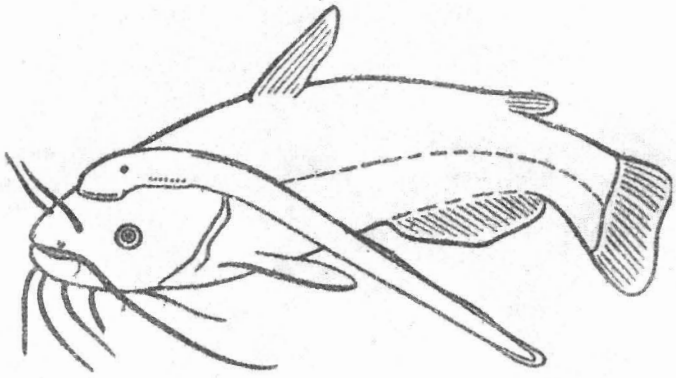
Quebec Lampreys

List of species and their economical importance

by

Vadim D. Vladykov



Department of Fisheries

QUEBEC
1949

A young Northern Lamprey (Ichthyomyzon unicuspis) *feeding on a Bullhead* (Ameiurus nebulosus), *9 inches long, photographed in life.*
Enlargement: *slightly smaller than the natural size.*

DEPARTEMENT OF FISHERIES

PROVINCE OF QUEBEC

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QUEBEC LAMPREYS (Petromyzonidae)

I.- List of species and their economical importance

by

Vadim D. VLADYKOV, Ph. D.
Biologist

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TABLE OF CONTENTS

INTRODUCTION

During recent years in the United States great attention has been given to Lampreys. An excellent revision of the Lamprey genus *Ichthyomyzon* was presented by Hubbs & Trautman (1937). This important work contains extensive bibliography not only on *Ichthyomyzon*, but on other genera of Lampreys as well. Leach (1939 and 1940) published his interesting studies on the life history of the Northern Brook Lamprey (*Ichthyomyzon fossor*). Raney (1941) extended the area of distribution of *Lampetra aepyptera* (Abbott) and gave a short comparison between this and other Eastern North American Lampreys.

In Canada, since Huntsman's important article (1917) no other papers on the taxonomy of Lampreys have been published. In the Province of Quebec, knowledge of Lampreys from Provancher's time (1876) until the present remains about the same. Even in a most recent publication by Cuerrier, Fry & Préfontaine (1946), only two species are mentioned: *Petromyzon marinus* and *Ichthyomyzon unicuspis*, both of which are common parasitic species.

Adults and larvae of Lampreys from different localities were collected extensively during the last decade. Living Lampreys in different stages of development are kept also in aquaria. The results of these observations will be published in several subsequent papers.

The main purpose of this article is to give a comprehensive description of transformed individuals only, while the distinction between larvae (*Ammocoetes*) will be dealt with in the following paper. In addition to the two parasitic Lampreys, already known to live in Quebec, two other nonparasitic species will be described here. These are *Ichthyomyzon fossor* and *Entosphenus lamottenii*, which are reported for the first time from the Province of Quebec.

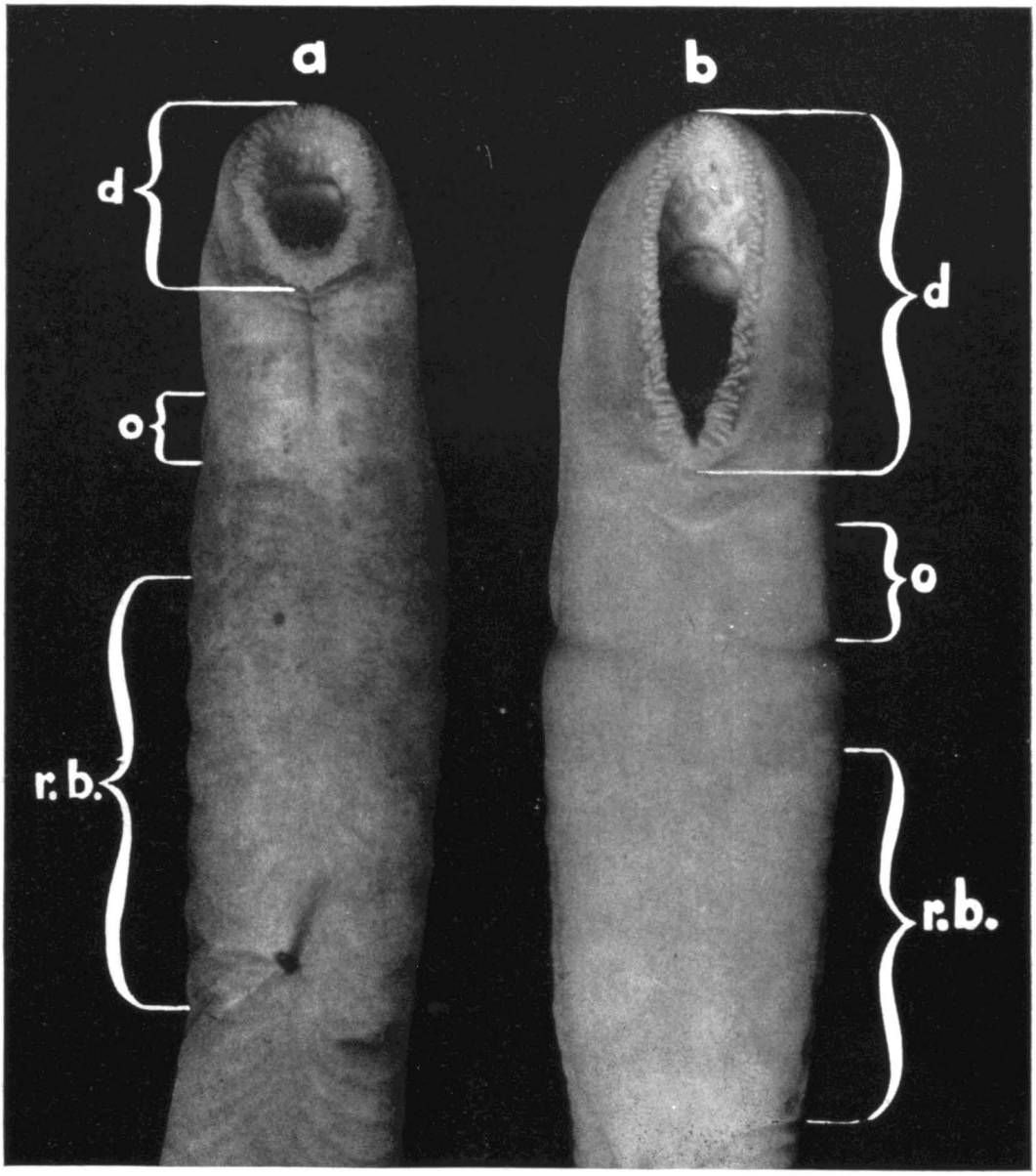

FIGURE 1. — *Comparison between the length of disc* (d), *diameter of eye* (o) *and length of the branchial region* (r.b.) *in two species of Lampreys of corresponding sizes:*

a. — *adult female of the American Brook Lamprey* (Entosphenus lamottenii), *133 millimeters long;*

b. — *young male of the Sea Lamprey* (Petromyzon marinus), *135 millimeters long.*

Note: *very small disc in the American Brook Lamprey.*

Enlargement: *almost five times the natural size.*

EXPLANATION OF TECHNICAL TERMS

To facilitate the use of the key for identification of Lampreys, an explanation of technical terms is added. It must be noted, however, that even in fundamental works on Lampreys from the Northern Hemisphere (Regan, 1911; Creaser & Hubbs, 1922; Berg, 1931 and 1932; Hubbs & Trautman, 1937, etc.) certain technical terms, particularly those referring to teeth, vary from one author to the other. As there exists a looseness in the use of particular terms, the present author feels at liberty to make his own choice. Characters generally employed for identification of Lampreys are grouped into eight broad categories.

1. Body proportions

Different body parts possess different taxonomic significance, hence it is advisable to discuss them separately.

Sucking-disc or ***buccal funnel.*** — It is the most important character for identification. The *diameter* or *length of disc* is measured longitudinally (Figures 1 & 2), the *oral fimbriae*, or leathery appendices, being included. This measurement is subject to great fluctuations due to shriveling. As Hubbs & Trautman (1937, pp. 39-40) pointed out, in the case of *I. unicuspis* « by firm preservation the disc may be compressed into a longitudinal slit, or puckered into a disc hardly more than half its normal diameter. Specimens taken fresh from the water and dropped directly into a rather strong formalin solution show this puckering to an extreme, while those long pickled in weak alcohol, or hardened after they have died or nearly died from exposure on a boat or fish house floor, show the huge mouth which the species consistently shows in life. »

Hubbs & Trautman (1937, p. 40) already observed that in all parasitic species of *Ichthyomyzon* the disc, « after enormously increasing in size during metamorphosis, gradually decreases in proportionate size with increasing total length ». This age variation in the diameter of

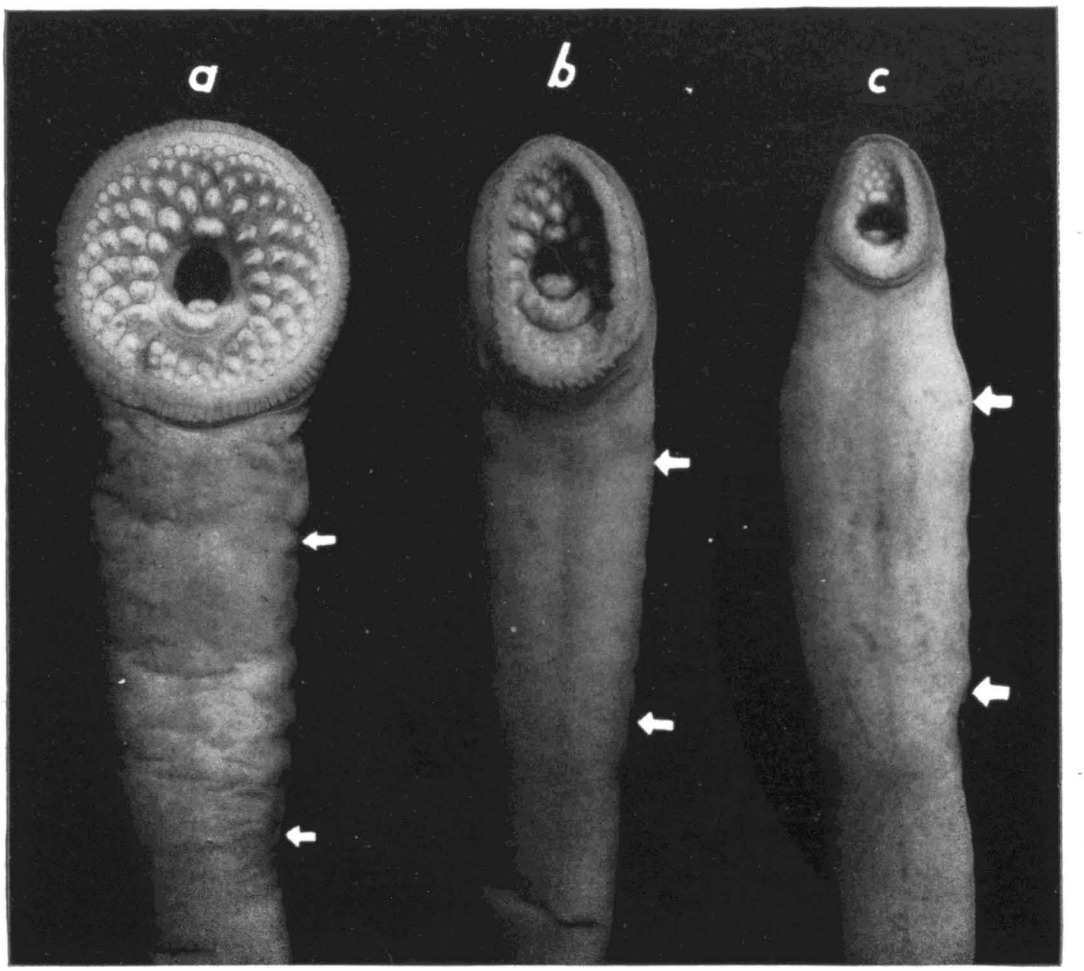

FIGURE 2. — *Comparison between the diameter of disc of two species of* Ichthyomyzon :
***a* & *b*.** — *young females of the Northern Lamprey* (I. unicuspis), *116 and 108 millimeters long respectively;*
***c*.** — *adult female of the Northern Brook Lamprey* (I. fossor), *119 millimeters long.*
Note: *very small disc in the Northern Brook Lamprey. White arrows indicate the length of the branchial region*
Enlargement: *four and a half times the natural size.*

disc (*d*), expressed as percentage of the total length (*Tl*), is particularly noticeable in the case of *P. marinus:*

Number of specimens	*Total length in mm.* Range	Average	*d/Tl %* Range	Average
3	135-147	140.0	8.5-9.3	8.83
4	344-348	345.7	7.3-7.8	7.63
3	431-433	432.0	6.9-7.6	7.33
2	757-835	796.0	6.0-6.1	6.05

Despite great fluctuations due to preservation and to individual variation, the disc measurements are of prime importance in separating different Lampreys. In parasitic species the diameter of the disc is much larger than in nonparasitic ones (Figures 1 & 2). There is sufficient evidence that in all species the disc of the male is relatively larger than that of the female. In general, among Quebec Lampreys of comparable sizes (131-148 millimeters) the diameter of the disc (*d*), expressed as percentage of the branchial region (*b.r.*) and of the total length (*Tl*), varies as follows:

Species	*d/b.r.* %	*d/Tl* %
I. fossor	33.0- 44.0	3.6- 4.0
E. lamottenii	37.0- 47.0	3.6- 4.8
P. marinus	96.0-104.0	8.5- 9.3
I. unicuspis	100.0-106.2	9.1-11.4

The disc (Figures 5-8, *d*) is limited by the *marginal membrane* (Figures 5 & 7, *m*). This membrane is much highly developed in parasitic species, particularly in *I. unicuspis.* In the case of our two nonparasitic Lampreys this membrane is vestigial, hence is not shown in Figures 6 and 8. Outside the membrane is surrounded by *oral fimbriae* (*f* in Figures 2-5). The form and number of rows of these fimbriae apparently vary with species (Gage, 1893, p. 455; Reighard & Cummins, 1916, p. 2; Creaser & Hubbs, 1922, pp. 4-7), but a special study is required to definitely prove this point.

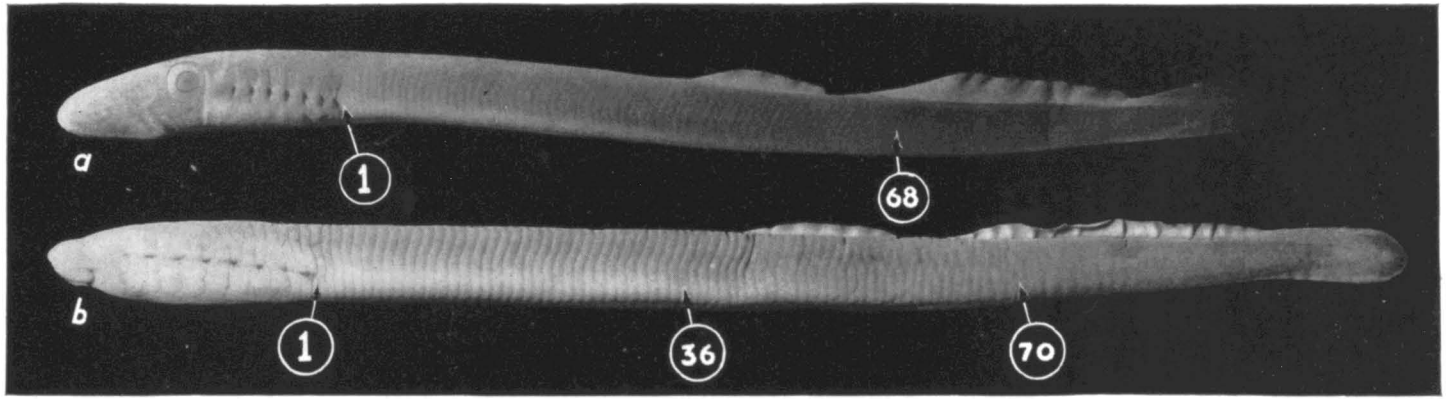

FIGURE 3. — *Sea Lamprey* (Petromyzon marinus):

a. — *newly transformed female, 139 millimeters long;*

b. — *Ammocoete, 156 millimeters long.*

Note: *numbers indicate the order of myomeres or body segments.*

Enlargement: *one and one eighth times the natural size.*

Eye. — To compare the size of the eye (*o* in Figures 5-8) the *horizontal diameter* is used. Among specimens of comparable sizes (131-148 millimeters), in the case of four Quebec species, the diameter of the eye (*o*), expressed as percentage of the total length (*Tl*), varies as follows:

Species	*o*/*Tl* %
I. fossor	1.4-1.5
I. unicuspis	1.8-2.3
E. lamottenii	1.9-2.2
P. marinus	2.7-3.6

It should be noted that young, half-grown adults have eyes proportionally larger than fully-mature specimens (Figures 3, 18-19). Among our species *P. marinus* possesses the largest eyes, which are particularly striking in newly transformed individuals (« macrophthalmia »).

