Acta Theriologica 45 (2): 281–287, 2000.
PL ISSN 0001-7051

Scent marking in Eurasian beaver *Castor fiber* during winter

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Rosell F. and Bergan F. 2000. Scent marking in Eurasian beaver *Castor fiber* during winter. Acta Theriologica 45: 281–287.

The Eurasian beaver *Castor fiber* Linnaeus, 1758 deposit castor fluid (castoreum) and/or anal gland secretion at scent mounds in their territory year round. We investigated the hypothesis that during winter Eurasian beavers may intensify use of scent, in year round ice-free water systems, during the breeding season. This study showed that the median number of scent marks in 7 territories increased significantly in the breeding (January–March 1996), compared to the nonbreeding portion of winter (October–December 1995), which is consistent with our prediction. The median number of scent marks was significantly higher during February, compared to January and March. This may be due to females approaching or being in oestrous in our study area during February. Further studies are, however, needed to clarify how information in scent marks are coded and transmitted during the breeding season.

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Key words: Castor fiber, scent marking, breeding season, Norway

Introduction

Various functions have been proposed for scent marking in mammals: identification of species, race, group, or individuals; signalling dominance status, reproductive status, or mood; promoting synchronisation of reproductive cycles, attracting members of the opposite sex, defence of a territory, and reassurance (see for example, reviews by Eisenberg and Kleiman 1972, Johnson 1973, Müller-Schwarze 1974, Thiessen and Rice 1976, Brown 1979).

In many mammalian species the frequency of scent marking increases markedly in the breeding season, and particularly during courtship as the female approaches oestrous (eg Johnson 1973, Gorman and Trowbridge 1989, Matochik *et al.* 1992, Setz and Gaspar 1997). Such increase involves both marking with scent organs (Rasa 1973, Kruuk *et al.* 1984) and especially marking with urine, which is a potentially rich source of information concerning reproductive state (Macdonald 1979, 1985, Wells and Bekoff 1981). In female mammals, blood titers of estradiol increase during the follicular phase of the oestrous cycle and drop abruptly at ovulation. Oestrogen levels are therefore an accurate indicator of changes in female receptivity (Gorman and Trowbridge 1989). Indeed, gonadal control of scent

marking is found in many different species (eg Stoddart 1972, Mech and Peters 1977, Macdonald 1979, 1985, Sun *et al.* 1994). Epple (1974) suggested that sexual odours might help synchronise seasonal breeding (see also Boinski 1992). Odours in this context serve as a kind of self-advertisement, functioning as an olfactory display, and synchronising sexual arousal and patterns of sexual behaviour (see also Houlihan 1989). Epple (1974) also suggests that pregnant *Saguinus* females monkeys could use scent-marking to strengthen the pair-bond.

Beavers (*Castor* spp.) are territorial and live in family units (eg Bradt 1938, Aleksiuk 1968, Wilsson 1971, Nolet and Rosell 1994). The basic family unit consists of a monogamous adult pair, young of the year, yearlings and sometimes two-year olds or older (eg Kudrjasov 1973, Bergerud and Miller 1977, Svendsen 1989, Schulte 1993). Eurasian beavers *Castor fiber* Linnaeus, 1758 deposit castor fluid from the castor sacs and/or anal gland secretion (AGS) at scent mounds inside the territory during the entire year (Rosell *et al.* 1998). All beavers may deposit scent, but the adult pair, especially the male, is the primary marker (Hodgdon 1978, Svendsen 1980, Buech 1995). The anal gland is a holocrine secretory gland, but the castor sac is only a pocket lined with a layer of nonsecretory epithelium (Svendsen 1978). The castor sac is believed to be used to store a mixture of secondary metabolites from urine, collectively called castoreum (Svendsen 1978).

