

Scent marking by male caribou: an experimental test of rubbing behavior

Craig A. Adams¹, R. Terry Bowyer^{2,4}, Jan E. Rowell², William E. Hauer³, & Jonathan A. Jenks³

¹ College of Veterinary Medicine, Washington State University, P.O. Box 647012, Pullman, WA 99164, USA.

² Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, AK 99775, USA.

³ Wildlife and Fisheries Sciences, South Dakota State University, Box 2140B, Brookings, SD 57007, USA.

⁴ corresponding author (ffrtb@uaf.edu).

Abstract: We studied scent marking by adult male caribou (*Rangifer tarandus*) during rut in September 1998 at the Large Animal Research Station in Fairbanks, Alaska, USA. We used an experimental approach involving two captive groups of two males each to test for effects of social status, tree size, texture, and scent on rubbing behavior by caribou. Dominant males did not rub more often or for a longer duration than subordinates. Caribou rubbed trees with smaller diameters more often than large-diameter trees. Males preferred trees with bark for rubbing to those trees with their bark removed prior to the experiment. Caribou exhibited no preference for posts with pine-oil applied compared with posts without that aromatic scent. We hypothesize that rubbing of trees by male caribou is related to synchronization or priming of estrus in females, but more research is needed to test that potential function of scent marking.

Key words: behavior, caribou, dominance, *Rangifer tarandus*, rubbing, rut, scent marking.

Rangifer, 21 (1): 21–27
κ

Introduction

Scent marking is a common behavior among mammals (Ralls, 1971), and has been particularly well described for the species of ungulates (Coblentz, 1976; Gosling, 1985). Glands involved and putative pheromones released also have been identified for some species (Quay & Müller-Schwarze, 1970; Müller-Schwarze *et al.*, 1978a, b; Mossing & Damber, 1981; Mossing & Kallquist, 1981; Atkeson & Marchinton, 1982; Flood, 1989). The Cervidae possess a rich repertoire of scent-marking behaviors that often involve deposition of urine, scraping the ground, wallowing, and

barking and rubbing of shrubs and trees (Bowyer *et al.*, 1994 for review).

The rubbing of trees (i.e., scent-posting) has been described for an array of cervids including territorial species such as fallow deer (*Dama dama*; Massei & Bowyer, 1999) and roe deer (*Capreolus capreolus*; Johansson *et al.*, 1995), as well as nonterritorial species including mule deer (*Odocoileus hemionus*; Bowyer, 1986), white-tailed deer (*O. virginianus*; Nielsen *et al.*, 1982; Miller *et al.*, 1987; Benner & Bowyer, 1988; Oehler *et al.*, 1985), North American elk (*Cervus elaphus*; Bowyer & Kitchen, 1987), and moose

(*Alces alces*; Bowyer *et al.*, 1994). The physical characteristics of trees and their aromatic properties are thought to play a role in determining which trees cervids select for scent marking (Benner & Bowyer, 1988; Bowyer *et al.*, 1994; Oehler *et al.*, 1995; Massei & Bowyer, 1999). The function of rubbing by cervids remains uncertain, but probably relates to dominance or reproductive status of individuals that perform those behaviors (Bowyer *et al.*, 1994; Oehler *et al.*, 1995; Massei & Bowyer, 1999). The rubbing of trees by reindeer and caribou (*Rangifer tarandus*) has been described (i.e., antler rubbing, Espmark, 1964; bush-thrashing, Bergerud, 1974; head rubbing, antler thrashing, Pruitt, 1966, Müller-Schwarze *et al.*, 1979), but accounts of this behavior are not as detailed as for other North American cervids. In addition, preferences for and against particular species of trees to rub have been determined in the field for many ungulates, but few experimental studies of scent marking exist for cervids, and none for rubbing by caribou. This lack of an experimental approach has led to controversy over which characteristics of trees are most important in determining rubbing behavior among the Cervidae (Benner & Bowyer, 1988; Oehler *et al.*, 1995).

We conducted an experiment using a captive herd of caribou to test hypotheses about scent marking (rubbing) by adult males during rut. We tested the following null hypotheses to gain insights into the potential function of scent marking in this arctic ungulate: 1) dominance status has no effect on rubbing behavior; 2) males do not select particular size-classes of trees to rub; 3) texture of trees do not affect selection by males; and 4) an aromatic scent has no effect on which posts are rubbed.