Branchial region. — Behind the eye lies the *branchial region* with seven gill-openings (Figures 1 & 2). Its length, or *length over gill-openings* was measured in the same way, as defined by Hubbs & Trautman (1937, p. 40): « this measurement is made with dividers from the front of the first gill-opening to the groove just behind the fimbriae on the posterior edge of the last opening ».

Length. — In our measurements the *total length* is employed instead of the standard length for the same reason as already pointed out by Hubbs & Trautman (1937, p. 34). *This length was measured from the most anterior tip of the oral fimbriae to the end of the caudal fin.* In parasitic Lampreys, newly transformed individuals are usually smaller than those of nonparasitic species. However, while the nonparasitic individuals do not increase in length anymore, the specimens of parasitic species continue to grow and thus eventually attain much larger size than the former. In general, adults of *I. fossor* are the smallest, measuring approximately 5 inches, and those of *P. marinus* the largest, reaching to 40 inches. It is of importance to note, that the length of fully-grown Lampreys progressively become smaller toward spawning time (Cotronei, 1926 & 1927; Leach, 1940, p. 3; Vladykov & Roy, 1948). So, fully-mature specimens are not the largest ones.

All measurements heretofore mentioned are made on specimens preserved in 4 or 5 per cent formalin solution. Due to shrinkage during the initial hardening in formalin, the length of preserved specimens is from 1 to 3 per cent shorter than that of fresh individuals.

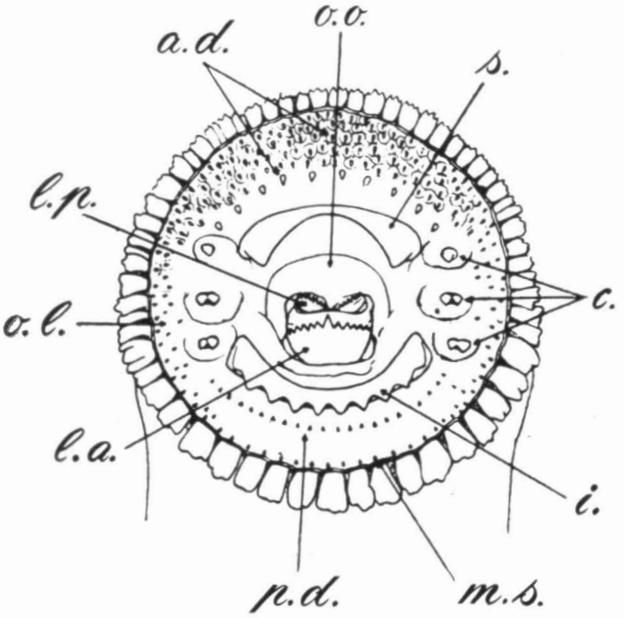

FIGURE 4. — *Schematic drawing of different types of horny teeth on the sucking-disc of Lamprey* (Lampetra), *after Berg (1932, p. 26):*

s. — *supraoral lamina (or supraoral cusps);*

i. — *infraoral lamina;*

c. — *circumorals or enlarged laterals;*

a.d. — *maxillary labials or rows of cusps of the anterior field;*

o.l. — *lateral labials or outer laterals;*

p.d. — *mandibular labials or row (rows) of cusps of the posterior field;*

m.s. — *marginal series or marginals;*

l.a. — *anterior or transverse lingual lamina;*

l.p. — *posterior or longitudinal lingual laminae;*

o.o. — *oesophageal opening.*

2. Number of trunk myomeres

The number of trunk myomeres (segments) is a very important taxonomic character, particularly in the case of Ammocoetes. It must be remembered, however, that in counting only the myomeres or muscle bands and not the intermuscular septa are included: each myomere is bound by two vertical grooves (intermuscular septa), one being anterior and the other posterior.

Certain European authors (Cotronei, 1927; d'Ancona, 1930) add to the trunk myomeres also those of the branchial region, as they count *all preanal myomeres*, situated between the cloaca and the eye. About this method of counting, Cotronei (1927, p. 415) stated: « immediatamente dietro l'occhio fino all'apertura anale, la conta dei miomeri è facile ». Thus, his counts are very high, varying from 86 to 91 myomeres as in the case of *P. marinus*. As myomeres of the branchial region are not always distinguishable and because they unnecessarily raise the total number of preanal myomeres, it was not considered important to count them.

In the present work, *the myomeres were counted between the last (7th) gill-opening and the anterior tip of the cloacal slit.* We follow the same method, as was described by Hubbs & Trautman (1937, p. 28): « the first myomere counted is the one whose posterior septum passes distinctly and entirely behind the groove, which surrounds the fringed margin of the last gill-opening . . . The last myomere counted is the one whose lower posterior angle lies in part or wholly above the cloacal slit » (1).

In transformed Lampreys the first trunk myomere is easily distinguishable from the last head segment carrying the seventh gill-opening, as the latter is divided horizontally by the gill-slit in two sections. The first trunk myomere has no horizontal groove or slit. In Ammocoetes, on the other hand, quite often several first trunk myomeres (from 1 to 3) display horizontal or oblique creases or grooves, which, however, are quite different from the gill-slit (Figures 3 & 2)).

The exact definition of the last trunk myomere in either larvae or transformed Lampreys is sometimes difficult to make. The posterior septum of the last myomere seldom descends to the cloaca, and the

(1) However, certain authors (Raney, 1941, p. 319) counted myomeres to the *posterior end* of the cloacal slit. Thus, their counts are 2, possibly 3, myomeres higher than that obtained by Hubbs & Trautman's method.

anterior tip of the cloacal slit is often hidden by swelled labia (1). Due to these various difficulties, a source of error exists, which may lead to a miscount of 1 myomere, or possibly 2, in some specimens. The danger of a miscount is particularly great when a comparison of counts executed by different persons is made.

For Quebec species the following variations in the number of trunk myomeres were found:

Species	*Number of specimens*	*Number of trunk myomeres*	
		Range	Average
I. unicuspis	138	47-55	50.7
I. fossor	150	51-58	53.5
E. lamottenii	154	64-70	67.5
P. marinus	131	67-74	70.1

3. Fins

Paired fins are lacking in Lampreys. Among vertical fins, from a taxonomic standpoint, the dorsal is most important to identify not only the adults, but Ammocoetes as well. In several genera (*Petromyzon*, *Entosphenus*, etc.) there are two distinct dorsal fins. They are usually well-separated in *P. marinus*, but are close together, practically touching each other, in *E. lamottenii*. In these two Quebec species the dorsal fin is separated from the caudal by a sharp notch; the shape of the caudal fin is rather an angular lobe (Figures 9, 18-20).

On the other hand, in all species of *Ichthyomyzon* the dorsal fin is continuous, often more or less deeply emarginated, but never divided into two distinct fins, as it is in other Lampreys. In *Ichthyomyzon* species the dorsal and anal fins are separated from the caudal fin by a shallow notch. Moreover, the shape of the caudal fin is broadly oval instead of an angular lobe (Figures 11 & 14).

Although several authors (Reighard & Cummins, 1916; Berg, 1932, etc.) mentioned the presence of the anal fin in females of different species of Lampreys the term « anal fin » is used rather metaphorically. In contrast with other fins, the anal in Lampreys is lacking in cartilage rays, hence we shall call it a *fin-like fold between the vent and the caudal fin*, after Gage (1893, p. 439). The anal fin-like fold is typically present only in mature females of all Quebec species, while in males it is either lacking or only very weakly developed close to spawning (Figures 9, 14 & 18).

(1) Hubbs & Trautman (1937, p. 29) give some practical suggestions on how to count myomeres in the case of preserved specimens which are shriveled.

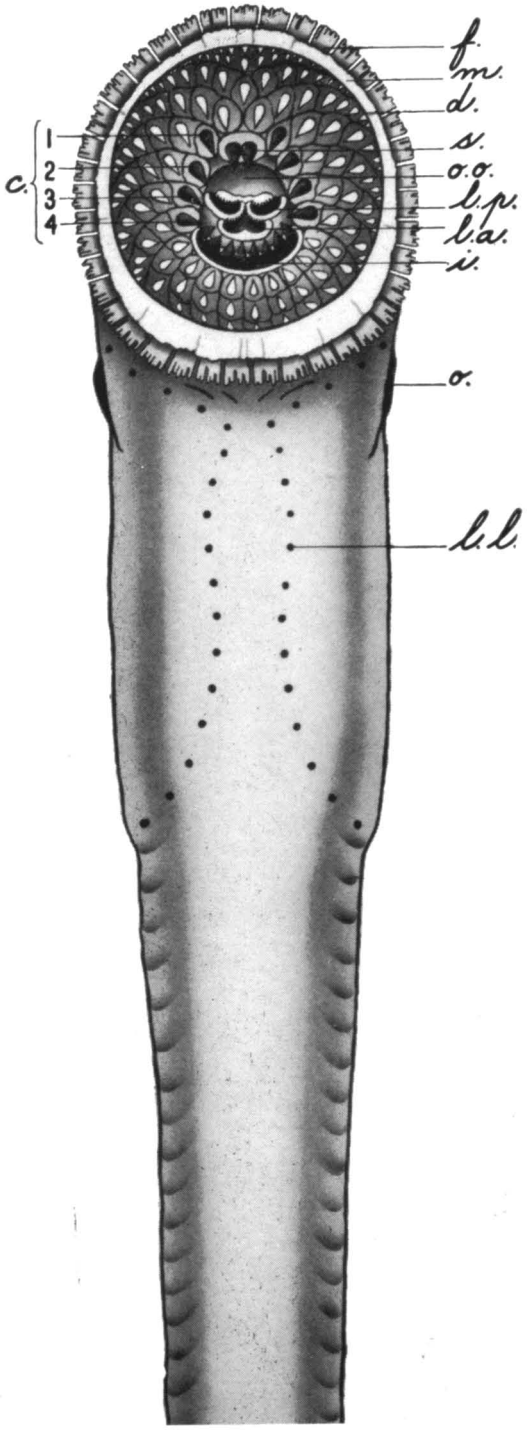

FIGURE 5. — *Schematic drawing of the head of the Northern Lamprey* (Ichthyomyzon unicuspis). *Significance of the letters in this and the three subsequent Figures (6-8) is as follows:*

f. — *oral fimbriae or leathery appendices;*
m. — *marginal membrane;*
d. — *sucking-disc armed with horny cusps;*
s. — *supraoral cusps;*
i. — *infraoral lamina;*
c. — *four circumorals or enlarged laterals;*
l.a. — *anterior or transverse lingual lamina;*
l.p. — *posterior or longitudinal lingual laminae;*
o.o. — *oesophageal opening;*
o. — *eye;*
l.l. — *lateral line organs.*

Note: *very large diameter of the sucking-disc, broad marginal membrane, four simple (unicuspid) circumorals on each half of the disc, sharpness of all teeth of the buccal funnel and their arrangement in radiating series.*

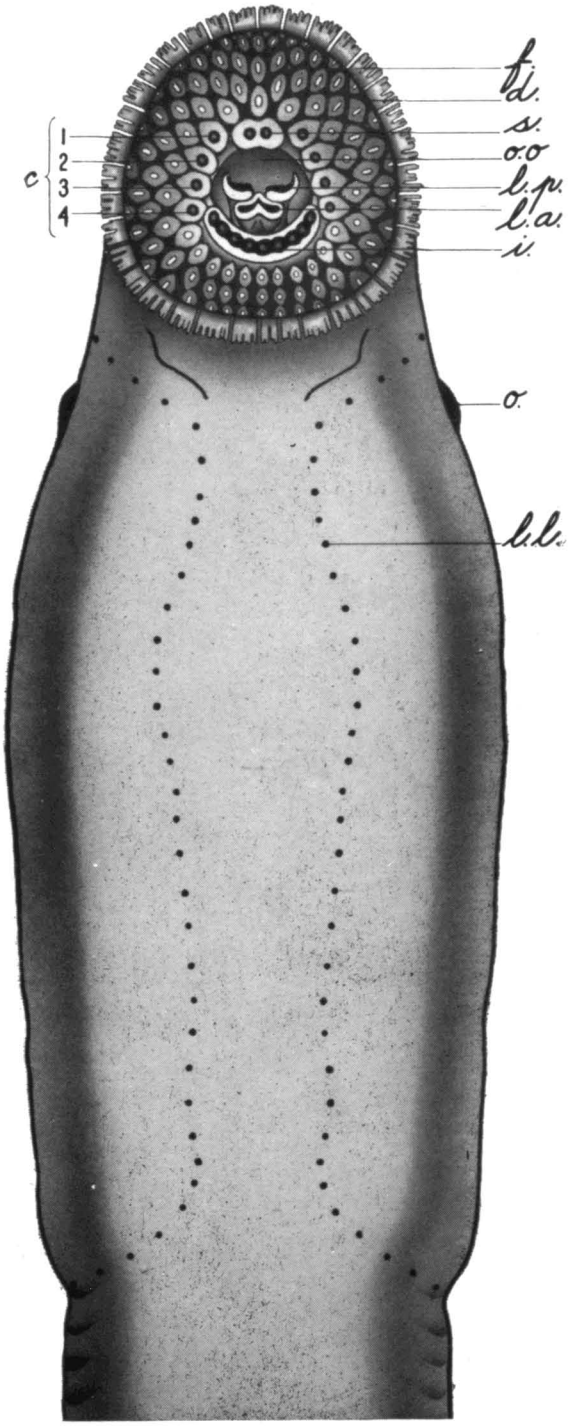

FIGURE 6. — *Schematic drawing of the head of the Northern Brook Lamprey* (Ichthyomyzon fossor). *Significance of the letters is given in Figure 5.*
Note: *small size of the sucking-disc, vestigial marginal membrane, unicuspid circumorals, small and blunt teeth of the buccal funnel and their arrangement in radiating series.*

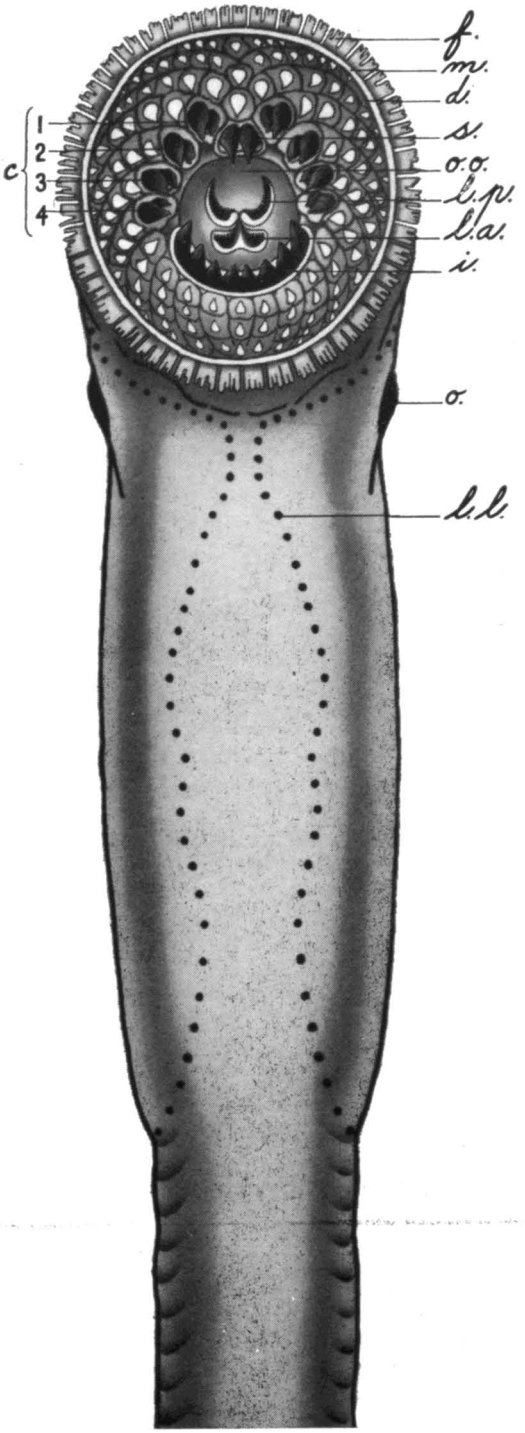

FIGURE 7. — *Schematic drawing of the head of the Sea Lamprey* (Petromyzon marinus). *Significance of the letters is given in figure 5.*

