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THE LIFE HISTORY OF *LAMPETRA PLANERI* BLOCH, WITH A STATISTICAL ANALYSIS OF THE RATE OF GROWTH OF THE LARVAE FROM WESTERN WASHINGTON

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INTRODUCTION

This paper attempts to describe the natural history of the larvae and adults of *Lampetra planeri* Bloch. It is especially concerned in the development of statistical methods for analyzing size-frequency curves of the larvae, and in comparing the results with those of authors who, it is thought, have drawn different conclusions from similar data.

Methods

All of the material used in this paper was collected from numerous creeks in the vicinity of Seattle, Washington. A small six-foot seine, made from fine meshed bobbinet, was first used to surround a small patch of silt which was agitated roughly and then to strain quickly the suspended matter. A dip net, 20 inches in diameter, lined with the bobbinet, was later substituted for the seine, because it was found to be more efficient. The soft silt was excavated by the latter apparatus and placed at once upon the bank of the creek without removal from the net, where the larvae were carefully searched out of the silt. Both methods yielded larvae in about the same abundance, but the latter method was more desirable because of less effort for the same results. The methods used by Creaser and Hubbs, who placed the sand and mud upon the bank and flattened it out with the hands, did not produce such satisfactory results in this case.

The usual method of statistical analysis was applied to the data. Lengths were measured by a pair of dividers and read from a millimeter rule. Length-weight data were attempted but discarded as unreliable, due to the difficulty of weighing such small specimens and to the fact that the moisture adhering to a small specimen was of greater weight than the larva itself.

Natural History of the Ammocoetes

The larva of the brook lamprey, *Lampetra planeri* Bloch, is one of the most abundant forms of fish life in the lower courses of the streams in the northwestern United States. Creaser and Hubbs (1922) recognized its range as the "streams of Eurasia and western North America." In Evans Creek, near Redmond, Washington, Plate II, and Newauken Creek, near Enumclaw, Washington, and in other creeks, the ammocoetes or larval lampreys are most abundant in the eddies where a rich deposit of silt, mixed with a little sand, has settled. They are also abundant in the concavities of the stream bed, where the general drift of débris and silt is mixed, or in the soft mud. None has been found in stiff muck or gravel. They are scarce in those parts of the stream subject to continual shifting of the bottom. Ammocoetes are occasionally found in pure sand, but never abundantly. An idea of their abundance in a favorable situation may be obtained from the collection on July 4 of 483 specimens, the result of about three hour's dredging. In Newauken Creek, 282 larvae were obtained in one hour and a quarter of work with the dip net. In this same locality, within a diameter of three feet, 170 larvae were taken, which included specimens between the lengths of 8 and 132 mm.

In a cross section of a creek, the abundance of the larvae is greatest in the silt deposit along the edges, while the bottom of the creek, where sand is continually shifting, contains very few. They are not abundant in firm silt upon which plants have become established.

Reighard and Cummins (1916) state: "When a larva is liberated in an aquarium or in the stream it swims a short distance, then erects the body almost vertically, head downward, and burrows with a rapid vibratory movement. It does not continue straight down, but turns horizontally, then upward, forming a burrow in the shape of a flattened *U*. The dorsal surface of the body is kept uppermost throughout this process." These habits of the ammocoetes of *Ichthyomyzon fossor* Reighard and Cummins are identical with those of *Lampetra planeri* Bloch, observed in an aquarium at the Department of Fisheries.

It has been stated that the larvae of brook lampreys migrate downstream as they grow older, so that the larger ones are more abundant in the lower courses of the stream than farther up. My collections do not verify this for Evans Creek, since larvae of all sizes have occurred in the same relative abundance at each end of the stream. No doubt some migration occurs, however, since the bed of the creek is continually changing its course, and as the silt is washed away the larvae seek new locations which may be downstream. Probably the lack of this passive migration is confined largely to our western streams of a nearly constant flow. There is an indication that the bulk of the migration occurs soon after hatching, as the smallest larvae are evenly distributed throughout the silt beds by the end of August. Those larvae that are metamorphosed have been taken as abundantly in the upper part of the stream as in the lower. The final word on the migration of the ammocoetes will necessarily wait until some investigator carries on extensive marking experiments.

The first evidence of metamorphosed individuals was obtained on August 30, after which date they were collected until March of the following spring, along with numerous adults, fully matured. The larvae of the brook lamprey, just before metamorphosis and when "eyed," is commonly called the lamprey "eel" in western Washington.

At this stage in life it is considered of economic importance. Certain individuals in Seattle and vicinity make it their business to collect the largest larvae between 100 and 130 mm. in length. They are used by the sportsmen when alive as bait for fishing for bass and trout. It is claimed that for this purpose nothing else equals them in attractiveness. Fish that refuse to take salmon eggs or bullheads (*Cottus*), rapidly take these squirming ammocoetes from the hook in preference to other living or artificial baits. The amount of lampreys used for these purposes is enormous, both by commercial bait collectors and the local sportsmen and boys. One individual sold $3,000 worth of lampreys during the season of 1928. He keeps the supply in live tanks in a nearby creek. It is unnecessary to feed them as the ordinary drift of the stream is sufficient for their sustenance in live tanks. His immediate supply, however, was kept in his backyard in partly buried crocks, into which a little stream of water trickled from a garden hose. He removed them with a net when needed by his customers who paid from $1.50 to $1.75 per dozen depending upon the size. These facts indicate a use for creatures heretofore considered largely as useless or even parasitic—except in New York and Pennsylvania, where they are used likewise for bait.

Rate of Growth of the Ammocoetes

The study of the rate of growth of larval lampreys is not new. Considerable has been written on their growth, but much disagreement on the length of the life cycle is apparent among investigators, owing probably to the lack of extensive material. Müller (1856) measured six larvae of *Lampetra planeri* Bloch of Europe and found their lengths to fall at 5.8, 6.3, 6, 15.3, 15.4, and 14 cm., respectively. The first he judged to be a little over a year old and the last three, over two years. Two metamorphosed individuals, which he concluded were at least two years old, measured 16.2 and 19.3 cm. each. Lubosch (1903), working on the same species, found three different sizes, those of the first few months between 1 and 2 cm.; those of the first year averaged about 5 cm.; the second year around 10 cm.; and the third between 15 and 18 cm. Loman (1912) found larvae of four different sizes in a single collection of this species, which Hubbs (1924) gives as "first-year larvae 27 mm., second-year larvae 54 mm., third-year larvae 80 mm., fourth-year 113 mm., adults 87, 88, 89, and 106 mm." The season of the year when these various collections were made was not mentioned, so it is impossible to judge whether an estimated age to spawning of four or five years is intended.

Hubbs (1924) collected specimens of *Lampetra planeri* from Coyote Creek, San José, California, on October 1 and May 25. Those collected in May, representing both *L. planeri* and *Entosphenus tridentatus,* were found to be between 10 and 20 mm., but in October those belonging to *Lampetra* had reached a length between 34 and 74 mm. One larva taken on May 23 was 94 mm. and "must have been more than one year old" (Hubbs, 1924). A still larger ammocoete on the same date was 172 mm. and "was in all probability still older, or more than two years of age. If these interpretations are correct it would follow that the age at breeding and death would be not less than three years" (Hubbs, 1924). Transforming individuals were taken between 135 and 175 mm.

Statistical Analysis of the Length-Frequencies of the Ammocoetes

The following statistical analysis of the length-frequencies of the larvae of *Lampetra planeri* is an attempt to find out, by methods free of opinion, the truth concerning their rate of growth. The material on which this study is based was collected from Evans Creek, near Redmond, Washington. All length measurements of the ammocoetes (2915 in all) were made from the tip of the snout to the posterior edge of the caudal fin. This distance, determined by dividers and measured on a millimeter rule to the nearest millimeter, is recorded in Table I. These data for Evans Creek were smoothed by a moving average of both 5 and 13 items. The purpose of smoothing by 5 was to eliminate the very shortest fluctuations in frequency, leaving the minor ones of possible significance. The purpose of smoothing by 13 was to eliminate all but the major fluctuations. There were thus produced two sets of curves for comparison of samples, one with another, those containing minor fluctuations and those containing major ones. The curves smoothed by 13 may be regarded as giving the basic trend and the minor fluctuations plotted as deviations from this trend (Yule, 1927).

TABLE I

Data on Lengths to Nearest Millimeter of Ammocoetes of *Lampetra planeri* Collected in Evans Creek, near Redmond, Washington, on Different Dates.

Collection of October 28, 1928 (119 specimens).—12(2), 15, 19, 26, 31, 32, 35, 36, 37(6), 38, 40(3), 41(2), 42, 43(7), 44(5), 47(2), 48(6), 49(7), 50(5), 51(3), 52(4), 53(2), 54(2), 55(6), 56(3), 57, 58, 59(2), 60(2), 61(4), 62, 63(2), 64, 65(5), 67(2), 68, 70(3), 71(3), 73, 74(2), 75(2), 76, 78, 79, 81, 82, 84, 87(2), 94, 97, 101, 106.

Collection of November 29, 1928 (210 specimens).—12, 15, 16, 17, 18, 19(2), 20(2), 21, 22, 23, 24(3), 25, 28, 31, 32(3), 33, 34(3), 35(3), 36, 37(2), 39(5), 40(6), 41(7), 42(2), 43(7), 44(4), 45(9), 46, 47(2), 48, 49(6), 50(6), 51(8), 52(2), 53(2), 54(4), 55(8), 56(3), 57(5), 58(4), 59(6), 60(4), 61(8), 62(8), 63(3), 64(2), 65(6), 66(4), 68(3), 69(4), 70, 71(4), 72, 74(2), 75(3), 76, 77, 78, 80(3), 82(2), 83, 84(3), 85(3), 86, 87, 88, 89, 90, 91, 92, 94(3), 96, 108, 129.