Materials and methods

We conducted research at the Large Animal Research Station, University of Alaska Fairbanks, Fairbanks, Alaska, USA (64°52'N, 147°51'W) where captive caribou, originating from the Porcupine herd in northeastern Alaska, are maintained for research purposes. The study pen was 2385 m² (Fig. 1) and was constructed of solid steel and plywood panels 1.8 m in height. Test animals were isolated visually from females (80 m away) with solid fence panels and from the

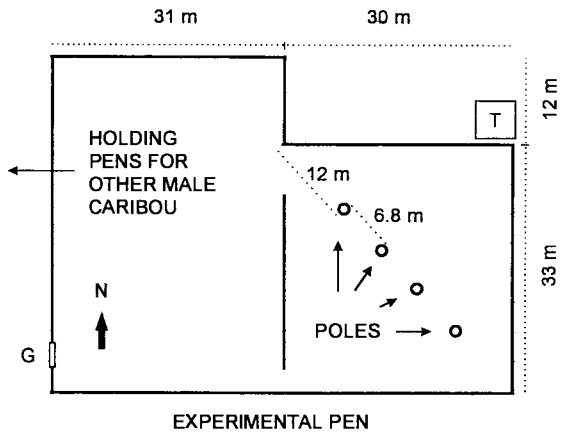


Fig. 1. Overview of the pen used for observations of scent marking by male caribou, Large Animal Research Station, University of Alaska Fairbanks, Fairbanks, Alaska, USA. Circles represent placement of posts. The observation tower (T) and the gate (G) through which the animals entered the trial pen from the holding pens are indicated. The pen was partially divided by a steel-paneled fence.

other males for the entire 19-day duration of the study. Four posts, which were offered in each treatment for scent marking by caribou, were anchored solidly into four buried steel pipes within the enclosure. The pipes were spaced 6.8 m apart, were 12 m from the corner of the pen, and were arranged to offer an unobstructed view from the 3.5-m high observation tower located immediately NE of the study pen (Fig. 1). Posts that were placed in pipes were approximately 2 m tall when measured from the ground, and were changed for each scent-marking trial; each post was used only once. A circle with a radius of 1 m was painted on the ground around each post to help quantify behaviors associated with scent marking.

On 21 September 1998, following velvet shedding and onset of rut, four adult male caribou were assigned randomly into two groups of two individuals each. The research was partitioned into 12 trials: two groups of males in two treatments with three replicates. For the first treatment, four birch trees (*Betula papyrifera*) without branches and with diameters 2.5, 5, 7.5, and 10 cm, respectively, as measured at the end not placed in the ground, were located in pipes randomly. Those posts were available to a group of two caribou for 24 h. During that period, animals were observed for two, 3-h periods, from

approximately 1500 to 1800 h Alaska Standard Time, when the animals were first introduced into the pen, and again the next morning from 0700 to 1000 h. All observations were made and recorded by C. A. Adams, who viewed caribou from the observation tower, using all-occurrences sampling (Altmann, 1974). Dominance status within each group was established via behavioral observations prior to and during the experiment; antler threats were used most often to establish and maintain dominance relations between pairs of males. Once established, dominance status of males was consistent throughout the duration of our study, as noted for other caribou by Barrette & Vandal (1986).

Activities occurring within the 1-m circle around each post were divided into seven categories. We defined an approach without intent as occurring when an animal came within 1 m of a post but did not stop or stare at the post. An approach with intent was similar except that the animal faced the post for >1s and also may have slowed or stopped within the 1-m circle. Approaches with intent were further subdivided into flehmens (Estes, 1973), sniffs, nibbles, and licks if associated with those other behaviors. Rubbing (scent posting) occurred when an animal performed some combination of those behaviors in addition to scraping or thrashing the post with the antlers and rubbing a preorbital gland or its forehead on the post or tree. Such events have been described elsewhere as «bush thrashing» (Bergerud, 1974), «head rubbing», and «antler thrashing» (Pruitt, 1966; Müller-Schwartz *et al.*, 1979). Rubbing events were timed to the nearest 1 s with a hand-held stopwatch. Posts were replaced randomly with similar poles for the next group of males and then those caribou were brought into the pen for 24 h.

