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Northern and Southern Brook Lampreys

(*Ichthyomyzon fosser* and *I. gagei*)

in Minnesota

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Running title: Brook Lampreys in Minnesota

ABSTRACT The presence of two brook lampreys of the genus Ichthyomyzon in Minnesota is confirmed. The northern brook lamprey (I. Fossor) occurs in the Blackhoof Creek in the Lake Superior drainage. The southern brook lamprey (I. gagei) has been found in five streams in the St. Croix River drainage. At least three relatively distinct microhabitats are used by I. gagei during its life cycle. Adults prior to spawning are found in crevices beneath boulders in deep, fast water, whereas spawning is associated with gravel substrate at the head of riffles, and larvae burrow in fine substrate in quieter water. The reproductive biology of I. gagei in Minnesota is similar to that of conspecifics in the southern part of its range.

Introduction

Previous reviews of Minnesota's fish fauna (1,2) have included four species of lampreys: the parasitic chestnut (Ichthyomzon castaneus), silver (I. unicuspis), and sea (Petromyzon marinus) lampreys, and the nonparasitic American brook lamprey (Lampetra appendix). Recently, however, two additional nonparasitic lampreys have been reported from the state. Krueger and Waters (3) mentioned the occurrence of northern brook lampreys (I. fossor) within their study section of the Blackhoof Creek in the Lake Superior drainage. Cochran (4) collected the southern brook lamprey (I. gagei) at several locations within the St. Croix River drainage in Wisconsin and reported its occurrence in Minnesota on the basis of one specimen. The purpose of this report is to confirm the occurrence of I. fossor in Minnesota, as documented by museum specimens, and to provide additional information on the distribution and ecology of I. gagei We also provide an updated taxonomic key for identifying Minnesota's lampreys (Appendix).

Methods and Materials

We attempted to time our sampling (26 May - 5 June, 1986) to coincide j with spring spawning, since it is during this period that adult brook lampreys in general are most readily detectable and most easily collected. Likely habitats were sampled by seining or by snorkeling with handnets; the latter method was especially useful where swift current and boulders made seining difficult. In some cases, spawning lampreys were first located visually and collected with dipnets.

At sites with brook lampreys, we recorded the occurrence of other fish species and such habitat characteristics as water temperature, depth, and bottom type. We preserved lampreys in 10% buffered formalin after anesthetization with tricaine methanesulfonate (MS 222) and measurement for total length. Upon return to the laboratory, lampreys were transferred to 70% ethanol prior to morphometric analysis according to Hubbs and Trautman (5). Voucher specimens will be cataloged into the Bell Museum of Natural History (BMNH), University of Minnesota, Minneapolis.

Results And Discussion

Ichthyomyzon fossor

Four male and one female I. fossor (BMNH 23793) were collected on 4 June 1986 at the County Trunk 105 crossing of the Blackhoof Creek Carlton county (T47N,R17W,S17). The lampreys were located beneath small boulders at a depth. of 0.3 m in slow current. Other than a few boulders and some gravel, the bottom was primarily sand; some eelgrass (Vallisneria) was present. Etheostoma nigrum and Cottus bairdi were collected at the same site.

Total length of the I. fossor prior to preservation averaged 110 mm (range = 106-121 mm). Subsequent to preservation, mean length declined to 107 mm (range =

100-114 mm) and body mass averaged 2.2 g. Mean number of trunk myomeres was 51.6 (range = 50-52) and oral disc diameter as a percentage of total length averaged 4.77 (range = 4.44-5.00).

The female I. fossor contained 501 eggs, 27.8% of her preserved total body weight. That this is much fewer than the range of 1050-1979 eggs/female reported by Manion and Hanson (6) and Becker (7) indicates that some spawning already occurred.

Previously, Cochran (8) observed lampreys in the Blackhoof Creek but did not identify them to species. The U.S. Fish and Wildlife Service has records of I. fossor collected at four locations along the Blackhoof Creek during surveys for Petromyzon marinus in 1978 and 1980, but did not save any preserved specimens (Paul Rugen, Marquette Biological Station, personal communication). Krueger and Waters (3) only mentioned the occurrence of I. fossor in their study section, but their paper can be consulted for further habitat information.

Ichthyomyzon fossor previously has been reported from nearby tributaries to three separate drainages shared with Minnesota: the Lake Superior and Mississippi River drainages in Wisconsin and the Red River (Hudson Bay) drainage in Ontario (9). Therefore, its occurrence in Minnesota is not unexpected, and it may occur elsewhere in the state.

