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Relationship of introduced mink, an island race of muskrat, and marginal habitat

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The influence of introduced mink (*Mustela vison*) on an island race of muskrat (*Ondatra zibethicus obscurus*) was studied in insular Newfoundland using harvest statistics, habitat surveys, and food habits. More mink than muskrats are now being harvested, contrary to elsewhere in North America and predator–prey theory. Paucity of cattail (*Typha* spp.) in Newfoundland for building and food evidently reduces habitat quality for muskrats, probably rendering them susceptible to mink predation. Muskrats use bank burrows almost exclusively in Newfoundland. Density of muskrats is higher where they build houses with water horsetail (*Equisetum fluviatile*). Circumstantial evidence suggests that predation of introduced mink on a race of muskrat unadapted to mink, combined with marginal habitat conditions, probably has caused muskrat populations to decline in Newfoundland.

1. Introduction

The Newfoundland muskrat is a distinct race located on the island of Newfoundland. This race of muskrat was classified originally as a distinct species and genus, *Fiber obscurus* (Bangs 1894), on the basis of a smaller skull size and a different pelage colour than the closest mainland race, *Ondatra zibethicus zibethicus*. In 1912 it was recognized as the same genus but a distinct species, *Ondatra obscurus* (Miller 1912), and was still reported as such by Miller and Kellogg (1955). Cameron (1958) changed the taxonomic classification to its current form, 1 of 16 races in North America (Perry 1982). Muskrats (*O. z. zibethicus*) from nearby New Brunswick, where food availability is greater, have larger skull measurements and other morphological characteristics than Newfoundland muskrats (Rigby & Threlfall 1982). Population density of muskrats was 1/11–100 km^2 in Newfoundland compared with 50/55–100 km^2 in New Brunswick (Boutin & Birkenholz 1987).

Mink are natural predators of muskrats (Errington 1943). Newfoundland was mink-free until 1935 when ranch mink were introduced (Northcott *et al*. 1974). Mink might suppress Newfoundland muskrats perhaps because this island race of muskrat occupies marginal habitat and might not

have evolved a mechanism to cope with mink predation, as island races and species have shown elsewhere (Primack 1993). Population density of mink in Newfoundland and New Brunswick was estimated to be similar at 1/21–100 km^2 (Eagle & Whitman 1987).

Broad-leaf cattail (*Typha latifolia*) is highly preferred muskrat food and building material; marshes dominated by it have higher muskrat densities than those comprised of other vegetation (Dozier *et al*. 1948, Errington 1948, 1963, Dozier 1950). Cameron (1958) suggested that cattail existing in Newfoundland is not endemic but introduced as packing material for merchandise. Rouleau and Lamoureux (1992) documented cattail at only 21 sites in Newfoundland; it also is widely distributed there in roadside ditches along the Trans Canada Highway. Muskrats in Newfoundland used cattail for food where available (E. Lear, unpubl.). Cameron (1958) reported a general scarcity of food plants, and an absence of cattail in muskrat areas, often causing muskrats to seek alternate feeding areas. If this is so, inadequate food and cover might be a potential limiting factor because of exposure to a new efficient predator, such as mink. The objective was to determine the relationship of introduced mink to the island race of muskrat in Newfoundland in different habitats.

2. Study area

Insular Newfoundland is a 112 300-km^2 island in the Gulf of St. Lawrence, 112 km from Nova Scotia and 18 km from Labrador. It is somewhat triangular in shape, with several peninsulas. It contains a mosaic of softwood forest (34%), scrub forest (22%), tundra (15.2%), peatland (14.3%), water (10.1%), rock barrens (3.4%), and agriculture and cleared land (1.0%) (Anonymous 1974).

We studied 4 marshes on the Northern Peninsula of Newfoundland; 3 were near the community of Plum Point on the northeast end of the Northern Peninsula about 45 km from Labrador, and 1 was near the community of Main Brook on the northwest end of the Northern Peninsula about 65 km from Plum Point. The climate was generally cold with a short growing season (Damman 1983). At study sites on the Northern Peninsula, water horsetail dominated shallow marshes. Soils were generally shallow with extensive areas of exposed bedrock and numerous ponds and streams (Damman 1983).