For the second treatment, animals were presented two posts of different texture and two with differing scent. Black spruce (*Picea mariana*) trees approximately 7.5 cm in diameter with branches removed, one with bark removed and the other with bark intact, were used for the texture trial. For the scent trial, two douglas fir (*Pseudotsuga menziesii*) commercial building studs each 3.8 by 8.9 cm were offered to caribou, one of the studs was treated with 3 ml of pine oil ((1S)-(-)- α -Pinene; 98%). Pine oil is a common constituent of conifers (T. Clausen, pers. commun.). Poles for scent and texture trials were pre-

sented together (i.e., the two spruce trees and two pieces of lumber were next to each other), but their position in the pipes was arranged randomly. A second set of poles with the same characteristics was erected for the next group of animals. Posts were cut on the day of the trial. One complete replicate took 4 days. Each replicate was repeated two more times for a total of 12 days of observations.

During trials, animals had access to water but there was no feeder, which potentially could bias the amount of time spent in one part of the enclosure. Male cervids reduce food intake during rut (Bowyer, 1981; Miquelle, 1990; Suttie *et al.*, 1992), and absence of food for 24 h was deemed humane. All aspects of this research were approved by an Institutional Animal Care and Use Committee at the University of Alaska Fairbanks, and were in keeping with guidelines established by the American Society of Mammalogists for experimental research on mammals (Animal Care and Use Committee, 1998).

Data were analyzed with *t*-tests and χ^2 analyses (Zar, 1996). The two-sample Z-test for proportions (Remington & Schork, 1970) was used to compare behaviors that were sampled with replacement (i.e., repeated behaviors by the same animal or dominance class of animals); thus, these samples were not pseudoreplicates. For other analyses, however, our domain of inference is our experimental area. During trials caribou broke some posts; consequently, expected values used in the χ^2 analyses were adjusted by the amount of time that each post was available for scent marking. An $\alpha = 0.05$ was adopted for all tests. Our analyses do not control for the sequence of marking behaviors by one individual and its effect on scent marking by the other during an experiment (i.e., a time-series effect is not considered). That potential bias, however, is similar for all our trials, and should not affect our tests of hypotheses markedly.

Results

Dominant male caribou rubbed posts in 54.3% and subordinates did so in 45.7% of 236 observations; this difference was not significant ($\chi^2 = 1.69$, 1 *df*, $P > 0.1$). Likewise, no difference ($Z = 0.7$, $P > 0.5$, $n = 385$) occurred in the total number of approaches toward a post between those

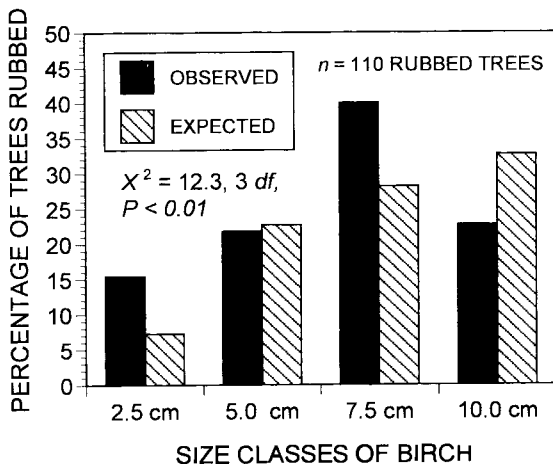


Fig. 2. Percentage of birch trees from four diameter classes rubbed (scent marked) by male caribou at the Large Animal Research Station, University of Alaska Fairbanks, Fairbanks, Alaska, USA, September 1998. Expected values varied based on the amount of time each post was available for rubbing, because caribou broke some posts while scent marking.

social categories of males. Dominant and subordinate males also rubbed posts for the same duration ($t = 1.57, P > 0.1$); mean duration of rubbing was 70 and 100 s, respectively. Consequently, data for dominant and subordinate animals were pooled for remaining analyses.

Caribou rubbed (scent marked) birch trees with differing diameters in a manner dissimilar from what was expected from the relative availabilities of those trees (Fig. 2). Partial χ^2 analysis indicated that overall difference (Fig. 2) was driven by selection (use > available) for trees with diameters of 2.5 cm ($P < 0.005$) and 7.5 cm ($P < 0.05$), and avoidance (use < available) of trees with diameters of 10.0 cm ($P < 0.08$). Males preferred to rub spruce trees with bark rather than trees with bark removed and did so in 74% of the observations (Fig. 3). Caribou showed no preference among poles scented with pine oil or unscented poles (Fig. 3).

