FLEHMEN IN CAPTIVE MOOSE CALVES (*ALCES ALCES AMERICANA*)

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ABSTRACT: A total of 256 instances of Flehmen was recorded for 12 (6 male/female pairs) captive moose calves (*Alces alces americana*). All calves displayed Flehmen and urine appeared to be the primary stimulus for the behaviour. Male calves displayed higher frequencies of Flehmen than did females (11.0 Flehmen/100 urinations *versus* 1.5 Flehmen/100 urinations). Males showed a seasonal pattern in the occurrence of Flehmen, with peak frequencies occurring mid-December to mid-February. Females did not display this trend. Most Flehmen were performed in response to an animal's own urine with male and female calves showing the same relative frequency of self-directed Flehmen.

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In ungulates, Flehmen (or lipcurl) is a stereotypic behaviour most often performed by mature males in response to conspecific female urine during the reproductive season (Henderson *et al.* 1980, Crump *et al.* 1984). Flehmen is thought to direct stimuli to the vomeronasal organ (Ladewig and Hart 1980, Altieri and Müller-Schwarze 1980) which appears to function as a chemoreceptor allowing males to assess the estrous status of females (O'Brien 1982; Bland and Jubilan 1987, Houpt *et al.* 1989). Although Flehmen is primarily a behaviour of adult males it is known in females (Pfeifer 1985; Nielsen and Luescher 1988, Thompson 1991) and subadults (Reinhardt 1983, Crowell-Davis and Houpt 1985).

In moose, Flehmen is usually displayed by bulls during the rut, after sniffing the external genitalia or urine of cows (Lent 1974). Geist (1963) reported that a captive male calf showed Flehmen upon smelling its own genitalia after urinating and that a wild calf showed Flehmen after pawing the ground and forming a wallow. Flehmen by cow moose has not been reported.

We collected data on the occurrence of Flehmen in calves as part of other studies on behaviour of captive moose. Since Flehmen in cow moose has not been reported, we expected that male calves would display higher rates of Flehmen than would females. Also, since wild male calves showed increased gonadal activity during mid-October to mid-November (Bubenik and Timmermann 1982), we expected increases in Flehmen behaviour in captive male calves during this period.

The purpose of this paper is to describe the occurrence of Flehmen in captive moose calves.

METHODS

Newborn moose calves were collected from the wild in May 1982 and raised in Algonquin Provincial Park, Ontario (45°33'N, 78°35'W) (Addison *et al.* 1983). Calves were cared for according to Ontario Ministry of Natural Resources animal care committee protocols and the facility received regular veterinary inspection. Twelve moose were used to study behaviour. One male and one

Table 1. Frequencies of Flehmen by captive Ontario moose calves.

Time Period		Immediate Flehmen[a] ♂		Immediate Flehmen[a] ♀		Observation Time(minute)
1	September-15 October	3.95	A[b]	0	A	9,483
16	October-15 November	10.5	B	1.40	A	16,320
16	November-15 December	11.6	B C	0.50	A	13,238
16	December-15 January	17.9	D	3.00	A	9,702
16	January-15 February	19.7	D	4.10	A	9,972
16	February-15 March	4.60	A E	1.30	A	10,242
16	March-12 April	6.10	A C E	0	A	9,524

[a] Flehmen occurring within 4 minutes of release of urine (Flehmen/Urination X 100).

[b] Frequencies with the same letter are not different ($P = 0.05$).

female were placed in each of six adjacent pens (30 x 17 m).

Pairs of moose were observed continuously for an average of 8 hours on 28 different days between 1 September 1982 and 12 April 1983. Activities including Flehmen, urination and defecation were recorded for each moose at 1 minute intervals. The sequence of actions that observers recognized as Flehmen was typical of true Flehmen behaviour with sniffing and/or licking of stimuli, parting of the jaws, curling of the upper lip, and raising and extension of the head (Altieri and Müller-Schwarze 1980).

We defined immediate Flehmen as those that occurred within 4 minutes of release of urine or feces. We chose this as an interval since > 75% of Flehmen that occurred following urination did so within 4 minutes, and because urine is a medium known to elicit Flehmen (Henderson *et al.* 1980, Crump *et al.* 1984). Frequencies of Flehmen/urination were calculated as follows: total number of Flehmen performed within 4 minutes of a urination/total number of urinations x 100.

Each observation period, which lasted longer than 5.5 hours, was included in the analysis. We chose this time interval since it exceeded the time needed to observe at least one Flehmen (overall Flehmen rate = 1 per 307 minutes). Data were compiled for individual moose and analyzed to determine the effect of sex, time, and sex X time interactions on Flehmen, controlling for the effect of observing the same moose throughout the experiment using repeated measures ANOVA (SAS Institute Inc. 1987). Seven time periods were established such that the period from 16 October to 15 November corresponded to the time when male moose calves should have shown their greatest testicular activity if the physiological development of our calves was consistent with those observed by Bubenik and Timmermann (1982). Multiple comparisons were made using Duncan's Multiple Range test ($\alpha = 0.05$) (Steel and Torrie 1980). We used chi-square tests to assess the effect of sex on the relative frequency of self-directed Flehmen behaviour (Steel and Torrie 1980).