Collection of December 31, 1928 (342 specimens).—12, 15, 16, 17, 18(2), 19(2), 20(5), 21(2), 23, 24, 25(3), 26, 27(3), 28(4), 30(6), 31(2), 32(8), 33(10), 34(5), 35(10), 36(4), 37(8), 38(6), 39(13), 40(14), 41(12), 42(8), 43(19), 44(5), 45(9), 46(8), 47(4), 48(6), 49(5), 50(10), 51(11), 52(10), 53(8), 54(5), 55(9), 56(4), 57(7), 58(2), 59(6), 60(3), 61(4), 62(5), 63(5), 64(3), 65(2), 66(3), 67(3), 68(4), 69(4), 70(4), 71(2), 72(3), 73(2), 75(3), 77, 78(3), 79(2), 80(2), 81(2), 82, 83(3), 84(2), 87, 92, 93(2), 95, 96, 98, 100, 101, 105, 112, 116, 121, 127.

Collection of February 26, 1929 (133 specimens).—17, 19, 20(2), 21, 22(3), 24, 27, 28(2), 30(3), 31(2), 33(3), 34(3), 35(4), 36, 37(3), 38(2), 39, 40(3), 41(4), 42(4), 43(5), 44(3), 45(2), 46(2), 47, 48(4), 49(2), 50(4), 51(2), 52(2), 53(4), 54, 55(7), 56, 57(3), 58(4), 59(2), 60, 61(3), 62(6), 63(2), 64, 65, 66(2), 67(3), 68, 69(2), 70(4), 71, 73(2), 75, 81, 82, 88(2), 89, 91, 97, 114, 121.

Collection of March 26, 1929 (670 specimens).—14, 16(4), 17(5), 18(3), 19(5), 20(9), 21(8), 22(12), 23(8), 24(4), 25(8), 26(6), 27(4), 28(4), 29(3), 30(7), 31(5), 32(5), 33(2), 34(4), 35(8), 36(9), 37(4), 38(12), 39(10), 40(10), 41(7), 42(13), 43(15), 44(20), 45(17), 46(14), 47(15), 48(17), 49(9), 50(19), 51(16), 52(11), 53(14), 54(22), 55(14), 56(12), 57(10), 58(12), 59(8), 60(10), 61(8), 62(7), 63(8), 64(13), 65(13), 66(9), 67(10), 68(11), 69(10), 70(7), 71(11), 72(11), 73(6), 74(4), 75(7), 76(6), 77(5), 78(5), 79(6), 80(4), 81(2), 82(4), 83(4), 84(4), 85(5), 86(3), 87, 88(3), 89(4), 90(7), 91(2), 92(2), 93(3), 94, 95(3), 96(2), 97(3), 98(4), 99(4), 100, 101, 103(2), 107, 108(2), 110(2), 113(2), 116, 118.

Collection of April 30, 1929 (189 specimens).—14, 15, 16(5), 17(3), 18, 19(3), 20(5), 21(2), 25(2), 27, 29(2), 30(2), 33(3), 35, 36, 39, 40, 41, 42(2), 43(3), 45(4), 46(3), 47(5), 48, 49, 50(6), 51(2), 52(3), 53(5), 54(4), 55(6), 56(3), 57(3), 58(6), 59(5), 60(4), 62(4), 63(6), 64(3), 65(2), 66, 67(4), 68(4), 69(4), 70(5), 71, 72(4), 73, 74(2), 75(3), 76, 77(2), 78(2), 79, 80(2), 81(3), 82(2), 83(3), 84, 85(2), 86, 89, 90(3), 92(4), 93(3), 94(2), 95, 100, 111, 112(2), 113, 116(2), 119, 123.

Collection of May 22, 1929 (172 specimens).—13, 15, 16(3), 17, 18(3), 19, 20(3), 21(6), 22(3), 23(4), 24(2), 25(2), 26(2), 27(3), 28(2), 29, 30(4), 31(9), 32, 33(3), 34, 35(2), 36, 37, 38(4), 39, 40(2), 41, 42, 43(2), 44(3), 45(3), 46(3), 47(6), 48(2), 49(4), 50, 51, 52, 53(3), 54(3), 55(7), 56, 57(3), 58(4), 59(3), 60(5), 61(4), 62(2), 63, 64(3), 65(2), 66(2), 67(3), 68, 69(3), 70, 71, 72(4), 74, 75(2), 76, 78, 79(3), 80(2), 82, 83, 85(3), 87, 89(2), 90, 91(2).

Collection of July 4, 1929 (483 specimens).—26(2), 28, 29(2), 30(5), 31(4), 32(8), 33(7), 34(4), 35(9), 36(8), 37(9), 38(9), 39(2), 40(9), 41(11), 42(8), 43(6), 44(5), 45(6), 46(6), 47(6), 48(2), 49(7), 50(7), 51(11), 52(11), 53(11), 54(3), 55(10), 56(11), 57(10), 58(8), 59(10), 60(10), 61(13), 62(12), 63(9), 64(6), 65(12), 66(9), 67(6), 68(14), 69(14), 70(12), 71(4), 72(6), 73(11), 74(10), 75(7), 76(8), 77(5), 78(4), 79(5), 80(3), 81(4), 82(7), 83(7), 84(4), 85(4), 86, 87(3), 88(3), 89(2), 90, 91(3), 92(4), 93(2), 94(2), 95(4), 96(2), 97(3), 98, 99(3), 100, 101, 105, 106, 107, 108, 111(3), 115(2), 124, 130, 133(2).

Collection of August 6, 1929 (235 specimens).—4, 27, 28(2), 29(2), 30(2), 31(5), 32(3), 33(7), 34(2), 35(7), 36(3), 37(4), 38(5), 39(9), 40(2), 41(4), 42(3), 43(3), 44, 45(2), 46(2), 48(5), 49, 50(5), 51(3), 52(6), 53(4), 54(4), 55(4), 56(5), 57(8), 58(13), 59(2), 60(10), 61(6), 62(4), 63(6), 64, 65(6), 66(6), 67(2), 68(5), 69(2), 70(5), 71(4), 72(5), 73(6), 74(2), 75, 76(3), 77(4), 79, 80(4), 81, 82(3), 85(3), 86, 87, 88(2), 92, 93, 95, 97, 106, 108, 111, 113(2), 114, 115.

Collection of August 30, 1929 (362 specimens).—10, 16, 26, 27, 29, 30, 31(4), 32(5), 33(7), 34(3), 35(4), 36(8), 37(7), 38(9), 39(6), 40(8), 41(6), 42(5), 43, 44(5), 45(4), 46(3), 47(4), 48(2), 49(4), 50(2), 51, 52(4), 53(3), 54(4), 55(7), 56(7), 57(3), 58(5), 59(9), 60(10), 61(2), 62(7), 63(3), 64(7), 65(5), 66(10), 67(8), 68(10), 69(11), 70(7), 71(7), 72(7), 73(6), 74(9), 75(4), 76(7), 77(5), 78(2), 79(4), 80(7), 81(4), 82(6), 83(2), 84(4), 85(2), 86, 87(4), 88(4), 89(2), 90(4), 91(3), 92(3), 93(5), 94(3), 95(3), 96(2), 98, 99(3), 100(2), 102, 103, 104(3), 105, 107, 108(2), 111, 113(2), 115, 118, 120, 125, 127(2), 128(2).

After carefully looking over the material and the peculiarly difficult problem of analyzing the data, it was concluded that before any attempt at deciding what constitutes a year class from the size-frequency curves was made, the value of each fluctuation must be determined. This could be done by the calculation of the probability that two populations come from the same stock, Pearson (1914). But this assumes that the individual is the unit of variation which is obviously not true in the present case where the larvae are segregated according to range of sizes and according to the location in the stream chosen by the collector. The situation is similar to that of the California sardine, as discussed by Sette (1926) and Thompson (1926).

However, the chance fluctuations in the frequencies may be greater than those indicated by statistical criteria based on the individual as a unit of variation. The larger modes must be tested by some method which will bring to light any consistency in their presence under differing conditions. This may be accomplished by at least three methods which are: (1) splitting up one of the collections into equal series by measuring alternate larvae as they are taken out of the container without any personal selection, and then comparing the size-frequency curves that result; (2) comparing, for samples in which no growth is supposed to have occurred, the coefficients of correlation for the deviations from the trend mentioned above, to see whether these deviations tend to vary similarly from sample to sample as shown by the various size-frequency curves; (3) finding by inspection the minor modes in the various series of curves and trying to follow their recurrence and progression throughout the year, Thompson (1926). The application of these methods to our data is outlined below.

1. The collection of March 26 was divided into equal parts by chance sampling and the specimens of each series measured. These data were smoothed by 5s and the curves shown in Fig. 1. The dotted line represents one-half and the solid line

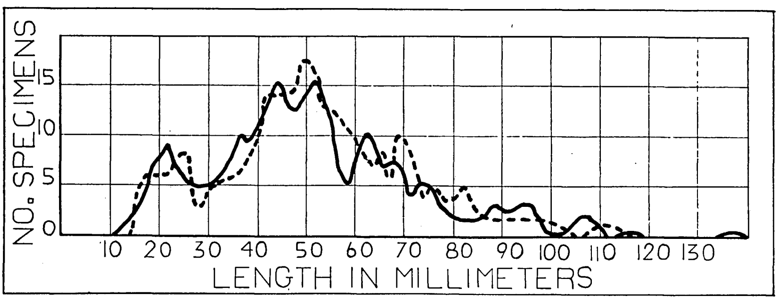

FIGURE 1. Size-frequency curves of the larvae collected on March 26, 1929, from Evans Creek.

