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Reduction of Aquatic Vegetation Following the Colonization of a Northern Swedish Lake by the Muskrat, *Ondatra zibethica*

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Summary. The muskrat (*Ondatra zibethica* (L.)) utilizes emergent hydrophytes both for housebuilding and for food. The impact of these activities on stands of *Equisetum fluviatile* L. in a northern Swedish lake was investigated. The areas of open water created by the muskrats were estimated from infrared air photographs, taken in July, on three occasions during a five-year period. During the first three years, with low muskrat densities, the areas of open water were estimated to represent removal of about one percent of the *Equisetum* stands. In the summer following a population peak the total area of open water had increased to about four percent. In that summer there were, on average, about 160 such areas per hectare and their combined perimeter length was about 1.5 km. The many small areas created by the muskrats were mostly very irregular in shape, each with a long perimeter in relation to its area. If not too numerous, the muskrats have a positive effect on the waterfowl population in well-vegetated lakes, by increasing the feeding areas available for both adults and young birds.

Introduction

The muskrat (*Ondatra zibethica* (L.)) is generally herbivorous and large quantities of plant materials are utilized both for housebuilding and for food. In localities where it is abundant it can have a marked effect upon the vegetation. Many cases of such impact of muskrats upon the vegetation have been reported from North America, where the species is native, and also from Europe and Asia, into which continents it has been introduced (for references see Danell, 1977). However, only a few quantitative estimates of this impact of the muskrat have been made. Pelikán et al. (1970) estimated the impact on stands of *Typha latifolia* L.[1] in Czechoslovakia and Akkermann (1975) estimated the effect on mixed stands of some emergent hydrophytes (*Schoenoplectus lacustris* (L.) Palla, *Phragmites communis* Trin. and *Glyceria maxima* (Hartm.) Holmberg) in Germany.

[1] Nomenclature for vascular plants follows Clapham et al. (1962)

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The muskrat entered northern Sweden relatively recently (Marcström, 1964) and is now gradually spreading southwards. Such conditions provide an unique opportunity of studying the impact of this new herbivore on previously intact stands of emergent hydrophytes. The main components of the vegetation of lakes in northern Sweden are *Carex* spp., *Equisetum fluviatile* L. and, locally, *Schoenoplectus lacustris* and *Phragmites communis*.

During a study of habitat selection by the muskrat, in a shallow lake rich in emergent hydrophytes, the *Equisetum* belt was found to be that most utilized for housebuilding (Danell, 1978b). A study of food habits, from analyses of faecal pellets, showed a high utilization of *Equisetum* for feeding too, at least during the studied period (May–November) (Danell, 1978c). The aim of the present investigation was therefore to estimate the impact of muskrats on stands of *Equisetum*. The qualitative changes in vegetation which took place following the colonization of the same area by muskrats have been described in an earlier paper (Danell, 1977).

Study Area

The study was carried out at Sladan lake in northern Sweden (65°55′N, 22°25′E). The general features and the vegetation of the lake have been described previously by Vallin (1953) and Danell (1977). The muskrat first appeared in the Sladan lake about 1963. A detailed information about the population dynamics of the muskrat at the lake is given by Danell (1978a).

Methods

The study area comprised about 19 hectares of *Equisetum*. A random sample of 30 (25 by 25 m) squares was examined on air photographs. The infra-red photographs were taken on 20–31 July (1970, 1973 and 1975), the time of the year at which aquatic vegetation had reached its maximum development. For further details about the air photography methods see Danell (1977).

The areas and perimeters of all clear-grazed areas of *Equisetum* present in all sample squares were estimated from enlargements, on a scale of approximately 1:175. The ratio "perimeter: $2\sqrt{\text{area} \cdot \pi}$" was also calculated for all areas of open water which lay entirely within each sample square.

Results

The mean estimated numbers of open-water areas per hectare were 26 (95% C.L. = 8-43), 33 (9–57) and 160 (104–215), in 1970, 1973 and 1975, respectively. Significantly more areas of open water were present within the 25 by 25 m squares in 1975, than were present within the same squares in either 1970 or 1973 (Fig. 1a).