RESULTS

A total of 256 occurrences of Flehmen was recorded during 78,481 minutes of ob-

servations on 6 pairs (male/female) of captive moose calves. All moose calves showed Flehmen. Overall, we observed 1 Flehmen per 307 minutes of observation.

Flehmen occurred more frequently within 4 minutes following a urination (n = 132) than within 4 minutes following a defecation (n = 19). The highest percent change in the occurrence of Flehmen following a urination occurred within 2 minutes (Fig. 1). There was no similar rapid increase in occurrence of Flehmen following defecations. Forty-one percent (n = 105) of all Flehmen occurred > 4 minutes after urination or defecation.

Frequency of immediate Flehmen/urination differed among time periods ($P < 0.0001$). Males had higher frequencies of Flehmen than females (11.0 *versus* 1.5, $P = 0.0070$) Table 1). There was a significant interaction effect ($P = 0.0130$) between time and sex indicating that males and females showed different temporal patterns of immediate Flehmen response to urine. Males showed highest frequencies (18.9) from 16 December to 15 February ($P < 0.05$) (Table 1). There was no effect of time on frequencies of Flehmen by females ($P > 0.05$).

Male and female calves showed the same frequency of self-directed Flehmen ($P = 0.339$). Seventy-seven percent of Flehmen performed by males (89 of 116) and 69 % by females (11 of 16) were directed towards their own urine.

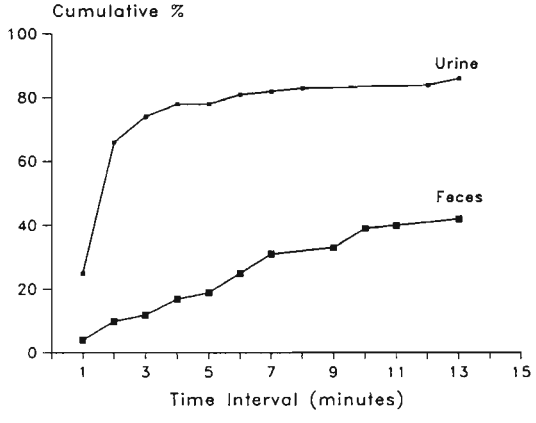

Fig. 1. Flehmen response of captive moose calves following release of urine (○) or feces (■).

DISCUSSION

The juvenile moose in our study displayed Flehmen relatively frequently. Flehmen in male moose calves occurred about as frequently as in dairy bulls kept in their home stalls (Houpt *et al.* 1989) and less often than Welsh ponies (*Equus caballus*) (Crowell-Davis and Houpt 1985). If frequency of occurrence of Flehmen was similar in captive and wild calves, continuous observations of animals in the wild would have to be of approximately 5 hours in duration to ensure a reasonable chance of observing the behaviour. Our observation of female calves performing Flehmen is unique.

Fresh urine appeared to be the primary stimulus for release of Flehmen in moose calves since over 70% of all Flehmen that occurred following urination occurred within 2 minutes. Other Flehmen may have been released by some other unidentified olfactory stimulant. Flehmen has been observed as an apparent response to feces in domestic sheep (Fan *et al.* 1988), reindeer (Mossing and Damber 1981), and Welsh ponies (Crowell-Davis and Houpt 1985). However, our data indicated that feces was not a significant factor releasing Flehmen in captive moose calves and that any apparent connection between defecation and Flehmen may be coincidental. For example, Flehmen was about 7 times more likely to be observed within 4 minutes of the release of urine than feces. In addition, the gradual monotonic increase in the relationship between elapsed time and frequency of Flehmen occurring after the most recent defecation supports a conclusion that fresh feces did not stimulate Flehmen.

A high percentage (41%) of Flehmen occurred at times > 4 minutes following

urination or defecation. Since direct contact with urine or feces was not a requirement for Flehmen, it is possible that some Flehmen occurred in response to urinations by moose in adjacent pens. Also, since urine and feces were not removed from pens, spontaneous Flehmen may have been released by old stimuli. DeBoer (1979) observed that the occurrence of Flehmen by male domestic cats (*Felis domesticus*) was not greatly affected by the age of urine marks (fresh < 4 hours *versus* old > 1 day old).

As expected, male calves displayed higher frequencies of Flehmen per urination than did females. However, males showed highest frequencies later than expected if the onset of Flehmen is coincident with an increase in testosterone concentration as suggested by Reinhardt (1983) for semi-wild cattle (*Bos indicus*). If the occurrence of Flehmen was related to increased testes mass in moose calves then we might have anticipated highest frequencies during mid-October to mid-November. The fact that Flehmen in male calves was most frequent from December to February may indicate that our captive calves experienced heightened testicular activity later than was observed by Bubenik and Timmermann (1982) for wild calves.

In summary, although much more is to be learned about releasing stimuli, the occurrence of Flehmen appears to be a common component of the ontogeny of moose during the first year of life, especially for males.

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