The 670 specimens were divided into two equal series by measuring and recording alternate larvae. The solid line represents one portion and the dotted line the other equal part. Data smoothed by a moving average of five.

the other equal portion. If the crests and troughs are of any significance they should appear over each other. An unprejudiced inspection of the curves between 10 and 30 mm. shows distinct correlation. The two crests (solid line) at 44 and 52 mm. do not correspond well with the single one in the opposite series (dotted line) at 50 mm.; the crest at 62 mm. (solid line) falls in a trough of the opposite curve. There is a slight crest in both series near 69 mm., but at 83 mm., a crest and trough again occur together. In fact at no place throughout the two curves beyond 30 mm. do we find any significant positive correlation in the minor crests and troughs, a lack which indicates that modes of that nature are purely accidental. This casts

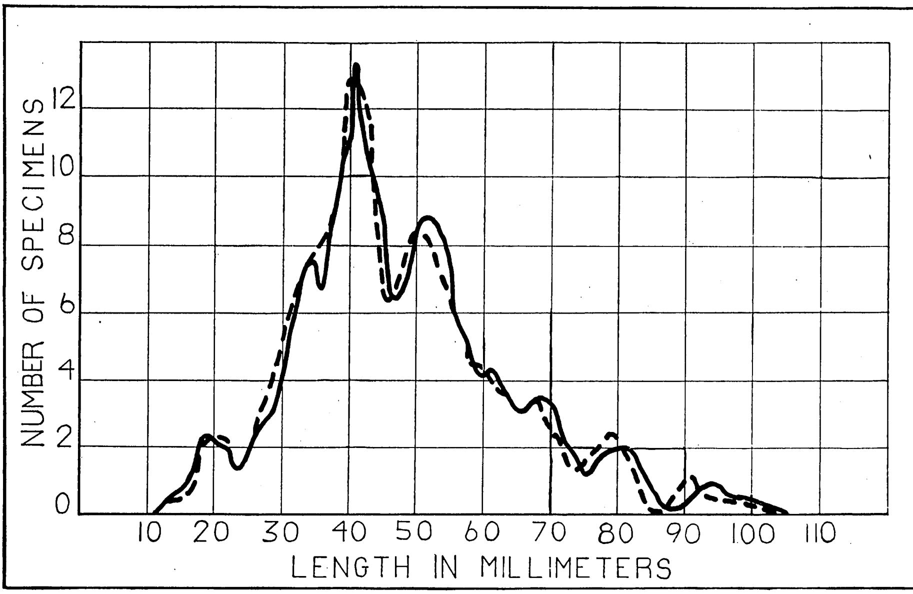

FIGURE 2. Size-frequency curves for the larvae of *Lampetra planeri*, collected on December 31, 1928.

These specimens were smoothed by the moving average of five. The curve resulting from the measurements of Edward Powers (dotted line) shows consistently the presence of shorter specimens than when measured by the author (solid line) 14 months earlier. Probably this discrepancy is caused by shrinkage in the preservative. However, the crests remain unchanged.

grave doubts at once upon their significance as representing year classes. However, the two larger groups obviously correspond with each other in both series, and the same two definite modes appear in all the size-frequency curves when smoothed by 9s and 13s and are traceable throughout the year.

The major mode between 6 and 32 mm., Fig. 3, progresses forward in all collections except that of April in which it moves backward. The second major mode beyond 32 mm. progresses backward during October, November, and December, but at all other times moves forward. Both modes make great progression in June. The decreased size in the winter of the second mode is caused probably by sampling, since smaller and smaller fish were captured. Such facts cast grave doubts upon the presence of any smaller modes within the larger crests.

2. Certain authors have considered the minor modes as significant of year classes, but the considerations just given make the significance of these extremely doubtful. In those samples taken during the winter there may be no growth. If so, the various modes, if significant, should recur and produce a positive correlation. But for the periods when no growth is presumed to have occurred, the position of the minor fluctuations may be caused by a measurement error. To determine this fact, Mr. Edward Powers kindly remeasured the December 31 collection. The frequencies of both measurements, smoothed by the moving average of five items are represented in Fig. 2. There is no marked difference in the position of the minor fluctuations as treated, thus eliminating the possibility of personal error in measuring.

The coefficients of correlations have been calculated for various portions of the curves, comparing different parts of the winter. In order to isolate the minor fluctuations, the deviations of the curves smoothed by 5 items were superimposed and compared with those smoothed by 13 items, as represented in Figs. 3, 4, and 5 B. The coefficients for the comparison of the sections of the curves between 6 and 30 mm. are: March 26, with November 29, $r = + .233 \pm .061$; March 26, with October 28, November 29, December 31, and February 26, $r = + .389 \pm .045$; March 26 and November 29, with October 26, December 31, and February 26, $r = + .250 \pm .050$. The coefficients of correlation for the comparison of the deviations of the actual frequencies from that smoothed by 13s between 6 and 30 mm. are: March 26, with October 28, r = — .045 ± .069; March 26, with November 29, r = + .023 ± .065; March 26, with December 31, r = + .102 ± .060; March 26, with February 26, r = + .186 ± .065. These figures of comparison indicate a probably significant mode or modes between 6 and 30 mm. when smoothed by 5s, but indicate no significance for the actual frequencies.

The coefficients of correlation for the deviations of the curve smoothed by 5s from the 13s in the section of the curve beyond 30 mm. are: For 30 to 60 mm., March 26, with October 28, November 29, December 31, and February 26, r = — .074 ± .023. For the curve from 30 to 142 mm., March 26, with October 28, r = — .065 ± .026; March 26, with November 29, r = — .059 ± .024; March 26, with December 31, r = + .137 ± .022; March 26, with February 26, r = + .007 ± .035; March 26 with October 28, November 29, December 31, and February 26, r = + .059 ± .019; March 26 and November 29, with October 28, December 31, and February 26, r = + .065 ± .019. The coefficients of correlation for the comparison of the deviations of the actual frequencies from that smoothed by 13s between 30 and 138 mm. are: March 26, with February 26, r = — .035 ± .065; March 26 with December 31, r = — .044 ± .060; March 26 with November 29, r = — .025 ± .065; March 26 with October 28, r = — .010 ± 0.69. These coefficients of correlation indicate an entire lack of correspondence between the minor modes and the actual frequencies of the various collections; this casts still greater doubt upon the significance of the minor crests.

3. If there were winter movement of the minor modes, the coefficients of correlation would obviously be of no significance. If growth occurs it should be possible to follow it by tracing the various modes in the curves of Fig. 3, as they progress forward due to growth, which would appear in the first year group if in any. The first mode, at about 22 mm., which is reasonably clear cut, progresses forward slightly between October and March but sags backward a little in April, casting grave doubt upon any definite growth during

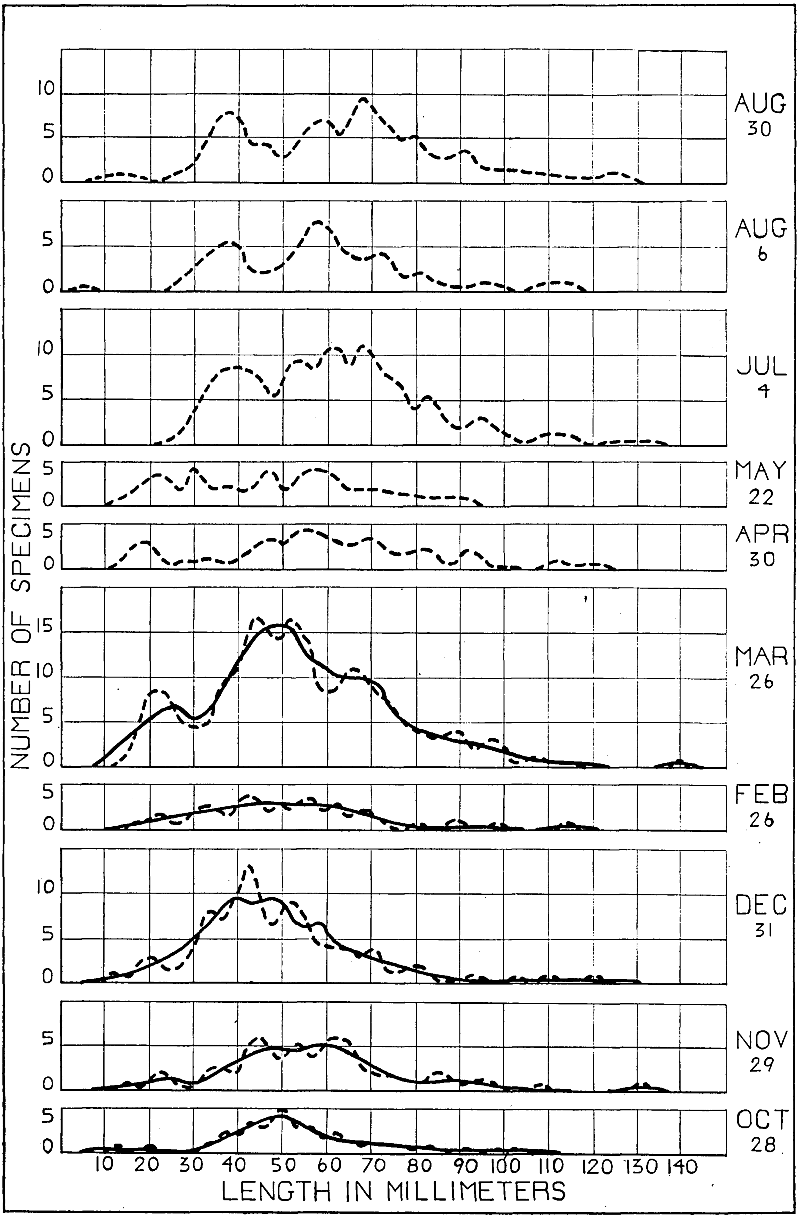

FIGURE 3. Size-frequency curves for the larvae of *Lampetra planeri*, collected from Evans Creek.