Ichthyomyzon gagei

We collected I. gagei at five localities in the St. Croix River drainage (Table 1), including the same site on Crooked Creek at which the only previously reported specimen (4) was captured. Although we found no I. gagei in such streams as Rock Creek and the Grindstone River, more extensive sampling would be required to conclude that they are not present at these sites; in particular, we expect that they occur in the Spruce (Upper Tamarac) River, which is very similar to the

streams in which I. gagei were found. At least two Minnesota tributaries to the St. Croix River have been sampled extensively with no evidence for I. gagei: the Sunrise River, during Hatch's (10) study of the gilt darter (Percina evides) and Valley Creek, during longterm studies by T.F. Waters and colleagues. (The senior author, however, has collected Ichthyomyzon castaneus in the Sunrise River and Lampetra appendix in Valley Creek).

Interestingly, the streams in which I. gagei were collected (Table 1), along with Hear Creek and the Spruce River, were treated by Waters (11) as a single unit on the basis of geological history, underlying topography, and water chemistry (e.g., brown stain and low alkalinity). These streams originate in marshes and swamps atop a moraine, increase in gradient and flow rapidly over gravel bars and riffles as they leave the moraine, then flow more slowly over sandy outwash plains below. Thus they contain a close juxtaposition of habitats suitable for brook lampreys. Gravel bars and riffles are used for spawning (see below), while regions of slower current and finer substrate downstream presumably provide habitat for the burrowing ammocoetes stage.

Some adult I. gagei of both sexes were found in relatively deep fast water in association with boulders, in habitat similar to that described by Cochran (4). For example, at Crooked Creek we observed 4-5 individuals beneath the edge of a large boulder at a depth of 46 cm. At the Tamarac River, we observed 5-6 lampreys at a depth of 60 cm in a crevice among rocks at the base of a boulder and another individual beneath a rock 60 cm deep. This microhabitat possibly represents a pre-spawning staging area or a habitat used by adults for overwintering. Crevices among boulders in deep fast water would provide a well-oxygenated environment out of the direct force of the current and protected from both visual predators and ice scour.

Boulders in combination with swift, deep water frequently occur at road crossings, where channels are often narrowed and reinforced with rubble. An additional feature of road crossings that may be attractive to lampreys, which are generally nocturnal (12), are the reduced light levels beneath them. Many of the records for I. gagei in both the present and Cochran's (4) study were found beneath bridges, although sampling effort was concentrated in the vicinity of road crossings. A crossing of the Tamarac River, constructed in 1981, served as habitat for I. gagei within 5 years (Table 1).

Aggregations of spawning lampreys and individual stragglers were found in shallow water over gravel bottoms in a variety of current speeds. At Crooked Creek, groups of 3, 35-40, and 11 individuals were found at depths of 33, 9-10, and 16 cm, respectively. The group of 3 was unusual in that they were partially obscured by a 20-cm rock and were apparently spawning in a side pool with little current and a bottom of sand overlain by silt; their activity had created a depression through the sand to underlying gravel. At Little Sand Creek, a loose aggregation of 10-11 individuals was located at a depth of 17-18 cm and a group of 7 on a gravel bar at 8.5 cm. At Sand Creek, a group of 5 lampreys occurred at 36 cm, with stragglers at 19, 25, and 20 cm. Two lampreys were observed at Hay Creek on a gravel riffle at a depth of 36 cm. Three spawning groups listed above, including the largest, were located at the head of a riffle, consistent with the observations of Dendy and Scott (13).

Spawning activity was observed during daylight (times of individual observations ranged from 0930-1730 CDT); nocturnal surveys were not attempted. Water temperatures ranged from 17-21°C (Table 1), within the previously published range of 15-24°C (13-15).

Our data suggest that reproductive intervals within individual streams may end abruptly. In Crooked Creek, where large spawning aggregations were present on

29 May, only two single stragglers and four dead spent lampreys were discovered during morning and evening visual surveys on 3 June, and none on the morning of 4 June. At Little Sand Creek, where spawning lampreys were present on 3 June, two pairs were present on the same riffle on 5 June. At Hay Creek, where two stragglers were observed on 3 June, a landowner claimed to have seen a dozen on the same riffle on 1 June.

