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Food habits of the muskrat, Ondatra zibethica (L.), in a Swedish lake

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The food habits of the muskrat were studied in a north-Swedish lake from May to November by microscopic analysis of faecal pellets. Remains of *Equisetum* were found in all pellets during the whole period. *Carex* spp. were constantly present from May to early July, thereafter only sporadically. *Schoenoplectus* was found in significantly more pellets between late July and early October than either from May to early July or in November. Other plant species were recorded only occasionally, and no remains of animal food were found in any pellets. After the thaw the *Schoenoplectus* belt can only be utilized with difficulty, because of the high water-level during the spring flood and the problems connected with constructing feeding platforms before the *Schoenoplectus* culms emerge above the water surface. The importance of absolute water-level in the utilization of *Schoenoplectus* by muskrats was confirmed by comparison of the observations made in years with above- and below-normal lake water-levels. The muskrat feeds in the immediate vicinity of its lodge and the seasonal changes in food habits correspond to the seasonal shift in habitat preference for lodge sites.

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1. Introduction

The muskrat, *Ondatra zibethica* (L.), in general feeds on hydrophytes, but to some extent on aquatic animals, e.g. mussels (WILLNER *et al.* 1975). Examination of food remains (WARWICK 1940, ASPISOFF 1957, ARTIMO 1960, AKKERMANN 1975), gross analysis of stomach contents (WARWICK 1940, MARCSTRÖM 1964, AKKERMANN 1975) and microscopic analysis of stomach contents (ASPISOFF 1957, LAVROV 1960, HOLIŠOVÁ 1975) show that in Europe the main food constituents are *Equisetum* spp., *Ranunculus fluitans* Lam., *Potamogeton* spp., *Typha* spp., *Schoenoplectus lacustris* (L.) Palla, *Carex* spp., *Phragmites communis* Trin. and *Calamagrostis stricta* (Timm) Koeler[1].

A 7-year study of habitat selection by muskrats in northern Sweden showed a seasonal shift in the lodges to different belts of emergent hydrophytes (DANELL 1978b). The *Carex* belt was the one most utilized in May and June, and after that the *Equisetum* belt. The *Schoenoplectus* belt, situated in the deepest water, was utilized mainly from August to October, especially in years with low lake water-levels.

The primary aim of the investigation was to find out whether the muskrat feeds only within the plant belt where its lodge is located, or whether it sometimes feeds in another plant belt. If muskrats feed in the immediate vicinity of their lodges, then one would expect a seasonal shift in food habits, corresponding to that in their habitat preference for lodge-building. A secondary aim was to compare the utilization of *Schoenoplectus* as a food source during 2 years, one with a low and the other with a high lake water-level.

2. Study area

The study area was the Sladan lake in northern Sweden (65°55'N, 22°25'E). The general features of the lake have been described by VALLIN (1953) and DANELL (1977b).

[1] Nomenclature follows CLAPHAM *et al.* (1962).

Table 1. Vascular plant species found within the study area of the Sladan lake, northern Sweden, from which the muskrat faecal pellets were collected. Nomenclature follows Clapham *et al.* (1962), except for Scandinavian species, marked with *, which follows Lid (1963).

Plant species	Vegetation belts		
	Carex	*Equisetum*	*Schoenoplectus*
Equisetum fluviatile L.	–	×	×
Nymphaea alba L. ssp. *candida* (Presl) A. & G.	–	×	×
Nuphar lutea (L.) Sm.	–	×	×
N. pumila (Timm) DC.	–	×	–
Stellaria crassifolia Ehrh. *	×	–	–
Potentilla palustris (L.) Scop.	×	–	–
Lythrum salicaria L.	×	–	–
Epilobium palustre L.	×	–	–
Myriophyllum verticillatum L.	–	×	×
M. spicatum L.	–	×	–
Hippuris vulgaris L.	–	×	–
Callitriche verna L. *	–	×	–
Cicuta virosa L.	×	–	–
Naumburgia thyrsiflora (L.) Rchb.	×	–	–
Utricularia vulgaris L.	–	×	–
Galium palustre L.	×	–	–
G. trifidum L. *	×	–	–
Bidens tripartita L.	×	–	–
Alisma plantago-aquatica L.	–	×	–
Sagittaria sagittifolia L.	–	–	×
Potamogeton natans L.	–	×	–
P. obtusifolius Mert. & Koch	–	×	–
Juncus filiformis L.	×	–	–
Calla palustris L.	×	×	–
Lemna minor L.	–	×	–
Sparganium simplex Huds.	–	×	–
S. angustifolium Michx.	–	×	–
S. minimum Wallr.	×	×	–
Typha latifolia L.	×	–	–
Eriophorum angustifolium Honck.	×	–	–
Eleocharis palustris (L.) Roem. & Schult.	–	×	–
Schoenoplectus lacustris (L.) Palla	–	×	×
Carex rostrata Stokes	×	–	–
C. aquatilis Wahlenb.	×	–	–
C. curta Good.	×	–	–
C. lapponica Lang *	×	–	–
Phragmites communis Trin.	×	–	–
Calamagrostis stricta (Timm) Koeler	×	–	–