We also studied 16 marshes in western Newfoundland within 100 km of Corner Brook, which is about 250 km southwest of Plum Point. Climatically this was the most favourable part of the island for plant growth; it is rugged and heavily forested (Damman 1983). Common wetland vegetation included sweet gale (*Myrica gale*), ericaceous shrubs, and sedges. Peatlands were distributed throughout the area. Slates and limestone were under most of the area, with numerous ponds and streams (Damman 1983).

3. Methods

We determined historical distribution and harvest of muskrats and mink by examining export permits and fur buyer reports for insular Newfoundland. Harvest information can be used as an index to population levels of furbearers, despite variables such as pelt price, weather, number of trappers, and trapper effort (Erickson 1981, Clark 1986). Fur ledgers were available from 1958–1959 to 1991–1992. Export permits were available only for the 1980s and 1990s.

During summer 1988 and 1989 we recorded vegetation types as an index of relative abundance on sample areas of at least 200 m^2, by using the Braun-Blanquet (1965) method of cover abundance, with a scale of 7 classes: very sparse, individuals plentiful but coverage small, under 5%, 6–25%, 26–50%, 51–75%, 76–100%. We obtained total estimates and an estimate of sociability of each species. Sociability groups plants into 5 classes: singly, turfs, small groups, large groups, extensive stands. We accomplished a more detailed analysis of cover by species at each site by use of vegetative plots (Daubenmire 1959) spaced at regular intervals along a transect line randomly selected (Oosting 1956, Gysel & Lyon 1980). Relative height-density was estimated with a height-density pole (Robel *et al*. 1970), and analyzed separately for each year with a multiple analysis of variance. No effort was made to relate height to weight because Robel *et al*. (1970) ran the correlation for grassland, not wetland.

We determined food habits of muskrats by observing remains of plants eaten during fall 1988 (Korschgen 1980). We determined food habits of mink by obtaining carcasses from trappers during fall 1988 and examining stomach contents. We identified hairs by using a negative impression technique (Adorjan & Kolenosky 1969). We identified feathers to family by examining downy barbules of covert feathers microscopically (Day 1966). We identified fish and frogs by bone and flesh remains.

4. Results

4.1. Harvest and Distribution

During 34 years, muskrat harvests (N = 118 955) decreased from 11 146 in 1958–59 to 897 in 1991–92; mink harvests (N = 69 548) increased from 932 in 1958–59 to 2 770 in 1991–92 (Fig. 1).

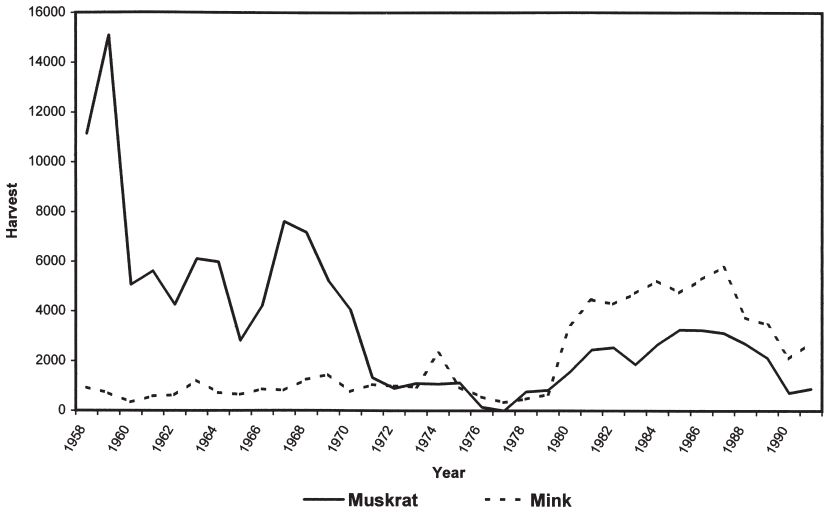

Fig. 1. Harvest of muskrats and mink in insular Newfoundland, 1958–91. Data from 1968–69, 1969–70, and 1974–75 includes Labrador.

