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Marking behavior of Asiatic black bears at rub trees

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Abstract: We studied the characteristics of the marking behavior of Asiatic black bears (*Ursus thibetanus*) at rub trees. We recorded the tree-marking (tree-rubbing and bark-scratching) and associated (stomping) behaviors in Japan between 2010 and 2015 using automatic cameras and compared the results with those from previous studies on other bear species. We recorded 22 visits to trees by ≥6 different individuals. During these visits, there were no differences in the frequency or duration between the 3 body orientations of back rubbing, front rubbing, and body-side rubbing, which differs from the findings for other bear species. However, bipedal standing was the most common posture, as observed in other species. We also analyzed the order of tree-marking actions. For a better understanding of the Asiatic black bear's marking behavior, further examples of marking behavior and anatomical studies of secretory glands are needed.

Key words: Asiatic black bear, body orientation, Japan, marking, scent-marking, stomping, tree-rubbing, *Ursus thibetanus*

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Among the Ursidae, tree-rubbing has been mainly studied in brown bears (*Ursus arctos;* e.g., Green and Mattson 2003, Clapham et al. 2012, Sato et al. 2014, Tattoni et al. 2015), American black bears (*U. americanus;* e.g., Burst and Pelton 1983, Taylor et al. 2015), Andean bears (*Tremarctos ornatus;* e.g., Filipczyková et al. 2016, Kleiner et al. 2018), and giant pandas (*Ailuropoda melanoleuca;* e.g., White et al. 2002, Nie et al. 2012). Tree-rubbing behavior in bears involves multiple individuals repeatedly rubbing the same tree, sometimes accompanied by bark-scratching with claws and teeth and urinating (Karamanlidis et al. 2007, Kendall et al. 2009, Taylor et al. 2015, Filipczyková et al. 2016).

Brown bears and American black bears rub parts of their bodies against artificial objects as well, such as creosoted power poles and fence posts (e.g., Karamanlidis et al. 2007). The function of bears' rubbing behavior is not yet fully understood, and there are a variety of speculations. One category is physiological drives experienced by the bears, which includes reasons such as reactions to skin parasites, inflammation, itching, or molting, as well as physical stimulation or curiosity (e.g., Green and Mattson 2003, Taylor et al. 2015). Another category relates to tree-marking with animal scents and is based on the observations that multiple bears may rub the same tree, that males are more likely to rub trees than females, and that tree-rubbing peaks during the breeding season (e.g., Green and Mattson 2003, Clapham et al. 2012, Taylor et al. 2015). Some researchers believe scent-marking is used for communication for these solitary animals, which are active across large areas (Clapham et al. 2012, 2014; Sato et al. 2014).

Recent detailed behavioral and physiological analyses of brown bears have indicated that differences in their actions and postures during tree-rubbing may be related to differences in scent-marking by glandular secretions. For example, Clapham et al. concluded that back rubbing (BR) on 2 legs was the core marking posture, based on observations of the motor activity of tree-rubbing, including analysis of the order of behavior with high probability. In addition, oily secretions and enlarged sebaceous glands have been found on the skin of the back during the breeding season, which suggests that the sebaceous glands on the back may be involved in BR (Tomiyasu et al. 2017). Furthermore, bears have been observed smelling the ground before tree-rubbing and sitting in front of the tree after tree-rubbing, and young males are able to distinguish mature males by their anal secretions (Rosell et al. 2011, Jojola et al. 2012). Also, mature males engage in pedal marking behavior, whereby a bear walks with a stomp and leaves distinctly recessed footprints (Green

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and Mattson 2003; Clapham et al. 2013, 2014; Sato et al. 2014), before and after tree-rubbing and other marking behavior.

In recent years, it has become clear that Asiatic black bears (*Ursus thibetanus*) also perform tree-rubbing (Latham et al. 2012). Indeed, multiple bears have been recorded rubbing against the same conifer tree (Ogawa et al. 2020), but there has been no detailed analysis of Asiatic black bear rubbing behavior to date, and there are no reports of studies on secretory glands.

The aim of this study was to study the characteristics of tree-marking behaviors in Asiatic black bears and compare them with those of other bear species. Previous studies in brown bears have shown that the order in which tree-marking behavior occurs varies by sex or age of the bear (Clapham et al. 2014) and may also vary among different species of bears. Thus, we focused on the characteristics of body-rubbing and bark-scratching behaviors (body posture, body orientation, and order of actions). We then compared the characteristics of tree-marking behaviors in Asiatic black bears and other bear species as an important step toward understanding the role of this behavior in intraspecific communication.