One of the main functions of scent marking appears to be the maintenance of territorial rights in both the North American *C. canadensis* Kuhl, 1820 (eg Houlihan 1989, Welsh and Müller-Schwarze 1989, Schulte 1998) and Eurasian beaver (Rosell and Nolet 1997, Rosell and Bergan 1998, Rosell *et al.* 1998). However, one aspect of beaver scent marking behaviour that has attracted little research is scent marking during the winter season. Presumably this is because the animals are difficult to observe under the cover of ice (see Hodgdon 1978, Bollinger 1980, Svendsen 1980), or they simply have not been observed during the winter season. In two studies, only a few scent mounds where recorded in two territories (Nitsche 1985a, b, Klenner-Fringes 1992). More definitive research of Eurasian beavers is needed to determine the relationship between winter season and scent marking activity.

We investigated the hypothesis that Eurasian beavers emphasize scent marking behavior during the breeding season in year round, ice-free water systems. We predicted that during winter, the number of scent marks would be significantly higher during the breeding (January–March) than the nonbreeding portion of winter (October–December).

Material and methods

The study was conducted on a 9.2 km section of the Bø River in the municipality of Bø (59°25'N, 09°03'E), Telemark County, Norway. The part of the river studied averages 35 m in width and meanders through a mixed woodland and agricultural countryside dominated by marine and fluvial deposits (Bergan 1996). Vegetation along the river consists mainly of alder (*Alnus incana*) with lesser

amounts of willow *Salix* spp., birch *Betula pubescens*, aspen *Populus tremula*, rowan *Sorbus aucuparia*, Norway spruce *Picea abies*, and Scots pine *Pinus sylvestris*. During winter, a hydroelectric power station upstream regulates flow and water temperature, keeping the river ice-free (Rosell *et al.* 1998). The river has been occupied by beavers since the 1930s (Olstad 1937).

Observations of scent marking activity were recorded biweekly during October–December (nonbreeding portion of winter) 1995, and weekly during January–March 1996 (breeding portion of winter). Each side of the river within the study area was searched, by canoe, for newly used scent mounds. All beaver ascents from the water were examinated closely. Scent mounds are usually small piles of mud and debris, scraped together on land by beavers upon which secretion from the castor sacs and/or anal glands are deposited (eg Wilsson 1971, Rosell and Bergan 1998). A freshly marked scent mound, ie with a scent detectable by the human nose at 2 cm or more, was termed a "scent mark". This definition also included marks directly on the ground or on tussocks. Minimum distance between two different scent mounds was 10 cm. If a scent mound did not have a smell detectable by the human nose, it was thought to be old and excluded from analysis (see however Bollinger 1980, Schulte 1993). Each scent mark was labelled for recognition, either with a small wooden stake placed 0.5 – 1 m behind the mark, or by writing the number on natural objects such as trees. All scent marks found were registered on a 1:5000 map. After each land visit, boots were cleaned in water to minimise transport of scent from one area to another. Whenever possible, marks were smelled from the canoe, ie without actually stepping out (Rosell *et al.* 1998).

We compared numbers of scent marks observed during the breeding versus nonbreeding portion of winter. The results from this comparison are presented with data based on scent mark registrations biweekly (see Rosell *et al.* 1998 for further details). The differences in number of scent marks during the breeding portion of winter are based on weekly registrations.

Rosell *et al.* (1998) recorded 28 beavers in the study area during autumn 1995. Family size varied from 3 to 7 ($\bar{x}$ = 4 ± 0.6 SE, n = 7). Seventy-one percent were adults (≥ 2-years-old), 22% were 1-year-olds and 7% were kits. Only one colony produced young in 1995 (two kits). This low number of kits was probably due to a flood in the end of May to the beginning of June during which many may have drowned inside their lodges. All families, except family 4, had one yearling (Rosell *et al.* 1998). Territorial borders for each family were as described by Rosell *et al.* (1998).

Because data do not fit assumptions of distribution and homogeneity of variance for parametric analysis (Sokal and Rohlf 1995), we used nonparametric statistics in accordance with Siegel and Castellan (1988). Nonparametric tests were corrected for ties. Probability values are two-tailed and 5% was used as the level of significance. Mean and median values are presented with standard errors.