Muskrat pellets were collected from a 27-ha shore segment which comprised a landward belt of *Carex* spp. (4 ha) including some clones of *Phragmites* (0.3 ha), an intermediate belt of *Equisetum* (7 ha) and an outer belt of *Schoenoplectus* (16 ha). Table 1 lists the vascular plant species in the area.

The phenology of the emergent hydrophytes was followed by measuring shoot length. The period of most rapid shoot-length increase for *Carex rostrata* Stokes was in late May, for *Equisetum fluviatile* in early June and for *Schoenoplectus lacustris* in late June (DANELL 1977a).

For a detailed history of the muskrats in the Sladan lake and their population dynamics see Danell (1977b, 1978a).

3. Material and methods

A. Faecal pellet analysis

Muskrats mostly defaecate on solid objects at the waterline, leaving small heaps of pellets. Boulders near the shore were frequently used for this purpose.

In 1973 pellets were collected at about weekly intervals from late May to early October. From each heap one pellet was chosen at random and preserved in 70 % ethanol. The defaecation site was then cleaned. Pellet samples (n = 71) were collected during 18 May — 2 June, 27 June — 3 July, 23 July — 2 August, 22 August — 1 September and 21 September — 1 October.

To obtain data for other seasons, one pellet was taken from the rectum of each of twelve muskrats trapped in their winter lodges during the period 17—20 November 1976.

Microscopic analysis of the pellets followed the general histological methods for the identification of plant tissues in stomach contents and in faecal samples (BAUMGARTNER & MARTIN 1939, DUSI 1949). After soaking in water for 24h, each pellet was placed on a sieve (0.15 mm mesh) and washed under running water for about 2 min. About a quarter of the washed residue was then mounted in Hoyer's solution (BAKER & WHARTON 1952) on a microscope slide and covered with a 24×40 mm cover slip. Ten microscope fields (each 3.7 mm in diameter at 40 ×) were chosen at random on all the slides made from single pellets. The plant remains (about 100—200, on average) in these 10 fields were identified with the aid of a reference collection. The 'frequency of occurrence' of any particular plant species means the percentage of pellets which contained this food item.

B. Muskrat grazing in stands of Schoenoplectus

In *Schoenoplectus* stands muskrats often confine their grazing to small patches, which are easily located. The number of patches in which culms had been cut down by the muskrats were counted, and their areas measured, in two sections of the study area, A (= 11.0 ha) and B (5.1 ha). The *Schoenoplectus* clones covered 1.5 and 1.6 ha, respectively. The surveys were carried out during calm weather on 28 August 1972 and 20 September 1974. The transparency of the lake water allowed observation from surface to bottom.

4. Results

The major food items in the muskrat pellets were *Equisetum fluviatile*, *Schoenoplectus lacustris*

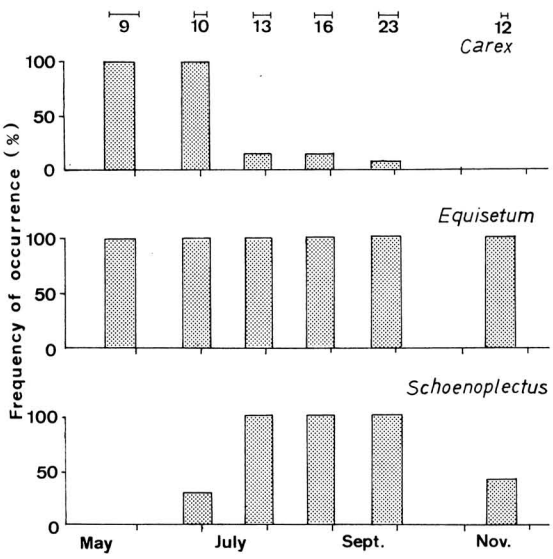

Fig. 1. The main plant species eaten by muskrats in a north-Swedish lake. The results are based on microscopic analyses of faecal pellets collected from defaecation sites beside the lake (May – October) or from trapped animals (November). The horizontal bars above indicate the collection periods. The total numbers of pellets examined are indicated below.

and *Carex* spp. Other plant species had been eaten occasionally, but only *Nymphaea/Nuphar* and *Phragmites communis* were found in more than one pellet. The only animal remains found was an exoskeleton of an acarid. *Equisetum* was present in all the pellets examined between May and November (Fig. 1). *Carex* remains were also found in all pellets until the beginning of July, but then there was a significant decrease (Fisher exact probability test, $P < 0.001$) and in November no fragments of *Carex* were identified. *Schoenoplectus* was present in all samples except those collected in May. It occurred to a significantly lesser degree in late June — early July ($P < 0.001$), and again in November ($P < 0.001$) than it did in late July — early October.