Note: *large sucking-disc; well-developed marginal membrane, four large bicuspid circumorals on each half of the disc, transverse lingual lamina large in size and strongly bent inward, the sharpness of all teeth of the buccal funnel and their arrangement in radiating series.*

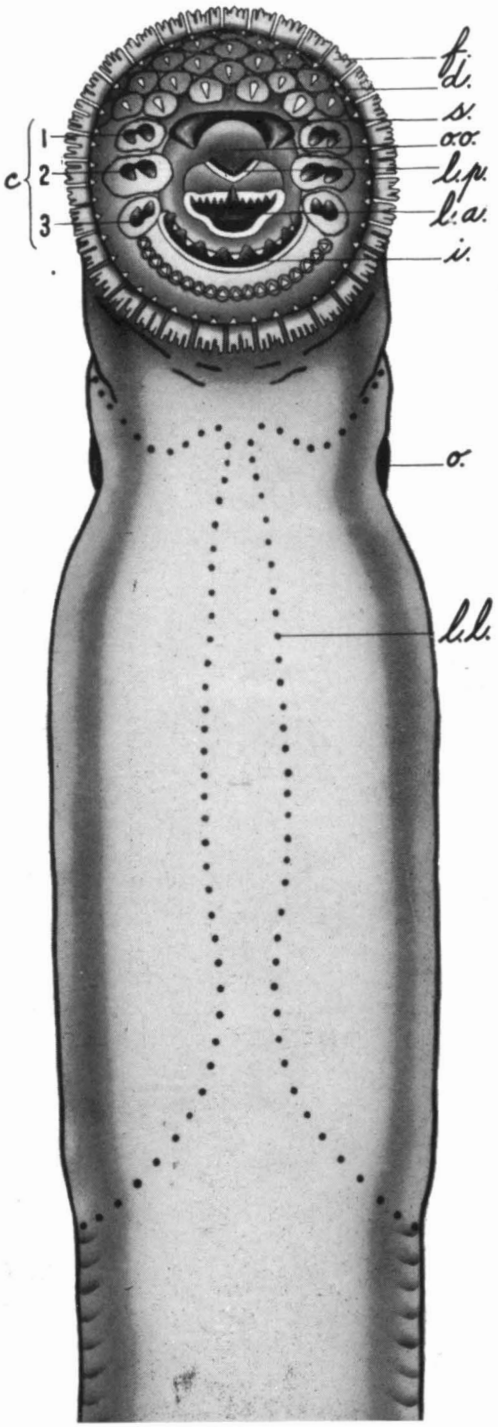

FIGURE 8. — *Schematic drawing of the head of the American Brook Lamprey* (Entosphenus lamottenii). *Significance of the letters is given in Figure 5.*
Note: *small size of sucking-disc, vestigial marginal membrane, broad supraoral lamina, three bicuspid circumorals on each half of the disc, concave transverse lingual lamina with greatly enlarged median cusp, single row of mandibular labials, absence of outer laterals and arrangement of teeth of the buccal funnel not in distinct series, but in several groups.*

4. Dentition

The buccal funnel is armed with horny teeth, which may be in radiating series or in several scattered groups. The colour of the teeth varies from pale yellow in *I. fossor* to dark yellow, almost orange-brown, in *P. marinus*. There is no age variation in the number of teeth, but a tendency, shared with all of the teeth, to become less sharp, even blunt, in the spawning season. Throughout the individual life of Lampreys there are continuous replacements of all old teeth by new ones: « each new tooth, formed as the core of its predecessor, is the image of the former tooth which is sloughed off as a hollow corneous structure » (Hubbs & Trautman, 1937, p. 29). Thus, quite often in examining a Lamprey it is found that the old tooth is still covering the new one. These old teeth can be easily removed with a needle.

At least in the case of some maturing *I. unicuspis*, we observed that under the old, ready-to-be shed disc teeth new cusps of a much smaller size are formed. Berg (1932, p. 38) presented drawings of infra-oral lamina in *Lampetra fluviatilis*, showing old sharp cusps just shedded and underneath new smaller blunt cusps. These facts explain why cusps of fully-mature parasitic Lampreys are weaker than cusps of half-grown adults.

For more critical studies, in examining the teeth, it is necessary to use a binocular microscope. It is well to first clean surplus mucous and dry the teeth by removing excess moisture with absorbent paper, or, still better, to employ jets of compressed air. In some cases staining of the disc with alizarine solution help to detect minute teeth (1).

Supraoral cusps or ***supraoral lamina*** (2) (*s* in Figures 4-8). — These teeth, which play a very important role in the identification of Lampreys, are innermost enlarged cusps at the anterior edge of the oesophageal opening (*o.o.* in Figures 4-8). In our four species, the typical number of supraoral cusps is 2. In the case of *E. lamottenii*, supraoral cusps are well separated by a broad bridge, thus they are called *supraoral lamina*. In the three other species, *supraoral cusps* sit close together, typically on a single base.

(1) Staining in picric acid, as recommanded by Reighard & Cummins (1916, p. 4), did not give us any satisfactory results.

(2) Eddy & Surber (1943, p. 49) used the following definition: « the anterior, or *supraoral* lamina is sometimes known as the *transverse lingual lamina* ». This statement is definitely erroneous.

A cusp distinctly divided at its tip is counted as 2. As rare exceptions, 1, 3 or even 4 cusps are found. The latter number was observed in a single specimen of *I. unicuspis*, in which the tip of each supraoral cusp was subdivided into two peaks, and consequently counted as 4.

Infraoral lamina (*i* in Figures 4-8). — This corneous plate, which bounds posteriorly the oesophageal opening, carries several cusps. The taxonomic significance of the number of infraoral cusps, as rightly pointed out by Hubbs & Trautman (1937, p. 29), is not very great. For our four species the following numbers were found:

SPECIES	*Number of infraoral cusps*		*Number of specimens*
	Range	Average	
I. unicuspis	5-12	7.82	409
I. fossor	6-10	7.98	50
P. marinus	6-10	7.89	221
E. lamottenii	6-10	8.04	87

Infraoral cusps are typically blunt in *I. fossor*, and are very sharp in both parasitic species. *E. lamottenii* occupies an intermediate position.

Enlarged laterals (*c* in Figures 4-8) (1). — Several authors (Regan, 1911 (2); Creaser & Hubbs, 1922; etc.) apply the term *enlarged laterals* for innermost disc teeth, bounding laterally the oesophageal opening between supraoral and infraoral cusps. However, Hubbs & Trautman (1937, p. 32) call these enlarged laterals the *circumorals*. Throughout the present paper we shall use both terms equally, but we believe that the term *enlarged laterals* better expresses the nature of these teeth.

In the case of our two species of *Ichthyomyzon*, the enlarged laterals are typically unicuspid, while in the two other genera they are bicuspid. In *E. lamottenii*, the number of enlarged laterals on each half of the disc is typically 3, or 6 on the entire disc. In the case of the remaining three species the typical number of enlarged laterals is 4 on each half of the disc. To distinguish between Quebec species, it is sufficient to count the number of enlarged laterals on half of the disc (left side of the Lam-

(1) Berg (1932, p. 26) calls them *inner lateral labials*.
(2) Regan in the same paper used occasionally the terms: *inner labial teeth* (p. 198) and *lateral labial teeth* (p. 199) in the same sense, as *enlarged laterals*.

prey). However, Hubbs & Trautman (1937) found it more advantageous to use the total number of circumorals, that is the combined number of enlarged laterals present on each half of the disc.

Labials. — The remaining disc teeth other than the *marginals* (see below), which we shall collectively call *labials* after Regan (1911, p. 199) and Berg (1932, pp. 21-26), have lesser taxonomic significance than the categories of cusps previously described. The labials are small cusps, which are subdivided into three groups according to their respective positions in the disc:

a) *Maxillary labials* (*a. d.* in Figure 4). — These small teeth are very numerous and are located in front of the supraoral cusps. In some genera (*Petromyzon*, *Ichthyomyzon*) they are arranged in radiating series, while in others (*Entosphenus*) they are less crowded and sit in a loose group. These teeth are considered by Regan (1911) as an *anterior group*, while Berg (1932, p. 26) gives them the name of *maxillary labials*, and Hubbs & Trautman (1937, p. 31) call them *rows of the anterior field.* The typical number of rows of maxillary labials in all our four species is 3, counted along the median line in front of the supraoral cusps.

b) *Mandibular labials* (*p.d.* in Figures 4). — These teeth are located posteriorly to the infraoral lamina, and will be called *mandibular labials* after Berg (1932, p. 26). The typical number of rows of these teeth along the median line, is 3 in the case of *Petromyzon* and *Ichthyomyzon*. *E. lamottenii* has only one row of mandibular labials (Figures 4 & 8). The presence of this single row of mandibular labials is sufficient in the opinion of several authors (Regan, 1911; Creaser & Hubbs, 1922, etc.) to separate the genus *Entosphenus* from *Lampetra*, which specimens are lacking in this series of teeth. Berg (1932, pp. 25-42), however, considers *Entosphenus* merely a subgenus of *Lampetra*.

c) *Lateral labials* (*o.l.* in Figure 4). — In some genera (*Petromyzon*, *Ichthyomyzon*), in addition to *enlarged laterals* (see above), several rows of smaller lateral teeth are present, situated outside of the enlarged ones, and known as *outer laterals* or *outer lateral labials* (Berg, 1932, p. 26). The absence of lateral labials in *E. lamottenii* is sufficient to distinguish it from other Quebec Lampreys. The common number of rows of lateral labials on half of the disc is from 3 to 5 in *Ichthyomyzon* and from 5 to 7 in *Petromyzon*.

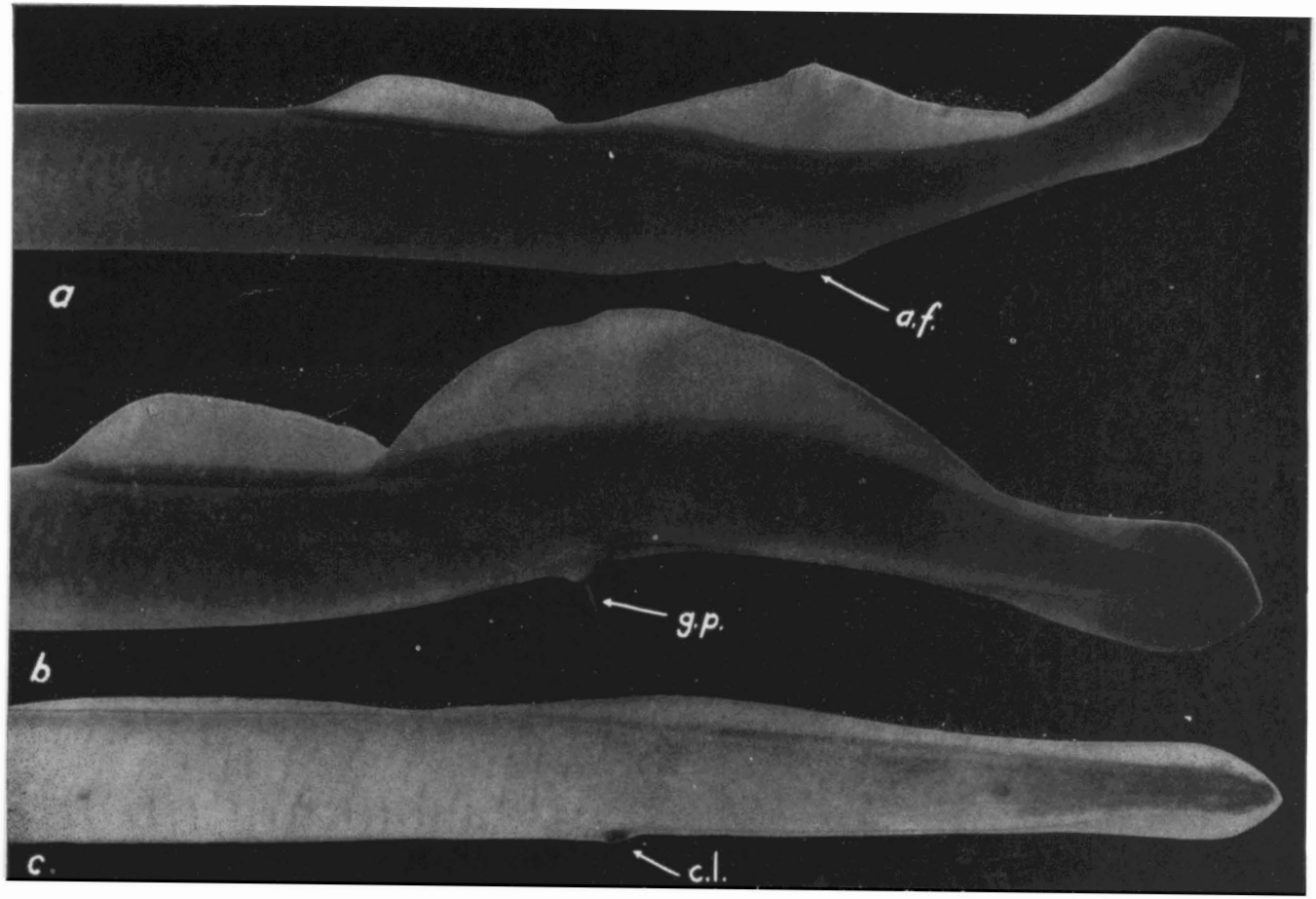

FIGURE 9. — *Sexual dimorphism in the American Brook Lamprey* (Entosphenus lamottenii):

a. *— female, 152 millimeters long;* ***b.*** *— male, 186 millimeters long;* ***c.*** *— Ammocoete, 193 millimeters long.*

Note: *in the mature female tail is bent upward and the anal fold* (a.f.) *well-developed; in the spawning male the tail is bent downward and the genital papilla* (g.p.) *is long; moreover in the male dorsal fins are very high and close together; in an Ammocoete there is no exterior distinction of the sex, the shape of the cloaca* (c.l.) *being not yet differentiated.*

Enlargement: *twice the natural size.*

Marginals. — In all Lampreys, along the inner edge of the *marginal membrane* is present a single row of small teeth, which is usually called the *marginal series*. In the case of *Ichthyomyzon* and *Petromyzon*, the outer row of labials intergradiates in size with the marginals, thus sometimes making a separation of the two categories of teeth very difficult. However, it should be kept in mind that *the marginal teeth sit between rows of labials*. This is seen very clearly on the posterior field of the disc, below the infraoral lamina (Figure 13). From a taxonomic standpoint the marginals are of very little significance.

Lingual laminae. — The « tongue » of Lampreys carries two sets of corneous laminae. One is a single plate, generally known as *anterior lingual lamina* (*l.a.* in Figures 4-8), and the other a double, called *posterior lingual laminae* (*l.p.* in Figures 4-8). However, the terms « anterior » and « posterior » are arbitrary. Hubbs & Trautman (1937, p. 32) rightly point out that, the anterior lamina « does lie in advance of a pair of longitudinal (« posterior ») laminae when the tongue is retracted in the mouth, but is the more posterior when the tongue is protruded as it is when functioning as a rasping organ » (1). We shall follow the lead of these authors in using the terms *transverse* instead of *anterior* and *longitudinal* instead of *posterior*.