During the 1960s, muskrat harvests decreased dramatically whereas mink harvests were stationary at low levels. During the 1970s, both harvests were low. During the 1980s, mink harvests increased markedly; muskrat harvests also increased, but less. Beginning in 1980, some 45 years after mink were introduced, consistently more mink than muskrat were harvested, although muskrat harvests also increased somewhat.

Harvests indicate that mink now occur throughout insular Newfoundland. The last areas of Newfoundland to be occupied by mink have been the northern half of the Northern Peninsula in the mid 1970s and the southernmost part of the Burin Peninsula in southeastern Newfoundland in the late 1980s. Harvests indicate that the largest mink populations are associated with coastal areas of Newfoundland.

From 1985–86 to 1989–90 the average annual harvest was 320 mink and 671 muskrats on the Northern Peninsula and 448 mink and 272 muskrats in western Newfoundland. These data and interviews with trappers suggest that relative densities of mink are lower and muskrats higher on the Northern Peninsula than in western Newfoundland.

4.2. Habitat Factors

No difference occurred in height of wetlands vegetation between the Northern Peninsula and western Newfoundland. Species composition and abundance were different ($P < 0.05$) between sites on the Northern Peninsula and western Newfoundland. On the Northern Peninsula in 1988, sedge, moss, buckbean (*Menyanthes trifoliata*), and water horsetail comprised 57% of the plant species when the Daubenmire method was used and 65% with the Braun-Blanquet method (Table 1). In 1989, results were similar: 62% with the Daubenmire method and 60% with the Braun-Blanquet method. In 1988, sedge, moss, and sweet gale comprised 68% of the vegetation at sites in western Newfoundland with the Daubenmire method and 47% with the Braun-Blanquet method. In 1989, results showed 62% with the Daubenmire method and 54% with the Braun-Blanquet method.

We observed muskrat houses at 3 of 16 study sites in western Newfoundland and 2 of 4 study sites on the Northern Peninsula. All were built of water horsetail.

4.3. Food Habits

Muskrats ate 17 plant species during fall (Table 2). On the Northern Peninsula, the diet consisted of sedge (35%), water horsetail (30%), and bull-head lily (25%). In western Newfoundland, sedge alone comprised 64% of the diet. Cattail comprised just 1% of the diet.

Muskrats appeared to use the most available plant species on the Northern Peninsula and western Newfoundland (Tables 1 and 2). Sedge and horsetail were the most abundant species on the Northern Peninsula; sedge was most abundant in

western Newfoundland. Bull-head lily also was an important food item, but only the emergent wetland vegetation, and not the submergent or floating-leaf vegetation, was quantitatively measured. Bull-head lily was common in ponds on the Northern Peninsula and western Newfoundland.

Table 1. Total percentage[1)] of the most abundant (≥ 5%) plant species on the Northern Peninsula and western Newfoundland, as determined with the Daubenmire and Braun-Blanquet methods of vegetation measurements.

	Daubenmire				Braun-Blanquet			
	Northern Peninsula		Western Newfoundland		Northern Peninsula		Western Newfoundland	
Species	1988[2)] Total %	1989[3)] Total %	1988[4)] Total %	1989 Total %	1988 Total %	1989 Total %	1988 Total %	1989 Total %
Carex spp.	19*	19**	41*	43**	8	7	31	39
Moss[5)]	14	10	13	7	22	17	12	8
Myrica gale	2*	0**	14*	12**	3	1	4	7
Sanquisorba canadensis	6	10	4	3	1	6	3	2
Solidago spp.	1	0	1	4	0	0	1	3
Equisetum fluviatile	11*	12**	tr[6)]	2**	26	23	3	2
Caltha palustris	8*	4	tr*	1	2	5	tr	1
Menyanthes trifoliata	13*	21**	tr*	tr**	9	13	tr	tr
Potentilla palustris	9*	4**	0*	0**	9	6	0	0
Other species	17	20	27	28	20	22	46	37