Measurements were made to the nearest millimeter and this data smoothed by the moving average of five, represented by the dotted line, then by thirteens for the winter collections shown as a solid line.

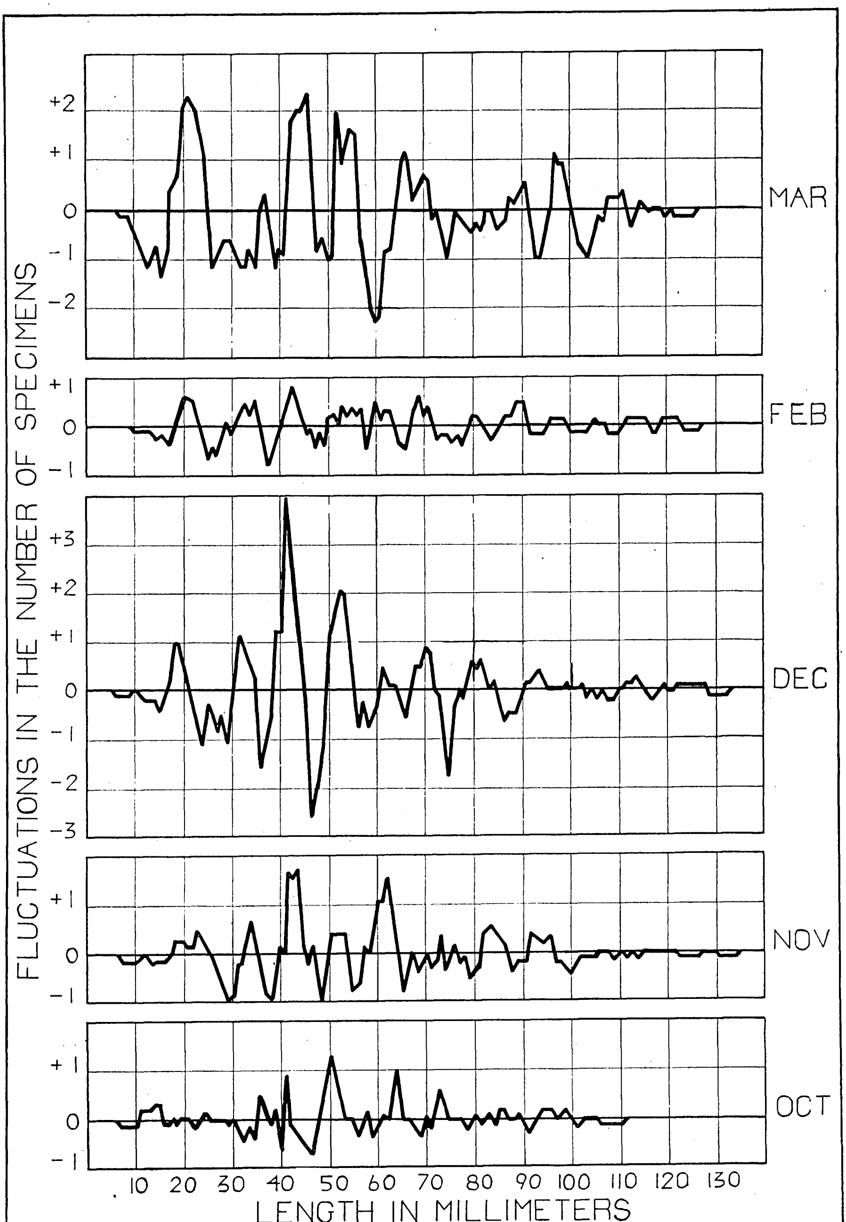

FIGURE 4. A comparison of the fluctuations in the number of lampreys from the trend.

The rugged solid line represents the deviations of the data smoothed by a moving average of five from the trend. The latter is smoothed by thirteens and is represented as a straight line at 0.

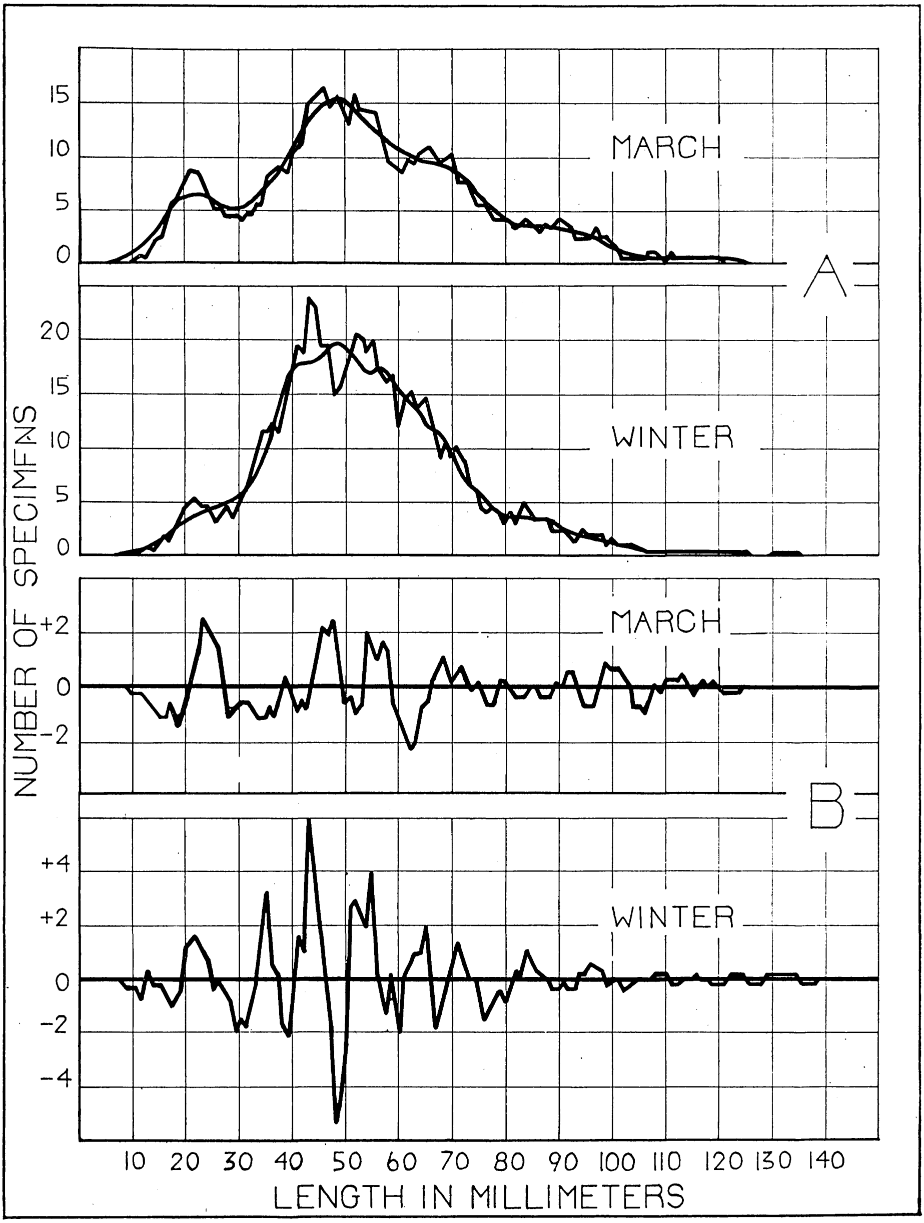

FIGURE 5. A. Size-frequeny curves for the larvae of *Lampetra planeri.*

The data were smoothed by the moving average of 5 (solid line), then by the moving average of 13 (broken line). Winter collections are those of October, November, December, and February, added together.

FIGURE 5. B. A comparison of the fluctuations in the number of lampreys from the trend.

The rugged solid line represents the deviations above and below this trend as in Fig. 4.

the winter. The second major mode (of the frequencies between 30 and 60 mm: see Fig. 6) progresses backward during October, November, and December, casting still further doubt on winter growth. Such fluctuations of the crests are very likely produced in sampling. An examination of the curves in Fig. 3 indicates but one set of minor modes starting in October at 50 mm., which permits a line to be drawn through them (Fig. 7) as was done by Thompson (1926) and Buchanan-Wollaston and Hodgson (1929) to represent growth. This line is parallel to the first mode until April when it is extremely questionable where to draw it. All the other minor crests, clearly, are not in line (Fig. 7) and can not be traced, especially after rapid growth in June. This inspection indicates still greater uncertainty on the validity of the minor modes as significant year classes.

The facts presented in the foregoing paragraphs cast such serious doubt upon the significance of the minor crests as representing year classes that it is concluded the first and second large humps are the only ones usable to represent year groups. The second major crest grades into a unimodal curve and flattens out to such an extent in its upper limits that no older year classes can be recognized. These considerations make it highly doubtful if the age and rate of growth of the larvae can be traced accurately and definitely by means of size-frequency curves to the time of metamorphosis as certain authors have attempted to do.

