AQUATIC FEEDING BY MOOSE IN SWEDEN - WITH IMPLICATIONS CONCERNING SODIUM

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ABSTRACT: In Fennoscandia there had been no scientific report of moose feeding on aquatic plants, other than one record of emergents found in rumens at Grimsö, Sweden. From a systematic survey at that site, we found in mid-summer that some moose were eating some emergent aquatics, primarily *Menyanthes trifoliata*, in bog-mat wetlands. The selection by moose both of aquatic species and of feeding sites appeared positively related to sodium availability. On the other hand, moose had ready access to salt stones, and there was a negative relation between seasonal use and seasonal accumulation of sodium in the plants being taken; thus sodium did not appear to be the primary objective. The relationship between sodium appetite and potassium levels in primary forage is discussed.

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In North America, aquatic feeding by moose (*Alces alces*) has been well-documented (Cobus 1972, Botkin *et al.* 1973, Fraser *et al.* 1980, 1982, 1984; Jordan 1987), but lack of such reports from Fennoscandia suggests that it is not common there. The only scientific documentation of aquatic feeding is the report by Cederlund *et al.* (1980) that small amounts of the emergent aquatics *Menyanthes trifoliata* and *Equisetum* sp. appeared in rumens of moose taken in May and June at Grimsö, Sweden.

It is widely believed that moose seek aquatic plants mainly for high levels of sodium (= Na) (Belovsky and Jordan 1981, Fraser *et al.* 1984). Jordan (1987) points out that relatively high levels of Na in terrestrial browse in Sweden, along with widespread use by moose of salt stones, suggests that aquatic feeding would not be common there if the hypothesis relating Na to aquatic feeding is valid.

The purpose of this study was 1) to examine through direct observations the extent and patterns of aquatic feeding by moose in central Sweden, including selection of species and of foraging sites; and 2) to relate any such findings to possible Na need based on the relative Na content of forages selected.

STUDY AREA

The study was within the Grimsö Wildlife Research Area in central Sweden between 59° and 60° N, and 15° and 16° E, in the southern part of the boreal forest zone (Sjörs 1965). The station's research area of ca. 14,000 ha are comprised of fairly flat, forested land with elevations of 75-150 m above mean sea level. Coniferous forest covers 74% with dominant trees being Scots pine (*Pinus silvestris*) and spruce (*Picea abies*) and subdominants being birch (*Betula* spp.) and aspen (*Populus tremula*). The area is interspersed with boggy and swampy wetlands (18%), lakes and rivers (5%), and farmland (3%).

Forest management in the area is intensive, with harvest mainly by clear-cutting of large patches (Cederlund *et al.* 1980, Widén 1984). Lowland forest areas are ditched for drainage. Density of moose within Grimsö was estimated for 1987 to be ca. 1.3/km^2 (unpubl. station reports). The population has been maintained at a relatively stable level through quota hunts. Salt stones were maintained for wildlife throughout the area (Fig. 1) (Jordan *et al.* 1989).

Wetlands examined in this study were classified as "poor swamps" (Swedish translation) by Sjörs (1971), which we interpret as

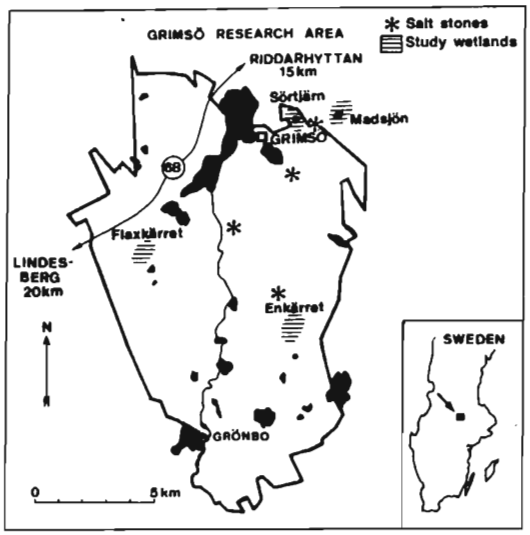

Figure 1: Wetland study areas within the Grimsö Wildlife Research area, central Sweden, showing locations of salt stones that are near the study areas.