Discussion

Scent marking is an important component of rutting behavior in cervids and may be used for both male-male and male-female communication. In white-tailed deer and mule deer, rubbing of trees can precede aggressive behavior between males (Marchinton & Hirth, 1984; Bowyer,

1986; Benner & Bowyer, 1988). Likewise, Pruitt (1966) noted thrashing behavior prior to aggressive behavior between male caribou. Scent-urination is another dominance display used by many male cervids (McCullough, 1969; Coblenz, 1976), but scent marking in some cervids (e.g., male moose) is directed primarily toward females (Miquelle, 1991; Bowyer *et al.*, 1994). One surprising outcome of our study was the absence of an obvious association between scent marking and male dominance (i.e., males of higher social status did not rub more often than subordinates).

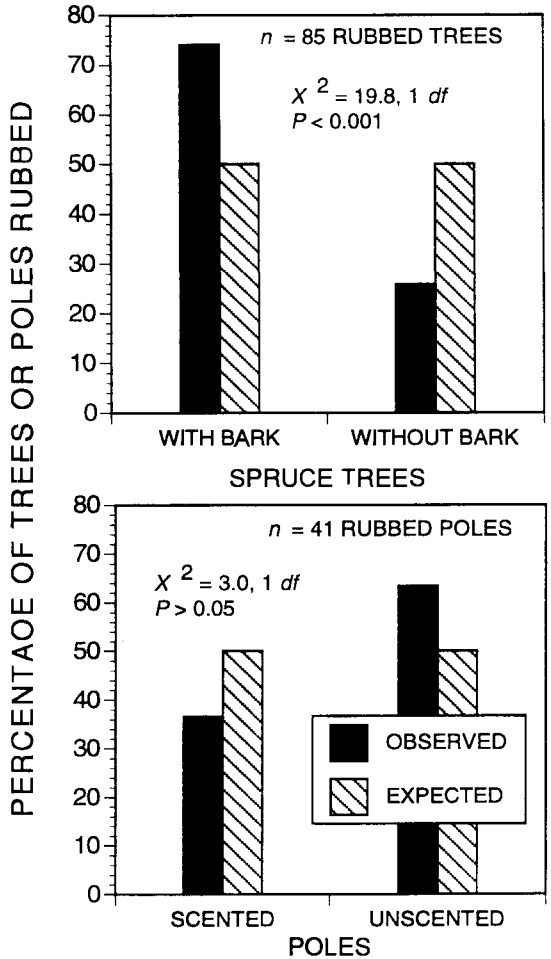


Fig. 3. Percentage of trees or posts rubbed (scent marked) by male caribou for two trials: spruce trees with and without bark; and commercial building studs with and without 3 ml of pine oil applied, Large Animal Research Station, University of Alaska Fairbanks, Fairbanks, Alaska, USA, September 1998. Caribou were expected to show no preference and, therefore, rub each post in 50% of the observations.

An association between scent-urination and dominance, but not rubbing of trees, has been well documented for North American elk (McCullough, 1969; Bowyer & Kitchen, 1987). A potential reason for dominant caribou not scent marking more than subordinates was that dominance relations were well established prior to the trials; there was no need for males to further establish dominance via scent marking. Males, however, continued to reinforce dominance status with antler threats throughout our study. Plainly, dominant male caribou did not use rubbing to reinforce or advertise social status during the course of our experiment. The absence of female caribou also may have contributed to the lack of association between rubbing of trees and dominance status. Females were held 80 m away from males, and males may have been aware of females because of olfactory cues; males did not, however, engage in fights over estrous females during our experiment. In our observations, dominance was less important in determining which animals scent marked posts than other factors. Research under natural conditions, where more caribou and other stimuli are available to elicit scent marking, is needed to resolve this issue.

Our data indicated that tree size (Fig. 2) and the absence of bark (Fig. 3) were important in selection of posts for scent marking. Smaller posts may produce louder sounds during antler thrashing than large posts, and that auditory cue may draw the attention of females or other males. Likewise, scraping bark and rubbing trees while scent marking may establish visual cues for females, which allow them to more easily identify the posts upon which the pheromones of the male were deposited (Bowyer *et al.*, 1994).

No preference occurred by male caribou for scented or unscented posts (Fig. 3). That outcome was the first critical test of the role of scent in selection of rubs for any cervid, where other factors such as size and species of tree were controlled. We used an aromatic substance (pine oil) common to many conifers, but cannot conclude that some other substance may have elicited scent-marking behavior by males. Selection of aromatic trees for scent marking is controversial, especially with regard to white-tailed deer (Kile & Marchinton, 1977; Benner & Bowyer, 1988; Oehler *et al.*, 1995). For caribou, pine oil on a post was less important than other attributes, a

conclusion also reached for rubbing by other cervids under natural conditions (Johansson *et al.*, 1995; Massei & Bowyer, 1999).

