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Black bear marking behaviour at rub trees during the breeding season in northern California

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Abstract

We studied the marking behaviour of American black bears (*Ursus americanus*) during the breeding season 2013. Six remote video cameras captured 529 trapping nights. We collected behaviour, sex, and age class of bears rubbing on trees. Marking events ($N = 31$) were observed between 26 April and 27 July with a median of 12 June. The majority (96%) of marking events were performed diurnally. All bears we could accurately identify to sex were males ($N = 16$) and 29 of 31 marking bears were adults. The most frequent use of contact with substrate was bipedal marking followed by pede marking, quadrupedal marking. Bears used their back, neck, head, and cheeks in nearly 90% of observations while scratching and biting occurred in less than a third of observations. We documented the novel behaviour 'groin marking'. This study suggests rub trees are locations for chemical communication through a variety of marking techniques in forested environments.

Keywords

American black bear, breeding season, communication, remote-video camera, rub trees, scent marking, *Ursus americanus*.

1. Introduction

Scent communication is an ideal method to broadcast messages when auditory or visual contact is made difficult due to thick foliage or features of the terrain (Thiessen & Rice, 1976). Deposition of odours can be used to delineate territorial boundaries, find mates, avoid physical interactions, or to avoid foraging in recently exploited areas (Henry, 1977; Gorman & Trowbridge, 1989; Allen et al., 2014). Information transmitted through odours

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may include species identification, sex and reproductive status, identities of individuals, relative age, and mood (Eisenberg & Kleiman, 1972). In carnivores, scent marking is likely used for multiple functions, and has been demonstrated for use to delineate territorial boundaries, increase scavenging efficiency, help conspecifics locate one another, and for inter and intra-group communication (Peters & Mech, 1975; Henry, 1977; Rogers, 1987; Sillero-Zubiri & Macdonald, 1998).

Solitary carnivores must be able to find mates and deter intrasexual competitors, and behaviours exhibited to accomplish these goals can vary between sexes (Rogers, 1987; Bothma & le Riche, 1993; Clapham et al., 2012; Allen et al., 2014). For example, both leopard (*Panthera pardus*) males and females scratch trees; however, male leopards spray urine on trees significantly more than females, and more frequently immediately before, during, and after mating (Bothma & le Riche, 1993). Communication can be difficult in forested environments, and as such, signals created may be intended for a specific purpose and contain multiple cues (Candolin, 2003). Furthermore, the method and intent of marking behaviour may vary throughout the year as the reason for communicating changes: females in oestrus, food larders, competition avoidance, or behavioural learning opportunities (Lloyd, 1979; Clapham et al., 2012).

Bears scent mark in a variety of forms, including actively rubbing against trees, rocks, or the ground, intentionally marking with their feet as they walk, urinating and straddling saplings, urinating as they walk or passively on vegetation as they move through brush (Tschanz et al., 1970; Lloyd, 1979; Klieman, 1983; Rogers, 1987). Giant pandas (*Ailuropoda melanoleuca*) possess a waxy-sticky anal gland secretion and use a handstand position to apply the anal gland secretion to the substrate (Kleiman, 1983). Neither the brown bear (*Ursus arctos*) nor the black bear (*Ursus americanus*) possesses an equivalent sticky anal gland secretion nor has been observed engaging in the scent marking behaviour exhibited by the giant panda (Pocock, 1921; Rosell et al., 2011). Experiments with captive bears have provided detailed observation of methods used to deposit scent, temporal differences in marking between sexes, the role of marking as a form of social communication (Tschanz et al., 1970), and marking as linked to the dominance hierarchy of the population (Rogers, 1977, 1987).