During 1972, a year with a low lake water-level, more patches of *Schoenoplectus* were grazed by the muskrats than in 1974, a year with high water-level (Fig. 2). The total area of *Schoenoplectus* cut down likewise differed; in 1972, 0.34 and 0.45 % of the *Schoenoplectus* stands were harvested in the two sections of the lake (A and B), respectively. The corresponding figures for 1974 were 0.19 and 0.22 %.

5. Discussion

The diet of the muskrats in the Sladan lake was exclusively vegetarian. In Finland freshwater mussels (*Anodonta* and *Unio*) are eaten (BRANDER 1951) and in northern Sweden mussels have also been found in muskrat stomachs (MARCSTRÖM 1964). In faecal pellets mussel remains are probably only recognized with difficulty, but in the present study their absence is due to the complete absence of these molluscs from the lake itself.

During the period of high water-level following the thaw the landward *Carex* belt is the one most accessible to muskrats, in particular because its outer margin floats up and down in relation to water-level changes. Field observations have shown that muskrats in the Sladan lake feed mainly on the basal parts of the shoots and on the roots and rhizomes. *Carex rostrata*, the dominant sedge species, attains its maximum shoot length in late June — early July (DANELL 1977a). BERNARD & MACDONALD (1974) showed that the underground standing crop of *Carex lacustris* Willd. was highest during the winter but, after rapid shoot growth in spring, decreased to a low value in summer, when maximal shoot length was attained. A correspondingly low value for the summer underground standing crop of *Carex rostrata* at the Sladan lake would suitably correspond to the period during which *Carex* remains were no longer found in all pellets (Fig. 1). During autumn, when food stores have once again been built up in the rhizomes, a higher degree of utilization of *Carex* by the muskrats would be expected. However, at this time of year the water-line is no longer situated near the *Carex* belt but lies further out, and most of the lodges built within it have been abandoned. Still later in the year, the *Carex* belt is even more difficult to exploit because of ice and snow.

Muskrats also feed on the rhizomes and basal parts of *Schoenoplectus* culms. The above discussion of *Carex* would lead one to expect a high degree of utilization of the *Schoenoplectus* belt early on in the ice-free season of the year. Moreover, utilization would be expected to continue somewhat longer than for *Carex*, because the *Schoenoplectus* shoots develop later. However, such was not the case (Fig. 1). The *Schoenoplectus* belt is situated in the deepest part of the lake where emergents occur (0.8—

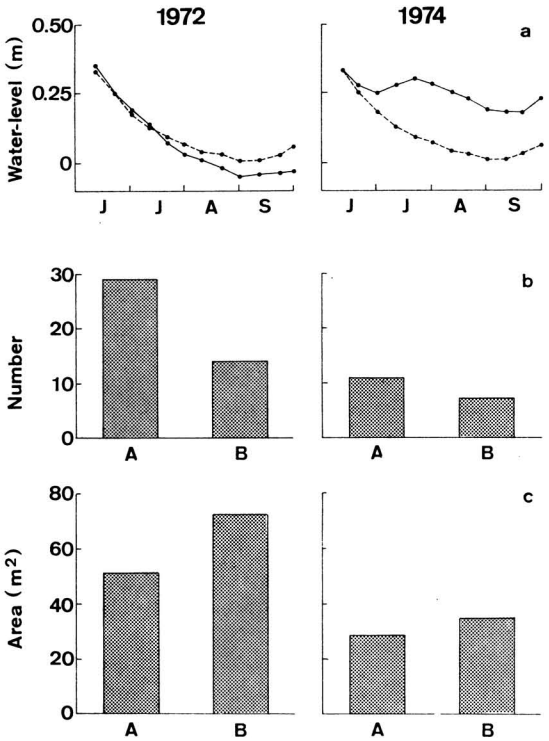

Fig. 2. Degree of muskrat grazing in the *Schoenoplectus* belt in a year with low (1972) and a year with high lake water-level (1974). a = the actual water-levels recorded (————) and the mean water-levels (– – – – –) during the period June – September in 1972–1975, b = the numbers of patches cut down in two separate sections (A and B) of the lake, and c = the total areas covered by these patches.

