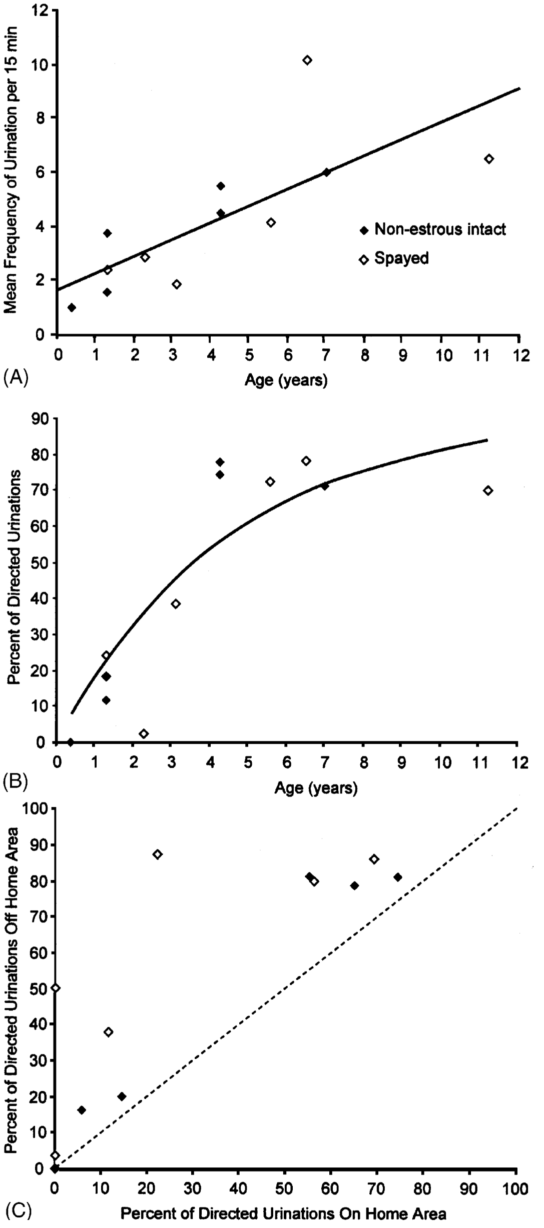


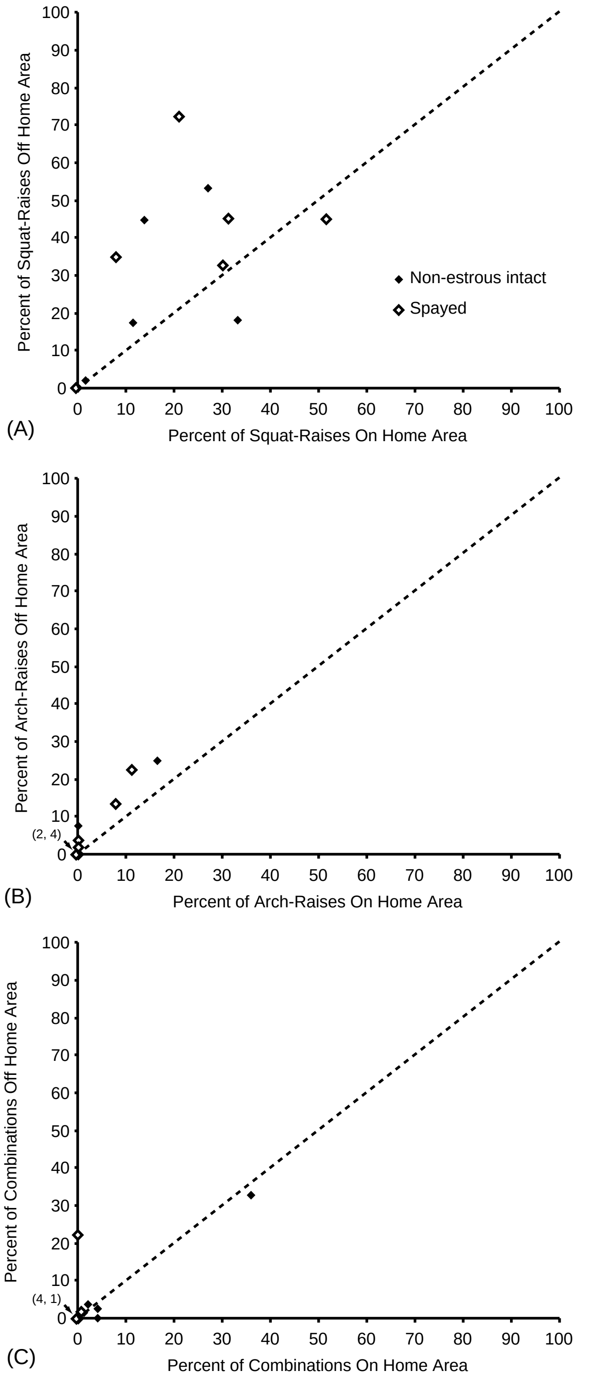
Fig. 2. Age and location-related patterns in the urinary behavior of 12 female Jack Russell Terriers. (A) Mean frequency of urination was positively correlated with age ($R^2 = 0.54$, $P = 0.005$). (B) The relationship between percentage directed urinations and age was nonlinear and could be represented by an exponential model ($R^2 = 0.77$). (C) Females directed more of their urinations when off their home area than when on their home area (Wilcoxon's Signed-Ranks Test, $P = 0.004$). Dashed line represents $y = x$; data points above the dashed line signify females that directed a larger percentage of their urinations when off their home area than when on their home area.