Marking, or rub, trees have an important role for communication in bear species; however, there are few visual observations of bears engaging in

marking events in the wild or captivity. From indirect observations, it has been reported that marking on trees occurs more frequently during the breeding season for grizzly bears and black bears (Rogers, 1977; Burst, 1979; Green & Mattson, 2003; Karamanlidis et al., 2007; Clapham et al., 2012), and is apparently performed more frequently by males; although, after the rut there is no difference between the frequency of marking for male and female grizzly bears (Rogers, 1987; Karamanlidis et al., 2007; Clapham et al., 2012). Interestingly, Clapham et al. (2012) also found females with cubs (<1 year old) increased their marking behaviour after the breeding season, possibly to introduce cubs to adult male scent and marking techniques when the chance of infanticide was lowest. Interspecific interactions also impact marking behaviour, as black bears reduce their use of rub trees after grizzly bears mark them (Shaffer, 1971). Some rubbing events may result from the inherent curiosity of this intelligent omnivore. However, with few studies systematically recording bears marking trees in the wild, there may be important behavioural aspects that are currently unknown.

We used remote video cameras to record marking behaviours of American black bears at rub trees during the breeding season in northern California. In this study we focused on the behaviours that American black bears exhibit at rub trees; rub trees refer to trees that are used as scent marking locations. Henceforth, marking events refer to behaviours recorded at rub trees. This is the first study to investigate the marking behaviours of free-ranging American black bears using video from remote cameras. Our goal was to examine the marking behaviours used during the breeding season to assess their frequency and duration, and the extent to which bears of different sex and age differed in the frequency and intensity with which they used marking behaviours.

2. Materials and methods

2.1. Study area

We conducted our study in northwestern California in Redwood National Park and adjacent Green Diamond Resource Company lands that are located north of the town of Orick, CA, USA, 78 km south of the Oregon–California border. Redwood National Park (RNP) is a protected area encompassing 534 km^2, with 158 km^2 of old-growth forest (Redwood National Park, 2013a). Green Diamond Resource Company harvests and sells timber products on lands adjacent to RNP, and manages its forests with sustain-

able practices that have resulted in a Forest Stewardship Council certification (GDRC, 2013). Due to timber roads, tree harvest locations, and regenerating stands of young forests, the landscape is a patchier environment with more increased edge habitat than Redwood National Park.

The study area is comprised of coastal redwood (*Sequoia sempervirens*) dominated forests, and mixed coniferous-hardwood forests inland and at higher elevations. Dominant trees of the park include big-leaf maple (*Acer macrophyllum*), Douglas fir (*Pseudotsuga menziesii*), red alder (*Alnus rubra*), Sitka spruce (*Picea sitchensis*), and tan oak (*Lithocarpus densiflorus*), while common understory and herbaceous plants include huckleberry (*Vaccinium* spp.), salal (*Gaultheria shallon*), salmonberry (*Rubus spectabilis*), skunk cabbage (*Lysichiton americanus*) and sword fern (*Polystichum munitum*) (Redwood National Park, 2013b). Large mammals that reside in the study area include black bear, black-tailed deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), bobcats (*Lynx rufus*), coyotes (*Canis latrans*) and pumas (*Puma concolor*) (Redwood National Park, 2013c).

The climate of the region is characterized by wet, cool winters and warm, foggy summers. The majority of precipitation is received in winter months, but coastal fog during summer condenses on trees and drips on the ground. Average annual precipitation is 152–203 cm, and temperatures vary from 4–15°C (Redwood National Park, 2013d).

Black bear densities in northwestern California are some of the highest reported for the species and can range from 1–2 bears/km^2 (Matthews, 2002; Early, 2010). Bears in the region maintain a home range but do not appear to be highly territorial (Early, 2010). Home range size estimates for bears near the study area range from 10.6–62.3 km^2 for males and 3.6–17.3 km^2 for females (Kellyhouse, 1980; Matthews, 2002; Early, 2010). Across its geographic range, the black bear's breeding season is consistent and ranges from 25 May to 10 August with a peak in June and July (Jonkel & Cowan, 1971; Rogers, 1977).