1) Total (%) = Sum of a species from all plots/total sum of all species × 100%.
2) Includes 1 area, Second Salmon Pond, not measured in 1989.
3) Includes 1 area, Gull Pond, not measured in 1989.
4) Includes 1 area, Grand Lake Brook, not measured in 1988.
5) Mosses were mainly sphagnum moss but because of the difficulty in identifying them they were classified only as moss.
6) Trace (tr) ≤ 0.05%.
*(**) Means were different ($P \leq 0.05$).

Table 2. Observations of plant clippings of muskrats in insular Newfoundland, September–October 1988.

Food item[1)]	Northern Peninsula		Western Newfoundland		Total	
	n	%	*n*	%	*n*	%
Sedge (*Carex* spp.)	25	35	50	64	75	50
Water horsetail (*Equisetum fluviatile*)	21	30	3	4	24	16
Bullhead-lily (*Nuphar variegatum)*	18	25	5	6	23	15
Bulrush (*Scirpus* sp.)	0	0	8	10	8	5
Blue flag (*Iris versicolor*)	3	4	0	0	3	2
Couch-grass (*Agropyron repens*)	0	0	3	4	3	2
Pondweed (*Potamogeton* spp.)	0	0	2	3	2	1
Buckbean (*Menyanthes trifoliata*)	2	3	0	0	2	1
New York aster (*Aster novi-belgii*)	0	0	1	1	1	1
Joe-pye-weed (*Eupatorium maculatum*)	0	0	1	1	1	1
Cattail (*Typha latifolia*)	0	0	1	1	1	1
Rush (*Juncus* sp.)	0	0	1	1	1	1
Bog goldenrold (*Solidago uliginosa*)	0	0	1	1	1	1
Canadian burnet *(Sanquisorba canadensis*)	0	0	1	1	1	1
Bur-reed (*Sparganium* sp.)	0	0	1	1	1	1
Willow (*Salix* sp.)	1	1	0	0	1	1
Unidentified sp.	1	1	0	0	1	1

1) A pile of 1 plant species constitutes 1 food item, i.e., 1 observation.

We found small piles of empty freshwater clam (*Anodonta*) shells along the water edge at 4 sites. They did not look fresh and appeared to have been deposited during winter.

In the sample of 78 mink, the most common item during fall was fish found in 38% of the mink, followed by mammals, amphibians, and birds (Table 3). We found muskrats in 6.4% of the mink.

5. Discussion

Circumstantial evidence from harvest, habitat conditions, food habits, and predator–prey interactions suggest that introduced mink have had a depressing effect on the Newfoundland race of muskrat. Harvest information for insular Newfoundland suggests that during the 1960s, low mink populations seem to have been adequate to impact Newfoundland muskrats negatively. During the 1970s, when mink and muskrats were at low levels, muskrats seemed to be achieving some equilibrium perhaps because mink were forced to seek other food. During the 1980s when both populations increased, although mink more than muskrat, mink seemed to be successfully exploiting fish resources, as their food habits indicate, while muskrats seemed to be constructing more vegetation houses. These strategies, plus the muskrat's probable acquired fear of mink if none existed earlier, probably enabled both populations to increase. Mink populations now appear to be at high levels in most areas of Newfoundland, while relatively high muskrat populations are restricted to a few areas.

The situation of more mink than muskrats being harvested is unique to Newfoundland. Elsewhere in North America considerably more muskrats than mink are harvested annually (Novak *et al*. 1987), reflecting the predator–prey relationship between the two species (Errington 1963). For example, in Wisconsin, which is similar in size to Newfoundland but contains extensive cattail marshes, from 1971 to 1991 the harvest averaged 612 232 muskrats/yr and 28 273 mink/yr, compared with 1 644 muskrats/yr and 2 790 mink/yr in Newfoundland, or a ratio of 1 mink:21.65 muskrats in Wisconsin and 1 mink:0.06 muskrats in Newfoundland.