In our experiment, rubbing of trees and posts by male caribou was not used to reinforce male dominance. Antler thrashing is a dominance display among most male cervids (Bowyer & Kitchen, 1987), and may occur independently of rubbing in numerous species, including reindeer and caribou (Espmark, 1964; Pruitt, 1966; Bowyer, 1986; Bowyer & Kitchen, 1987; Bowyer *et al.*, 1994). Thus, antler thrashing followed by rubbing of a tree or shrub by male caribou might impart different information to conspecifics than antler thrashing alone. For instance, in moose (Bowyer *et al.*, 1994) and bison (*Bison bison*; Bowyer *et al.*, 1998), the rubbing of trees occurred in a male-female context and was hypothesized to be related to estrus in females. Given the behavioral context of rubbing in other ungulates, we hypothesize that the purpose of the rubbing behavior in caribou is primarily male-female communication, and that this behavior may relate to priming or synchronization of estrus in females. Additional research, however, will be needed to test this hypothesis, especially studies on the behavioral and physiological responses of females to trees rubbed by male caribou.

Acknowledgments

We are indebted to the staff and volunteers at the Large Animal Research Station for their assistance. D. R. Klein and K. M. Stewart provided helpful reviews of our manuscript. This study was funded by the Institute of Arctic Biology at the University of Alaska Fairbanks.

References

- Altman, J. 1974. Observational study of behavior: sampling methods. – *Behaviour* 49: 227–267.
- Animal Care and Use Committee. 1998. Guidelines for the capture, handling, and care of mammals as approved by the American Society of Mammalogists. – *J. Mammal.* 79: 1416–1413.
- Andersson, G. 1979. Volatile ketones from the preorbital gland of reindeer (*Rangifer t. tarandus* L.). – *J. Chem. Ecol.* 5: 629–634.
- Atkeson, T. D & Marchinton, R. L. 1982. Forehead glands in white-tailed deer. – *J. Mammal.* 63: 613–617.