The percentage of males in preserved samples of at least eight lampreys from individual sites ranged from 20 to 63% (table 1), and was 43% for all preserved samples pooled (n=51). Within a sample of 26 lampreys collected from a single spawning aggregation of 35-40, the percentage of males was similar (427). Previously, Cochran (14) found 100% males among 6 I. gagei collected in Sawyer County, Wisconsin, in 1982, and 76% males among 13 in 1984. Several authors (13-15) have reported excesses of males among. adult I. gagei, but Beamish and Thomas (16) reported a slight preponderance of females.

Total lengths of living adult I. gagei ranged from 107-150 mm (Table 2), but declined subsequent to preservation (96-133 mm). Preserved body mass ranged from 1.05-4.25 g.

We have recorded the cooccurrence of eighteen fish species with I. gagei in Wisconsin and Minnesota (Table 3). Frequent associates include common shiners (Notropis cornutus), longnose dace (Rhinichthys cataractae), johnny darters (Etheostoma nigrum), and mottled sculpins (Cottus bairdi). At Little Sand Creek, we observed three common shiners holding position among a loose aggregation of I. gagei, possibly foraging for eggs of the latter, and several lampreys when disturbed took refuge in a cavity containing the nest of a johnny darter.

Ichthyomyzon gagei cooccurs with I. castaneus in the Namekagon River (Table 3) and probably in Minnesota as well. To date we have not collected any other species of brook lampreys in streams with I. gagei in Minnesota or

Wisconsin. It is of interest, however, that all three of Minnesota's brook lampreys can be collected within a linear distance of 200 km. Lampetra appendix occurs in Valley Creek, a tributary of the St. Croix River, whereas I. fossor and I. gagei occur in watersheds with adjacent headwaters.

Further information on the distribution of I. gagei is needed before its status can be fully assessed. Although its known range in Minnesota is relatively small, it is encouraging that the streams it inhabits are contained at least partially within St. Croix State Park and the St. Croix State Forest. Park and regional fisheries personnel should be alerted to the need for additional records. To that end we have provided an updated key for the identification of Minnesota's lamprey species (Appendix).

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Appendix

The updated key to Minnesota's lampreys presented herein reflects the recent addition of two nonparasitic species (Ichthyomyzon fossor and I. gagei) to the state's known lamprey fauna. Terminology follows that of Eddy and Underhill (1974, 1978). It is hoped that the use of this key will contribute to a more complete understanding of lamprey distributions in Minnesota, especially for the nonparasitic species. The senior author would be happy to examine and provide identifications for any specimens accompanied by appropriate locality data.

1a **Oral opening surrounded by U-shaped hood; eyes undeveloped .....**

.....Larval (ammocoetes) stage.

It is not yet possible to identify ammocoetes conclusively to species.

1b **Oral opening surrounded by circular sucking disc (buccal funnel); eyes developed (adult lampreys)** 2

2a Dorsal fin completely separated into two distinct parts 3

2b Dorsal fin continuous (Ichthyomyzon) 4

3a Parasitic; diameter of buccal funnel greater than width of head; may reach a length > 0.5 m (but begins adult life at approximately the same size as nonparasitic species); restricted to Great lake drainage

..... **Sea lamprey** (Petromyzon marinus)

3b **Nonparasitic; diameter of buccal funnel at most only slightly greater than width of head; maximum length roughly 17-20 cm; known to date from Minnesota River drainage, Mississippi River drainage below St. Anthony Falls, and St. Croix River drainage below Taylors Falls**

..... **American brook lamprey** (Lampetra appendix, formerly referred to as Lampetra lamottei and Lethenteron lamottenii)

4a Circumoral teeth (immediately lateral to oral opening on each side) unicuspid (with one point) **5**

4b Some or all circumoral teeth bicuspid (with two points) 6

5a Parasitic; diameter of buccal funnel greater than width of head; may reach a length of 0.3-0.4 m (but begin adult life at approximately the same size as nonparasitic species)

..... **Silver lamprey** (Ichthyomyzon unicuspis)

5b Nonparasitic; width of buccal funnel less than width of head; maximum body length approximately 25 cm, but often much less .....

....**Northern brook lamprey** (Ichthyomyzon fossor)

Teeth are smaller and more poorly developed than those of southern brook lamprey, I. gagei (see below). Known in Minnesota to date only from Blackhoof Creek in Lake Superior drainage, but not unexpected in Red River (Hudson Bay) drainage and Mississippi River tributaries.