The total area of open water present within the sample squares was also significantly greater in 1975 (Fig. 1b). In the summer of 1975, which had been

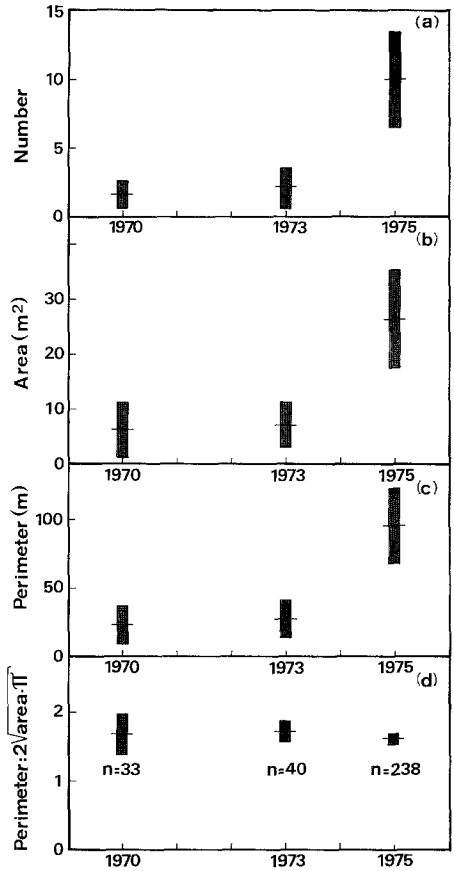

Fig. 1a–d. Number (**a**), area (**b**) and perimeter (**c**) of open water areas created by muskrats per grid square (25 by 25 m) within the *Equisetum* beds of the Sladan lake, northern Sweden. The ratio of perimeter to area (**d**) is given for all areas of open water which lay entirely within the 30 sample squares studied. Horizontal lines indicate mean values and vertical bars represent the 95% confidence limits

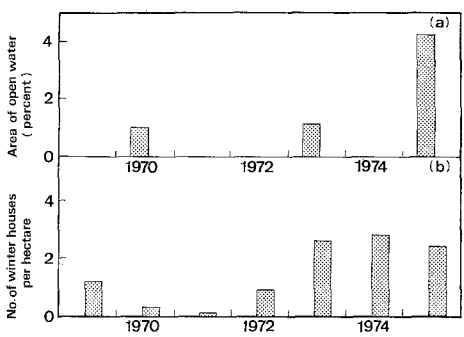

Fig. 2a and b. The estimated total areas of open water in July (**a**) and the numbers of muskrat houses present in October (**b**), in homogeneous *Equisetum* stands

preceded by two winters with high muskrat densities, the area of open water created by muskrats represented about 4% of the total area covered by the *Equisetum* beds (Fig. 2). During both of the summers (1970 and 1973) which were preceded by winters with low muskrat densities, the corresponding figures were about 1%.

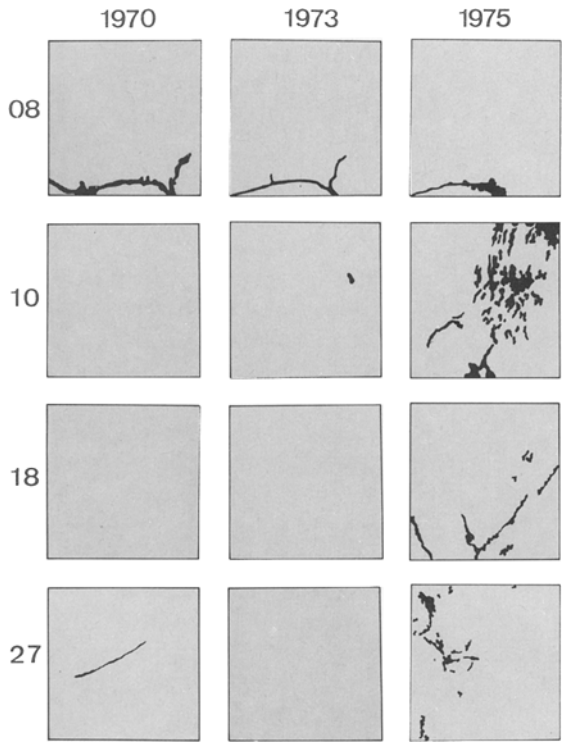

Fig. 3. A random sample of four of the 30 sample squares (25 by 25 m) studied, in homogeneous *Equisetum* stands. The areas of open water (*Black*) have been copied from infra-red air photographs taken in July each year. Permission for distribution approved by the Security Officer of the National Land Survey of Sweden (7 November, 1977)

The perimeter of the open water areas was significantly greater in 1975 than in previous years (Fig. 1c). The estimated, combined perimeter length per hectare for all the open water areas were 370 (142–598), 444 (225–663) and 1528 (1089–1967) m in 1970, 1973 and 1975, respectively.