- Barrette, C. & Vandal, D.** 1986. Social rank, dominance, antler size, and access to food in snow-bound wild woodland caribou. – *Behaviour* 97: 118–146.
- Benner, J. M. & Bowyer, R. T.** 1988. Selection of trees for rubs by white-tailed deer in Maine. – *J. Mammal.* 69: 624–627.
- Bergerud, A. T.** 1974. Rutting behaviour of Newfoundland caribou. – In: V. Geist, F. Walther (eds.). *The behaviour of ungulates and its relation to management*. Publ. No. 24 (n.s.), IUCN, pp. 395–435. Morges, Switzerland.
- Bowyer, R. T.** 1981. Activity, movement, and distribution of Roosevelt elk during rut. – *J. Mammal.* 62: 574–582.
- Bowyer, R. T.** 1986. Antler characteristics as related to social status of male southern mule deer. – *Southwest. Nat.* 31: 289–298.
- Bowyer, R. T. & Kitchen, D. W.** 1987. Significance of scent-marking by Roosevelt elk. – *J. Mammal.* 68: 418–423.
- Bowyer, R. T., Van Ballenberghe, V. & Rock, K. R.** 1994. Scent marking by Alaskan moose: characteristics and spatial distribution of rubbed trees. – *Can. J. Zool.* 72: 2186–2192.
- Bowyer, R. T., Manteca, X. & Hoymork, A.** 1998. Scent marking in American bison: morphological and spatial characteristics of wallows and rubbed trees. – In: L. Irby & J. Knight (eds.). *International Symposium on Bison Ecology and Management in North America*, pp. 81–91. Montana State University, Bozeman, MT.
- Coblentz, B. F.** 1976. Function of scent-urination in ungulates with special reference to feral goats (*Capra hircus*). – *Am. Nat.* 110: 549–557.
- Espmark, Y.** 1964. Rutting behaviour in reindeer (*Rangifer tarandus* L.). – *Anim. Behav.* 12: 159–163.
- Estes, R. D.** 1973. The role of the vomeronasal organ in mammalian reproduction. – *Mammalia* 36: 315–341.
- Flood, P. F., Abrams, S. R., Muir, G. D. & Rowell, J. E.** 1989. Odor of the muskox: a preliminary investigation. – *J. Chem. Ecol.* 15: 2007–2217.
- Gosling, L. M.** 1985. The even toed ungulates: order Artiodactyla. Sources, behavioral context, and function of chemical signals. – In: R. E. Brown & D. W. MacDonald (eds.). *Social odors in mammals*, pp. 560–618. Oxford Univ. Press, Oxford, U.K.
- Kile, T. L. & Marchinton, R. L.** 1977. White-tailed deer rubs and scrapes: spatial, temporal, and physical characteristics and social role. – *Am. Midland Nat.* 97: 257–266.
- Johansson, A., Liberg, O. & Wahlstrom, L. K.** 1995. Temporal and physical characteristics of scraping and rubbing in roe deer (*Capreolus capreolus*). – *J. Mammal.* 76: 123–129.
- Marchinton, R. L. & Hirth, D. H.** 1984. Behavior. – In: L. K. Halls (ed.). *White-tailed deer: ecology and management*, pp. 129–168. Stackpole Books, the Wildlife Management Institute, Washington D.C.
- Massei, G. & Bowyer, R. T.** 1999. Scent marking in fallow deer: effects of lekking behavior on rubbing and wallowing. – *J. Mammal.* 80: 633–638.
- McCullough, D. R.** 1969. The tule elk: its history, behavior, and ecology. – *Univ. Calif. Publ. Zool.* 88: 1–209.
- Miller, K. V., Kammermeyer, K. E., Marchinton, R. L. & Moser, B. E.** 1987. Population and habitat influences on antler rubbing by white-tailed deer. – *J. Wildl. Manage.* 51: 62–66.
- Miquelle, D. G.** 1990. Why don't bull moose eat during the rut? – *Behav. Ecol. Sociobiol.* 27: 145–151.
- Miquelle, D. G.** 1991. Are moose mice? The function of scent-urination in moose. – *Am. Nat.* 138: 460–477.
- Mossing, T. & Damber, J.** 1981. Rutting behavior and androgen variation in reindeer (*Rangifer tarandus* L.). – *J. Chem. Ecol.* 7: 377–389.
- Mossing, T. & Källquist, L.** 1981. Variation in cutaneous glandular structures in reindeer (*Rangifer tarandus*). – *J. Mammal.* 62: 606–612.
- Müller-Schwartz, D., Källquist, L., Mossing, T., Brundin, T. & Anderson, G.** 1978a. Responses of reindeer to interdigital secretions of conspecifics. – *J. Chem. Ecol.* 4: 325–335.
- Müller-Schwartz, D., Ravid, U., Claesson, A., Singer, A. G., Silverstein, R. M., Müller-Schwartz, C., Volkman, N. J., Zemanek, K. F. & Butler, R. G.** 1978b. The «deer lactone»: source, chiral properties, and responses by black-tailed deer. – *J. Chem. Ecol.* 4: 247–256.
- Müller-Schwartz, D., Källquist, L. & Mossing, T.** 1979. Social behavior and chemical communication in reindeer (*Rangifer t. tarandus* L.). – *J. Chem. Ecol.* 5: 483–517.
- Nielsen, D. G., Dunlap, M. J. & Miller, K. V.** 1982. Pre-rut rubbing by white-tailed bucks: nursery damage, social role, and management options. – *Wildl. Soc. Bull.* 10: 341–348.
- Oehler, M. W., Sr., Jenks, J. A. & Bowyer, R. T.** 1995. Antler rubs by white-tailed deer: the importance of trees in a prairie environment. – *Can. J. Zool.* 73: 1383–1386.
- Pruitt, W. O., Jr.** 1966. The function of the brow-tine in caribou antlers. – *Arctic* 19: 111–113.
- Quay, W. B. & Müller-Schwartz, D.** 1970. Functional histology of integumentary glandular

- regions in black-tailed deer (*Odocoileus hemionus columbianus*). – *J. Mammal.* 51: 675–694.
- Ralls, K.** 1971. Mammalian scent marking. – *Science* 171: 443–449.
- Remington, R. D. & Schork, M. A.** 1970. *Statistics with applications to the biological and health sciences*. Prentice-Hall, Englewood Cliffs, N.J.
- Suttie, J. M., White, R. G. & Littlejohn, R. P.** 1992. Pulsatile growth hormone secretion during the breeding season in male reindeer and its association with hypophagia and weight loss. – *Gen. Comp. Endocr.* 85: 36–42.
- Zar, J. H.** 1996. *Biostatistical Analysis*. Prentice Hall, N.J.

*Manuscript received 25 April, 2000
accepted 13 November, 2000*