2.2. Field methods

We deployed six remote video cameras with infrared flash (Truthcam 35, Primos, Flora, MS, USA) to record marking events between 25 April and 9 August 2013 in order to encompass the breeding season. The six cameras were active 24 h/day for a total of 529 trapping nights. Trapping hours were not equally distributed across camera stations because of electronic malfunctions (from condensation inside the unit) and one camera being stolen. We

located rub trees by walking along bear trails, and trees were determined to be a rub tree by presence of a combination of hair, bite and claw marks, wounds on the tree, and a depression of tracks leading to and from the tree (Burst, 1979; Burst & Pelton, 1983; Elbroch, 2003). We set up each camera to record bear visits and marking behaviours at a rub tree by placing them knee to shoulder height facing the rub tree. We subsequently changed 1 camera set up to 5 m high pointing down in order to stop bears from displacing the camera during visits. We set the cameras to record 60-s videos with a 10-s delay between triggers, and we replaced batteries and memory cards every 1 to 3 weeks, depending on how often cameras were capturing videos.

We defined a video event as each time a black bear was documented on camera, and defined a marking behaviour event as each time a bear exhibited one of the marking behaviours (Table 1) during a visit. We determined sex from external reproductive organs (testicles and penis or vulva),

Table 1.
Ethogram of marking behaviours exhibited by black bears, captured with remote video cameras, during the breeding season 2013 in northwestern California.

Behaviour	Description
Biting	The bear's teeth are in contact with tree and the bear uses its teeth to remove bark or wood.
Dorsal marking	The bear rubs its back against the tree.
Facial marking	The bear rubs its neck, head, or cheeks against the tree.
Orientation during marking	The direction a bear faces during marking behaviours. Direction can be dorsal, where the bear is standing with its back to the tree, or ventral where its stomach is facing the tree.
Olfactory investigation	The bear uses its nose to smell footprints leading up to a tree or smell the tree.
Pede marking	The bear walks with a stiff-legged gait, deliberately placing rear feet in same location as front feet, and twisting feet into ground or shuffling foot forward-backwards before taking the next step.
Scratching	The bear's claws make contact with the tree and are used to hold or scrape the tree.
Stance during marking	How a bear stands during marking; marking can occur from a bipedal stand, where the bear is standing on its hind feet to rub the tree, or a quadrupedal stand, where all four feet are in contact with the ground and the bear is rubbing its side against the tree.

a vulva-patch of hair (M. Clapham, pers. comm.), swollen mammae (Larivière, 2001), or the presence of cubs. Age class was subjectively assigned based on size to cub (<1 year), yearling (1–2 years), and adult (>2 years); however, due to difficulty in assigning age class from video data we did not incorporate it into any statistical analyses. Identification of individual bears was based on sex, size, spatial and temporal differences in the area and time of event capture, and amount of dorsal hair loss. Cameras were distributed at a distance to maximize independence among events. Three cameras were close enough to potentially capture the same individual; however, the high density of bears allowed us to capture multiple different animals on these cameras.

2.3. Statistical analyses

We created an ethogram of marking behaviours by black bears that included 8 observed behaviours (Table 1). For each marking behaviour event we recorded occurrence, frequency and duration of the behaviours exhibited.

We analysed the distribution of marking behaviour events by date and time period. First, we divided each month of the study into two equal periods and then analysed the frequency of behaviour events using a generalized linear model with Poisson link in program R (R Core Team, 2014). Second, we divided each day (24 h) into 4-h time periods: 00:01–04:00, 04:01–08:00, 08:01–12:00, 12:01–16:00, 16:01–20:00 and 20:01–00:00. We then analysed the frequency of behaviour events by time period using a 2×6 Fisher's exact test (Sokal & Rohlf, 1987), rather than a chi-square test to account for low sample sizes in some time periods. We then did a post hoc comparison based on diurnal, crepuscular and nocturnal time periods, with crepuscular defined as within 1 h of sunrise and sunset and time between crepuscular during the day, diurnal and night, nocturnal. For each analysis with significant statistical results we calculated post hoc effect size as φ coefficients (Nakagawa & Cuthill, 2007) to measure the magnitude of the effect; we considered scores of 0.10 small effects, 0.30 medium effects and 0.50 large effects (Cohen, 1992).