area followed by ground-scratching. We ran ANCOVA with the variables age, reproductive status, and the interaction between age and reproductive status. None of the explanatory variables was a significant predictor of "difference." We then ignored the variable location and ran the ANCOVA with percentage total urinations followed by ground-scratching as our dependent variable; reproductive status was a significant predictor of percentage total urinations followed by ground-scratching ($F = 7.65$, d.f. $= 1, 10$, $P = 0.02$, $R^2 = 0.43$). On average (±S.E.), spayed females ground-scratched following $30.2 \pm 9.8\%$ of their urinations and non-estrous intact females did so after $2.4 \pm 1.9\%$ of their urinations. The difference between spayed and non-estrous intact females in percentage urinations followed by ground-scratching failed to reach statistical significance (Mann–Whitney U-test, $P = 0.06$).

The results for ground-scratching after defecating were similar to those for ground-scratching after urinating. Again, no clear pattern emerged with respect to location and none of the explanatory variables (age, reproductive status, interaction) was a significant predictor of "difference" in the ANCOVA. When we ignored the variable location and ran the ANCOVA with total percentage of defecations followed by ground-scratching as our dependent variable, we found that reproductive status was a significant predictor of the total defecations percentage followed by ground-scratching ($F = 10.31$, d.f. $= 1, 10$, $P = 0.01$, $R^2 = 0.51$). On average, spayed females ground-scratched following $49.7 \pm 13.0\%$ of their defecations and non-estrous intact females did so after $6.3 \pm 4.3\%$ of their defecations. The difference between spayed and non-estrous intact females in percentage of defecations followed by ground-scratching was significant (Mann–Whitney U-test, $P = 0.03$).

Overall, squat-raise was the most common urinary posture displayed by females (55.1%; 387/702). The other postures, in order of their frequency of occurrence, included squat (18.4%; 129/702), arch-raise (15.5%; 109/702), combination postures (10.0%; 70/702), and handstand (1.0%; 7/702). We examined whether any pattern emerged with respect to location and urinary posture by plotting for each posture the urinations percentage in which the posture was used on home area against the urinations percentage in which the posture was used off home area. Some females used squat-raise and arch-raise more when urinating off their home area than when urinating on their home area (Fig. 3A and B). We examined whether these patterns were significant by first calculating "difference" for each female, where difference = percentage urinations off home area in which the female used the posture minus percentage urinations on home area in which the female used the posture. We then used Wilcoxon's Signed-Ranks Test to test the null hypothesis that the median "difference" $= 0.00$. We were able to reject the null hypothesis for squat-raise ($P = 0.03$) and for arch-raise ($P = 0.02$); we were unable to reject the null hypothesis for

Fig. 3. Location-related patterns in the urinary postures of 12 female Jack Russell Terriers. In each panel, the dashed line represents $y = x$; data points above the dashed line signify females that used the particular posture more when off their home area than when on their home area. (A) Females used the squat-raise posture more when urinating off their home area than when urinating on their home area (Wilcoxon's Signed-Ranks Test, $P = 0.03$). (B) Females used the arch-raise posture more when urinating off their home area than when urinating on their home area (Wilcoxon's Signed-Ranks Test, $P = 0.02$). Two spayed females and four non-estrous intact females never displayed this posture; see numbers in parentheses and arrow. (C) There was no pattern with respect to location for combination postures (Wilcoxon's Signed-Ranks Test, $P = 0.71$). Four spayed females and one non-estrous intact female never displayed combination postures.


100
90
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30
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0 10 20 30 40 50 60 70 80 90 100
Percent of Squat-Raises Off Home Area
Percent of Squat-Raises On Home Area
Non-estrous intact
Spayed
(A)
Percent of Arch-Raises Off Home Area
Percent of Arch-Raises On Home Area
(2, 4)
(B)
Percent of Combinations Off Home Area
Percent of Combinations On Home Area
(4, 1)
(C)

squat ($P = 0.15$), handstand ($P = 0.18$), and combination postures ($P = 0.71$; Fig. 3C). Finally, using "difference" as our dependent variable, we ran ANCOVA for each of the five postures with the variables age, reproductive status, and the interaction between age and reproductive status. None of the explanatory variables was a significant predictor of "difference" for any posture.