Although the upper part of the size-frequency curve can not be analyzed statistically, it is still fairly apparent from circumstantial evidence that at least one additional year class is represented in the upper part of the size-frequency curves (see Fig. 6). In this figure the size-frequencies of adults and metamorphosed individuals are represented by dotted and broken lines, respectively, the former over the March 26, and the latter over the August 30 curves. By fall the oldest year class or classes should be ready for metamorphosis, but the collection on August 30 shows that the majority of the fishes of the year group II are still far too small for metamorphosis.

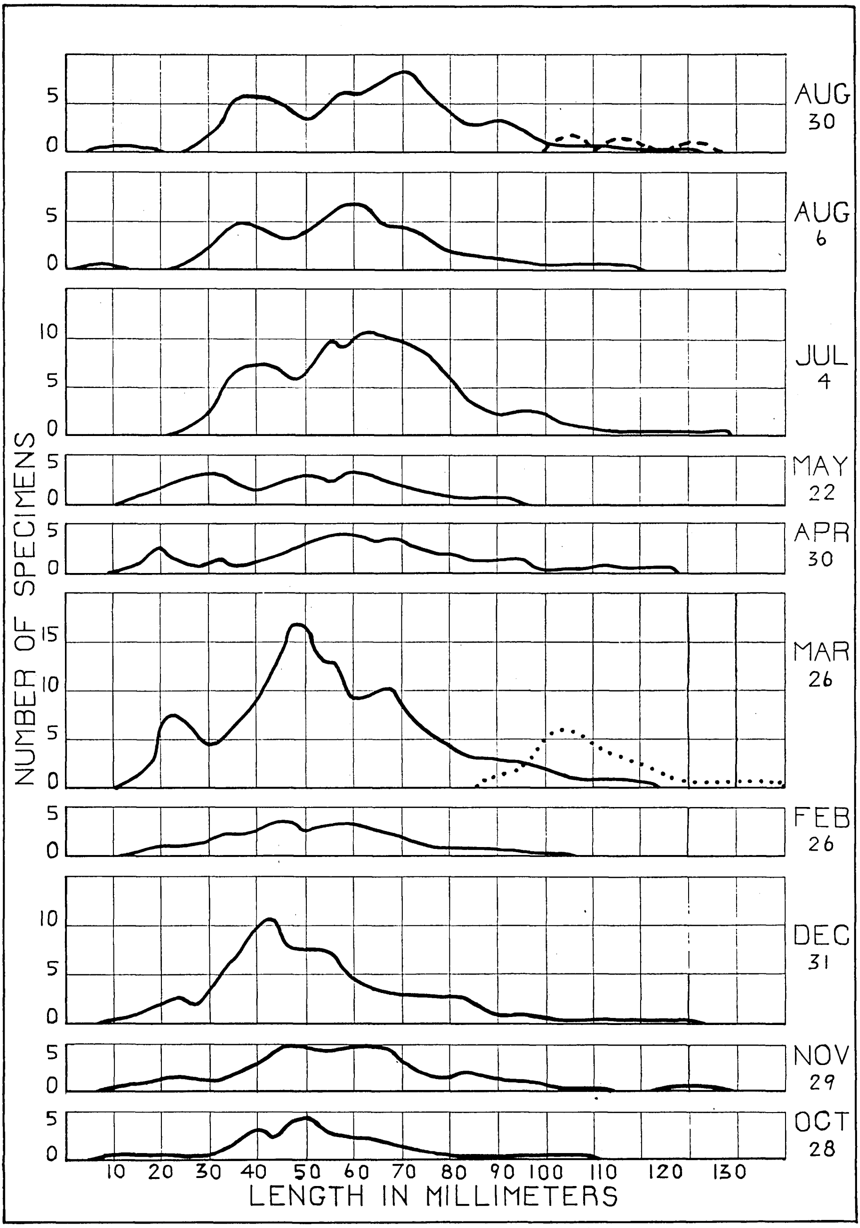

FIGURE 6. Size-frequency curves of the larvae of *Lampetra planeri* collected from Evans Creek.

Measurements made to the nearest millimeter and then smoothed by the moving average of 9. The size frequencies of the adults are represented as a dotted line over the March 26 curve and the metamorphosed larvae as a broken line over the August 30 curve.

Therefore, considering the known facts of time of metamorphosis of brook lampreys and their lack of growth after transformation, we must expect that at least another year elapses before metamorphosis, which must occur at an age of

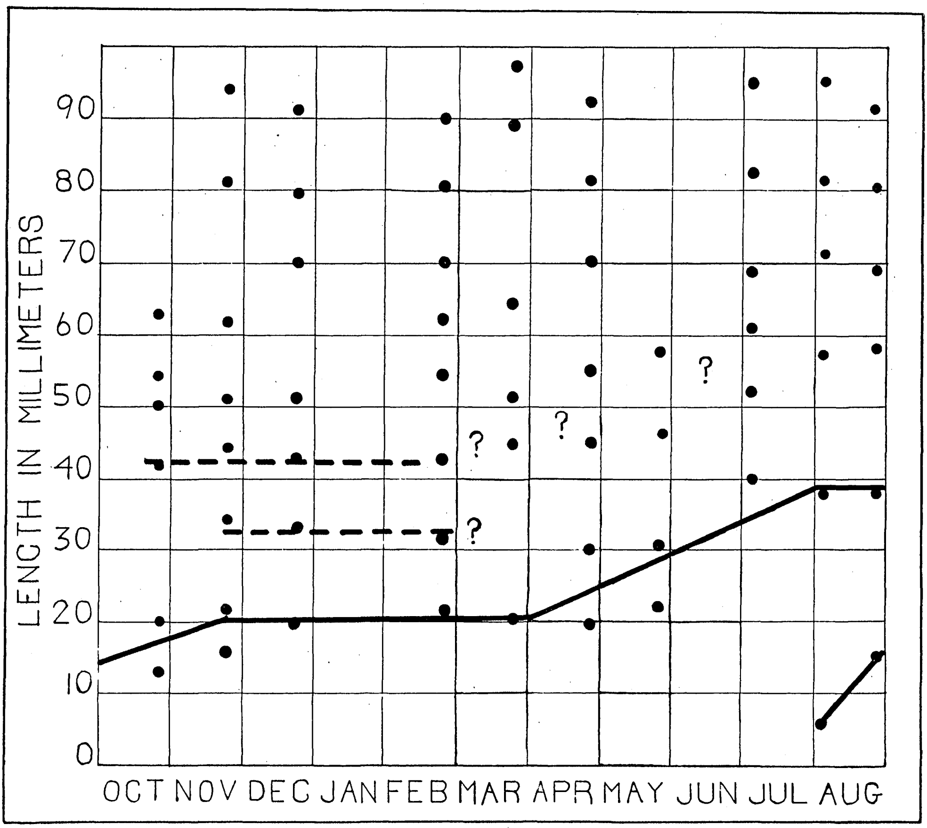

FIGURE 7. The dots indicate the location of the minor modes of the size-frequency curves of Fig. 3, as smoothed by five items.

The lines drawn indicate the progression of modes throughout the year, but since it is impossible to connect most of these points a lack of significance is strongly indicated.

more than three years. Spawning would occur usually, if not always, at the end of the fourth year. Some, of course, might mature at three years and others perhaps at five years or more, but the majority indicate a four year life cycle.

Similar evidence for *Entosphenus appendix* (Fig. 9), on similar interpretation indicates a life span of at least four and quite possibly five years; that for *Ichthyomyzon fossor,* a life of at least four and possibly several more years.

Okkelberg (1922) and Hubbs (1924), working on the rate of growth of *Ichthyomyzon unicolor* (=*I fossor*) attached considerable weight to minor crests (Fig. 8) and on only relatively small collections. They concluded that the larval life was seven years to spawning, estimating from 167, 229, 162 specimens in three collections from separate creeks. It will be noticed that for *Ichthyomyzon fossor* from Thunder Bay River, Gilchrist Creek, and Rifle River, Michigan, that none of the crests exactly coincide. They attribute this disagreement to a slightly different rate of growth in each creek. My data on specimens of *L. planeri* from the same creek and same locality, but in separate collections during the same winter, show as much difference between the modes, yet two or three times as many specimens were used. If the curves (Fig. 3) are reëxamined, several minor crests like those considered significant by previous authors, are evident but these have been demonstrated to be of no significance. Therefore it is concluded that the rate of growth of *Ichthyomyzon fossor* needs further study; that the estimated life cycle of seven years is not warranted from the small amount of available data; and that the minor crests which were assumed to be year classes may well be only accidental modes.

