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Predation by Ruffe (*Gymnocephalus cernuus*) on Fish Eggs in Lake Superior

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ABSTRACT. *Ruffe* (Gymnocephalus cernuus) *were introduced to North America in the Duluth, Minnesota—Superior, Wisconsin harbor, which is the westernmost point on the Laurentian Great Lakes. The species proliferated in the harbor and became the subject of research which has gradually revealed certain characteristics of the biology and population growth of the ruffe. In this study ruffe in Southwestern Lake Superior were found to have eaten benthic organisms and eggs of lake herring* (Coregonus artedii). *Overwinter predation by ruffe on eggs of lake herring and of other fall spawning Great Lakes fishes might pose a substantial new source of overwinter mortality.*

INDEX WORDS: *Ruffe, egg predation, Lake Superior, fishery.*

INTRODUCTION

The ruffe (*Gymnocephalus cernuus*), a percid native to Europe and Asia, was accidentally introduced into the St. Louis River estuary in the 1980s and has since become a predominant species there (Pratt *et al.* 1992; Lake Superior Biological Station, unpublished data). Simon and Vondruska (1991) and Pratt *et al.* (1992) documented the establishment of ruffe in North America while Ogle *et al.* (1995) described food and feeding of ruffe in the St. Louis River estuary in 1989 to 91.

In Europe and Asia, ruffe are generally considered to be of little importance or to be a nuisance to sports anglers due to their aggressive feeding habits and small size. Ruffe have been considered to be serious competitors with valuable species such as the Eurasian perch (*Perca fluviatilis*) (Bergman 1990, Bergman and Greenberg 1994) and other European and Asian fishes (Boikova 1986, Sokolov and Vasil'ev 1989, Duncan 1990, Winfield 1992). Ruffe have also been implicated as potentially serious predators of the eggs of various whitefishes (*Coregonus* spp.) (Pokrovskii 1961, Adams and Tippett 1991).

In the late 1980s and early 1990s, ruffe began to appear outside of the St. Louis River estuary, in Lake Superior proper, and in the estuaries of other Lake Superior tributaries (Pratt *et al.* 1992). Ogle *et al.* (1995) found that the ruffe were primarily benthophagous in the St. Louis River estuary, as they are in Europe and Asia, but found little evidence of predation on eggs in the St. Louis River estuary. In this paper the diet of ruffe taken in early winter in Lake Superior several km off the St. Louis River estuary is examined.

METHODS

A collection of ruffe was obtained from a commercial trawl fishery operation for rainbow smelt (*Osmerus mordax*) and lake herring (*Coregonus artedii*). Several bottom trawl tows of various durations were made in December off the St. Louis River estuary at about 10 to 20 m depth in 1993 and at 15 to 30 m depth in 1994 (Fig. 1). Ruffe taken in the several drags were processed with the smelt and herring and were flash-frozen by passing through a brine tank. The frozen individual ruffe were than bagged and held in a freezer. Ruffe were aggregated into 10-mm length classes (total length), and stomachs of up to five randomly selected individuals in each 10-mm length class were collected. Stomachs were preserved in formalin and then processed individually. Each stomach was slit open, the contents of the stomach were