The *transverse lingual lamina* is bilobed in *P. marinus*, being strongly bent inward along a median longitudinal line. In *Ichthyomyzon* it is bilobed also, but the inward bending is much less pronounced than in *P. marinus*. In *E. lamottenii* the transverse lamina is a simple, not bilobed plate slightly concave on the outer surface and possesses an enlarged median cusp, which is lacking in the two other genera.

The *longitudinal lingual laminae* are of about the same shape in all Quebec Lampreys, but display a considerable specific difference in dentition and size. The denticulated ridges are particularly strong in *P. marinus*. In the case of *I. fossor* there are no real cusps, but simply irregular denticulation of the anterior edge of different lingual laminae. With a magnification of one hundred diameters, these denticulations are barely visible, their number being about 20 on the transverse lamina and 17 on one of the longitudinal laminae.

In a few specimens of different Quebec Lampreys, in which we examined the lingual laminae, we found that the number of cusps on

(1) This can be clearly seen while observing a live Lamprey attached to the glass wall of an aquarium. In our Figures 5-8 the lingual laminae were executed in that position.

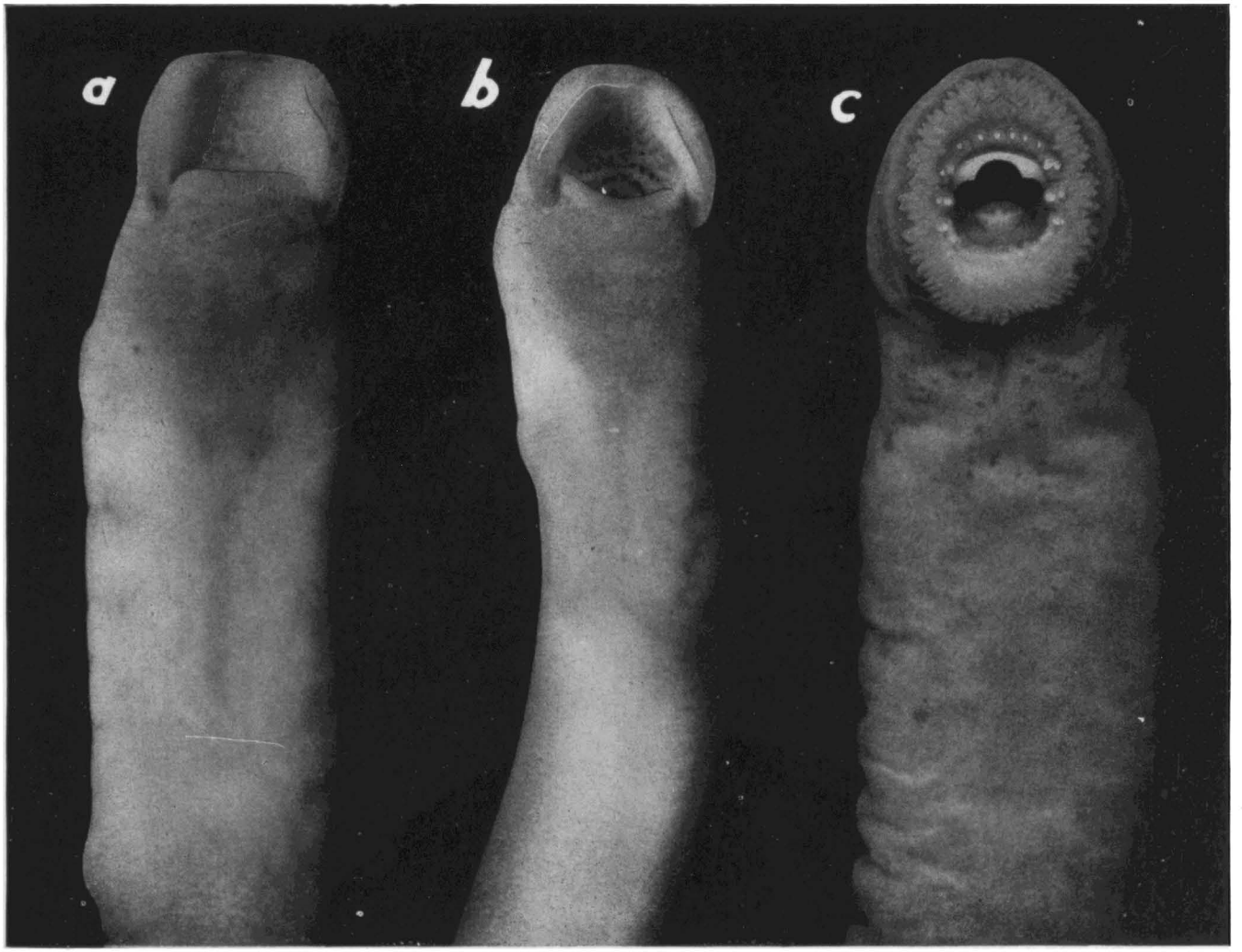

FIGURE 10. — *Ventral view of the heads of larval and adult American Brook Lamprey* (Entosphenus lamottenii):

***a* & *b*.** — *the same Ammocoete, 150 millimeters long;* ***c*.** — *adult female, 152 millimeters long.*

Note: *in Ammocoete the toothless mouth with the upper lip of a squarish, hood-like form, while in the adult the sucking-disc is circular, armed with horny teeth.* ***b*** *represents an anterior view of Ammocoete buccal cavity with the « sieve apparatus ».*

Enlargement: *four and a half times the natural size.*

one longitudinal lamina differs quite often from that of the other. This difference in the case of *P. marinus* and *E. lamottenii* is from 1 to 4 cusps, while in *I. unicuspis* it may be even greater, up to 10 cusps. However, these individual differences do not overshadow the specific significance of the number of cusps on the lingual laminae. Thus, the dentition of the lingual laminae is a very important taxonomic character. In Quebec species were observed the following variation in the number and degree of the development of the lingual cusps:

SPECIES	*Number of cusps on transverse lamina*	*Number of cusps on* (1) *longitudinal lamina*
I. fossor	very minute, uncountable	very minute, uncountable
I. unicuspis	small in size, around 35	small in size, 33-40
P. marinus	large in size, typically 14	large in size, 12-14
E. lamottenii	large in size, typically 15	small in size, 5-8

5. Lateral line organs

In Lampreys the lateral line system (*l.l.* in Figures 5-8) comprises several rows of sense organs on the head and body. There is a row of organs along the upper edge of the gill-openings, and two parallel rows above the gill region; also a pair of strongly arched rows, one on either side of the snout. The latter curve backward on each side behind the disc, almost to the mid-ventral line, on either side of which they are continued backward as a pair of parallel rows on the ventral surface of the branchial region. Moreover, a row of sense organs is located along the base of the dorsal fin, and a separate overlapping row runs from below the middle of the dorsal fin forward, along the upper sides, to the head. It appears that in the four Quebec Lampreys there are certain differences in the pattern of distribution of the sense organs, but not in the number of rows. Before definitely settling this question a special study should be made.

(1) Number of cusps is given for only one longitudinal (or posterior) lamina.

FIGURE 11. — *Northern Lamprey* (Ichthyomyzon unicuspis):

a. *— young female, 106 millimeters long;* ***b.*** *— nearly adult female, 240 millimeters long.*

Note: *in this species there is only one dorsal fin, which is not sharply separated from the caudal; the black pigmentation of lateral line organs is present in the larger specimen.*

Enlargement: ***a.*** *— natural size;* ***b.*** *— three quarters the natural size.*

As already pointed out by Hubbs & Trautman (1937, p. 41), a definite dark pigmentation (with melanin) of sense organs develops in certain *Ichthyomyzon* species. This is the case in our specimens of *I. unicuspis*. However, the pronounced blackening of lateral line organs is noticeable only in half-grown transformed specimens of about 170 millimeters in total length (Figure 11). In the remaining three species of Quebec Lampreys the sense organs remain uncoloured even in fully-mature individuals.

6. Coloration

The general colour of Lampreys varies not only with the species, but also with the age of the specimen. Nonspawning adults tend to vary from light yellow tan on the belly to slate blue on the sides and back. Spawning individuals become progressively darker. In the case of *I. unicuspis* specimens with well-developed gonads have bluish or dark greyish colour even on the lower surface. Adults of *I. fossor* are definitely bicoloured: the dark grey brown colour of the back and sides contrasts with the pale grey or silvery white lower parts.

Newly transformed *P. marinus* (135-175 millimeters) have the colour grading from silvery white on belly to grey-blue above; there is a metallic violet reflexion on the sides, but there is no evidence of a mottled effect. The typical marble marking of this species first appears in specimens measuring about 450 millimeters. Adults of *E. lamottenii* have uniform slate brown coloration.

7. Sexual dimorphism

In the case of nonparasitic species (*I. fossor* and *E. lamottenii*) sexes can be told apart very soon after transformation, but in parasitic Lampreys the sexual dimorphism appears several months later. While some characters, such as the large diameter of the sucking-disc in males, develop quite early in half-grown individuals, others are noticeable much later, only close to the spawning season.

Among four Quebec species the most important secondary sexual characters are the following:

a) *The anal fin-like fold* is well-developed in sexually mature females, while it is almost completely lacking even in spawning males (Figures 9, 14 & 18).

b) The genital papilla, a short tube extending from the abdominal cavity to the exterior through which the sexual products are extruded, is barely visible in females. But the papilla is well-developed in fully-mature males, being the longest in *E. lamottenii* (Figures 9, 14 & 18).

c) The curve of the tail bends downwards in breeding males, but in females typically turns upwards or sometimes remains straight (Figures 9, 14 & 20). This peculiarity is particularly pronounced in the case of two nonparasitic Lampreys.

Moreover, in contrast with other species, mature males of *P. marinus* have a large « rope-like » ridge extending along the back from the gills to the dorsal fin (Figure 18).

8. Life history

During their life-cycle individual Lampreys pass through two distinct stages: that of an *Ammocoete* and that of an *adult*. The Ammocoete, or simply a larva of a Lamprey, can be recognized by its peculiar toothless, horseshoe shaped mouth with a fleshy hood overhanging it. The characteristic sucking-disc mouth of a Lamprey with numerous horny teeth develops only several years later, when the larva transforms into an adult (Figures 3, 10 & 14).

Soon after hatching young Ammocoetes drift downstream, until they become lodged in the mud-banks of spawning streams or rivers in rather shallow and quiet water. Here they burrow into the soft bottom and spend several years (probably from 4 to 7) as larvae, feeding on materials which they strain from the oozy layer on the bottom.

In due time, when a size of 5 to 8 inches has been reached (varying with the species), the Ammocoetes begin to transform towards late summer and fall into adult Lamprey. The metamorphosis is rather a slow process, requiring several months for its completion. So, in nature, practically in every month of the year, Ammocoetes may be found in different stages of transformation.

During metamorphosis the following changes take place in Ammocoetes. The hooded, horseshoe shaped mouth gradually changes to a circular disc-shaped mouth. The sieve over the throat disappears, and on the buccal funnel appear numerous horny teeth. In the throat appears a piston-like « tongue », armed with a double row of rake-like horny teeth. The eyes instead of being rudimentary and deeply imbedded in the tissues of the head, appear at the surface and have a tran-

sparent cornea. A horizontal groove on each side of the branchial region, which unites the gill-openings in Ammocoetes, disappears now, and the gill-openings become rounded in outline. There are several other changes that take place during transformation, but they have lesser taxonomic significance and consequently will not be described here.

After metamorphosis the life of the Lampreys follows one of two courses. In one type of life-cycle, the transformed individuals retain a functional alimentary system and develop strong sharp teeth. They feed by attaching themselves to fishes and, after rasping a hole through the body covering, suck the blood from the host. They continue to live and grow for one or two years more. Upon reaching sexual maturity they re-ascend the streams or rivers in spring migration, spawn, die, and thus complete their life-cycle. This is the case of *I. unicuspis* and *P. marinus*.

The two other Quebec species (*I. fossor* and *E. lamottenii*) belong to the contrasting life history type. They cease entirely to feed and grow in length after metamorphosis, which begins in the late summer or early fall. Without taking any food, they continue to live, however, for a few months more. In these nonparasitic adults the alimentary system is present in a non-functional condition or even degenerates. Having thus passed through the winter, they spawn the following spring; then die, as do the parasitic species.

Only once in their lives all fully-grown Lampreys ascend streams to spawn in the spring. They ordinarily nest on gravelly riffles, where they dig shallow pits, within which they subsequently spawn. After reproduction all spent Lampreys die.

The eggs are quite small, their diameter being about one millimeter (1/25 inch). The number of eggs laid by Lampreys of different species is roughly in proportion to the size of the female. In round numbers they have been found as follows:

Species	*Number of eggs* (1)
I. fossor	1,200
E. lamottenii	3,200
I. unicuspis	10,800
P. marinus (landlocked)	108,000
P. marinus (anadromous)	236,000

(1) Number of eggs for *I. unicuspis* were evaluated by the author, while data for *I. fossor* were quoted after Leach (1940, p. 32), and for the remaining species after Gage (1928, pp. 168-169).

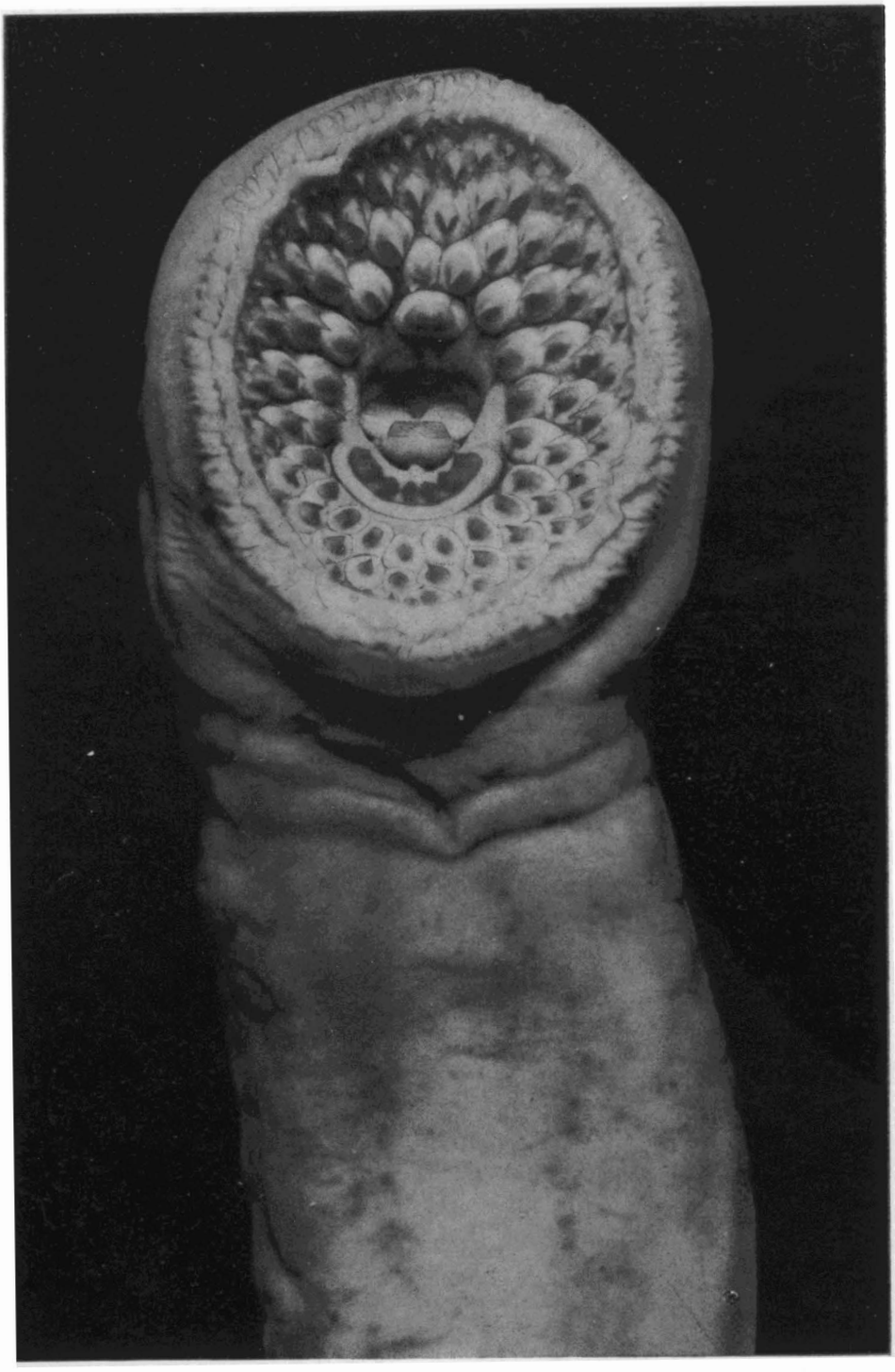

FIGURE 12. — *Ventral view of the sucking-disc of an adult female of the Northern Lamprey* (Ichthyomyzon unicuspis), *312 millimeters long.*
Note: *four unicuspid circumorals on each half of the disc and sharpness of all teeth.*
Enlargement: *three times the natural size.*

There is a definite habitat preference among Quebec Lampreys. The two nonparasitic species (*I. fossor* and *E. lamottenii*) are found in brooks of rather small rivers. On the other hand, *I. unicuspis* inhabit larger bodies of water, being confined in Quebec almost without exception to the St. Lawrence River. All these three Lampreys are exclusively fresh water species: they cannot resist even the slightest degree of salinity. Hence, they are not found east of Cap St. Ignace, along the southern shore of the St. Lawrence River. On the contrary, transformed individuals of *P. marinus* live equally well in both fresh and salt water, however in the sea they attain a much larger size than in lakes. In conclusion, it should be stressed again that all Lampreys, regardless of their habitat preference, spawn only in fresh water.