Okkelberg (1921) and Hubbs (1924), working on *Entosphenus appendix* (Fig. 9) of Michigan, applied the same methods as on *Ichthyomyzon unicolor* with perhaps considerable justification. However, a comparison with the present data, especially the August 11 collection from Newauken Creek (Fig. 10) which parallels their "summer" curve (Fig. 9), casts grave doubt upon the modes they indicate as year classes if *L. planeri* grows the same in this creek as in Evans Creek. It is admitted that year groups II and III of Fig. 8 of Hubbs' data may be significant because the short early spawning season in Michigan would be expected to produce clearer year

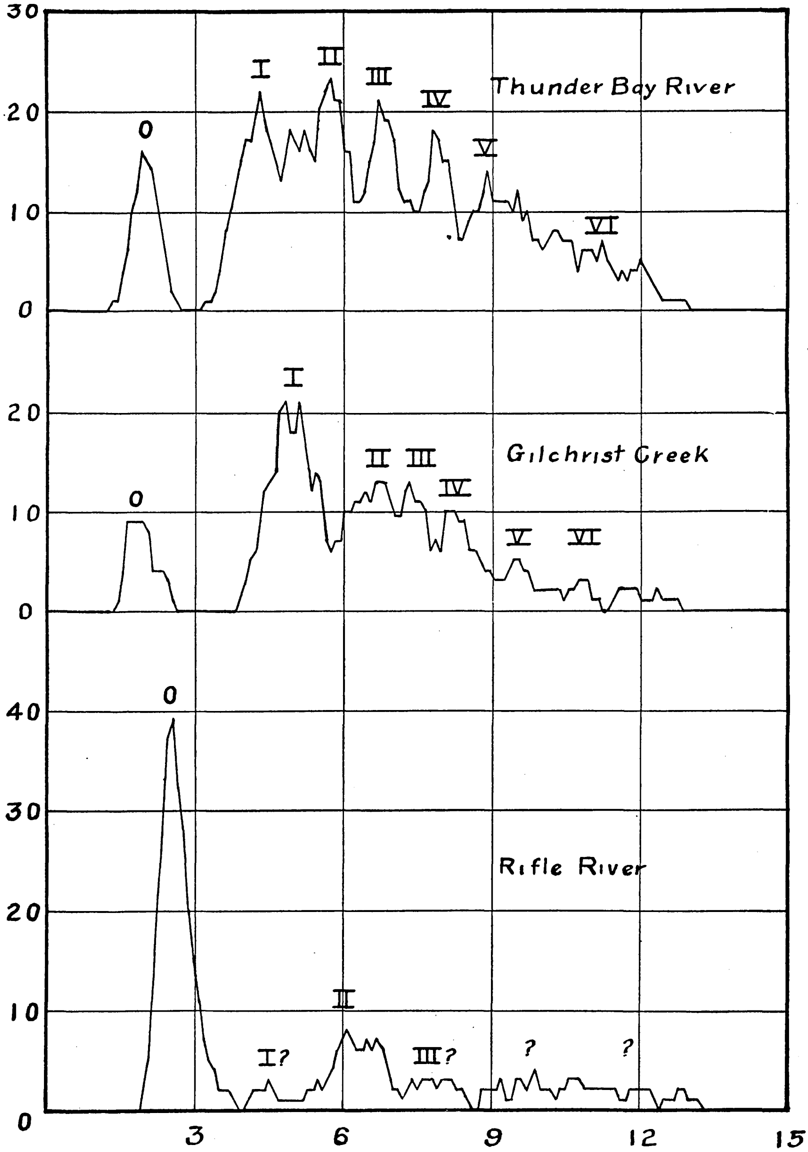

FIGURE 8. The size-frequency for *Ichthyomyzon unicolor* from data used by Okkelberg (1922) and replotted by Hubbs (1924).

Measurements were made to the nearest millimeter, then smoothed by fives. The number of specimens as indicated on the ordinate was inadvertently not divided by five. This graph reproduced by permission from the publication of Hubbs (1924).

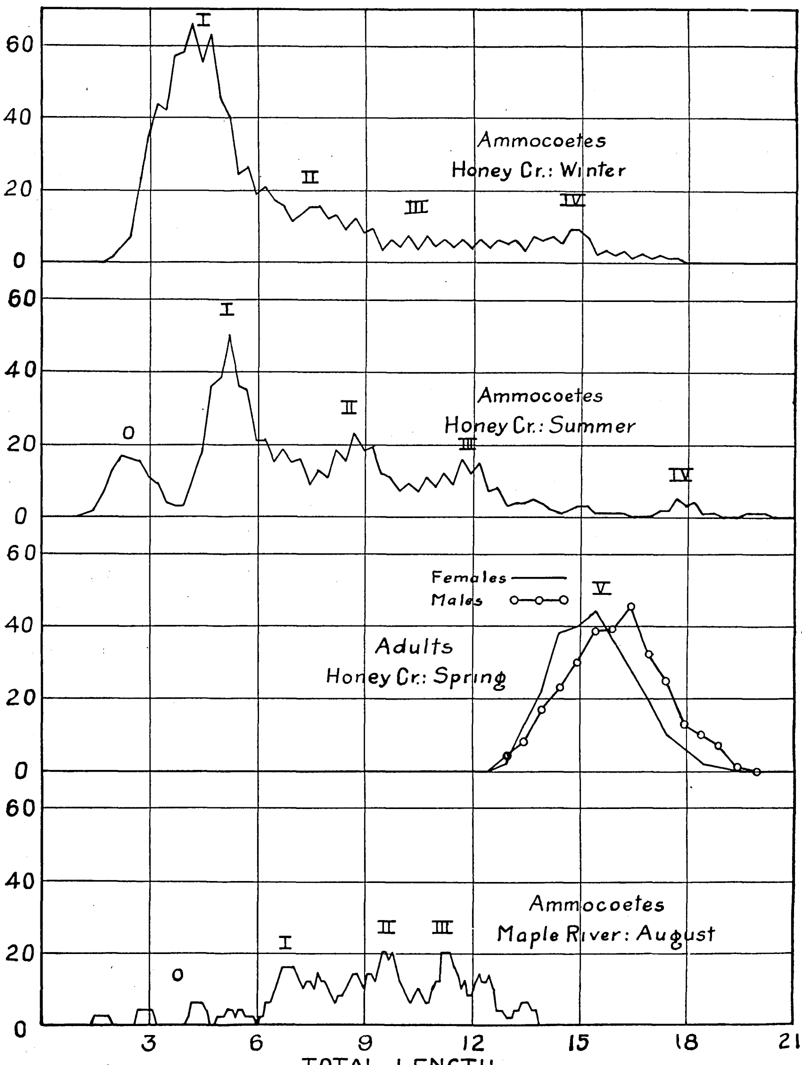

FIGURE 9. The size-frequency curves for *Entosphenus appendix* from data used by Okkelberg (1922), added to and replotted by Hubbs (1924). Measurements for first two graphs to nearest fourth centimeter, smoothed by threes; for third graph measured to nearest half centimeter, then smoothed by threes; for fourth graph, measured to nearest millimeter then smoothed by fives. The number of specimens as indicated should have been divided by the number of items by which the average was smoothed. Reproduced by permission from the publication of Hubbs (1924).

groups than the prolonged spawning period in Washington. These year classes are yet to be certainly demonstrated for any year group which can not be identified in winter as well as in summer collections from the same creek.

The adult females of *L. planeri* were found to average shorter than the males (Table 2), a result similar to that obtained by Hubbs on *Entosphenus appendix.* The results have a probable but not certain significance, owing to the small number of specimens involved.

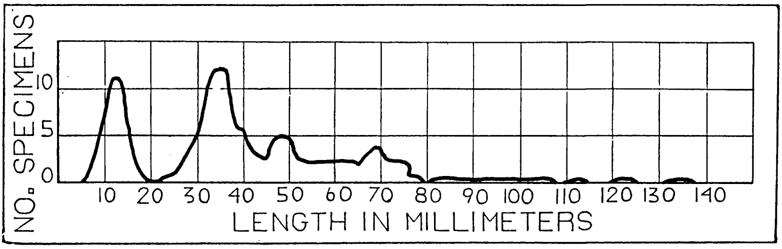

FIGURE 10. Size-frequency curve of the larvae of *Lampetra planeri* collected from Newauken Creek, near Enumclaw, Washington, on August 11, 1929.

Measurements made to the nearest millimeter and then smoothed by the moving average of five.

TABLE II

DATA ON LENGTHS TO NEAREST MILLIMETER OF ADULT MALES AND FEMALES OF *Lampetra planeri* COLLECTED IN EVANS CREEK, WASHINGTON, ON DIFFERENT DATES.

Collection of October 28, 1928.—Length of one female: 106.

Collection of November 29, 1928.—Lengths of two females: 118, 134.

Collection of December 31, 1928.—Lengths of two females: 112, 117.

Collection of March 26, 1929.—Lengths of four males: 109, 117(2), 141.

Collection of April 30, 1929.—Lengths of two males: 117, 126.

Collection of May 11, 1929.—Lengths of 7 males: 98, 110, 112, 113, 118, 119, 125. Length of one female: 109.

Collection of May 14, 1929.—Lengths of 23 males: 97, 104(2), 105(2), 106(2), 107(3), 108 109, 110, 111, 112, 115, 118, 119(2), 121, 122, 123, 128. Lengths of 9 females: 102, 103(2), 105, 108(2), 117, 118, 124.

Collection of May 22, 1929.—Lengths of 23 males: 91, 98, 99, 100(2), 102, 103, 106, 108, 109, 111(3), 112, 113, 114, 115, 116, 121, 124, 125, 136, 140. Lengths of 11 females: 96, 101, 102(2), 105, 107, 108, 110, 112, 113, 125.

Collection of May 30, 1929.—Lengths of 15 males: 95, 101, 102(2), 103, 105, 111, 114, 116(2), 117, 118, 121, 129(2). Lengths of 2 females: 111, 113.

Collection of June 13, 1929.—Lengths of 4 males: 112, 115, 127, 129. Length of one female: 105.

Collection of July 4, 1929.—Lengths of 12 males: 96, 100(3), 101, 104, 105, 106, 107, 110(2), 112. Lengths of 10 females: 89, 95, 97, 99, 101(2), 103, 104, 107, 114.

Collection of August 30, 1929.—Lengths of 5 males: 106(2), 113, 120, 132. Lengths of 2 females: 118, 121.