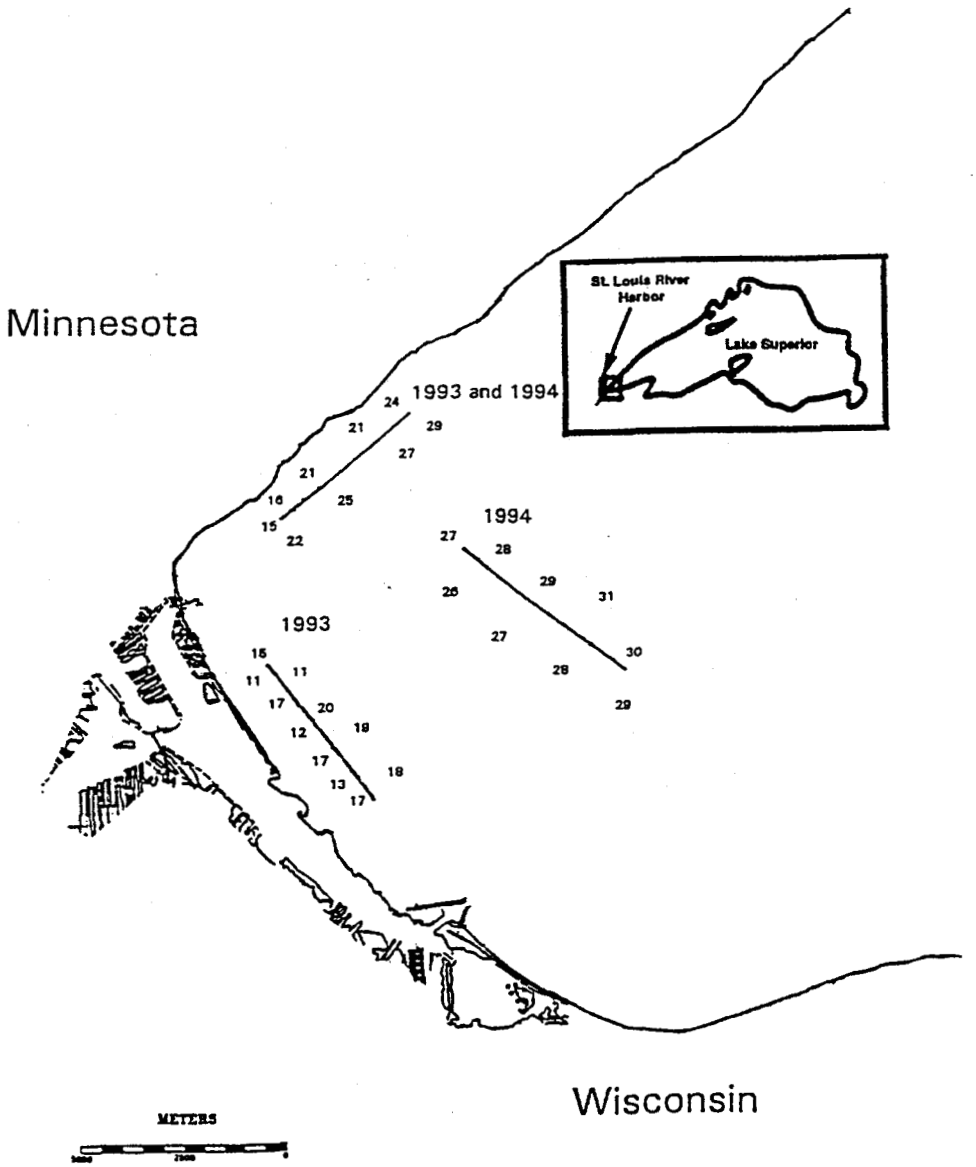

FIG. 1. Map of southwestern Lake Superior showing the approximate tracks of commercial trawl tows in 1993 and 1994. Numbers along the trawl tracks are depths in meters.

weighed and then washed into a petri dish, and the food organisms in each stomach were enumerated. To create an index for conversions among number, weight, and volume, whole food items were pooled and large samples of the whole items were randomly selected, pooled, and mean settled volumes and wet weights of individual items were determined. Total settled volume and wet weights were then estimated for each stomach by multiplication of the mean volume and weight of individual food items times the total number of each item in each stomach.

RESULTS AND DISCUSSION

Food items eaten by ruffe were entirely benthic (Table 1). Opossum shrimp (*Mysis relicta*), bur-

TABLE 1. Winter diet of ruffe in Southwestern Lake Superior, 1993-94, and the mean percent weight and mean percent volume of each item. Standard errors of the means are in parentheses.

	1993 N = 40[a]	1994 N=51[b]	Mean
Diaporeia affinis			
Mean Number	30.7 (6.6)	23.0 (5.7)	26.9
%Weight	44.6	32.7	38.7
%Volume	45.5	42.2	53.9
Chironomidae			
Mean Number	10.2 (2.9)	11.7 (5.7)	11.0
%Weight	8.7	3.5	6.1
%Volume	8.9	3.4	6.2
Mysis relicta			
Mean Number	1.0(3.2)	3.1(8.7)	2.1
%Weight	12.4	16.0	14.2
%Volume	15.4	18.4	16.9
Fish Eggs			
Mean Number	9.4 (2.0)	44.8 (8.7)	27.1
%Weight	34.3	47.8	41.0
%Volume	30.1	36.0	33.1

[a]34 of 40 stomachs contained food.
[b]49 of 51 stomachs contained food.

rowing amphipods (*Diaporeia affinis*), and midge larvae (Chiromonidae) were major items in ruffe diets. Of the benthic organisms commonly eaten both years, *D. affinis* was predominant by number, weight, and volume (Table 1) while Chironimidae were second in abundance and *M. relicta* was second by weight and volume. A few other small food items such as benthic copepods were also eaten. In addition to the benthic organisms, fish eggs were eaten both years but were more abundant in the stomachs in 1994 than in 1993. Fish eggs made up the largest wet weight of all food items and were second only to *D. affinis* in volume of food eaten.