Next, we analysed the frequency of occurrence for each behaviour compared to others using 2×2 chi-square tests (Sokal & Rohlf, 1987). We compared differences in the frequency of display of the stances used while marking, including the display of pede marking (on the ground) before marking to after marking on the tree, the display of bipedal marking to

quadrupedal marking, and the display of dorsal marking to ventral marking. For each analysis with significant statistical results we calculated post hoc effect size as φ coefficients, as above.

3. Results

Over the duration of the study, we captured 49 videos of bears that included 31 marking behaviour events at rub trees (Table 2). During marking events, we assigned sex to 16 of 31 bears (51.6%) as male. We were unable to assign sex to the remaining 15 marking bears because either they did not face the camera while marking or the video quality was too poor to distinguish necessary details. We were able to confidently identify 12 individual bears based on coloration, size, and patterns of hair loss. Adult bears ($N = 29$; 93.5%) were observed marking more than cubs or yearlings ($N = 2$).

Table 2.
Mean time spent in behaviour (s) in order of decreasing frequency (number of events per videos), and 95% confidence intervals (CI) for marking behaviours of black bears, captured with remote video cameras, during the breeding season 2013 in northwestern California.

	All marking bears		Known male marking bears	
	Mean (s)	95% CI	Mean (s)	95% CI
Total video length	20.4	12.0–28.8	30.8	26.2–35.4
Bipedal marking	9.5	2.5–16.5	15.3	4.9–25.7
Dorsal orientation	7.8	4.0–11.6	12.3	7.2–17.4
Dorsal marking	7.9	4.1–11.7	12.1	7.1–17.1
Facial marking	10.1	1.2–19.0	16.3	4.7–27.9
Pede marking leaving tree	5.9	2.2–9.6	6.2	5.1–7.3
Scratching	8.1	−15.7–31.9	25.1	−8.1–58.3
Olfactory investigation prior to rubbing	1.9	−3.0–6.8	6.0	0.1–11.9
Olfactory investigation while rubbing	3.1	1.7–4.5	3.7	1.9–5.5
Quadrupedal marking	2.5	−14.2–19.2	4.0	1.1–6.9
Biting	3.0	2.6–3.4	3.0	2.6–3.4
Pede marking approaching tree	9.8	8.2–11.4	9.8	9.3–10.3
Ventral orientation[a]	24.4	n/a	48.7	n/a
Groin marking[a]	25.5	n/a	n/a	n/a

[a] Ventral orientation and groin marking were only observed once.

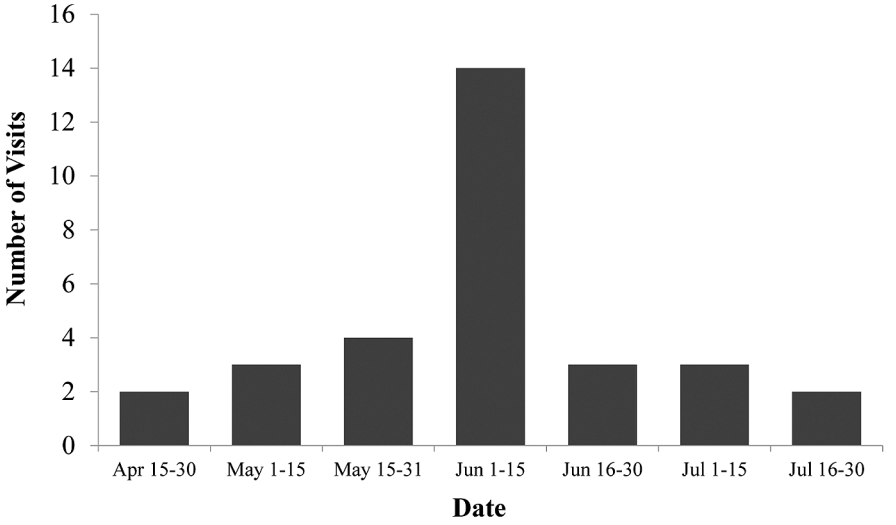

Figure 1. Number of visits by black bears exhibiting marking behaviours at rub trees by 2-week intervals, observed with remote video cameras, during the breeding season 2013 in northwestern California.