All collections.—Lengths of 95 males: 91, 95, 96, 97, 98(2), 99, 100(5), 101(2), 102(3), 103(2), 104(3), 105(4), 106(6), 107(4), 108(2), 109(3), 110(4), 111(5), 112(5), 113(3), 114(2), 115(3), 116(3), 117(4), 118(3), 119(3), 120, 121(3), 122, 123, 124, 125(2), 126, 127, 128, 129(3), 132, 136, 140, 141. Lengths of 41 females: 89, 95, 96, 97, 99, 101(3), 102(3), 103(3), 104, 105(3), 106, 107(2), 108(3), 109, 110, 111, 112(2), 113(2), 114, 117(2), 118(3), 121, 124, 125, 134.

Dr. Hubbs has contributed many facts on the life history of *L. planeri* from observations made at Coyote Creek in California. There is perfect agreement on the significance of the O group of *L. planeri* in both regions, as well as for other species. In fact the O group is more clearly represented in material from Coyote Creek, and for other species that he has studied, than in the present study owing, as Hubbs has suggested, in correspondence, "to the earlier and shorter spawning period in the relatively warmer waters," and he concluded "that *L. planeri* from Coyote Creek lives at least three years and not improbably four years," which the present data corroborates.

These results contrast very interestingly with those of Dr. Hubbs on *L. planeri* in numerous ways, namely: the adults reach an apparently larger size in Coyote Creek than in Evans Creek; the breeding season is earlier and much shorter in Coyote Creek than in Evans Creek of Washington; there is (according to Hubbs' correspondence previously referred to) "almost perfect flooding out of the ammocoetes in Coyote Creek," which never happens in Evans Creek because of the constant flow of water throughout the entire year. Dr. Hubbs suggests that the more compact O group in Coyote Creek is due to the restricted spawning season and the flooding out or carrying down stream of the ammocoetes during the rainy season. In the streams of this vicinity little extra carrying down of the ammocoetes is in evidence. The larvae from Coyote Creek show a more "rapid growth in the warm water during the first summer and attain a larger size by October" (Hubbs, 1924) than the larvae do during their first summer in streams of western Washington. Most of these points of contrast are no doubt caused by climatic and stream difference in the two regions.

Dymond, Hart, and Pritchard (1929) estimated the life cycle or age of *Petromyzon marinus* of Lake Ontario, by means of minor crests in the size-frequency curves, similar to those of Okkelberg and Hubbs, but rightfully have questioned the accuracy of their own conclusions.

The larvae collected from other localities of western Washington indicate a similar rate of growth to those found in Evans Creek. The only collection of any size was that of 282 specimens of ammocoetes from Newauken Creek, near Enumclaw, Washington, taken August 11, 1929. These data were treated by the same methods as other material and recorded in Table 3 and Fig. 10. Two very clear crests are formed, one of which, falling between 7 and 20 mm., doubtless represents the young of the year; the other, between 25 and 45 mm., doubtless represents the fish more than one year old. The remainder of the curve is nearly unimodal, and from it year groups can not be determined. But since the curve is similar to that of Evans Creek in all respects, it is concluded that the rate of growth and age are probably the same in both localities. No statistical foundation was found upon which to consider the crests at 50 and 70 mm. as representing significant year groups.

It is concluded from this statistical study of the data presented as to the larvae of *Lampetra planeri* from western Washington that only two definite year classes can be identified in the size-frequency curves; that our data indicates no such length of life as was estimated for *Ichthyomyzon fossor*

TABLE III

DATA ON LENGTHS TO NEAREST MILLIMETER OF AMMOCOETES OF *Lampetra planeri* FROM MISCELLANEOUS LOCALITIES IN WASHINGTON NEAR SEATTLE.

Collected in White River below Auburn, November 9, 1928 (22 specimens).—30, 31(3), 33, 34, 35, 36, 37, 39(2), 40, 41, 43(2), 44, 57, 59, 63, 67, 70, 93.

Collected from a creek, near Kent, Washington, November 9, 1928 (3 specimens).—96, 99, 112.

Collected from Lyons Creek at Lake Forest Park, Seattle, Washington, January 12, 1929 (9 specimens).—20, 29, 40, 41, 44, 56, 60, 91, 103.

Collected from McAleer Creek at Lake Forest Park, Seattle, Washington, January 12, 1929 (20 specimens).—15, 19, 25, 26, 28, 33, 37, 38, 52, 55, 56, 57(2), 60, 63, 65, 67, 73, 77, 93.

Collected from North Creek, tributary of Sammammish River near Bothel, Washington, July 15, 1929 (8 specimens).—8(2), 9(3), 10(2), 11.

Collected from Newauken Creek, two miles north of Enumclaw, Washington, August 11, 1929 (282 specimens).—9, 10(5), 11(11), 12(11), 13(13), 14(8), 15(12), 16(3), 17, 26, 27, 28(4), 29(4), 30(3), 31(7), 32(5), 33(11), 34(10), 35(13), 36(13), 37(12), 38(11), 39(9), 40(4), 41(2), 42(6), 43(3), 44(2), 45(3), 46(3), 47(2), 48(8), 49(7), 50(3), 51(2), 52(4), 53(3), 55(3), 56(3), 57(2), 58, 59(2), 60(3), 61(3), 62(2), 63(2), 64, 65(2), 66, 67(2), 68(6), 69(4), 70(2), 72(5), 73(3), 76, 82, 83, 84, 85, 88, 89, 92, 94, 100, 103, 112, 122, 135.

from similar data by certain authors; that the spawning population may be composed of more than one year class and our data would not reveal it. Good circumstantial evidence, however, indicates a minimum age of four years to spawning in the spring and early summer for the majority of the individuals of *Lampetra planeri,* as also for the other brook lampreys, the life history of which has been investigated, namely *Ichthyomyzon fossor* and *Entosphenus appendix.*

NATURAL HISTORY OF THE ADULTS

The western brook lampreys show external sexual differences during the breeding season (Plate I), but are externally indistinguishable at metamorphosis. The chief sexual characters are: (a) Presence of a genital papilla on the male, absent on the female; (b) enlarged anal fin on the female, almost absent on the male; (c) enlarged swollen portion at the anterior edge of the second dorsal fin of the male but not of the female. These differences correspond with those found by Panizza (1845) and Gage (1893) for *Petromyzon marinus,* by Reighard and Cummins (1918) for *Ichthyomyzon fossor,* by Maskell (1929) for *Geotria,* by Vladykov (1927) for "*Lampetra Bergi,*" by Berg (1923) for *Caspiomyzon* and others, by Okkelberg (1921) for *Entosphenus appendix,* and by myself on the last-named species in Michigan. They agree also with Hubbs' unpublished observations on all these species and also on *Entosphenus tridentatus, E. japonicus, E. mitsukurii, Lampetra fluviatilis,* and *L. lamottenii.*

Lampetra planeri, which is nonparasitic during its adult life, only lives then to reproduce the species. Its intestine on transformation becomes degenerated and about the size of a linen thread. A closely related species of lamprey, identified by Creaser and Hubbs (1922) with *Lampetra fluviatilis,* occurring in certain lakes and streams of the Pacific drainage, is parasitic. It is easily distinguishable from the nonparasitic form by the following characters: *L. fluviatilis* has the dorsal fins well separated by an interspace, while in *L. planeri* the dorsals are connected at their bases; all the teeth are sharp in the former, but the teeth of *planeri* are all weak and blunt.

The time of the year when *Lampetra planeri* spawns is probably closely correlated with the temperature of the water, which roughly follows that of the air temperature in western Washington (Table 4). The weather of western Washington is steady throughout the spring and not subject to the warm and cold spells and the rapid rises which occur in the midwestern United States. Therefore, spawning is likely to take place gradually instead of within a very short period of two or three weeks as is the case of *Ichthyomyzon fossor* of Michigan, which spawns from about the last of April to the end of May, depending on the time of the first warm spell when the critical temperatures of the creeks reach 20 to 22 degrees centigrade (Reighard and Cummins, 1916). However, in Washington the spring is usually delayed until April when numerous clear warm days occur, previous to which there is cloudy to more or less rainy weather.

TABLE IV

WATER AND AIR TEMPERATURE AT EVANS CREEK, NEAR REDMOND, WASHINGTON.*

Date	Water Temperature		Air Temperature
	F.	C.	F.
March 11	44.0	6.7	43
March 27	45.0	7.2	48
April 20	47.4	8.6	50
April 30	51.8	11.0	61
May 11	51.8	11.0	70
May 14	51.8	11.0	75
May 22	58.1	14.5	80
May 30	54.5	12.5	65
June 13	55.4	13.0	70
July 4	55.4	13.0	80
August 30	53.6	12.0	80
September 20	51.8	11.0	60
October 19	50.9	10.5	55

* All temperatures taken between 11 A. M. and 1 P. M.

Just before April 20, 1929, the first week of fine spring weather occurred, with sunshiny days and cool nights. The air temperature varied from between 40° and 70° F. The temperature of Evans Creek was about 48° F. No adults were seen on the riffles, though many were taken from mud banks in the vicinity. On April 30, following a few days of good weather again, when the air temperature was up to 80° F. with cool nights, the water of Evans Creek reached 51.8° F. Two adult males were observed and collected from a small nest on the riffles though no others occurred on all the riffles examined for three miles of the creek.