The total amount of food and the number of eggs eaten varied among individual ruffe. Although the numbers of eggs eaten by individual ruffe ranged from 0 to 270 per stomach, the mean number of eggs per stomach generally increased with fish length (Table 2).

Samples of the eggs from ruffe stomachs were unambiguously identified as lake herring (*C. artedii*) with a polymerase chain reaction-restriction fragment length polymorphism test (PCR-RSLP, Hoffman-LaRoche, Inc.) that produces species specific genetic markers for salmonids (Burnham-Curtis and Selgeby, unpublished). Such identity also is consistent with the size of the eggs, the season of the year, and the area from which the ruffe were collected.

Scientists have held that ruffe predation on whitefish eggs might limit vendace (*Coregonus albula*) in certain situations (Pokrovskii 1961), or might adversely affect the endangered powan (*Coregoneus lavaretus*) in Loch Lomond (Adams and Tippett 1991). Although the extent that ruffe may eventually colonize Lake Superior is not known, examination of the literature indicates that ruffe will mainly inhabit the margins of the lake in depths less than 60 to 70 meters but they likely will inhabit increasingly larger areas of the lower Great Lakes which are all shallower and warmer than Lake Superior. Ruffe sometimes move from the estuarine habitats they prefer in summer into deeper waters of lakes in winter (Kolomin 1977). This characteristic is currently being expressed by the ruffe population in the St. Louis River estuary. Lakeward movement of ruffe in fall and winter in

TABLE 2. Winter diet of ruffe in Southwestern Lake Superior, 1993–1994.

Length	No. Stomachs		Mean No. Mysis		Mean No. Diaporeia		Mean No. Chironomidae		Mean No. Fish Egg	
Class (mm)	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
50–59	0	2		0.5		0.0		0.0		3.5
60–69	1	2	0.0	1.0	0.0	0.0	0.0	0.0	3	0
70–79	5	5	1.0	0.2	2.0	16.2	0.0	1.8	9	31
80–89	5	5	0.0	0.6	0.0	0.0	1.6	0.0	15.8	3.6
90–99	5	4	5.0	0.0	14.0	13.8	12.2	4.8	27.8	2.2
100–109	5	5	3.0	0.0	13.6	50.6	15.0	7.0	5.0	25.2
110–119	5	5	1.0	1.0	37.8	69.4	10.6	19.6	11.5	46.0
120–129	5	5	2.0	5.2	60.6	25.0	11.4	14.2	10.2	38.4
130–139	5	5	4.4	8.2	49.6	11.8	27.8	49.4	5.8	114.6
140–149	1	5	0.0	4.0	42.0	2.6	73.0	3.0	28.0	36.0
150–159	3	5	2.0	8.8	119.8	7.8	7.0	9.2	14.2	85.8
160–169	0	1		0.0		1.0		9.0		32.0
170–179	0	2		1.5		118.0		0.0		135.0

this and in other areas of the Great Lakes would bring them into contact with the ova of fall and winter spawning fishes such as lake herring, lake whitefish (*Coregonus clupeaformis*), bloater (*Coregonus hoyi*), round and pygmy whitefish (*Prosopium* spp.), and lake trout (*Salvelinus namaycush*), which might result in predation by ruffe on eggs of those species. Eggs deposited (mainly broadcast) by these fishes lie exposed and are vulnerable to predation for up to 6 or 7 months in Lake Superior, and for somewhat shorter periods in the lower Great Lakes. During those long exposures, dense concentrations of ruffe might severely affect egg survival.

Ruffe in the St. Louis River estuary were found at a mean density of 2,168/ha in 1995, but occasional concentrations had been found of up to 51,730/ha (Lake Superior Biological Station, unpublished data). If winter concentrations of ruffe were to develop in Lake Superior such as those seen in the St. Louis River estuary, the predation on eggs might cause significant mortality. When ruffe inhabit the lower Great Lakes substantial predation on eggs could occur if large numbers of ruffe occupy salmonid spawning areas throughout the winter.

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