In most cases the open water areas were very irregular in shape (Fig. 3), i.e. they yielded high values for the ratio: "perimeter: $2\sqrt{\text{area} \cdot \pi}$" (Fig. 1d). No significant differences were found between the ratio values of different years.

Discussion

The peak muskrat density at the Sladan lake, viz. 3–6 animals per hectare of *Equisetum* (estimated by removal trapping in winter houses) is low when compared to the values found for the more southern populations. In a Czechoslovakian lake, Pelikán et al. (1970) found, that an autumn muskrat population of 28–55 muskrats per hectare reduced the annual net production of *Typha*

by 5–10%. In a German lake, Akkermann (1975), using estimated population size values and assumed food consumption values, considered that about 13% of the emergent hydrophytes would have been removed by the muskrats. Despite a muskrat population approximately 10 times greater in the Czechoslovakian lake than that studied in the Sladan lake, the estimated harvest of emergent hydrophytes by the muskrats was only 1–2 times greater. This fact is explained by the higher annual productivity of hydrophytes per unit area in the more southern locality. Pelikán et al. (1970) reported a standing crop of *Typha* shoots in late September of 1.7 kg dry weight/m^2. The corresponding figure for the *Equisetum* stand in the Sladan lake was about 0.3 kg (obtained by harvesting 22 squares, each of 0.5 by 0.5 m, taken at random in early August).

The presence of muskrats in *Equisetum* beds leads to the creation of numerous small, and some larger, patches of open water close to the muskrat houses. If muskrats occupy the same house site for many years the area of open water steadily increases (Brander, 1949; Akkermann, 1975; Danell, 1977). Even if the immediate impact of the muskrats on the emergent hydrophytes is heavy and prolonged in any one year or period of years, especially serious because the basal parts of the plants are destroyed, the surviving plants can subsequently recolonize the lost areas quite rapidly (Danell, 1977). Other vegetational changes also took place. The areas of open water created in the stands of emergent hydrophytes are usually rapidly colonized by submerged hydrophytes (e.g. species of *Myriophyllum*, *Potamogeton* and *Sparganium*) (Danell, 1977).

Thus the final result of several years of muskrat activities in dense stands of emergent hydrophytes is an increase in plant diversity, both in terms of community structure and number of species (Danell, 1977). In the Sladan lake the total area of open water created was in itself not very great, but the irregular shape of the open water areas resulted in quite a high "edge effect" (about 1.5 km of combined perimeter lengths per hectare in 1975).

Out of all the habitats occupied by other species of vertebrates present at the Sladan lake, that of the dabbling ducks is influenced by the muskrats to the greatest extent. During the first days of life, animal food is of great importance for their ducklings (Beard, 1953; Chura, 1961; Perret, 1962). The very young ducklings only take food items from the water surface, or from the emergent vegetation, since only reluctantly will they submerge their bills deeper than the nares (Chura, 1961). The increased edge between the area of open water and that of emergent hydrophytes, produced by muskrat grazing, thus increases the possibility for the ducklings to exploit the invertebrate population present within the dense stands of emergent hydrophytes. In addition, the previously extant areas of open water often contain submerged hydrophytes, which themselves represent a valuable source of food for ducks and ducklings as also their rich aquatic invertebrate fauna (Krull, 1970, and references therein).

Under such conditions, the presence of muskrats must be regarded as a positive factor in waterfowl management, because they increase the available resources for the dabbling ducks. However, abnormally high muskrat populations may lead to a severe destruction of the aquatic vegetation ("eat-out") (see Danell, 1977, for references) and thereby probably to a decrease in duck populations. In northern Sweden some such cases of heavy impact of muskrats

on the vegetation have in fact already been reported (e.g. Marcström, 1964), especially in localities with poor stands of such hydrophytes and some years after the muskrat invasions. However, such events are of only temporary nature, since many of the animals subsequently move elsewhere as the vegetation cover becomes sparser (Artimo, 1960).

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