Several factors might influence harvest of furbearers, including fur prices, weather, number of trappers, and trapper effort (Erickson 1981, Clark 1986), but harvest information still can be used as an index to population levels (Erickson 1981), if other methods are unavailable. Generally the higher the population, the higher the harvest.

Although trappers could be putting more effort into trapping mink than muskrat because of higher pelt value, such a drastic decline in muskrat harvest more likely results from lower muskrat populations. The paucity of cattail in Newfoundland suggests habitat is marginal for muskrats (Dozier *et al*. 1948, Errington 1948, 1963, Dozier 1950). Before introduction of mink, this island race of muskrat was able to exist in poor quality habitat probably because of low predator

Table 3. Frequency of occurrence of foods in stomachs[1)] of 78 mink from Newfoundland, 1988.

Food item	*n*	%
Unidentified mammal[2)]	6	8
Muskrat (*Ondatra zibethicus*)	5	6
House mouse (*Mus musculus*)	1	1
Meadow vole (*Microtus pennsylvanicus*)	1	1
Snowshoe hare (*Lepus americanus*)	1	1
Masked shrew (*Sorex cinereus*)	2	3
Birds[3)]	3	4
Frog[4)]	4	5
Fish	30	38
Unidentified material	7	9
Empty	19	24

1) One stomach contained 2 items: house mouse and bird.

2) Norway rat (*Rattus norvegicus*) suspected.

3) The technique used to distinguish bird remains requires examination of the distal barbules of feather. But feather remains often are fragmented in stomach contents, making it difficult to determine if the appropriate part of the feather is being examined.

4) The green frog (*Rana clamitans*), occurs throughout insular Newfoundland. The American toad (*Bufo americanus*), wood frog (*Rana sylvatica*), northern leopard frog (*Rana pipiens*), and striped chorus frog (*Pseudacris triseriata*) occur in western Newfoundland (Buckle 1971). The American toad and wood frog were introduced to the Avalon Peninsula in 1978 and 1980, respectively, but their success in establishing has not been documented (Maunder 1983).

pressure (Northcott *et al*. 1974). With indigenous populations of mink and muskrats, to reduce mink predation and improve survival, muskrats use a foraging strategy (Lacki *et al*. 1990), which might be lacking in the Newfoundland race with absence of mink. Clough (1987) reported that absence of predators was probably the key factor in adaptation of an island population of muskrat to upland habitat. Because island species adapt to survive in simple and fragile ecosystems of islands (Primack 1993), predator–prey relationships can be upset readily. For example, a dramatic effect was observed in Newfoundland early in the century when arctic hare (*Lepus arcticus*) and caribou (*Rangifer tarandus*), two important herbivors on the island, began to decrease in numbers. In both instances, cause of decline was rapid increase in numbers of lynx (*Felis lynx*) due to their response to increasing numbers of introduced snowshoe hares (*Lepus americanus*) (Bergerud 1967, 1971).

On the Northern Peninsula, muskrat populations decreased after introduction of mink, but unlike many areas of Newfoundland, trappers reported and trapped more muskrats; horsetail forms large monotypic stands there in shallow waters, apparently offering better habitat for muskrats. In many other areas of Newfoundland, muskrats depend on bank burrows for shelter (E. Lear, unpubl.) probably because of lack of cattail or other suitable vegetation for constructing houses. Muskrats seem to be less susceptible to mink predation where horsetail houses were used perhaps to augment burrows, although houses have higher maintenance costs (Messier & Virgl 1992); such areas had higher densities of muskrats. In Saskatchewan, houses seemed to provide less protection against predators in summer when water level might drop (Proulx *et al*. 1987), and in winter when mink can penetrate houses easier than burrows (Messier & Virgl 1992). In Newfoundland, water levels do not seem to fluctuate much. Survival of muskrats probably is enhanced when they use burrows and houses (Brooks 1985), including thermoregulation with burrows used in summer and houses in winter (MacArthur & Aleksiuk 1979), reduced aerial and ground predation (Brooks 1985, Lacki *et al*. 1990), and escape from flooded burrows. For example, Horicon Marsh in Wisconsin is the largest freshwater cattail marsh in the world, with large populations of mink and muskrats; muskrats build cattail houses and few use bank dens because of a low gradient along the shoreline (Bluett 1992). With lack of cattail for house building, most Newfoundland muskrats must burrow, which is limited by characteristics of soil and bank. In northeastern United States, muskrat burrowing was absent where the combined sand and gravel content was > 90%, bank height was < 0.2 m, or slope was < 10° (Brooks 1985). In Newfoundland, soils tend to be shallow with extensive areas of exposed bedrock, thus limiting burrowing. For example, unlike elsewhere, beaver (*Castor canadensis*) do not burrow in Newfoundland (Payne 1981).