We observed 31 marking behaviour events between 26 April and 27 July with a median of 12 June. The marking events varied significantly in their date of occurrence ($F_{6,35} = 3.35$, $p = 0.0103$), with 45.1% occurring from 1 June to 15 June (Figure 1). Marking events occurred between the hours 05:45–20:45 with a median of 10:43. Marking events varied significantly in their time period of occurrence ($p = 0.0187$, $\varphi = 0.26$), with 53.8% of events occurring from 08:01–12:00 (Figure 2). When compared by time period, 83.9% of visits occurred during the diurnal time period, 16.1% were crepuscular and 0% nocturnal.

Rubbing was displayed at 83.9% of visits, significantly more frequently than pede marking (38.7%, $\chi^2_1 = 11.49$, $p = 0.0007$, $\varphi = 0.46$), olfactory investigation (41.9%, $\chi^2_1 = 9.95$, $p = 0.0016$, $\varphi = 0.43$), facial rubbing (54.8%, $\chi^2_1 = 4.86$, $p = 0.0275$, $\varphi = 0.32$), scratching (22.6%, $\chi^2_1 = 20.99$, $p < 0.0001$, $\varphi = 0.61$), or biting (9.7%, $\chi^2_1 = 31.36$, $p < 0.0001$, $\varphi = 0.74$) (Figure 3). Scratching was less frequently displayed than facial rubbing ($\chi^2_1 = 5.51$, $p = 0.0190$, $\varphi = 0.33$), while biting was less frequently displayed than pede marking ($\chi^2_1 = 5.63$, $p = 0.0177$, $\varphi = 0.34$), olfactory investigation ($\chi^2_1 = 6.82$, $p = 0.0090$, $\varphi = 0.37$) and facial rubbing ($\chi^2_1 = 12.47$, $p = 0.0004$, $\varphi = 0.48$).

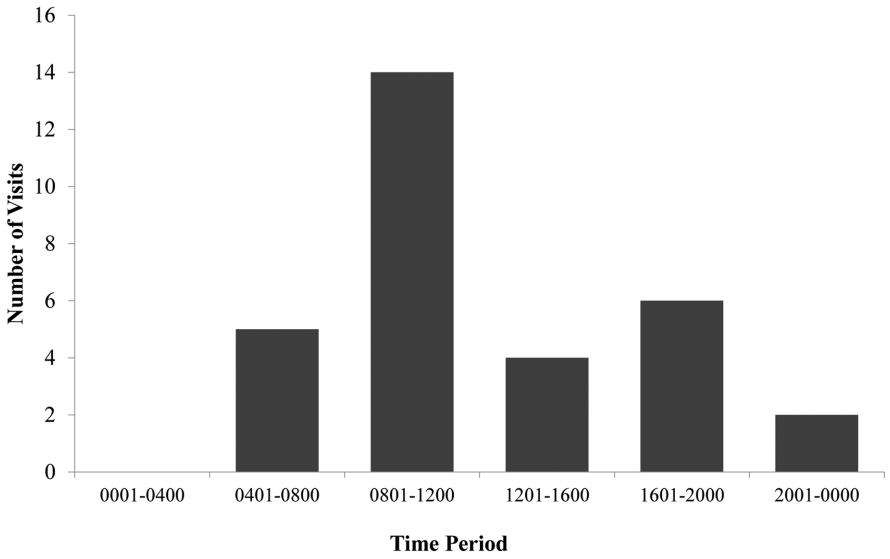

Figure 2. Number of visits by black bears exhibiting marking behaviours at rub trees by time of day, observed with remote video cameras, during the breeding season 2013 in northwestern California.