Study area

We conducted this study in Okutama (35°48′N, 139°5′E), the westernmost suburb of Tokyo, Japan (Fig. S1, Supplemental material). The region has a Pacific Ocean-type climate, with heavy rainfall in summer and little snow in winter. The mean annual precipitation is 1,510 mm, and the mean annual temperature is 12.4°C, ranging from 0.6°C in January to 24.2°C in August (2006–2017; Japan Meteorological Agency 2018).

The study area is mainly covered with natural forests (40%) and conifer plantations (50%; Koike et al. 2008). The natural forests are dominated by *Castanea crenata* and *Quercus serrata* in the lower mountain zone (400–500 m above sea level [a.s.l.]); *Q. crispula, C. crenata,* and *Fagus crenata* in the middle zone (500–1,500 m a.s.l.); and *Abies homolepis* and *Tsuga diversifolia* in the upper zone (1,500–1,800 m a.s.l.). The conifer plantations include Japanese cedar (*Cryptomeria japonica*), Japanese cypress (*Chamaecyparis obtusa*), and Japanese larch (*Larix kaempferi*). We conducted the present camera survey in a mixed plantation of Japanese larch and Japanese cedar (elevation range: 950–1,000 m a.s.l., area size: 20,000 m^2).

Materials and methods

Camera setup

To record the tree-marking behavior of bears in the study area, we installed automatic video cameras (HCO Scoutguard SG550 [HCO Outdoor Products, LLC., Johns Creek Pkwy, Georgia] and Bushnell HD Max [Bushnell Corporation, Overland Park, Kansas]) and photo cameras (Reconyx RC55 [Reconyx, Inc., Holmen, Wisconsin]) pointing at Japanese larch and Japanese cedar trees that had bark damaged from antler sharpening by sika deer (*Cervus nippon*) and on which bear hairs had previously been found (unpublished data). We conducted the survey on 16 different trees between 2010 and 2015: 5 Japanese cedar in 2010; 4 Japanese cedar and 2 Japanese larch in 2011; 2 Japanese larch in 2013; and 2 Japanese larch and 1 Japanese cedar in 2015. The cameras were generally in place between early May and early November in the survey years and were installed 2–5 m away from the target trees at a height of 1–2 m above the ground. We installed photo cameras on 3 Japanese cedar and 1 larch in 2011, and installed video cameras on all the rest. We set the video cameras to take 60-second videos each time they were activated, with 5-second intervals between recordings; whereas, we set the photo cameras to take a series of 10 still pictures at 1-second intervals as a single camera activation, with 5-second intervals between series. During each survey period, we changed memory cards and batteries once per month.

Classification of actions

In the video recordings and captured images, we defined any behavior in which part of an individual bear's body touched a target tree (specifically, tree-rubbing or bark-scratching) as tree-marking, and we regarded any tree-marking behavior that was captured during a single camera activation as one visit. In cases where 2 individuals performed simultaneous tree-marking, we considered that as 2 visits. If tree-marking by the same individual was captured within 30 minutes of the end of a preceding video sequence, we considered it as a single visit. We identified gender by external genitalia, and identified individuals on the basis of a number of observed details, including chest markings, degree of body hair depletion, and physique, according to the Individual Identification Reporting Checklist (Choo et al. 2020).

We classified the characteristics of the tree markings as shown in Figure S2 (Supplemental material) and recorded the number of times each action was performed for each visit. We classified "tree-rubbing" as a type of tree-marking behavior that involved 1 of the following

5 actions, which were based on a combination of posture (which relates to the height on the tree where the body part was rubbed) and body orientation (which relates to the part of the body that is rubbed): rubbing the side of the body and neck against a tree with all 4 feet in contact with the ground (quadrupedal standing position, body-side rubbing [4BsR]); rubbing the front of the body against a tree with 2 feet in contact with the ground (bipedal standing position, front rubbing [2FR]); rubbing the back of the body against a tree with 2 feet in contact with the ground (bipedal standing position, back rubbing [2BR]); sitting while rubbing the front against a tree (sitting position, front rubbing [SFR]); and sitting while rubbing the back of the body against a tree (sitting position, back rubbing [SBR]). We classified "bark-scratching" as another type of tree-marking behavior that comprised 2 actions: scratching bark while standing on 2 feet (bipedal standing position, bark-scratching [2Sc]) or scratching bark while sitting (sitting position, bark-scratching [SSc]). We included stomping (St) as an associated behavior in our observations, whereby the bear, after leaving the tree, walked heavily around over the same spot with both the front and back feet while looking down and smelling for ground odors.