KEY TO THE SPECIES OF QUEBEC LAMPREYS

(*transformed individuals*)

A. — ***Dorsal fin:*** continuous, more or less emarginated, but never divided into two distinct fins.
Number of trunk myomeres: from 47 to 58.
Supraoral cusps: typically 2, close together.
Enlarged lateral cusps: typically 4 on each side of the disc; with rare exceptions, *all unicuspid.*
Teeth of the buccal funnel: in radiating series.

a.— *Sucking-disc:* large, its diameter equal to 100.0-106.2 (1) per cent of the length of the branchial region and 9.1-11.4 per cent of the total length.
Marginal membrane of disc: well-developed.
Teeth of the buccal funnel: rather long and sharp.
Transverse lingual lamina: bilobed, with about 35 cusps (all small).
Longitudinal lingual laminae: 33-40 cusps (all small) on each lamina.
Total length: from 89 to 312 millimeters.
Life history type: parasitic; completely transformed individuals found any month of the year.
(Figures 2, 5, 11-13) ..... ***Ichthyomyzon unicuspis.***

aa.— *Sucking-disc:* very small, its diameter equal to 27.0-44.0 per cent of the length of the branchial region, and 3.8-4.0 per cent of the total length.
Marginal membrane of disc: vestigial.
Teeth of the buccal funnel: small and blunt.
Transverse lingual lamina: bilobed, with minute, uncountable denticulations instead of cusps.
Longitudinal lingual laminae: weakly developed with minute, uncountable, denticulations.
Total length: from 109 to 150 millimeters.
Life history type: nonparasitic; completely transformed individuals found in the spring only (May and June in Quebec).
(Figures 2, 6, 14 & 15) ..... ***Ichthyomyzon fossor.***

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(1) Throughout the Key and the subsequent chapter, measurements of this and other species are given for specimens of comparable sizes (131-148 millimeters).

B. — ***Dorsal fins:*** 2, either well-separated or close together.

Number of trunk myomeres: from 64 to 74.

Supraoral cusps: 2, either close together or well-separated by a broad bridge, thus forming a *supraoral lamina.*

Enlarged lateral cusps: either 3 or 4 on each side of the disc; *all bicuspid.*

Teeth of the buccal funnel: either in radiating series or in several groups.

b.— *Sucking-disc:* large, its diameter equal to 96.0-104.0 per cent of the length of the branchial region, and 8.5-9.3 per cent of the total length.

Marginal membrane of disc: moderately developed.

Supraoral cusps: 2, close together.

Teeth of the buccal funnel: well-developed sharp cusps in distinct radiating series; typically 4 *enlarged bicuspid laterals,* 5 to 7 rows of *lateral labials* on each side of the disc, and 3 rows of *mandibular labials.*

Transverse lingual lamina: bilobed, strongly bent inward along a median longitudinal line; typically with 14 cusps (all large).

Longitudinal lingual laminae: long, with 12-14 cusps (all large) on each lamina.

Dorsal fins: separated in anadromous specimens, but close together in breeding specimens of the landlocked form.

Total length: from 135 to 860 millimeters.

Life history type: parasitic; completely transformed individuals found any month of the year in either fresh or salt water.

(Figures 1, 3, 7, 16-19)....., ***Petromyzon marinus.***

bb.— *Sucking-disc:* small, its diameter equal to 37.0-47.0 per cent of the length of the branchial region, and 3.6-4.8 per cent of the total length.

Marginal membrane of disc: vestigial.

Supraoral cusps: 2 (1), well-separated by a broad bridge, thus forming a *supraoral lamina.*

Teeth of the buccal funnel: not in distinct radiating series, but in several groups: a group of *maxillary labials*, typically 3 *enlarged bicuspid laterals* on each side of the disc but lacking in *lateral labials*, and a single row of *mandibular labials*, parallel to the marginal series, connecting the last pair of enlarged lateral teeth.

Transverse lingual lamina: single, not bilobed, transverse denticulated ridge, slightly concave on the outer surface; typically 15 cusps (rather large) with median one particularly enlarged.

Longitudinal lingual laminae: 5-8 cusps (all small) on each lamina.

Dorsal fins: 2, close together, almost continuous in mature individuals (in spring).

Total length: from 112 to 187 millimeters.

Life history type: nonparasitic; completely transformed individuals found in the spring only (May and June in Quebec).

(Figures 1, 8, 10, 20 & 21) ..... ***Entosphenus lamottenii.***

(1) Occasionally there is a third small cusp present in the middle of the supraoral lamina[e]

LIST OF SPECIES

Up to the present, only four species of Lampreys, belonging to three different genera, are found in Quebec waters. Two parasitic kinds are widely distributed and are well known to fishermen. The other two, which are nonparasitic species, due to their short existence in transformed stage, are practically unknown to the general Quebec population. However, the larvae (Ammocoetes) of the latter species are often dug up by local fishermen and used as bait.

1. *Ichthyomyzon unicuspis* Hubbs & Trautman, 1937

Ichthyomyzon unicuspis. — Hubbs & Trautman, 1937, p. 52, Pls. 1-2 (original description and figures; Swan Creed, tributary of Maumee River, at Toledo, Ohio). Cuerrier & others, 1946, p. 2.
Ichthyomyzon castaneus. — Provancher, 1876, p. 262 (St. Lawrence River in Quebec).

Figures: Frontispiece, 2, 5 and 11-13.

Local name: Petite Lamproie, Sangsue. *Book name:* Northern Lamprey.

Sucking-disc: large, its diameter equal to or even larger than the length of the branchial region.

Teeth of the buccal funnel: given in the Key.

Dorsal fin: continuous, more or less emarginated, but never divided into two distinct fins.

Caudal fin: broadly oval, not separated by a sharp notch from the dorsal fin.

Eye: moderate in size, its diameter from 1.8 to 2.3 per cent of the total length.

Lateral line organs: colourless in young transformed individuals; dark, almost black, in specimens from 170 millimeters on.

Coloration: half-grown transformed individuals, up to about 170 millimeters, are usually light yellow tan, very light on belly, without grey pigmentation, gradually darkening toward the back; the lateral line organs first colourless become dark later on. Larger specimens taken during winter or early spring, which are sexually mature, exhibit general darkening to blue or blue-grey on the sides and back, and show pronounced greyish or bluish pigmentation on the lower surface. In Quebec specimens of *I. unicuspis* with silvery coloration are never seen.

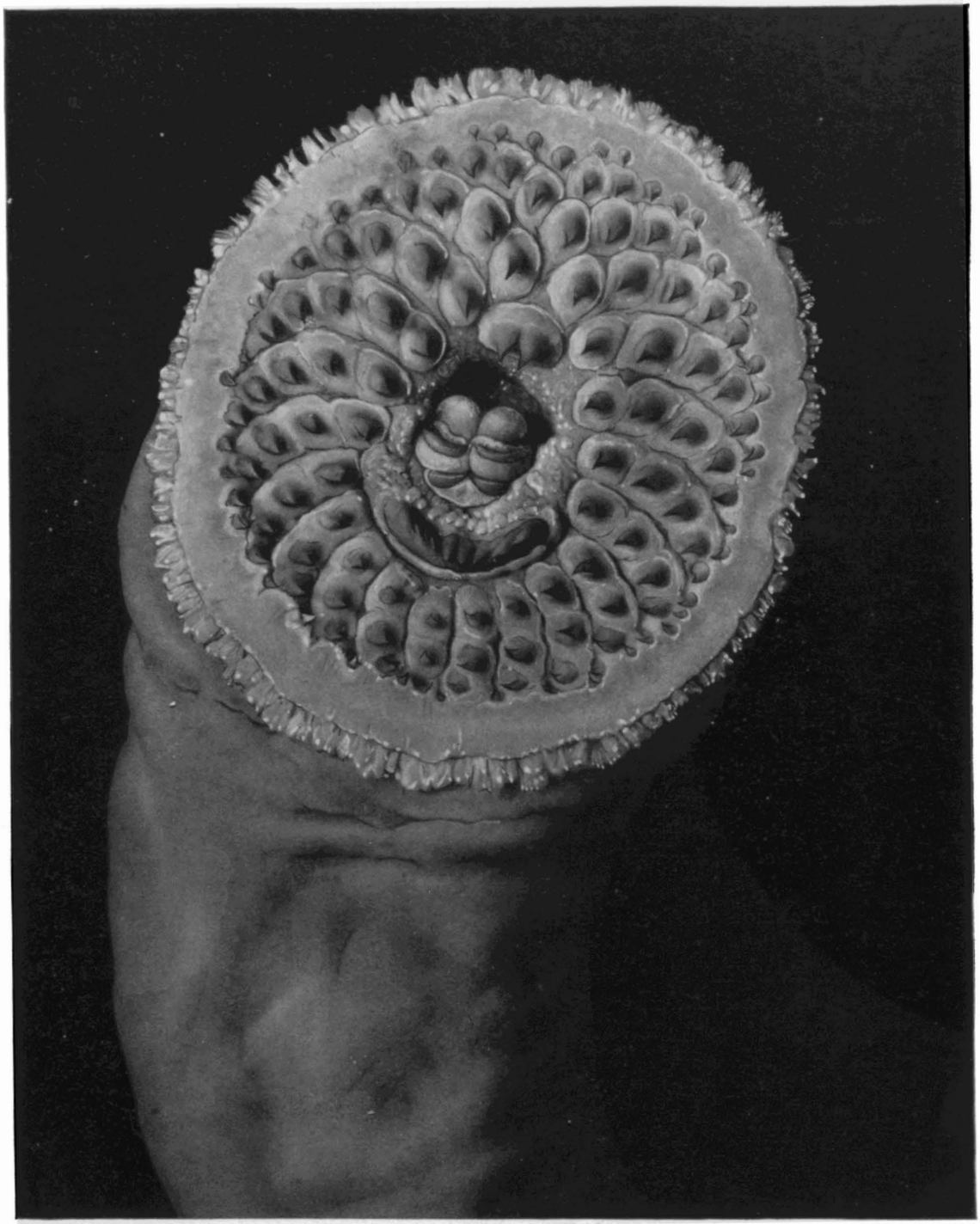

FIGURE 13. — *Ventral view of the sucking-disc of a half-grown Northern Lamprey* (Ichthyomyzon unicuspis), *219 millimeters long.*

Note: *broad marginal membrane, unicuspid circumorals and small cusps of the marginal series. The marginals are clearly seen along inner edge of the marginal membrane, between rows of mandibular labials.*

Enlargement: *four times the natural size.*

Trunk myomeres: rather broad, from 47 to 55, with an average of 50.7 (138 specimens). Hubbs & Trautman (1937, p. 63) give an average of 50.5 myomeres for 278 specimens from the Great Lakes.

Sexual dimorphism: weakly developed; small genital papilla in males and the anal fin-like fold in mature females.

Spawning: as our collections indicate, *I. unicuspis* should spawn in Quebec during May and June. We know at least of one definite spawning ground for this species, namely in the lower section of the St. Francis River, near Pierreville. No doubt it spawns in several other tributaries of the St. Lawrence River.

Life history: parasitic. The alimentary system functional in transformed individuals, whose life span is from 12 to 13 months (Vladykov & Roy, 1948).

Usual habitat: large rivers (St. Lawrence River) and large lakes.

Total length of transformed individuals: from 89 to 312 millimeters. Hubbs & Trautman (1937, p. 64) had a specimen from Lake Erie, which measured 328 millimeters in length.

Distribution in Quebec: several hundreds of transformed individuals were collected in fresh-water sections of the St. Lawrence River, from Lachine Rapids to Montmagny.

General distribution: according to Hubbs & Lagler (1947, p. 27), *I. unicuspis* is found in the interior regions from the Ohio River to the western tributaries of the Hudson Bay; basins of lakes Superior, Michigan, Huron, Erie and Ontario (rare and local in Lake Ontario); the St. Lawrence drainage (below eastern end of Lake Ontario) and Lake Champlain. Some were reported from Lake Nipissing in Ontario and the Nelson River, Manitoba (Dymond, 1947, p. 4).

Economical importance: transformed individuals are very dangerous parasites on a number of important fishes, such as Sturgeons (*Acipenser fulvescens* and *A. oxyrhynchus*), etc. They were collected in Quebec at least on 11 different fish species, and Hubbs & Trautman (1937, pp. 53-56) reported *I. unicuspis* feeding on 9 other species.