As can be seen from the three examples depicted in Fig. 3, individual females varied in the postures displayed while urinating. For example, although squat-raise was the most common posture displayed by females, there were two females (S5 and I6) that never displayed this posture (Fig. 3A). Similarly, one female (I3) frequently used combination postures (particularly the squat-raise into handstand into squat-raise) whereas most females rarely performed combination postures (Fig. 3C).

4. Discussion

In our study, some patterns of behavior differed with age of females. Older females urinated more frequently than did younger females, and females four or more years old directed the majority of their urinations whereas younger females did not. Ranson and Beach (1985) conducted a longitudinal study of the development of urinary behavior in young beagles. These authors reported a marked increase from 4 to 14 months of age in frequency of urination and percentage of directed urinations in males, and relatively small increases in these behaviors in females. Our study, though cross-sectional in nature, suggests that frequency of urination continues to increase in adult female dogs as they age, and that this increase occurs in a linear fashion. We found a different age-related pattern for directing urinations; directed urinations reached 70–80% by about 4 years of age and then this level characterized all females older than 4 years. Ranson and Beach (1985) found substantial increases from 4 to 14 months of age in investigatory behavior of males (measured as the frequency with which they sniffed posts within the observation pen), and only slight increases in this behavior in females. We did not find increases in the frequency of sniffing with age. Although Ranson and Beach (1985) did not study frequency of defecation with respect to age in beagles, studies with coyotes (Gese and Ruff, 1997) and wolves (Peters and Mech, 1975) have indicated that rates of defecation do not differ between pups and adults. Similarly, we found no age-related differences with respect to frequency of defecation. The age-related data presented here are preliminary. Ideally, in future studies we would confirm the age-related patterns we found for urination frequency and directing urine by studying a number of females at each age and by conducting a long-term longitudinal study.

Female dogs in our study urinated more frequently and directed more of their urinations when off their home area than when within their home area. They also used the squat-raise and arch-raise urinary postures more when off their home area than when within their home area. Sprague and Anisko (1973) found that adult male beagles directed their urine toward the scent of other males or vertical objects while adult females urinated at random locations within a relatively small pen. Nevertheless, location has been found to strongly influence male and female urinary behavior of free-ranging dogs and other species of canids, though no study is strictly comparable to our study. Free-ranging male and female dogs exhibited higher rates of marking (defined as urinations directed at a target in the environment) in areas in which they spent the least amount of time (Bekoff, 1979a). Pal (2003) found that free-ranging male dogs marked near territory boundaries whereas females marked most frequently at nest sites. Wolves performed raised leg urinations more commonly at the edges of their territory than at the center (Peters and Mech, 1975). Gese and Ruff (1997) observed that adult coyotes urinated more frequently than expected along the periphery of their territory as compared to the interior, and Allen et al. (1999) found a preponderance of coyote scent marks at the periphery of territories. Additionally, rates of raised leg urinations by coyotes were highest in areas of frequent intrusion (Wells and Bekoff, 1981). Location did not influence the frequency of defecation in our study. Similarly, frequency of defecation by coyotes did not differ between the periphery and interior of their territory (Gese and Ruff, 1997). Finally, we found that location did not influence the likelihood of ground-scratching following urination or defecation. In coyotes, ground-scratching has been found to occur randomly within territories (Wells and Bekoff, 1981) or more frequently at the periphery relative to the interior (Bowen and Cowan, 1980; Gese and Ruff, 1997; Allen et al., 1999).

For the most part, the behavior of spayed and non-estrous intact females in our study was similar. Spayed and non-estrous intact females urinated, defecated, and sniffed at similar frequencies and did not differ in the percentage of directed urinations. We found a substantial difference between the two groups of females in ground-scratching. Specifically, spayed females ground-scratched more frequently than did non-estrous intact females following defecation and there was a similar trend for ground-scratching following urination. To our knowledge, only one previous study of dog urinary behavior explicitly compared the behavior of spayed and intact females that were not manipulated in some way through the injection of hormones. Martins and Valle (1948) found no differences between spayed and intact females in urination frequency or posture. Unfortunately, these authors did not monitor ground-scratching.