We used Quick Time Player 7 (Apple Inc. Version 7.6.6, Cupertino, California) to analyze the duration, frequency, and order of each of the aforementioned 8 actions recorded during each visit. We treated the same action observed to continue across camera activations as a single action, whereas we treated the same action performed again after other actions as a separate action.

Data analysis

We conducted multichannel attribution analysis to investigate whether observable patterns of behavior occurred during a visit to a target tree. This type of analysis determines the starting point of the behavior, the specific intermediate actions performed during the behavior, and the end point of the behavior in order of action, and also divides the sequence from the start point to the end point into 2 points and calculates the probability that these sequences of events will be passed through. We used the Markov chain model to investigate the probability that a bear would pass through each action sequence, whereby we placed the starting point before the behavior labeled "tree-marking," we labeled the 7 intermediate actions, and we set "St" or "leaving without St" as the end point. We constructed the model using the Channel Attribution package (Altomare and Loris 2018) and displayed the results using the visNetwork package (Thieurmel 2016) in Program R (R Core Team 2019).

We analyzed differences in the frequency of occurrence of and mean percentage of time spent in (hereafter, "percentage duration" of) each body orientation (namely FR [front rubbing], BR [back rubbing], or BsR [body-side rubbing]) and posture (namely 2R [bipedal standing position, rubbing], 4R [quadrupedal standing position, rubbing], or SR [sitting position, rubbing]) using 2×2 chi-squared tests. Specifically, these tests compared the differences in the percentage of a visit in which a given bear displayed FR versus BR, FR versus BsR, BR versus BsR, 2R versus 4R, 2R versus SR, and 4R versus SR. In addition, we compared differences in the dispersion of the percentages of time spent in each body orientation or posture during the visits in which each behavior was observed using a *t*-test.

Results

With the automatic cameras, we observed ≥6 different individual bears visiting 5 of the 16 target trees (2 Japanese cedar and 3 Japanese larch) 22 times between May and October across all years. There were 13 visits from males, 1 visit from a female accompanied by 1 offspring (gender unknown; counted as 2 visits), and 7 visits from bears of undetermined gender.

We observed 74 instances of tree-marking behavior over the 22 visits. The average tree-marking rate was 3.4 ± 2.9 times/visit (range = 1–12 times). The average tree-marking duration per bear was 33.8 ± 37.9 seconds (1–161 sec), and there was a positive correlation between the number of times tree-marking was performed per visit and the visit duration ($r = 0.96$). Not all visits resulted in established tree-marking behaviors (Table 1). The analysis of body orientation revealed that there was no difference in the percentage of visits in which BR, FR, and BsR were displayed (59.1% each). By contrast, the analysis of body postures showed that 2R was displayed in 72.7% of visits, significantly more frequently than 4R (59.1%; $\chi^2 = 4.14$, $P = 0.042$) and SR (40.9%; $\chi^2 = 20.6$, $P < 0.001$), and 4R was displayed significantly more frequently than SR ($\chi^2 = 6.61$, $P = 0.010$). In terms of body orientation and posture, there was no significant difference in the percentage duration between FR and BR or BsR, between BR and BsR, between 2R and 4R, or between 4R and SR. However, the percentage duration of 2R was significantly higher than that of SR ($t_{24} = 2.15$, $P = 0.042$).

Both bark-scratching actions (2Sc and SSc) were observed on Japanese larch trees, and the damaged bark

Table 1. Percentages of visits between 2010 and 2015 in which Asiatic black bears (*Ursus thibetanus*) in Japan exhibited tree-marking or associated behaviors and the average (SD) percentage of time occupied by each behavior.