Remarks: as it is pointed out above, *I. unicuspis* of the silver colour has never been seen in Quebec. Hence we do not consider the name « Silver Lamprey » proposed by Hubbs & Lagler (1947, p. 27) a good one. We prefer the original name for this species: « Northern Lamprey », as was offered by Hubbs & Trautman (1937, p. 53). Provancher (1876, p. 262) erroneously identified specimens of *I. unicuspis* from the St. Lawrence

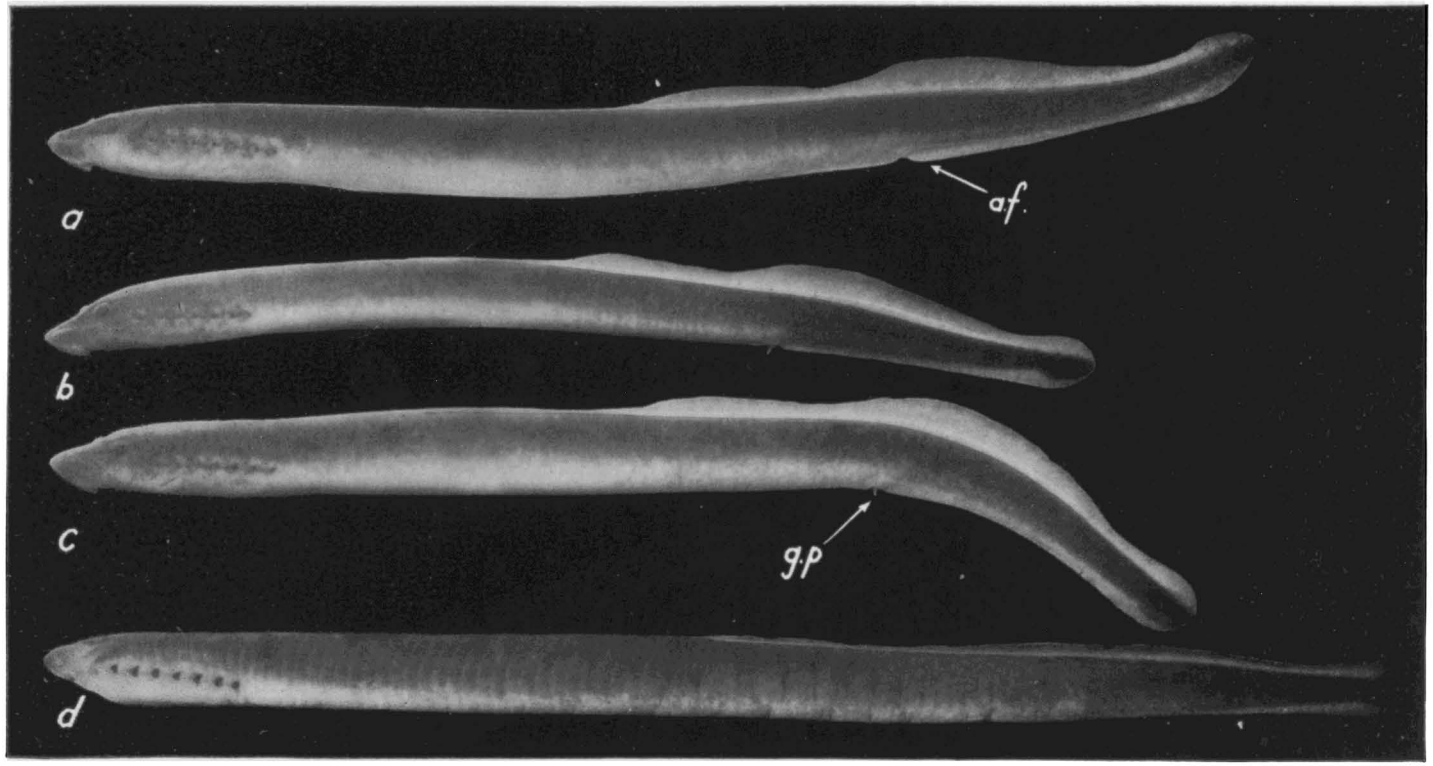

FIGURE 14. — *Northern Brook Lamprey* (Ichthyomyzon fossor):

a. — *spawing female, 133 millimeters long;* **b.** — *mature male, 115 millimeters long;*
c. — *spawning male, 129 millimeters long;* **d.** — *Ammocoete, 154 millimeters long.*

Note: *in this species there is only one dorsal fin, which is not sharply separated from the caudal; in the female the upward bent tail and the well-developed anal fold* (a.f.); *in the males the rather long genital papilla* (g.p.) *and the downward bent tail.*

Enlargement: *slightly larger than the natural size.*

River in Quebec, as *I. castaneus*. In Canada, according to Hubbs & Trautman (1937, p. 77), *I. castaneus* is known only from western Manitoba, where it is found in the Hudson Bay drainage, namely Lake Manitoba, Assiniboine and Red Rivers.

2. *Ichthyomyzon fossor* Reighard & Cummins, 1916

Ichthyomyzon fossor. — Reighard & Cummins, 1916, p. 1. Pls. 1-2 (original description and figures; breeding habits; Mill Creek at Dexter and Huron River at Ann Arbor, Michigan). Hubbs & Trautman, 1937, p. 65 (taxonomic data and distribution).
Reighardina unicolor. — Jordan, Evermann & Clark, 1930, p. 9 (Lake Champlain).

Figures: 2, 6, 14 and 15.

Local name: None. *Book name:* Northern Brook Lamprey.

Sucking-disc: very small, its diameter less than one half of the length of the branchial region.

Teeth of the buccal funnel: given in the *Key*.

Dorsal fin: continuous, more or less emarginated, but never divided into two distinct fins.

Caudal fin: broadly oval, not separated by a sharp notch from the dorsal fin.

Eye: small, its diameter equal to 1.4-1.5 per cent of the total length.

Lateral line organs: nonpigmented even in mature specimens.

Coloration: definitely bicoloured; dark greyish brown colour of the back and sides contrasts with pale grey or silvery white lower parts. The ventral surface, back of the pharynx, is often tinted with orange. This is particularly noticeable in the female, where the eggs show through the body wall. Along the dark back is clearly distinguishable a pale median line. The posterior part of the tail (but not the membrane of the caudal fin) is dark grey, almost black. The dorsal fin tends to be a light tan where it joins the body. The iris is bluish.

Trunk myomeres: rather broad, from 51 to 58, with an average of 53.6 (150 specimens). Hubbs & Trautman (1937, p. 70) for 78 specimens from the Great Lakes region give a much lower average figure, namely 50.9.

Sexual dimorphism: moderately developed; a narrow genital papilla in males, which is relatively better developed than in *I. unicuspis*, and the anal fin-like fold in mature females.

FIGURE 15. — *Ventral view of the sucking-disc of the Northern Brook Lamprey* (Ichthyomyzon fossor):
a. — *adult male, 147 millimeters long;* **b.** — *adult female, 148 millimeters long.*
Note: *small diameter of sucking-disc and blunt buccal funnel teeth.*
Enlargement: *four times the natural size.*

Spawning: in 1948 there were collected fully-mature specimens of *I. fossor* in the Yamaska River, near St. Césaire village, from May 8th to 30th, when water temperatures ranged from 12.8 to 17.2° C. Thus the spawning season in Quebec coincides with the month of May and reaches its peak at water temperatures of 13.3° C. to 15.6° C. Reighard & Cummins (1916, pp. 7-10) described the spawning activities of *I. fossor.*

Life history: nonparasitic; the alimentary system is nonfunctional in transformed individuals, whose life span is very short, less than 6 months. Leach (1940, pp. 24-27) described the details of transformation in this species.

Usual habitat: small rivers, with rather warm water, unsuitable for Speckled Trout (*Salvelinus fontinalis*).

Total length of transformed individuals: from 109 to 150 millimeters.

Distribution in Quebec: I. fossor were collected only in the Yamaska River, near St. Césaire village, and in the St. Francis River, near Pierreville. In the former locality were numerous adults and larvae, while from the latter were found many Ammocoetes, but only one almost completely transformed individual, which was taken on October 10, 1947.

General distribution: according to Hubbs & Lagler (1947, p. 27), *I. fossor* is found in the « Mississippi River drainage in Wisconsin and northern Indiana, and from all of the Great Lakes basins in Michigan and southern Ontario to a Lake Erie tributary in New York ». Dymond (1947, p. 4) for Ontario indicates only the Thames River system, where *I. fossor* was taken.

Economical importance: useful species, whose Ammocoetes are sold as bait for sport fishing.

Remarks: I. fossor never before was reported from Quebec waters. The book name preferred is that used by Hubbs & Trautman (1937, p. 65): « Northern Brook Lamprey ». Hubbs & Lagler (1947, p. 27) call this species « Michigan Brook Lamprey ». As the area of distribution of this species is not limited by Michigan, the latter name is rather confusing.

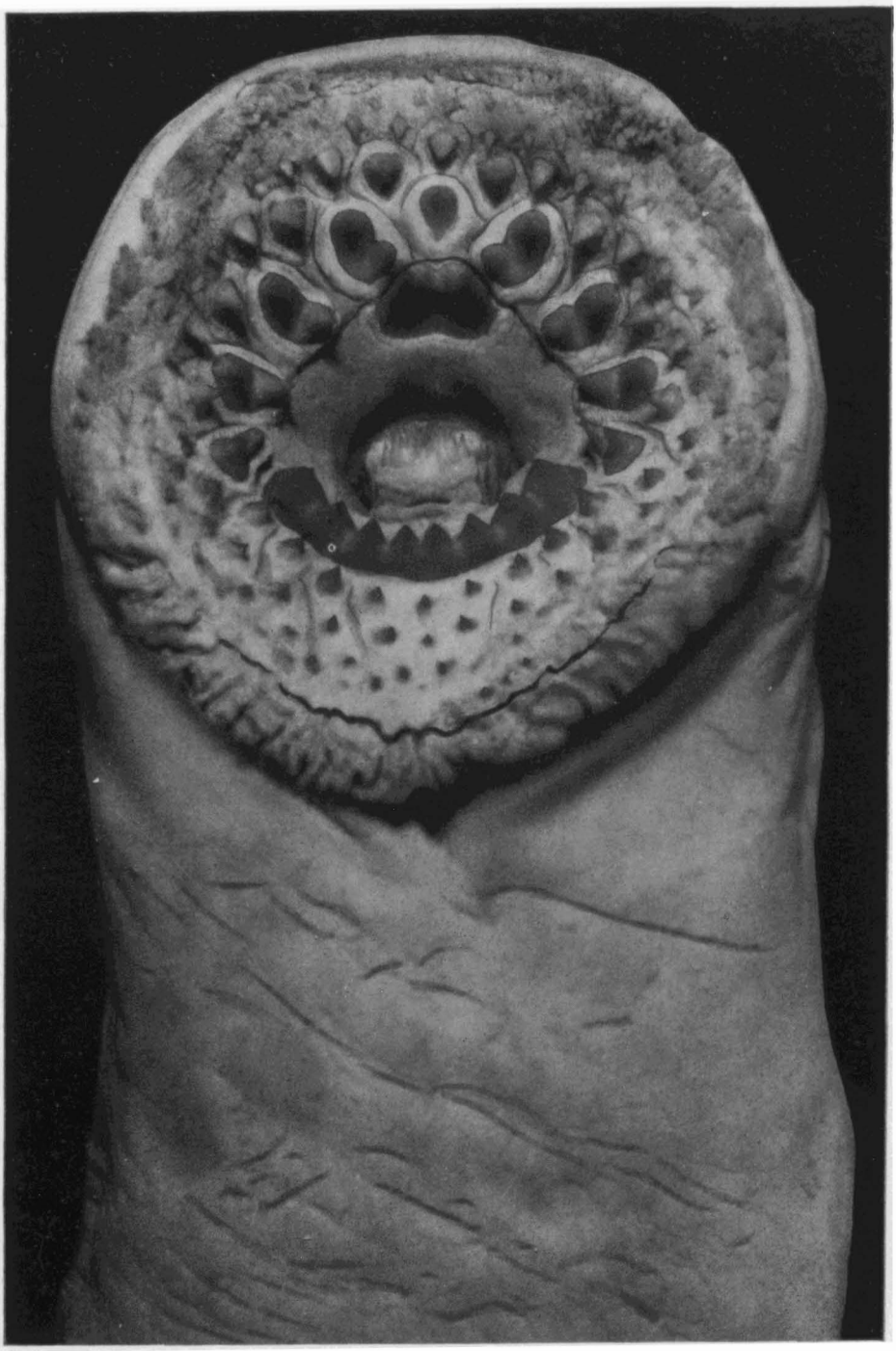

FIGURE 16. — *Ventral view of the sucking-disc of an adult female of the Sea Lamprey* (Petromyzon marinus), *622 millimeters long.*
Note: *large circumorals, which are all bicuspid.*
Enlargement: *two and a half times the natural size.*

3. *Petromyzon marinus* Linnaeus, 1758

Petromyzon marinus. — Linnaeus, 1758, p. 230 (original description; European seas). Creaser & Hubbs, 1922, p. 9. Cuerrier & others, 1946, p. 3.
Petromyzon nigricans. — Provancher, 1876, p. 262 (young specimens; Gulf of St. Lawrence).
Petromyzon marinus dorsatus. — Jordan, Evermann & Clark, 1930, p. 9 (landlocked in Cayuga Lake and other lakes of western and central New York).

Figures: 1, 3, 7 and 16-19.

Local name: Grosse Lamproie, Fifre, Oeillet (1). *Book name:* Lamproie marine, Sea Lamprey (anadromous form) or Lake Lamprey (landlocked form).

Sucking-disc: large, its diameter about equal to, or in younger adults, even larger than the length of the branchial region.

Teeth of the buccal funnel: given in the *Key*.

Dorsal fins: 2, well-separated in anadromous specimens, but close together in breeding specimens of the landlocked form.

Caudal fin: a rather angular lobe, separated by a sharp notch from the dorsal fin.

Eye: rather large, especially in young adults, its diameter from 2.7 to 3.6 per cent of the total length.

Lateral line organs: colourless.

Coloration: newly transformed adults (135-175 millimeters) grade in colour from silvery white on belly to greyish blue above; there is a metallic violet reflexion on the sides, but there is no evidence of a mottled effect. The marble marking, characteristic of fully-grown individuals, first appears in specimens measuring not less than 450 millimeters. There is a dark blotch at the end of the tail, extending to the margin of the caudal fin membrane.

Trunk myomeres: narrow and numerous, from 67 to 74, with an average of 70.1 (131 specimens).

Sexual dimorphism: strongly developed; a « rope-like » ridge along the back, but small genital papilla, in breeding males; anal fin-like fold in mature females. Many years ago, Gage (1893, p. 444) pointed out that in breeding males of the landlocked form, the two dorsal fins are continuous, (2) while in anadromous specimens they are separated (Figures 3 & 18).

Spawning: although Sea Lamprey are taken in commercial weirs (*pêches*) along the St. Lawrence River, between Kamouraska and Three

(1) On account of large gill-openings, this Lamprey suggests a ressemblance to a flute or eyelets on shoes.

(2) In breeding females of anadromous *P. marinus* from Lake Michigan in Wisconsin we also observed that the dorsal fins are close together, nearly touching each other.

FIGURE 17. — *Ventral view of the sucking-disc of an adult male of the Sea Lamprey* (Petromyzon marinus), *745 millimeters long.*
Note: *the size and shape of the lingual laminae.*
Enlargement: *three and a half times the natural size.*

Rivers, from the end of April to the beginning of July, the month of June should be considered as the principal spawning season in Quebec. Hussakof (1912), who made a very interesting study of the spawning habits of this species, saw the spawning of Sea Lamprey at Long Island Sound, New York, on June 1st and 2nd, 1911. Some years ago Coventry (1922, p. 133) gave a good account of the breeding habits of the landlocked form of *P. marinus* in the Humber River, near Toronto. Although numerous adults were seen near the spawning place on May 27th, 1921, the nesting period took place from June 4th to June 21st, when the water temperature varied from 18° C. to 23° C. This author added: « no adults were seen later than June 22nd ». According to Gage (1928, p. 191), in New York lakes the spawning time for *P. marinus* extends from the end of May to the first few days of July.

Life history: parasitic; with a functional alimentary system in transformed individuals, whose life span is long, around 24 months.

Usual habitat: in large bodies of fresh and salt water such as lakes, sea, etc.

Total length of transformed individuals: from 135 to 860 millimeters in the case of anadromous specimens, but up to 528 millimeters only in the landlocked form (Hubbs & Pope, 1937, p. 173).

Distribution in Quebec: in 1905 fishermen of Levis brought to l'abbé Roy (1906) a specimen of « la Grande Lamproie de Mer » (*P. marinus*) taken locally. They mentioned also that numerous Lampreys of the same kind ascend the St. Lawrence River every year as far as that city. Cuerrier & others (1946, p. 3) reported the presence of adult *P. marinus* in Lake St. Peter (1). In our collections we have several of these Lampreys taken in salt water from Trois-Pistoles to Rivière-Ouelle. Among numerous specimens collected in fresh water, the following three are most interesting: two adult males (715 and 636 millimeters) taken in 1945 on June 8 and 17 respectively, in the Yamaska River, below the St. Hyacinthe dam (2); and a half-grown male (415 millimeters), caught by Mr. Z. Oscar Thuot, St. John, P.Q., in the Richelieu River at Iberville, on May 19, 1948. Numerous Ammocoetes were collected in several

(1) These authors mentioned also the capture of « deux jeunes individus », one of which 135 millimeter long was taken in the Richelieu River at St. Ours village, on August 1, 1944. Thanks to Mr. J. P. Cuerrier we had the opportunity of examining this specimen. It is an Ammocoete with 64 trunk myomeres. On basis of this low count of myomeres and its characteristic pigmentation, we consider it as a larval *E. l. mottenii* and not *P. marinus*.

(2) These Lampreys were kindly sent to us by Mr. Eugène Côté, St. Hyacinthe, P. Q. In his letter of June 18, 1945, Mr. Côté mentioned that there were several identical Lampreys in the rapids below St. Hyacinthe. He tried to explain this unusual abundance by heavy rain falls of that year.