1.5 m at the time of the mean summer low water-level and earlier in even deeper water; cf. Fig. 2a). For muskrats to build feeding platforms in this belt before the culms emerge above the water surface (late June) is therefore difficult, because in windy weather the platforms are easily broken up and carried away by wave action.

The importance of lake water-level for the utilization of *Schoenoplectus* as food by muskrats was further supported by the results of a comparison of the amount of grazing in years with high and low water-levels. The total number of cut patches was fewer and their combined area was smaller in 1974, when the water-level was high, than in 1972, when it was low, although the muskrat population was larger in 1974 (DANELL 1978a) and the survey was made approximately one month later that year.

The seasonal pattern of feeding in the muskrat seems roughly to correspond to the pattern already found for habitat selection for lodge building throughout the year (DANELL 1978b), except for one point, viz. *Equisetum* is utilized to a high degree even in May (Fig. 1), when only a few lodges are built in this belt. At that time most lodges are built in the *Carex* belt. Nevertheless, many of them are near its outer margin, close to the *Equisetum* belt, i.e. an earlier utilization of the *Equisetum* belt than expected is not incompatible with the conclusion that the animals normally feed in the immediate vicinity of their lodges. This habit has obvious advantages, both in reducing predation losses and in minimizing conflicts with neighbours.

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References

AKKERMANN, R. 1975: Untersuchungen zur Ökologie und Populationsdynamik des Bisams (Ondatra zibethicus L.) II. Nahrung und Nahrungsaufnahme. — Zschr. Angew. Zool. 62:173—218.

ARTIMO, A. 1960: The dispersal and acclimatization of the muskrat, Ondatra zibethicus (L.), in Finland. — Pap. on Game Res. 21:1—101.

ASPISOFF, D. I. 1957: Acclimatization of muskrats in the Volga-Kama region: material on muskrat biology. — Translations of Russian Game Reports 2:156—202 (1955) (Canadian Wildlife Service, Ottawa).

BAKER, E. W. & WHARTON, G. W. 1952: An introduction to acarology. — 465 pp. New York.

BAUMGARTNER, L. L. & MARTIN, A. C. 1939: Plant histology as an aid in squirrel food-habit studies. — J. Wildlife Mgmt 3:266—268.

BERNARD, J. M. & MacDONALD, J. G., Jr. 1974: Primary production and life history of Carex lacustris. — Can. J. Bot. 52:117—123.

BRANDER, T. 1951: Till kännedomen om bisamråttans musseldiet. — Acta Soc. Fauna Flora Fennica 67 (3):22—52.

CLAPHAM, A. R., TUTIN, T. G. & WARBURG, E. F.

1962: Flora of the British Isles. — 2nd ed., 1269 pp. Cambridge.

DANELL, K. 1977a: Dispersal and distribution of the muskrat (Ondatra zibethica (L.)) in Sweden. — Viltrevy 10:1—26.

—»— 1977b: Short-term plant successions following the colonization of a northern Swedish lake by the muskrat, Ondatra zibethica (L.). — J. Appl. Ecol. 14:933—947.

—»— 1978a: Population dynamics of the muskrat in a shallow Swedish lake. — J. Animal Ecol. (in press).

—»— 1978b: Intra- and interannual changes in habitat selection by the muskrat. — J. Wildl. Mgmt (in press).

DUSI, J. L. 1949: Methods for the determination of food habits by plant microtechniques and histology and their application to cottontail rabbit food habits. — J. Wildl. Mgmt 13:295—298.

HOLIŠOVÁ, V. 1975: The foods eaten by rodents in reed swamps of Nesyt fishpond. — Zool. Listy 24:223—237.

LAVROV, N. P. 1960: Selections from "Acclimatization of muskrats in the USSR". — Translations of Russian Game Reports 7:1—150 (1957). (Canadian Wildlife Service, Ottawa).

LID, J. 1963: Norsk og svensk flora. — 800 pp. Oslo.

MARCSTRÖM, V. 1964: The muskrat Ondatra zibethicus L. in northern Sweden. — Viltrevy 2:329—407.

VALLIN, S. 1953: Zwei azidotrophe Seen im Küstengebiet von Nordschweden. Inst. Freshwater Res. Drottningholm, Rep. 34:167—189.

WARWICK, T. 1940: A contribution to the ecology of the musk-rat (Ondatra zibethica) in the British Isles. — Proc. Zool. Soc. London (A) 110:165—201.

WILLNER, G. R., CHAPMAN, J. A. & GOLDSBERRY, J. R. 1975: A study and review of muskrat food habits with special reference to Maryland. — Maryland Wildlife Administration, Publ. Wildlife Ecol. 1:1—25.

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