"palustrine scrub-shrub wetlands of the broad-leaved deciduous type," according to the nomenclature of Cowardin *et al.* (1979), although woody plants were mostly absent. These wetlands are dominated by floating bog mats of ca. 75-cm thickness and strong enough to support moose. Water depth, including the intervening bog mat, varied between 1.4 and 1.8 m. Major vegetative elements of the mats were sedges (*Carex rostrata, C.lasiocarpa, C.limosa*), sphagnum mosses (*Sphagnum spp.*), and cranberries (*Vaccinium* spp); other species present included *Eriophorum angustifolium, E. vaginatum, Trichophorum caespitosum, Scheuchzeria palustris, Myrica gale, Molinia coerulea,* and *Potentilla palustris.* There were small, scattered openings and depressions in the mats, and it was in these that emergent plants of interest, *Menyanthes trifoliata* and *Equisetum fluviatile,* were found. Water pH, measured in August, was 5.6.

METHODS

Within the Grimsö Wildlife Research Area, seven wetland areas were identified as potential aquatic feeding sites, based on past sightings of moose in summer around each of them. Systematic observations were made at each site to record presence and feeding activities of moose. Visitation days were randomly selected, and times of visits were distributed over the span of daylight hours, 0430-2330 h. During each visit, we scanned the entire area with binoculars from a fixed location. If no moose were seen within 30 minutes, the visit was terminated. For each moose seen, sex and age were recorded; a cow with calf was counted as a single sighting. Detailed notes on feeding were made, and the location within a meter or so was mapped in order to relocate the feeding site the following day to estimate what species had been taken, based on plant remains.

The observations were begun 12 June 1987; by late June it became apparent that some of the sites were not being used at all. Between 26 June and 2 July, a walking survey was made around the perimeter of each of the seven wetland areas in search of moose sign. We also recorded presence of the four common emergent aquatic macrophytes that were judged most likely to be used by moose: *Calla palustris, Equisetum fluviatile, Menyanthes trifoliata,* and *Potentilla palustris.* Clear evidence of aquatic feeding by moose was found at four of the sites-- Enkärret, Flaxkärret, Madsjön, and Sortjärn (Fig. 1), so observations were continued only at these. All data and their interpretation here are from those four sites only.

The four study wetlands were similar in physical appearance, and all were ca 22 ha. Plant composition appeared relatively similar, except that at one, Flaxkärret, *Menyanthes trifoliata* was considerably less abundant. From radio-tracking records of local moose (Cederlund unpubl. data), the probability that any one moose would be visiting more than

one of these sites during mid-summer was judged unlikely. All were "poor swamps," but only Sortjärn had open water.

To determine concentrations of Na and potassium (K) in aquatic plants, 25-g (dry-wt) samples of each of the four emergent species of interest were collected at each of the four wetland study areas. A first set was taken during 26 June-2 July, when aquatics were not fully emerged but were visible, and a second set 4-5 August, just after the plants had begun to die back. There were no apparent differences in phenology of aquatic plants among the four study sites. Plant material was oven-dried at 75°c for 48 hours, starting the day of collection. Concentrations of Na and K were determined in duplicate specimens, using atomic absorption spectrophotometry.

RESULTS

The number of observation visits to each of the four areas varied from 11 to 17 with a total of 55 individual-site visits. Adult moose were recorded at the areas on 12 visits, and in 11 of these cases animals were seen feeding on emergent aquatics (Table 1). In the other instance, an animal was seen moving away from the wetland, possibly having just finished feeding. In six instances a cow with calf was observed; in none of these was the calf seen feeding on aquatics. Among the four sites, Enkärret was the only one being consistently used.

Between 30 June and 8 July, a radio-collared cow with calf made up 4 of the 9 records at Enkärret. This suggests that the probability of seeing the same animal on more than one visit was high. This in turn suggests that, while some individuals may have been regular aquatic feeders, the overall low frequency of observed feeding in an area of relatively high density indicates that many of the local moose were not coming to such habitats for aquatic feeding.

Feeding on aquatics peaked during 6-12 July, when seven moose were seen in the course of five site-visits (Fig 2). This temporal pattern is based primarily on observations at the one site, Enkärret, where most feeding was seen.

The duration of feeding bouts was not timed, but we did note that some individuals

Table 1. Total and average numbers of adult moose seen feeding on emergent, aquatic plants at four wetland study sites during systematic observation visits, Jun-Aug 1987, within the Grimsö Wildlife Research Area.