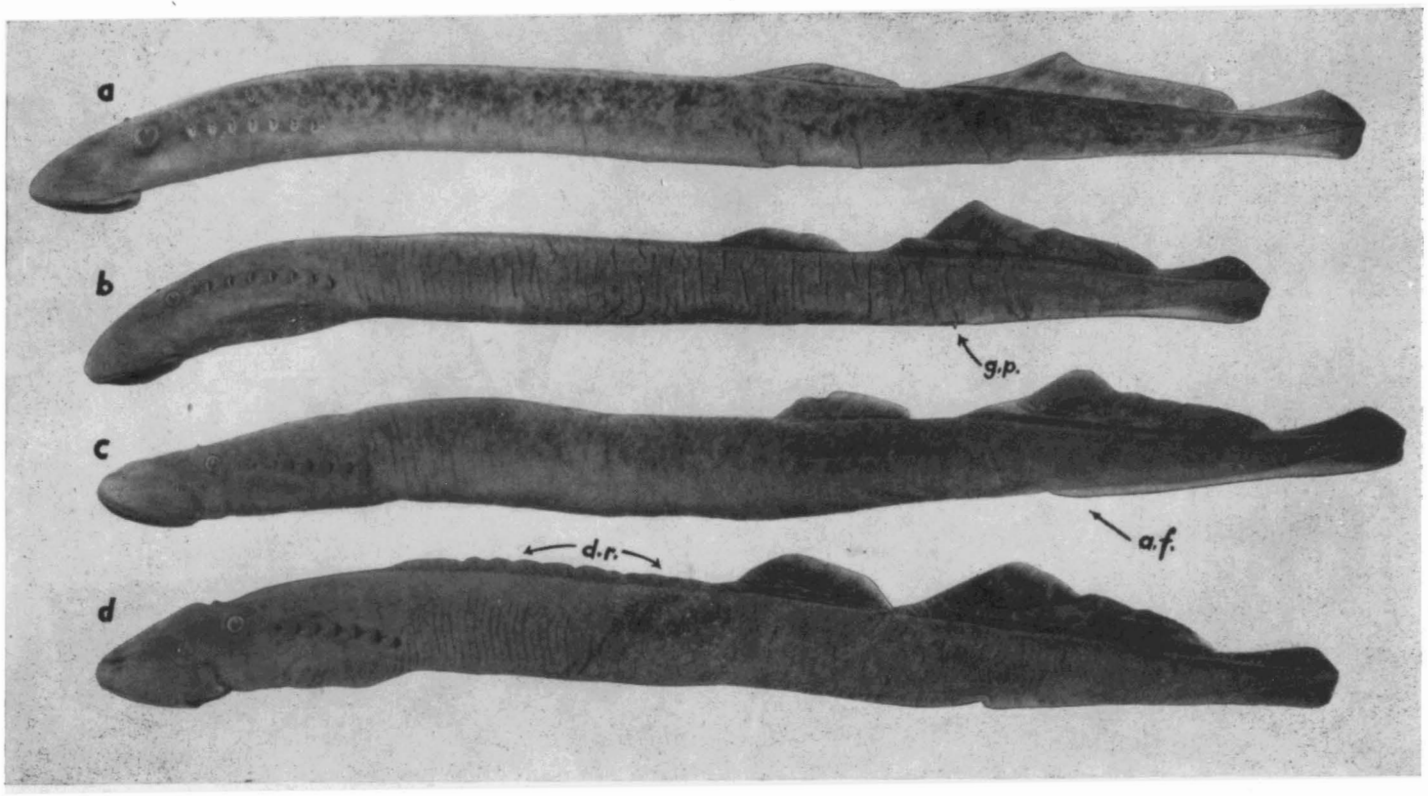

FIGURE 18. — *Sea Lamprey* (Petromyzon marinus). *Comparison between anadromous specimen (**a**) from Quebec and landlocked specimens (**b-d**) forms Lake Michigan in Wisconsin:*

a. *— half-grown female, 466 millimeters long;*

b. *— male, 417 millimeters long, in pre-spawning conditions (dorsal fins as yet far apart and dorsal ridge undeveloped), but with rather long genital papilla* (g.p.);

c. *— pre-spawning female, 455 millimeters long, with well-developed anal fold* (a.f.);

d. *— spawning male, 428 millimeters long, with very pronounced dorsal ridge* (d.r.).

Note: *the coloration of the anadromous specimen (**a**) is different from that of landlocked individuals, on account of only better preservation.*

Enlargement: *about two fifths the natural size.*

tributaries of the St. Lawrence River from St. Vallier to Pierreville. Thus in Quebec *P. marinus* is found throughout the entire Gulf of St. Lawrence and ascends the St. Lawrence River with its main tributaries at least as far as Sorel. Some individuals, no doubt, could ascend even further and probably will be found in the Ottawa River.

General distribution: the anadromous form, that is the typical *P. marinus*, is widely distributed on both sides of the Atlantic, from Iceland (Hubbs & Lagler, 1947, p. 28) and northern Europe to northwestern Africa, and from the Grand Banks to Florida; it is found also in the Mediterranean (d'Ancona, 1930) and Baltic Seas (Berg, 1932, p. 23). In Canada, it is spread throughout the Maritime Provinces (Cox, 1897, p. 42; Huntsman, 1922, p. 7; Bigelow & Welsh, 1925, p. 19; etc.) and Quebec. Some years ago we reported (Vladykov, 1936) the capture of a specimen taken in a depth of about 86 fathoms, north of Emerald Bank (43° 50 N. Lat., 62° 25 W. Long.). The landlocked form (1) was originally found in Lakes Champlain and Ontario and their tributaries; recently it has spread through canals to become well established in all the other Great Lakes (Hubbs & Pope, 1937).

Economical importance: dangerous predatory species, which parasites on both fresh and salt water fishes. Its activities are particularly destructive in lakes. Moreover, it sometimes annoys bathers by clinging to them.

Remarks: some years ago l'abbé Huard (1902, pp. 168-169) wrote: « le 8 juin 1895, lors d'un séjour que nous fîmes aux Sept-Isles, Labrador, un pêcheur du lieu nous donna un petit poisson, d'une longueur de 6 à 7 pouces, qu'il avait trouvé attaché par la bouche au corps d'une Morue. Nous avons noté, dans le temps, qu'à part le ventre qui était blanc, la couleur générale était bleu foncé sur le dos et surtout à l'extrémité du corps, bleu pâle sur les côtés ». He identified this specimen as *Lampetra wilderi* Gage, which is known to-day as *Entosphenus lamottenii* (LeSueur). The coloration of this specimen agrees very well with that of a young Sea Lamprey, and not of a Brook Lamprey. Moreover, as we know now, *E. lamottenii* is not a parasitic species and not found in salt water, thus Huard's specimen was in reality a young *P. marinus*.

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(1) It formerly was considered as a distinct subspecies, *P. marinus dorsatus* Wilder (Jordan, Evermann & Clark, 1930, p. 9); now it is not separated from the typical anadromous form (Hubbs & Lagler, 1947, p. 28).

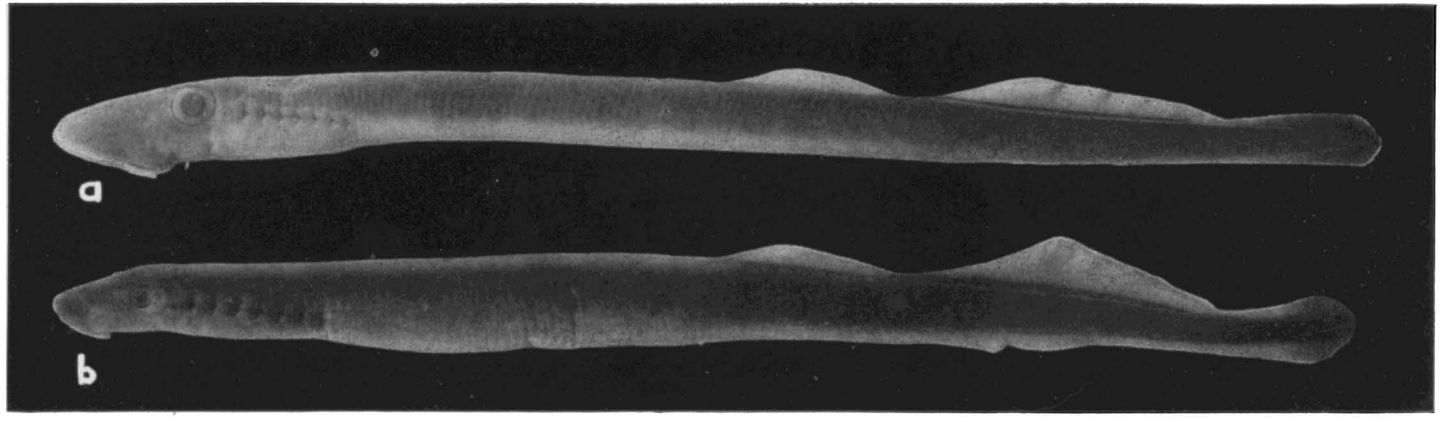

FIGURE 19. — *Comparison between two species of Lampreys with separated dorsal fins:*

a. *— newly transformed male of the Sea Lamprey* (Petromyzon marinus), *135 millimeters long;*
b. *— mature female of the American Brook Lamprey* (Entosphenus lamottenii), *132 millimeters long.*

Note: *large eye and well-separated dorsal fins in the Sea Lamprey* (**a**), *while in the American Brook Lamprey the eye is small, dorsal fins close together and second dorsal quite high. In both species the second dorsal fin is separated by a notch from the caudal fin.*

Enlargement: *one and one third the natural size.*

4. *Entosphenus lamottenii* (LeSueur) 1827

Petromyzon lamottenii. — LeSueur, 1827, p. 9, Pl. 6 (original description; Lamotte mine in Missouri).
Lampetra wilderi. — Jordan & Evermann, 1896, p. 13 (Cayuga Lake, N. Y.).
Entosphenus appendix. — Creaser & Hubbs, 1922, p. 11 (from New England and New York south to Maryland, and west to Wisconsin and Iowa).
Lethenteron appendix. — Jordan, Evermann & Clark, 1930, p. 9 (New York to Iowa, in tributaries of the Great Lakes and of the Ohio and Mississippi, south to Virginia).
Entosphenus lamottenii. — Hubbs & Trautman, 1937, p. 24.

Figures: 1, 8-10 and 19-21.

Local name: None. *Book name:* American Brook Lamprey.

Sucking disc: small, its diameter less than half of the length of the branchial region.

Teeth of the buccal funnel: given in the *Key.*

Dorsal fins: 2, close together, practically continuous in mature individuals (in spring).

Caudal fin: a rather angular lobe separated by a sharp notch from the dorsal fin.

Eye: moderate in size, its diameter from 1.9 to 2.0 per cent of the total length.

Lateral line organs: colourless.

Coloration: rather uniform dirty brown, darker on the back and much paler on the lower surface; fins with dirty yellow tinge; a dark blotch at the end of the tail around the notochord, but not extending to the margin of the caudal membrane.

Trunk myomeres: narrow and numerous, from 64 to 70, with an average of 67.5 (154 specimens).

Sexual dimorphism: strongly developed; relatively long genital papilla and high dorsal fins with a rather shallow notch in breeding males; well-developed anal fin-like fold and low dorsal fins with deep notch in females (Figures 9 & 20).

Spawning: in Quebec during 1948 mature individuals were collected from May 11th to June 4th in water with the temperatures ranging from 8.3 to 20.5° C. However, the peak of spawning occurs at temperatures around 17° C. (62° F.). Several papers were published on the spawning habits of this species: Dean & Sumner, 1898; Young & Cole, 1900; Reighard, 1903. Observations and a drawing of spawning in *E. lamottenii* made by Dean & Sumner (1898) may be considered as classical ones, which are widely reproduced by numerous subsequent authors.

Life history: nonparasitic; the alimentary system is nonfunctional in transformed individuals, whose life span is very short, about 6 months.

Usual habitat: cold brooks and small rivers, in which are always present the following fish species: Slimy muddler (*Cottus cognatus*) and Speckled Trout (*Salvelinus fontinalis*).

Total length of transformed individuals: from 112 to 187 millimeters. There is a definite size variation among individual populations of *E. lamottenii* from different localities.

Distribution in Quebec: numerous adults and larvae of *E. lamottenii* were collected at Pont-Rouge in the Noire River, tributary of the Jacques-Cartier River, and at St. Raymond and Chute Panet in brooks, tributaries of the St. Anne-de-la-Pérade River. One adult was taken in the St. Lawrence River (probably washed out from a brook) above St. Nicolas. Many Ammocoetes of this species were collected in several tributaries of the St. Lawrence River, from St. Vallier to Bécancour, and in the St. Maurice River. Here should be included an Ammocoete from the Richelieu River mentioned by Cuerrier & others (1946, p. 3) under the name of *P. marinus*. In general, *E. lamottenii* is a widely distributed species, but often remains unnoticeable, due to its short existence in the transformed stage when this Lamprey is most active; previous to spawning it is usually hidden under stones.

General distribution: according to Hubbs & Lagler (1947, p. 28) *E. lamottenii* is found: « in the Mississippi River drainage from southern and eastern Minnesota to western Pennsylvania, south to Tennessee and Missouri; throughout all the Great Lakes basins; on the Atlantic slope from Connecticut and Hudson River systems to Maryland ». In Ontario it was recorded only from streams flowing into the western end of Lake Ontario (Dymond, 1947, p. 4).

Economical importance: useful and inoffensive species, whose Ammocoetes are extensively sold as bait.

Remarks: the presence of *E. lamottenii* in Quebec was never reported before. About an erroneous statement by Huard (1902, pp. 168-169) on the finding of *E. lamottenii* in the Gulf of St. Lawrence, near Seven Islands, attached to a Cod, see our remarks on page 49.

ECONOMICAL IMPORTANCE

Lampreys, particularly the parasitic species, have very different economical significance according to the stage of their development.

Ammocoetes

Larvae, known as Ammocoetes, of all Lamprey species should be considered as useful animals. From their excellence as fish food, and their tenacity on life, they make very good fish bait and are much sought after for that purpose. In the Province of Quebec, Ammocoetes are sold as bait for sport fishes, such as Doré (*Stizostedion vitreum*), Black Bass (*Micropterus dolomieu*), Muskellunge (*Esox masquinongy*), Striped Bass (*Roccus saxatilis*), etc. Along the St. Maurice River, there are everywhere signs announcing: *Lamproies à vendre.* In many other places, around Lake St. Peter and St. Anne-de-la-Pérade, the Ammocoetes are dug from mud-banks and sold as bait. During 1947 and 1948 Ammocoetes were offered for sale from 50¢ to $1.00 per dozen. To our knowledge two local men in 1947 sold at least 8,000 dozens of Ammocoetes for the total amount of $4,000.

In the United States, Ammocoetes are equally in demand as bait (Gage, 1928, pp. 181-182). In the State of Washington larvae of *Lampetra planeri* were « collected in great numbers for bait and used in fishing for Bass and Trout. They sell for $1.50 to $1.75 per dozen » (Schultz, 1930, p. 32).

Ammocoetes, due to their method of feeding by straining different materials from the oozy bottom and using them for body-building, make a valuable link in the food chain of a brook. In this chain Ammocoetes themselves constitute a natural food for many valuable fishes, such as Speckled Trout, Black Bass, Doré, etc.

Ammocoetes, as well as adult Lampreys, are used extensively in zoological research. So they « have some value as study specimens in schools, for they represent a very primitive group of fishes. Among living animals, the larval Lamprey is regarded as most like the prototype of the Vertebrates » (Hubbs & Lagler, 1947, p. 26). All this should be added to the good or credit side of Lampreys.