Evidence from harvest returns and habitat quality suggests that mink predation has been the main factor in depressing muskrat populations in marginal habitat; other factors such as cycles, other predators, habitat loss, and disease do not seem responsible. Errington (1954) reported cycles in muskrats, but muskrat populations have been low in Newfoundland too long to be explained by cycles. Muskrats also were well-adapted to other predators on the island before introduction of mink.

Habitat loss cannot be a factor because much of Newfoundland is still relatively pristine. Disease is not suspected as the cause of the decline in the muskrat population because no dead carcasses or unusual outward signs of disease were reported by trappers or wildlife personnel. Trapping probably did not cause decline of muskrats. In 1976 and 1977, the Newfoundland Wildlife Division closed trapping seasons for muskrat. Although population growth in muskrats can be dynamic, none was apparent.

The most important muskrat foods are cattail in Canada, and cattail and bulrush in the United States (Wilner *et al.* 1975). Neither is common in Newfoundland. Muskrats in Finland preferred cattail but sedges, reeds, and rushes were the most commonly found food fragments (Artimo 1960). Muskrat foods and feeding habits vary widely with habitat and season (Perry 1982). We found 17 plant species used as food in fall by Newfoundland muskrats; Lear (unpubl.) found 36.

The 6 mammalian species found in our sample of mink stomachs during fall represent most of the species of small mammals occurring on the island (Cameron 1958). Mink commonly take

muskrats elsewhere in North America (Eagle & Whitman 1987). The percentage (6.4%) of muskrats found in our mink sample was low probably because of the general paucity of muskrats in many areas of Newfoundland and/or because trappers had trapped out muskrats early in the season — a feat readily accomplished in poor habitat and when muskrats are relatively scarce. Jennings *et al.* (1982) reported the occurrence of food items from 48 mink sampled in Newfoundland to be 44.4% salmonids, 22.2% masked shrews (*Sorex cinereus*), 16.6% muskrat, 8.3% snowshoe hares, 5.5% meadow voles (*Microtus pennsylvanicus*), and 3% unidentified or empty. In our study, the percentage of fish (38%) was similar to Jennings *et al.* (1982), but nothing else was. Fish were important to mink in Sweden because of low water levels and temperatures (Gerrell 1967). Mink feed on various aquatic, semi-aquatic, and terrestrial animals (Allen 1986). Mink exhibit considerable variation in diet relative to season, prey availability, and habitat type (Linscombe *et al.* 1982). Mink dietary data from Newfoundland suggest that mink basically are sustained by fish; a numerous mink population could have high predation impact on its preferred prey, the muskrat, especially in the marginal habitat available to Newfoundland muskrats, and their probable lack of avoidance strategy while foraging (Lacki *et al.* 1990). Mink might eat more muskrats during summer.

Harvests of muskrats should be controlled carefully, due to the combined impact of mink and trappers in marginal muskrat habitat. Cattail is beginning to spread where it has been planted artifically. Newfoundland muskrats do not use cattail yet in the few places where it is available. Where muskrats use cattail and horsetail, trapping seasons could be more liberal. In other areas, the muskrat trapping season might require closure.

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