Results

Characteristics of scent marks and sites

A total of 678 scent marks ($\bar{x}$ = 97 ± 16.2 per family) were found within 7 territories during January–March in 1996. During 30 November 1995 to 9 March 1996, beavers in this study only made mounds of snow (no mud was collected from the bottom of the river). In this period, the river banks were covered with snow to the water's edge.

Number of scent marks during breeding- and nonbreeding portion of winter

We found a significant difference in the median number of scent marks between the nonbreeding- and breeding portion of winter (Wilcoxon matched-pairs signed-ranks test: Z = –2.4, n = 7, p = 0.018). The median number of scent marks was 72 ± 9.6 during the breeding portion of winter and 31 ± 4.9 during the nonbreeding portion of winter.

There was also a significant difference in the median number of scent marks during the breeding portion of winter (Friedman two-way ANOVA: $\chi^2 = 14.0$, df = 2, $p = 0.0009$), between the months January and February, January and March, and between the months February and March (Wilcoxon matched-pairs signed-ranks test: $Z = -2.4$, $n = 7$, $p = 0.018$ for all comparisons), with February higher than January and March (January: 17 ± 2.4, February: 62 ± 9.2 and March: 3 5 ± 4.9).

Discussion

Beavers in our study area scent-marked significantly more during the breeding (January–March) versus the nonbreeding portion of winter (October–December). This finding is consistent with our prediction. Within the breeding portion of winter, the significantly higher median number of scent marks during February, compared with both January and March, suggests that in our study area females are approaching or in oestrus during February. Indeed, several recordings of blood-red marks on the mounds in our study area during February 1996, 1997 and 1998 (F. Rosell, unpubl.) suggested that oestrous females scent marked during this period. No blood-red marks were recorded during January 1996, 1997, or 1998. Further, the gestation period of Eurasian beaver is considered to last 105–107 days (Wilsson 1971, Djoshkin and Safonow 1972, Doboszyńska and Żurowski 1983), so parturition should then occur from mid-May to the beginning of June. This is consistent with parturition dates for our area (F. Rosell, unpubl.). Brenner (1964) found scent marks only during breeding time (in January–February 1959 and in February 1960) in his study of the North American beaver. His estimated breeding dates corresponded with observations of scent marking in the field.

Svendsen (1980) stated that the adult beaver pair are in contact with each other daily inside the lodge and oestrous cues produced by the female can easily be perceived by the male and need not be spread around to attract a mate (see also Houlihan 1989). However, in some places the adult male and female maintain two or more winter lodges and may be found in separate lodges (F. Rosell and F. Bergan, unpubl., B. Schulte, pers. comm.). Also, during ice-free conditions in winter, Eurasian beavers are active outside the lodge for approximately 12 hours daily (Nolet and Rosell 1994). Because the female is receptive for only about 12 hours during each oestrous cycle (Wilsson 1971), she may need an effective method to advertise her reproductive status even if she mates with her lodge-mate. Females may deposit castoreum [volatiles with low molecular weight (Tang *et al.* 1993, 1995)] at scent mounds to signal to males that ovulation has occurred and to attract them from a distance. In contrast, AGS [high molecular weight (Grønneberg 1978, Grønneberg and Lie 1984, Sun 1996)] may give detailed information at the individual level and therefore induce mating when at a close-range. However, males are thought to be the primary markers (eg Buech 1995) and they may increase their scent marking activity during the breeding season to keep other males away from

the territory which contain the receptive female, probably by using both castoreum and AGS.

The results supported our hypothesis that Eurasian beaver emphasize scent marking behavior during the breeding season in year-round, ice-free water systems. The results also supported our prediction that in winter the number of scent marks would be significantly higher during the breeding versus the nonbreeding portion of winter. Further studies are, however, needed to clarify how information in scent marks are coded and transmitted during the breeding season.

Acknowledgements: We thank G. Hartman, J. Heggenes, B. A. Schulte, A. Sliwa and L. Sun for comments on an earlier draft, two anonymous reviewers for comments on the submitted manuscript and H. Parker for valuable discussions. The study was supported financially by the Telemark County Conservation Department, and Telemark College, Norway.

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Received 16 November 1998, accepted 16 August 1999.