In dogs and other species of canids, ground-scratching may serve as a visual signal and as a chemical signal (Peters and Mech, 1975; Bekoff, 1979b; Bekoff and Wells, 1986). The visual component may involve the act of ground-scratching or the marks left on the ground by such scratching (Kleiman and Eisenberg, 1973; Bekoff, 1979b). The chemical component may involve either scent deposited from interdigital glands or the dispersion of olfactory cues from deposited urine or feces (Peters and Mech, 1975; Fox and Cohen, 1977). Females in our study were walked one at a time, and all incidents of ground-scratching occurred out of sight of other dogs. Thus, the only potential recipient of the act of ground-scratching as a visual signal was the researcher walking the dog. While dogs are known to use a variety of signals, some of which are visual, when interacting with humans (Borchelt, 1983; Millot and Filiatre, 1986), we were unable to find any published reports that ground-scratching is such a signal. The performance of ground-scratching in wild canids has been linked to increasing group size (Barrette and Messier, 1980; Bekoff and Wells, 1986) and high social status (Peters and Mech, 1975; Gese and Ruff, 1997). At this time, it is unclear why spayed females in our study were much more likely than intact females to ground-scratch. However, given the data from wild canids, it is possible that ground-scratching is associated with dominance status in dogs. Several studies have suggested that spayed dogs more commonly display dominance aggression toward humans than do intact females (Wright and Nesselrote, 1987; Podberscek and Serpell, 1996; Guy et al., 2001). Further, O'Farrell and Peachey (1990) found that dominance aggression increased following spaying of female dogs that had shown a tendency to display such aggression when young. If ground-scratching is a dominance display in dogs that may sometimes be directed at humans, then perhaps it too is increased by spaying.

The most common urinary posture used by females in our study was the squat-raise; this was followed by the squat, arch-raise, combination postures, and handstand. Previous reports have suggested that raising the leg while urinating is unusual among female dogs and may be associated with estrus (Hart, 1974, 1975), old age (Berg, 1944; Martins and Valle, 1948), or ovariectomy (Berg, 1944). Beach (1974) found that the vast majority of urinary postures used by female beagles were either squats (which he called "full squats") or squat-raises (which he called "squat lifts"), but he did not provide separate percentages for the two postures. Sprague and Anisko (1973) found squats to be more common than squat-raises among female beagles, and Bekoff (1979a) and Pal (2003) reported similar findings for free-ranging female dogs of different breeds and crosses. We do not know if the frequent use of the squat-raise posture by females in our study is characteristic of the Jack Russell breed. Nevertheless, the predominant use of squat or squat-raise postures by female dogs is consistent with descriptions of female urinary postures for wild canids (Kleiman, 1966; Bekoff and Wells, 1986; Gese and Ruff, 1997). Female dogs in our study infrequently performed the handstand posture as the only posture during urination; female beagles also rarely performed handstands (Sprague and Anisko, 1973). In contrast, female bush dogs routinely performed handstands against a vertical surface (Kleiman, 1966). Finally, we noted pronounced individual variation in the urinary postures used by females. Beach (1974) and Sprague and Anisko (1973) also found substantial individual variation in the urinary postures used by female beagles.

The main criterion used to differentiate scent marking from simple elimination in canids is the directing of urine toward a conspicuous object (Kleiman, 1966; Peters and Mech, 1975; Bekoff, 1979a; Bowen and Cowan, 1980). Some authors have suggested additional criteria for marking (Kleiman, 1966) while others have found the distinction between scent marking and elimination unnecessary, at least for some species (Barrette and Messier, 1980; Wells and Bekoff, 1981). Martins and Valle (1948) viewed urination by female dogs as simply elimination and urination by males as elimination and scent marking. However, if we consider directing urine at a specific object as the prime criterion for marking, then 61% of the urinations performed by spayed females and 57% performed by non-estrous intact females were scent marks in our study. These percentages are higher than the 18% previously reported for free-ranging female dogs by Bekoff (1979a) and the 39% reported by Pal (2003), and disagree with Kleiman's (1966) observation that female dogs only mark during proestrus and estrus. Thus, our data suggest that urination in female dogs serves eliminatory and scent marking functions, and that marking is neither unusual nor limited to certain reproductive states.

5. Conclusion

The urinary behavior of female Jack Russell Terriers varied with age, location, and reproductive status. Additionally, there was considerable individual variation in certain patterns of behavior, such as ground-scratching following urination and defecation and urinary posture. Nevertheless, spayed and non-estrous intact females directed more than half of all urinations at specific targets in the environment. The high percentages of directed urinations suggest to us that urination in female dogs functions in scent marking as well as in elimination, even when females are not in estrus.

Acknowledgements

We thank the staff of the Clark Science Center and members of the Department of Biological Sciences at Smith College for their enthusiastic support of this project. We also thank Bob and Genie Franklin of Farmcliff Kennels, Ann Shepard of Highwater Kennels, and Valerie Whiterock for allowing us to observe their Jack Russell Terriers. Finally, we thank Katherine Halvorsen and Linjuan Qian for statistical advice and William Bemis for help with the figures.

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