Type of tree-marking or associated behavior		% (no.) of visits in which behavior was displayed (*N* = 22)	Average % (SD) of time occupied by behavior during visits in which the behavior was displayed
Tree-rubbing actions			
4BsR	Quadrupedal standing position, body-side rubbing	59.1 (13)	55.3 (33.6)
2FR	Bipedal standing position, front rubbing	40.9 (9)	40.0 (25.5)
SFR	Sitting position, front rubbing	40.9 (9)	45.3 (17.2)
2BR	Bipedal standing position, back rubbing	59.1 (13)	54.1 (33.9)
SBR	Sitting position, back rubbing	4.5 (1)	10.2 (n/a)[a]
Tree-rubbing orientations			
BsR	Body-side rubbing	59.1 (13)	55.3 (33.6)
FR	Front rubbing	59.1 (13)	59.0 (21.9)
BR	Back rubbing	59.1 (13)	51.0 (35.2)
Tree-rubbing postures			
4R	Quadrupedal standing position, rubbing	59.1 (13)	55.3 (33.6)
2R	Bipedal standing position, rubbing	72.7 (16)	66.5 (32.2)
SR	Sitting position, rubbing	40.9 (9)	41.7 (20.8)
Debarking actions			
2Sc	Bipedal standing position, bark scratching	22.7 (5)	—
SSc	Sitting position, bark scratching	22.7 (5)	—
Associated behaviors			
St	Stomping	36.4 (8)	—

[a]Sitting position, back rubbing was observed only once.

was surrounded by a border entirely stripped of bark by repeated claw-scratching. No bark-biting behavior was observed. Of the 8 visits in which St was confirmed on the same Japanese larch tree (25 Jul to 8 Sep 2011), 6 were by the same male and 2 were by bears of unknown gender. Up to 13 stomps over the same spot were confirmed to have been made as the bears moved away from the target tree (Fig. S3, Supplemental material). We could not observe the urinating behavior.

In the analysis of the order of each action, 4BsR was shown to have the highest probability of being performed immediately after the start of the visit (57%; Fig. 1). Following 4BsR, leaving without St had the highest probability of occurring (48%), followed by 2BR (26%). Following 2BR, 2FR had the highest probability of occurring (38%). Actions that occurred after 2FR included leaving (45%) and 2Sc (36%), and St behavior had a high probability of occurring after 2Sc (60%). The probability of 2BR occurring after 2FR was 0%.

Discussion

To our knowledge, this is the first study of the tree-marking behavior of Asiatic black bears. We found that there were no significant differences in the frequencies or durations of FR and either BR or BsR and of BR and BsR during tree-marking visits, but that a bipedal standing (2R) posture occurred in a high percentage of visits and had a high percentage duration. Other studies have shown that brown bears and American black bears are most likely to perform BR on 2 legs (2BR), rather than BsR while standing on 4 feet (4BsR) or rubbing while standing on 2 legs facing the tree (2FR, Clapham et al. 2014, Taylor et al. 2015). Notably, brown bears may perform scent-marking while sitting and rubbing their backs against the tree in order to mark it with their anal glands and sebaceous glands located on the back (Rosell et al. 2011, Tomiyasu et al. 2017). On the other hand, in a study of Andean bears (Filipczyková et al. 2016), the percentage of visits in which FR and BR were performed was about the same, similar to our findings with Asiatic black bears. In the Andean bear study, however, a lower percentage of 4BsR occurred. In any case, to date few analyses have been conducted on Asiatic black bear glandular secretions and their role in tree-marking.

We also examined the order in which tree-marking actions occurred to determine whether it is related to the ease of transition between actions or to the transition preference; however, it might not be explained by the ease