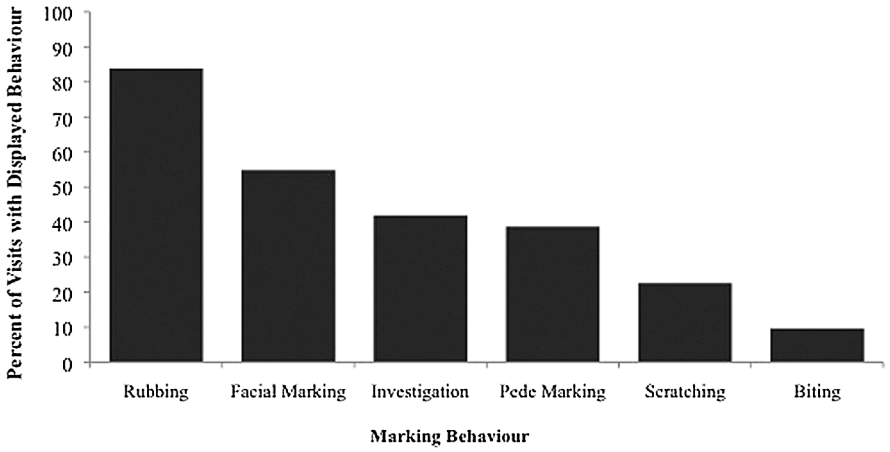

Figure 3. Frequency of marking behaviours by black bears during 31 marking events at rub trees, captured with remote video cameras, during the breeding season 2013 in northwestern California.

When pede marking was exhibited, it was performed significantly more after rubbing (100% of events) than before rubbing (16.7% of events) ($\chi^2_1 = 13.89$, $p = 0.0002$, $\varphi = 0.85$). Bipedal stance was exhibited during 92.3% of rubbing events, significantly more frequently than the 23.1% of quadrupedal marking observed ($\chi^2_1 = 22.77$, $p < 0.0001$, $\varphi = 0.70$). Dorsal orientation was exhibited during 100% of rubbing events, significantly more frequently than the 4.0% of events in which bears also rubbed using a ventral orientation ($\chi^2_1 = 43.38$, $p < 0.0001$, $\varphi = 0.96$).

Five of six rub trees had a series of ground marks that were evidence of previous pede marking. The sixth tree, which lacked ground marks, only had one marking behaviour observation during the study period. Three bears that did not themselves mark investigated the ground marks longer than they investigated the rub tree. Furthermore, some male bears were observed pede marking past the rub tree then turning around to pede mark in the same ground marks before rubbing themselves against the tree. All six rub trees were located along bear trails that were used frequently enough to create a visible path through the forest.

We also observed a novel behaviour we termed 'groin marking', which has not previously been described in the literature. A juvenile black bear approached a marking tree, and initially exhibited quadrupedal marking before reaching its rear legs back until they were nearly parallel with the ground (as in a push-up position). The bear then apparently made contact with the ground with its lower torso or groin while continuing to rub the side of its hip against the tree. The bear then pulled its rear legs under its body again quadrupedal marking. At 33 s into the video, the bear stopped marking and sat against the tree, then continued marking at 42 s with its rear legs stretched back behind it and vigorously rubbing the tree from its ribs along its hip.

4. Discussion

Rubbing was the most common marking behaviour exhibited by black bears at trees, and bipedal stance was the most common position observed. Although we did observe a sow with a cub walk past a rub tree, among events where we could identify the sex, all marking bears were male. These findings support previous observations of marking during the breeding season being performed primarily by male American black bears (Rogers, 1977, 1987; Burst, 1979; Burst & Pelton, 1983) and are similar to findings for brown

bears (Tschanz et al., 1970; Clapham et al., 2012). We observed very few instances of bears investigating rub trees without marking, possibly suggesting communication may be intrasexual between male bears that mark (Clapham et al., 2012). Black bears' preference to mark in a bipedal stance more than in other positions was in agreement with observations of marking techniques by captive brown bears (Tschanz et al., 1970), although the quadrupedal stance was also observed in this study.