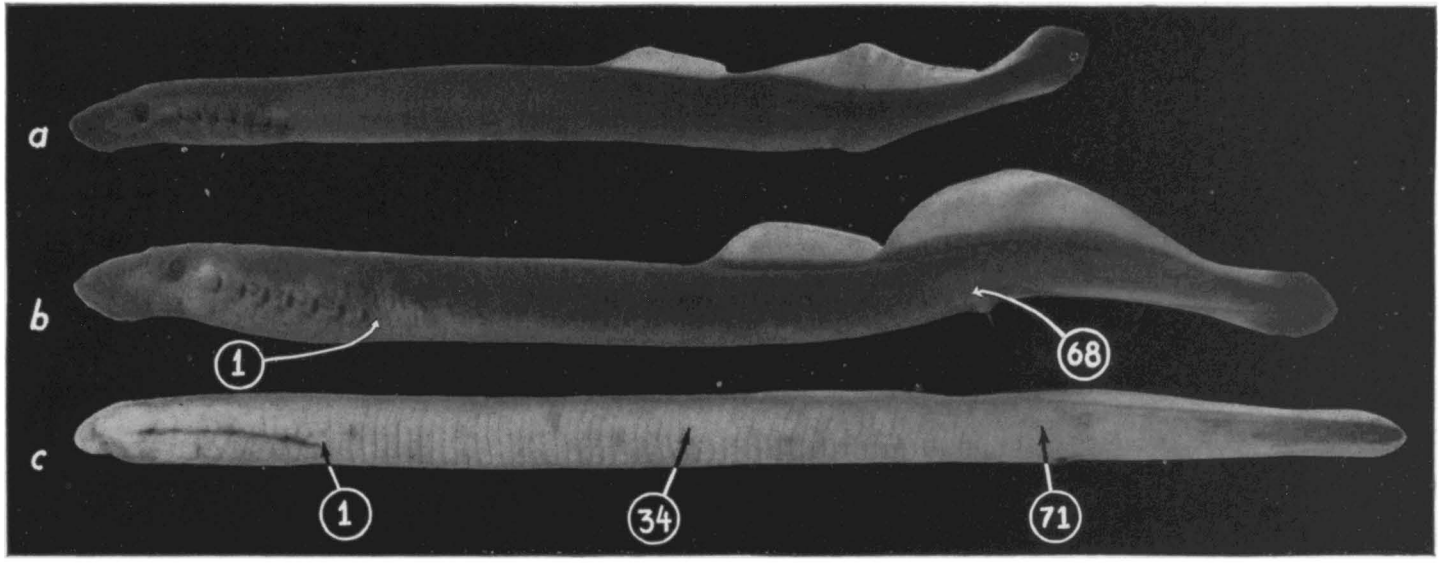

FIGURE 20. — *American Brook Lamprey* (Entosphenus lamottenii):

a. *— spawning female, 152 millimeters long;* ***b.*** *— spawning male, 186 millimeters long;* ***c.*** *— large Ammocoete, 193 millimeters long.*

Note: *these are the same specimens as shown in Figure 9. Numbers indicate the order of myomeres.*

Enlargement: ***slightly smaller than the natural size.***

Adult Lampreys

Economically the adult Lampreys have different significance according to their life history types. The nonparasitic species (*I. fossor* and *E. lamottenii*) are useful even during their short existence after metamorphosis as food for sport fishes. The parasitic species (*P. marinus* and *I. unicuspis*) may be considered as possessing two sides, good and bad, at least from the point of view of certain countries.

Usefulness. — On the good, or credit, side even the parasitic species form excellent bait for marine fishes. According to Seeley (1), as many as 450,000 Lampreys (*Lampetra fluviatilis*) in England have been used as bait in a single year in the Cod and Turbot and other deep sea fisheries.

Lampreys of different species (*Lampetra fluviatilis*, *Petromyzon marinus*, *Caspiomyzon wagneri*, etc.) have been used from early days for human consumption. According to Berg (1932, p. 25), there exists in Russia, around the Caspian Sea, an important fishery for the local Lamprey (*Caspiomyzon wagneri*), which is used for both human consumption and extraction of oil.

In Europe, during the Middle Ages, Lampreys were estimed as a great delicacy, a real royal dish. In order to impart a higher flavour to the flesh of Lampreys, it was once the custom to drown them in wine and then stew them. « It is stated by Lacépède that King Henry I, of England, came to an untimely end by too full a repast of Lampreys » (2). According to Jenkins (1925, p. 347), the City of Gloucester was under an obligation to forward a dish of Lampreys to the Sovereign of England on his accession to the throne, and annually at Christmas. King John fined the men of Gloucester 40 marks because « they did not pay him sufficient respect in the matter of his Lampreys ».

On the European continent, particularly in France, Germany and in the Baltic countries, Lampreys are always in great demand. They are often cooked in earthenware jars with vinegar and spices, and served as *hors-d'œuvre*. There exist several other elaborate recipes to make tasty dishes of Lampreys. In general, they are prepared in the same way as Eels, that is grilled, fried, marinated, or steamed and served with different sauces. They are also salted and canned. Some recipes for the preparation of Lampreys can be found in *Larousse Gastronomique* (Montagné, 1938, p. 633) and in a valuable volume by the late Dr. Classen (1925, pp. 289-290).

(1) Quoted after Goode (1884, p. 680).
(2) Quoted after Goode (1884, p. 680).

Formerly in the United States, particularly along the Connecticut River, Sea Lampreys (*P. marinus*) locally known as « Lamprey-Eel », were greatly estimed as food. « It was then the custom of the country for each family to salt down several barrels of Lampreys for winter use » (1). According to Gage (1928, p. 182), Lampreys are still in great demand in Alaska: « the Indians look forward to the annual migrations of the Pacific Lampreys (*Entosphenus*) up their rivers and collect large numbers of them to supply food for their dogs as well as for themselves ». There is no particular reason why at present in Canada and in the United States Lampreys are not listed on the regular menus of « sea food » restaurants. No doubt, Lampreys would be a wholesome food for fur animals as well.

Harmfulness. — The predatory habit of both Quebec parasitic Lampreys (*I. unicuspis* and *P. marinus*) makes an unestimated amount of damage to fishes of both sport and commercial significance. While *I. unicuspis* feeds only in fresh water attacking more often Sturgeons, Catfishes and Suckers, the Sea Lamprey usually spends its growing period in the sea. Thus, the damage done by anadromous specimens of *P. marinus* is very difficult to evaluate.

According to Quebec fishermen, Sea Lamprey attach, themselves to Salmon, Shad and Herring. L'abbé Provancher (1876, p. 262) mentioned Cod, Mackerel and Sturgeon, on which *P. marinus* parasites in the Gulf of St. Lawrence. For New Brunswick, among the victims of Sea Lampreys in addition to Salmon and Cod, Cox (1897, p. 42) mentioned: « Squirrel-Hake taken through the ice near the mouth of the Kennebecasis frequently have two or three small Lampreys, from six to twelve inches long, clinging to a single fish. Once a Lamprey has attached itself to a young Sturgeon . . . Indeed the writer has seen many Sturgeons which had seemingly been killed in this way, as the circular wound on the side just behind the gill indicated ».

Although both our parasitic Lampreys do considerable damage to fishes in Quebec waters, the destructive activities of Lake Lamprey (that is landlocked *P. marinus*) in the Great Lakes are more manifold. There, *P. marinus* attack Lake Trout, Ciscoes, and other equally important commercial species. Several authors mentioned in detail the damage caused in the Great Lakes by the Lake Lamprey to valuable fishes; among these could be mentioned: Gage, 1928; Dymond & others, 1929; Hubbs & Pope, 1937; Schneberger, 1947; Applegate, 1947, etc.

(1) Quoted after Goode (1884, pp. 680-681).

The situation that exists at present in the Great Lakes region can be summarized by quoting from articles by anonymous authors (1), one of which was published in *Time* (1947) and the other in *Life* (1947). In *Life* we read: « in 1921 a few Sea Lampreys made their way into Lake Erie, detouring around Niagara Falls by way of the Welland Canal (2). Since then they have migrated into Lake Huron, Lake Michigan and Lake Superior, feeding principally on thin-scaled Lake Trout. Between 1939 and 1946 the Sea Lampreys' voracious appetite cut the U.S. Trout catch in Lake Huron from 1,345,000 pounds a year to 41,000 ». Of course, it is very difficult to prove that the reduction in the Lake Trout yield is caused exclusively by the predatory activities of *P. marinus*. But there is no doubt that Lampreys contribute greatly to the reduction of the Lake Trout stock, which was already diminishing. Commercial fishermen of Lake Michigan « report from 25 to 85 per cent of Lake Trout in their catches as being marked » by Lampreys (Schneberger, 1947, pp. 12-13). In addition to damage done by the actual killing of Trout, Lampreys make fish unsightly by wounding (« marking ») them, thus greatly reducing their market values.

Moreover, *P. marinus* sometimes annoy bathers by clinging to them. Dymond & others (1929, p. 11) reported: « a number of the swimmers competing in a twenty-one mile race in Lake Ontario in August 1927 had Lampreys attach themselves to them ».

Possibilities of the riddance of parasitic Lampreys

The problem of ridding of parasitic Lampreys is not a new one, nor an easy one. Many authors, as, for instance, Surface (1899), Gage (1928, pp. 190-191) and Applegate (1947), offered several suggestions on this subject. Schneberger (1947, pp. 13-14), speaking of the Great Lakes, is rather pessimistic about the whole thing: « the complete elimination of the Sea Lamprey is impossible and that the best that can be hoped for is to develop some control practices to reduce the numbers of the pest . . . It is recognized that despite the apparently insurmountable difficulties that face a control program the job is an important one since the pest is causing considerable economic loss to the Great Lakes Fisheries ».

(1) Evidently these articles were based on data gathered by Applegate (1947).

(2) There always exists another possibility, that *P. marinus* could have been introduced into Lake Erie, and in any other locality as well, by bringing in live Ammocoetes to be used as bait for sport fishing.

FIGURE 21. — *Ventral view of the sucking-disc of the American Brook Lamprey* (Entosphenus lamottenii):
a. *— mature male, 150 millimeters long;* ***b.*** *— mature female, 153 millimeters long.*
Note: *broad supraoral lamina, typical for this species. In the case of the male* (***a***) *the sucking-disc is larger than in the female.*
Enlargement: *slightly more than five times the natural size.*

Abundance. — There is no definite information as to the extent of the populations of parasitic Lampreys in Quebec. In the case of *P. marinus*, each fishing weir (*pêche*), situated along the shores of the St. Lawrence River, may catch during May and June as many as 10 and even 25 Lampreys twice a day (per tide). So, the total number amounts to several thousands per season.

For the New England states, Goode (1884, p. 680) gives the following account of the former abundance of *P. marinus*. In Massachussets it was formerly taken « in almost incredible numbers in the Merrimack . . . When the Saint Lawrence dam, in 1847, was first completed, several cart-loads were daily taken by one man for a considerable period. In 1840 Mr. Joseph Ely took thirty-eight hundred in one night at Hadley Falls ».

For the landlocked form of *P. marinus* in New York we have an interesting account by Gage (1928, p. 188): « one year accurate count was kept of all the Lampreys caught on the spawning beds, and the number of nests were counted in the extent of about 2¼ miles, and more than one thousand Lampreys were actually caught. That of course did not make the full number that spawned that year . . . On May 31, 1920, members of the Department of Zoology were taken to the inlet of Seneca lake above Montour Falls. The water was teeming with Lampreys and nearly five hundred were secured in a couple of hours ». Judging by the extent of damage done by *P. marinus* in the Great Lakes region, its population must be very considerable.

To have an idea how abundant Lampreys can be, we may quote Berg (1932, p. 25): during the period 1910-1913, catches of Caspian Lamprey (*Caspiomyzon wagneri*) in the lower Volga only varied from 17 to 33 millions of individuals per year (1).

Riddance of Ammocoetes. — Although no definite measures for the destruction of larvae of parasitic species are in existence, the following suggestions may be found effective.

1. *Expansion of digging:* by use of dredges or in some cases even by mechanical shovels. Digging with an ordinary shovel or dip net, if done frequently in the same stream, results in obtaining a lot of Ammocoetes. This could be stimulated by popularizing the use of larvae as bait for fishing, by organizing fishing contests with Ammocoetes as bait only, etc. (2) Ammocoetes collected in large quantities could, no doubt,

(1) Grown-up individuals of *C. wagneri* correspond in size to those of landlocked *P. marinus*.

(2) In the case of Lake Lamprey (landlocked *P. marinus*) precaution must be taken not to introduce them into areas where this parasite is not naturally found.

be used as food for fur animals. Frequent digging will eventually not only reduce the number of larvae, but also will bring unfavourable changes in the natural habitat of parasitic Lampreys.

2. *Eradication of larvae:* by use of different poisonous substances, such as rotenone, etc. However, there is little hope that poisonous substances could penetrate in sufficient concentration in muddy bottoms, where Ammocoetes usually live. Any withdrawal of water from streams inhabited by Ammocoetes which exposes the bottom for one or more days will be fatal to larvae. This could be accomplished, for instance, by diverting the water to another channel (by digging pikes) or by the damming of streams.

Riddance of adults. — The destruction of parasitic Lampreys could be carried out more easily in the case of fully-mature individuals while on their upstream migration for spawning, than during the period of their intensive growth which corresponds with that of active parasitism.

3. *Removal of mature specimens:* by increasing the efficiency of fishing methods. At present, in the Province of Quebec, *P. marinus* are taken during spawning migration in weirs (*pêches*), constructed along the shores of the St. Lawrence River (1). No doubt a much larger number of Sea Lamprey could be taken by introducing certain European methods, as, for instance, a trap corresponding to an « Eel-pot » used in Nova Scotia for Eels (2). Eel-pots, constructed on the « principle of mouse trap », are made of wicker (willow, dogwood, etc.) or wire. Several Eel-pots attached to a rope are lowered to the bottom of the river. Lampreys, which usually swim near the bottom, enter these pots in large numbers. Hoop-nets could serve also to great advantage to catch adult *P. marinus* during their upstream migration.

Blocking the spawning run through the use of various types of traps in streams would be helpful in many cases. But as Hubbs & Lagler (1947, p. 26) pointed out « indications are that control by weirs across streams may work, but such operations would be costly and

(1) There is no special fishing for *I. unicuspis* in Quebec.

(2) A *bourolle*, part of a fascine weir for Eels in the shape of a funnel, employed around Rivière-Ouelle, Quebec, could be used with slight modifications in Lamprey fishing. The description and illustrations of different types of Eel-pots can be found, for instance, in Roule (1914, pp. 254-255), Davis (1927, p. 109) and de Loture (1946, pp. 59-62).

somewhat impracticable because of the large scale on which they presumably would need to be conducted ».

Lampreys (*P. marinus*) taken thus in larger numbers in spring, when they are in their best condition, could be used either for human consumption or as food for fur animals. Fresh or frozen they could be employed also as bait for Cod, Halibut, etc.

In some cases, it would be advantageous to use poisonous substances (rotenone), or the electric shocker in certain streams to exterminate the spring run of parasitic Lampreys.

4. *Removal of young adults:* by use of traps baited with live fish. It is very difficult to get rid of younger adults, as they never aggregate in large numbers as fully-mature specimens do in the spring. However, observations on the feeding habits of these adults suggest the use of traps made of chicken wire or cord with 1½ or 2-inch mesh (1).

Our experiments in aquaria with *I. unicuspis* clearly indicate that this parasitic species has a definite preference for Bullheads (*Ameiurus nebulosus*) and fine-scaled Suckers of the genus *Catostomus*. No doubt in the case of *P. marinus* its favorite fish hosts could also be found. Traps baited with live fish could be lowered on ropes in places frequented by parasitic Lampreys. Several times a day they should be raised and the attached Lampreys collected. The repeated use of these traps at the principal fishing grounds, no doubt, would reduce the local abundance of parasitic Lampreys, and thus save many valuable fish. This method would be particularly effective in the spring (May and June in Quebec), when young Lampreys, still staying in shallow water, not very far from their native streams, begin to feed voraciously.

In conclusion it should be stressed again, that the problem of getting rid of parasitic Lampreys is extremely difficult, time consuming and costly. Before reaching a definite solution better knowledge of the habits of Lampreys is needed. Numerous trials of different methods of destruction must be made in order to eliminate the less effective. Commercial uses for disposal of larvae and adults must be widened. More education is required to re-establish on this continent the former popularity of Lampreys as a wholesome and palatable dish.

(1) The bottom of the trap should be made of wire net of smaller mesh (½ inch), so as to retain any young Lamprey, which could detach itself from live fish when trap is raised from water.

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