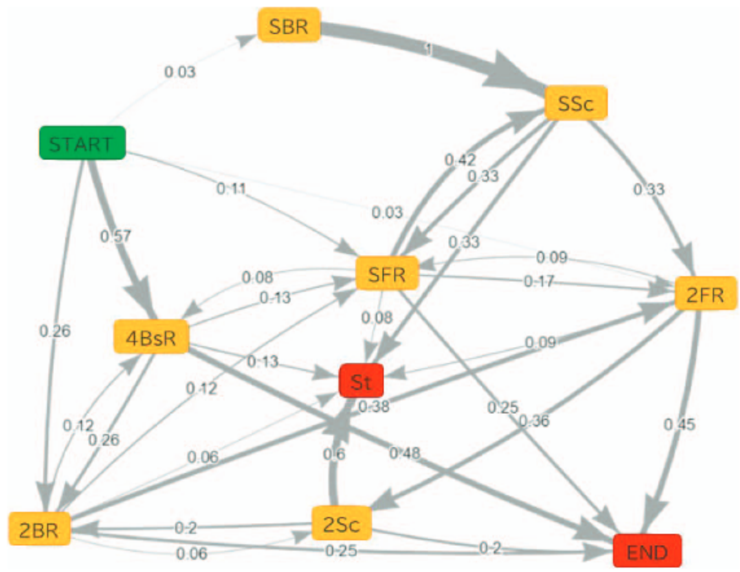

Fig. 1. Order of tree-marking behaviors or actions in Asiatic black bears (*Ursus thibetanus*) in Japan between 2010 and 2015, as determined by multichannel attribution analysis. 2BR, bipedal standing position, back rubbing; 4BsR, quadrupedal standing position, body-side rubbing; 2FR, bipedal standing position, front rubbing; 2Sc, bipedal standing position, bark-scratching; SBR, sitting position, back rubbing; SFR, sitting position, front rubbing; SSc, sitting position, bark-scratching; St, stomping. (The numbers indicate the probability that each behavior will happen next; 0.5 indicates a 50% probability.)

of transition. The bears we observed had a high probability of performing 4BsR immediately after the start of a visit, as observed in mature male and female brown bears (Clapham et al. 2014), likely because the bear approaches the tree while in quadrupedal locomotion. Also, there was a shift from 4BsR to 2BR in 26% of cases, whereas no shifts from 4BsR to 2FR were observed, possibly because the former shift can easily be achieved by slightly moving the direction of the hind legs, whereas the latter also involves changing the direction of the upper body. However, this does not explain why the behavioral transition from 2BR to 2FR was observed, but not the reverse, which would involve an easy postural shift. According to a study of posture transitions conducted in adult brown bears, the most probable transitions were flank-rubbing, BR, and sitting behaviors, in that order (Clapham et al. 2014). In contrast, the Asiatic black bears in this study, albeit a small number of individuals, showed the same behavior as brown bears up to BR, but the next behavior with the highest probability here was FR on 2 legs.

We confirmed that St is associated with tree-rubbing behavior in Asiatic black bears and found that many of the visits in which St was observed were by males. St has also been associated with tree-rubbing behavior in brown bears and American black bears (Clapham et al. 2014, Taylor et al. 2015), and apocrine sweat glands and sebaceous glands have been found on the soles of the feet of mature male brown bears (Sergiel et al. 2017). Brown bears and American black bears also perform St when approaching trees (Clapham et al. 2014, Taylor et al. 2015), but we observed St only when bears were leaving the tree.

We also observed actions 2Sc and SSc, which were associated with the removal of bark, as a series following many instances of tree-rubbing. It is possible that peeling marks function as a visual signal of markings, as is the case for American black bears (Burst and Pelton 1983). Although there are few observations of North American brown bears performing bark-scratching behaviors during tree-rubbing, Japanese brown bears have been observed performing peeling actions, including making bite marks on barks (Sato et al. 2014). The behavior of stripping the bark from the trunk and then feeding on the cambium is known for brown bears in Poland (Żyśk-Gorczyńska et al. 2016), American black bears (Ziegltrum 2009), and Asiatic black bears (Kobashikawa and Koike 2016). However, although both bark-scratching and cambial feeding are performed on the bark of conifers, it is unknown whether these behaviors are related to each other, and no cambial feeding was observed in this study. More research is needed to address these questions.

In summary, we studied the characteristics of the marking behavior of Asiatic black bears at rub trees and found possible differences from other bears in the body orientation tendency when rubbing against a tree and the order of marking behaviors, although the number of bears observed here was limited. To understand the unique characteristics of communication by scent-marking in Asiatic black bears, we need to study a much larger sample of bears, with behavioral analysis from a wider area and specific data on the presence, position, and composition of sebaceous glands and the relationship between them.

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Supplemental material

Fig. S1. Map of the study area and survey site in Okutama, Tokyo, Japan, where we used automatic cameras to record tree-marking and associated behavior of Asiatic black bears (Ursus thibetanus) between 2010 and 2015.

Fig. S2. Classification of tree-marking actions in Asiatic black bears (Ursus thibetanus).

Fig. S3. Sample photographs of steps 1–13 of the stomping behavior by an Asiatic black bear (Ursus thibetanus) in Japan that occurred after tree-rubbing behavior on 25 July 2011, at 1842 hours.