Wetland area	Observa. visits	Total adults seen		$\bar{x}$ Per visit
		Cows	Bulls	
Enkärret	17	6	3	0.53
Flaxkärret	11	1	0	0.09
Madsjön	13	1	0	0.08
Sortjärn	14	0	0	0
Totals/$\bar{x}$	55	11		0.20

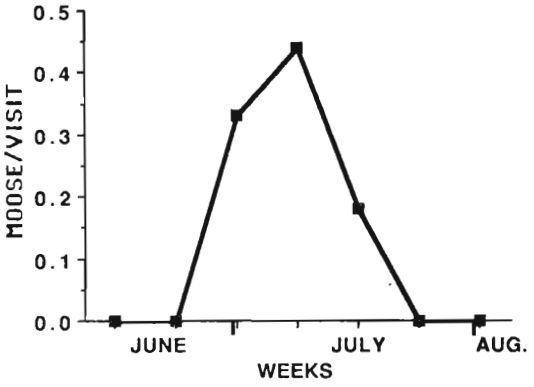

Figure 2. Number of adult moose seen feeding on aquatic vegetation per systematic oberservation visit, early June through mid August, 1987, at four wetland sites within the Grimsö Wildlife Research Area. Data were summarized on a weekly basis.

fed continuously for as long as 1 hour. Feeding was somewhat more common in the morning and evening than in the afternoon. In all cases during the systematic observations, the moose seen feeding were walking on top of bog mats; while they did not break through, they weighted the mats down some 0.5 m. Bog mats at Grimsö show conspicuous moose trails.

In the observed aquatic feeding, moose typically moved their heads from side to side, grazing nearly continuously. They would then move forward 1-2 m and resume grazing. On several occasions, individuals were observed moving 40-50 m while feeding in this manner. Moose clipped the emergents at the water surface, never submersing their heads, even partially, as is common in North American moose (Cobus 1972).

From direct observation and later inspection of feeding sites, it was found that *Menyanthes trifoliata* was the predominant species being taken. *Equisetum fluviatile* was the only other aquatic species seen being eaten. Feeding-site records indicated that use of *Equisetum* was only light and occasional; also, due to its growth form, feeding on this plant was not as easily seen by us as was the use on *Menyanthes*[1].

Sodium levels (dry-wt) in the four emergent species analyzed showed sharp differences among species and among sites (Table 2). For all four areas *Menyanthes trifoliata* had the highest Na concentrations. However, some differences within a single species were greater between areas than were differences between two species from the same locale: e.g. there was more difference in Na between *Menyanthes* samples from Enkärret and Madsjön than in Na between *Menyanthes* and *Equisetum* at the same site, Madsjön. Few statistical analyses were run because each cell was represented by only one specimen. However, values for the three species that were found and collected from all four areas were averaged, and Na concentrations were compared between early and late summer. Paired t-tests indicate that Na concentrations were significantly higher in the late- vs. early summer material for *Menyanthes* ($p < 0.05$) and perhaps for *Potentilla palustris* ($p < 0.10$). An increasing accumulation of Na in

Table 2. Sodium concentrations (ppm-dry) in four emergent aquatic species growing at four study areas and collected at two periods of summer 1987-- 26 Jun-2 Jul and 4-5 Aug. Each entry is based on n=1.

Area	Enkärret		Flaxkärret		Madsjön		Sortjärn	
Month	Jun	Aug	Jun	Aug	Jun	Aug	Jun	Aug
Species								
Equisetum fluviatile	1175	1730	690	1650	590	550	450	2175
Menyanthes trifoliata	1805	3420	905	3765	705	1710	1590	3090
Calla palustris	-	-	-	-	520	1120	490	2655
Potentilla palustris	380	605	455	505	390	440	335	785

aquatics through summer has been reported by others (Jordan 1987).

DISCUSSION

At Grimsö, an area typical of much of the forested portion of central Sweden, at least some moose in summer fed regularly in bog-mat swamps on at least one aquatic species, the emergent, *Menyanthes trifoliata*[1]. The one report of aquatic plants in rumen samples (Cederlund *et al.* 1980) did not point out that aquatic feeding was previously unreported for Fennoscandia. That we observed this feeding only in bog-mat swamps rather than in open waters, as is typical for aquatic feeding by moose in North America, may account for the lack of published records. Quantitative patterns of aquatic feeding reported here must be interpreted with caution due to our limited number of systematic observations.

Jordan *et al.* (1973) first suggested that moose are attracted to aquatic vegetation for its high Na content, as later corroborated by Fraser *et al.* (1984). Jordan (1987) suggested that aquatic feeding had not been reported in Fennoscandia because moose there should not require aquatics to meet their Na needs. In interior North American boreal regions, year-round Na in browse is generally < 50 ppm; whereas in Sweden it ranges from 100 to > 500 ppm (Lindlöf *et al.* 1974, 1978; Pehrson 1981; Pehrson unpubl.). Furthermore, throughout much of Fennoscandia moose can and do take pure NaCl from salt stones that are widely distributed by hunters.