6a Parasitic; width of buccal funnel greater than width of head; maximum body length 0.3-0.4 m (but begin adult life at approximately the same size as nonparasitic species) . . . . . .

. ..... **Chestnut lamprey** (Ichthyomyzon castaneus)

6b Nonparasitic; width of buccal funnel less than width of head; maximum body length approximately 25 cm (but largest Minnesota specimen to date was 15 cm) . . . . . … **Southern brook lamprey** (Ichthyomyzon gagei) known to date from St. Croix River tributaries above Taylors Falls.

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Table 1. Sampling localities, including county, section., township, and range, sampling dates, water temperatures, sampling gear (Se = seines Sn - snorkeling, D = dipnet, V = **visual sighting), and museum catalog numbers of voucher specimens (BMNH - Bell Museum of Natural History; a "-" indicates that no lampreys were seen). The numbers preceding localities where lampreys were collected identify the same localities in Tables 2 and**

Location	County	S	T	R	Date	Temp. °C	Gear	Lampreys
Rock Creek at County 3	Chisago	-	-	-	26 May	17	Se,Sn	-
Rock Creek at County 5	Chisaqo	-	-	-	26 May	-	Se	-
Snake River at St Croix River	Pine	31	39N	19W	27 May	18	Se	-
Grindstone River at State 48	Pine	20	41N	20W	1 June	20	Se	-
Grindstone River at County 26	Pine	33	42N	21W	1 June	21	Se	-
Grindstone River at County 140	Pine	10	41N	21W	1 June	-	Se	-
					3 June	-	Sn	-
Grindstone River at State 48	Pine	27	41N	20W	1 June	-	Se	-
1. Crooked Creek at State 48	Pine	19/20	41N	17W	29 May	21	Se,D	BMNH 23794
					3 June	-	V	+
					4 June	-	V	-
Bear Creek at State 48	Pine	21/25	41N	19W	1 June	-	Se	
2. Tamarac River at State 25	Pine	36	42N	17W	2 June	15	Sn	BMNH 23798
Spruce River at State 25	Pine	25	42N	16W	2 June	19	Sn	-
3. Little Sand Creek at State 48	Pine	30	41N	18W	3 June	17	SE,D	BMNH 23797
					5 June		V	+
4. Sand Creek at State 48	Pine	23	41N	19W	3 June	19	Se,D	BMNH 23796
5. Hay Creek at County 136	Pine	6	40N	18W	3 June	18.5	D	BMNH 23799

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Table 2. Sex ratios, mean lengths of living and preserved lampreys, and mean body mass of preserved lampreys from localities numbered as in Table 1.

Location	Sex ratio (M:F)	Live length (mm)	Preserved length (mm)	Preserved body mass (g)
1	13:17	116(107-120)	107(96-117)	1.99(1.43-2.69)
2	2:0	114(107-123)	107(101-118)	1.84(1.05-2.62)
3	2:8	138(122-133)	118(105-125)	2.24(1.58-2.52)
4	5:3	122(116-127)	110(107-112)	2.29(1.89-2.61)
5	0:1	150	133	4.25

Table 3. Fish species collected with Ichthyomyzon gagei in Wisconsin (Cochran 1987) and Minnesota. Wisconsin localities are indicated by letters (A-U: four sites along Namekagon River in Sawyer County; E: Wood River in Burnett County). Minnesota localities indicated by numbers are described in Table 1.

	LOCATION								
SPECIES	A	B	C	D	E	1	2	3	5
Icthyomyzon castaneus	+		+	+					
Salmo gairdneri						+			
Salvelinus fontinalis									+
Nocomis bigutattus	+	+		+					
Notropis cornutus	+	+		+	+			+	
Pimephales notatus		+						+	
Rhinichthys atratulus		+							
Rhinichthys cataractae			+	+	+	+	+		
Semotilus atromaculatus		+				+			
Catostomus commersoni		+		+					
Moxostoma erythrurum		+							
Moxostoma sp.	+			+					
Noturus gyrinus		+							
Percopsis omiscomaycus				+					
Etheostoma nigrum	+	+		+	+	+	+	+	
Percina caprodes		+		+					
Percina maculata					+		+		
Perca flavescens				+					
Ambloplites rupestris		+		+					
Cottus bairdi		+	+	+					+