Pede marking occurred in a little over a third of our observations, and may have been more frequently observed if the cameras had been more sensitive and faster to trigger, as some videos began with a bear at or almost at the rub tree. This suggests that for black bears depositing scent, pede marking could be nearly as important as rubbing against a tree. A few bears showed more apparent interest in (more time spent investigating) ground marks than the tree, and after marking, some bears engaged in a very deliberate grinding of their feet into the ground. This pede marking could be a method of deploying scent by male bears as they move across the landscape, similar to how female bears are known to drip urine as they walk while in oestrus (Rogers, 1977, 1987). On one occasion, we noted pede marks from a male bear that extended for approximately 400–500 m from the marking tree. Very little is known about how this behaviour is used and if American black bears have an interdigital gland that leaves scent. On video, bears were clearly using their noses to investigate the trail of pede marks. We hypothesize pede marking may be used as an ephemeral and moveable communication behaviour to mark or leave scent regarding what a bear is interested in (females in oestrus, food larders, a carcass) along with more stable marking substrates like a rub tree.

Marking behaviour was exhibited most frequently by adult bears during diurnal hours, and was most frequent from 1 to 15 June. These findings suggest that in our study area the peak of breeding season was in early June. With the exception of one young bear, only adult bears marked trees. We estimated the young bear to be $\leqslant$2 years old based on body size, and it was one of only two individuals that did not mark diurnally. The juvenile was also the only bear to exhibit the novel groin marking behaviour. We noted bears on camera during nocturnal hours, but only two of those individuals exhibited any marking behaviours. The diurnal nature of marking may reflect the regular rhythm of activity by black bears in this area, which, in the absence of human disturbances, is usually crepuscular or diurnal (Bridges

et al., 2004). Rub trees may be easier to find during the day because of the visual stimuli on the marked tree (exposed wood from biting and scratching, frayed bark, and sap).

There may be more involved in scent marking at rub trees than we could observe through the video recordings. Shaffer (1971) watched a black bear urinating during a marking event and Rogers (1977, 1987) could smell bear urine on a rub tree. However, we could not determine if bears were urinating while marking, although in some cases the penis was apparent protruding out of the sheath during marking. Nor could we see if saliva was deposited when facial marking or biting. Black bears do not possess the waxy anal gland secretions of giant pandas, and only recently was the anal gland secretions of brown bears determined to possibly code for sex (Rosell et al., 2011). American black bear marking is less clear because of the lack of external scent glands (Pocock, 1921; Burst, 1979); saliva, urine, or anal gland secretion deposition while marking would help explain bear communication. Saliva deposition is supported by the high frequency of facial rubbing observed but is countered by the low frequency of biting. Likewise, if urine was used during scent marking we would have expected bears to stand in the ventral orientation to place urine on the tree, but ventral orientation was only observed once. Regardless of scents, most contact with trees resulted in some fur trapped in bark or sap.

Our findings could have important implications for bear population monitoring. Active, noninvasive hair-snares lure an animal to the wire brush, carpet, or barbed wire fence with bait or scent. Passive hair-snares take advantage of natural rubbing objects or den entrances (Kendall & McKelvey, 2008). Biologists use DNA extracted from hair gathered from natural rub trees to monitor populations (Schwartz et al., 2006; Karamanlidis et al., 2007), however behaviour of a species can bias passively gathered data toward one sex or age class, in this case, towards adult males in the population. Because black bears are managed as a game species, it is important for managers to use appropriate techniques to assess their population structure and number and to understand their natural history and behaviours to set seasons and quotas to match desired target population demographics and density.

In summary, American black bears preferred to mark in a bipedal stance, but pede, quadrupedal, and groin marking were also exhibited. While in bipedal stance most bears used the dorsal orientation and rubbed their back, neck, head, and cheeks against the rub tree. Ventral orientation, scratching,

and biting were observed infrequently. Bears clearly displayed olfactory investigation of rub trees and ground marks near rub trees, implying scent communication occurred between bears visiting the rub trees. The majority of marking events occurred during the diurnal time period, with more than half occurring between 08:01 and 12:00. A novel behaviour, groin marking, was engaged by the only young bear observed to mark in the study. This behaviour was unique among our observations and is likely a cryptic behaviour that is rarely used. Further investigations should research scent marking of individuals of known sex, age, and reproductive status throughout the entire non-denning period. A finer-scale mapping and observation of all rub trees within a set of home ranges may further illuminate our understanding of black bear communication.

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