At Grimsö, salt stones were being used year-round by moose, with a peak from late spring through early summer (Jordan *et al.* 1989). If, to obtain Na, moose at Grimsö were taking aquatics instead of using the stones, then aquatic feeding should have been highest in areas where stones were least available. This, however, did not appear the case, because an inverse relation between the proximity of stones (Fig. 1) and the use of aquatics was not found (Table 3).

Other results here suggest that aquatics were being taken for Na. The most clearly preferred species, *Menyanthes trifoliata*, had the highest Na values among emergents examined at all four sites. Furthermore, of the four areas studied, the one showing highest moose use, Enkärret, also had the highest Na values for all four aquatic plants tested. At the same time, it is puzzling why, if moose at Grimsö are seeking Na, they do not feed on a source found elsewhere to be much higher in Na-- submerged macrophytes. These are commonly available in shallow to deep open waters around the research station. Such feeding would be readily observable, but has not been recorded[1]. While we have not yet analyzed submerged macrophytes at Grimsö, North American data show that Na concentrations in submergents tend to be roughly an order of magnitude higher than in emergents from the same wetlands (Botkin *et al.* 1973, Fraser *et al.* 1982).

Staaland and Jacobsen (1983) point out that a low Na:K ratio can drain the sodium pool of reindeer. In early summer, when the common terrestrial forage plants used by moose are putting out new foliage, these tissues show a considerable increase in K concentration relative to levels the rest of the year, while Na in the same materials remains essentially unchanged (Pehrson unpubl.). For moose depending on these forages, this may create an unfavorable Na:K ratio, leading to increased Na loss. To compensate, animals may seek out sources high in Na alone, a characteristic of many aquatic plants. Later in summer, K concentrations in terrestrial forage return to normal, and this could underlie the drop-off in aquatic feeding by moose we found then. A similar hypothesis was offered both by Fraser *et al.* (1984) for aquatic foraging in moose and by Weeks and Kirkpatrick (1976) for sodium appetite in white-tailed deer (*Odocoileus virginianus*).

In summary, our observations, while documenting light use of emergent aquatic vegetation, cannot at this point be tied to any

Table 3. Distance between aquatic feeding sites and the nearest salt block with observed use of aquatics ranked among the four sites, "1" being highest.

Site	Distance to Nearest Block (km)	Rank of site in use of Aquatic Emergents
Enkärret	0.7	1
Madsjön	1.0	2
Flaxkärret	3.0	3
Sortjärn	0.3	4

hypothesis concerning a need for sodium as in North America, or, for that matter, for any other nutrient that may be unique to these plants. That moose used submergent but not emergent aquatics at Grimsö, and that they had salt stones available, seem to rule out a clear strategy to acquire sodium, despite some suggestive evidence to the contrary. And the apparent fact that only some moose were using aquatics suggests that whatever is nutritionally important in these plants is also sufficiently available in other food sources nearby. We will continue this inquiry by next analyzing emergents such as *Menyanthes* for other nutrients which, relative to other types of forage being taken in the same area, may suggest whether water plants are a better source of some nutrient(s) than are terrestrial plants.

[1] After the presentation of this paper, some additional relevant observations were made by WF and PAJ at Grimsö in August 1988. In the backwater of a small river, Sverkestan, at Nyhammer, we found that several patches, 1-5 m^2 each, of *Menyanthes trifoliata* had been grazed by moose. We estimated these recent removals affected < 5% of the stand that extended out from shore 4-10 m in water 0.2-0.7 m deep.

Also at Grimsö that month we accompanied a 2-yr old male captive moose, "Kalle," and his keeper to the edge of a major lake. We took a row boat out through a marshy, shallow area, and the moose followed us closely. When we stopped, the animal foraged. It first fed on *Menyanthes trifoliata,* and then, when it encountered scattered stands of *Equisetum fluviatile*, it shifted its selection as though showing a preference for the latter species. Several times we collected handfuls of a submergent plant, *Potamogeton* sp., growing abundantly at the same site and offered them to Kalle, who was accustomed to being hand fed. The animal completely rejected these plants. In North America *Potamogeton* is probably the most important genus of aquatic plants consumed by moose (Jordan 1987).

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