On May 11, after two weeks of cold rainy weather with only one or two warm days, the temperature of Evans Creek was again 51.8°, and considerable breeding activity, especially nest building, was observed. One female and seven males were captured though none were observed in the act of spawning, even after many hours of watching. On May 14, after four days of excellent summer weather, 9 females and 23 males were captured while actively breeding in the nests, though no change in the temperature of the water had occurred. Again on May 22, 11 females and 23 males were captured after a very warm week, which raised the temperature of Evans Creek to 58.1° F. On May 30, 2 females and 15 males were captured. The water of Evans Creek varied between 52° and 56° F. the rest of the summer. The higher temperature in May is owing no doubt to the warm surface water running into the creek from the rains which occur in the spring. Later in the summer as the rains stop, the creek is fed entirely by springs which are cooler than the surface water drainage. This may have a retarding effect on the spawning but no direct evidence of this factor is available. The adults were in fair abundance on the riffles as late as July 4 when 10 females and 12 males were captured. The proportion of males and females is unequal: the ratio in my collections is 2.32 males to one female. There is apparently a tendency for the males to appear on the spawning ground prior to the arrival of the females although this tendency is not strongly marked and certainly is not of clear statistical significance because of the small numbers collected.

Owing to the warm weather of April, 1930, spawning began in great abundance by April 22, when the water temperature of Evans Creek was 57° F. No spawning adults were found on the riffles after July 4, 1929, and we may conclude from these facts that *Lampetra planeri* has a prolonged spawning period covering the time from about the middle of April to the first or middle of July, or about twelve weeks. This fact may help explain the difficulty of distinguishing the year groups from the length-frequency distributions of the ammocoetes. No such length of spawning has been reported for other species of lampreys to my personal knowledge. The critical temperature at which spawning is stimulated is between 51° and 52° F., since no adults were observed on the riffles until this temperature was reached by the water of Evans Creek.

The western lamprey, like all other known species, ascends the smaller rivers and creeks to find a suitable situation in which to build nests and deposit its eggs. The nest of *Lampetra planeri* is constructed in riffles composed of stones mixed with fine to coarse gravel and sand, over which the water is moving rapidly. The nest for this species is crude and ill-defined, often little more than areas in the stony bottom where sand and pebbles have been cleared away between or under larger stones. Little excavation occurs, but as the spawning season draws to a close in July, some of the nests by continual use, if not disturbed or abandoned, become considerably enlarged. The average nest is seldom more than two inches in depth and four or five inches in its greatest diameter. On May 11, 1929, a nest was observed which measured four inches in diameter, three inches deep, bounded above by a three-inch stone, to one side by a four-inch stone, and below and on the other side by a number of pebbles. The bottom was composed of fine gravel and sand. This nest was constructed in a riffle of unusually coarse stones, ranging around ten inches or less. On the same day other nests which were similar were examined downstream. A considerably different type of nest is built when the conditions are just right for it. Such a nest was observed in a riffle composed of stones all less than three inches in diameter. This nest was located at the upper end of the gravel bed so that the upper half was composed of sand only, while the downstream portion was of small gravel. The current over this nest, 14 inches in length and 10 inches wide, $1\frac{1}{2}$ inches deep, was weak. Six others were examined, varying from four to six inches in diameter, constructed in riffles between fairly large stones where little excavation was necessary. Nest construction is partly accomplished by the lampreys wedging themselves between the stones and crowding them apart by the lateral vibrations of the body. This loosens the sand and fine gravel of the bottom, and it is carried away by the current.

The brook lamprey is not a strong swimmer and makes little use of its suctoral mouth, either when resting or for carrying gravel from the nest. The smaller pebbles of from $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter are the largest sizes carried from the nest, and these only for distances of from three to six inches. None of the adults have been observed to transport a stone upstream, but occasionally an attempt was made to carry one a few inches downstream. Two stones were removed in a period of 30 minutes when 9 adults were present. The nest building is very apparently degenerate when compared to the fine construction of nests by *Entosphenus appendix* of Michigan. The gravel riffles selected for spawning are of a definite type, composed of stones of various sizes, with enough current to keep them clean but not strong enough to carry away the sand at the bottom of the stones. The nests are invariably constructed at the head of the riffles in comparatively quiet water.

The behavior of the western brook lamprey is interesting and somewhat similar to that of *Ichthyomyzon fossor*. It is inactive and sluggish and is concealed in the riffle part of the time. The population in any given nest is constant for, although they go and come, they do not leave the riffle itself but instead, swim away from the nest and hide under nearby stones and later return. One nest was found to contain nine lampreys; it was empty ten minutes later, but half an hour afterward four had returned. Of six nests examined, the population consisted of 9, 9, 12, 1, 2, 5 individuals respectively. At times it is difficult to decide, unless it is occupied, whether a nest is present on a riffle or not, on account of the ill-defined construction. A nest observed on May 14 to contain nine lampreys was examined again on May 22, on which date no adults were swimming in its vicinity, but knowing their tendency to hide, when not actively engaged in spawning, excavation of the entire riffle was begun, which, after about 35 minutes of work, revealed 14 adults. A similar procedure at other times has resulted in the capture of between 10 and 20 specimens. On certain riffles thus excavated all the adults were killed and preserved in formaldehyde, yet the spawning stock was not affected a week later when as many more were taken from the same riffle. This indicates that the supply of adults is continually refreshed, probably from the stock found in the sediment banks of the stream a little downstream where the adults were taken previous to spawning, but where none were found the latter part of June.

This nonparasitic brook lamprey was not easily frightened. In bright sunshine the shadow from the arm or the dip net had no effect on it. Objects moving on the bank of the stream were apparently not recognized by the lampreys, since they did not disturb their spawning. Wading in the water in the vicinity of the nest did not frighten them, but the slightest touch or disturbance of the nest caused the lampreys to leave and seek protection under nearby stones. When in the nest, the adult was not oriented in relation to the current of the stream for its head was downstream, sideways, etc., a large percentage of the time. However, while swimming on the riffle, its head was always pointed upstream against the current. Numerous specimens of *Cottus rhotheus* lurk around the nest and breeding grounds of the lampreys, presumably feeding upon the eggs though no stomach contents were examined.

The spawning act of *Lampetra planeri* is very difficult to see and record accurately by observation, owing to the rapidity with which it occurs and its concealment by the stones of the nest. At the beginning of the breeding season, about May 11, 1929, though one female and 7 males occupied a nest, none were seen in the act of spawning. But on May 14, in a nest of nine, the spawning act took place occasionally. This act, as well as was observed, consisted of a male attaching itself to the back of the female and gliding forward to a location above the branchial basket. The female was attached to a stone, headed upstream. The male quickly curved his body over and between the dorsal fins of the female, then sharply under the ventral side of the female, crossing in the region of the vent so that the vents of both male and female were in close proximity. This contact was accompanied by rapid vibrations of both, the entire act taking place in less than a minute.

The writer has observed the breeding behavior of *Entosphenus appendix* in Flemming Creek, near Dixboro, Michigan. Two breeding activities are recognized: first, the vibrations of the spawning act; and second, the vibrations in the stone movement of nest construction. No difference was observed in the former between *Lampetra planeri* of Washington and *Entosphenus appendix* of Michigan, but the latter is only feebly developed in *Lampetra planeri.* Reighard and Cummins (1916), on *Ichthyomyzon unicolor,* state: "Although the excavation of nests is prosecuted with great vigor, with sometimes as many as seven or eight individuals present, attempts at spawning in them are rarely seen. On the contrary, the spawning act takes place almost invariably when the animals are more or less hidden among stones." *Lampetra planeri* was not observed to spawn under stones, nor were two individuals ever found resting together under the same stone. Therefore it is concluded that spawning takes place only in the nests.

Like all other lampreys, *Lampetra planeri* dies after spawning. A few dead were picked up in quiet water just below the riffles.

Summary

1. The ammocoetes of *Lampetra planeri* Bloch are very abundant in many of the streams of western Washington, living in the quieter places where a mixture of silt and sand has settled. They are very common in the débris of the creek but rare in stiff muck and shifting bottom sands.

2. The larvae are of some economic importance as they are collected in great numbers for bait and used in fishing for bass and trout. They sell for $1.50 to $1.75 per dozen.

3. The size-frequency curves of the larvae of *Lampetra planeri* indicate that only two year classes can be definitely distinguished. A statistical analysis of the data shows the minor modes are not significant and do not represent year classes. They are rather accidental modes owing to sampling.

4. Circumstantial evidence indicates a minimum age of four years at spawning for the majority of the population. Perhaps certain individuals mature at three years and others at five years or more.

5. These data on *L. planeri* are comparable with those of certain other investigators who estimate a span of life of five and seven years respectively for *Entosphenus appendix* and *Ichthyomyzon fossor,* but our analyses indicate the unreliability of these estimates. The life span of *E. appendix* may be only four instead of five years, although the evidence for a five year period is fairly good. The life cycle of *I. fossor* is apparently at least four years, but there is no significant evidence that the period is seven years.

6. The ill-defined nests are located usually on stony riffles over which the water flows rapidly. The instinct of nest building is somewhat weak in this species, as evidenced by the fact that little excavation takes place.

7. The critical temperature at which spawning begins was found to be between 51° and 52° F. in May of 1929. The spawning period was prolonged from about May 11 to the first week in July, but in 1930 spawning commenced about the middle of April.

8. The spawning act, difficult of observation, is similar to that described for other lampreys and occurs in the nest. The adults, when not actively engaged in nest construction or breeding, hide under nearby stones.

9. In general *L. planeri* is sluggish and little use is made of the mouth for nest construction or for clinging to stones when resting.

10. All of the adults die after spawning. None are parasitic on fish.

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PLATE I.

UPPER FIGURE. Adult female of *Lampetra planeri* Bloch, collected in May, 1929, from Evans Creek, near Redmond, Washington.

LOWER FIGURE. Adult male of *Lampetra planeri* Bloch, collected as in upper figure.

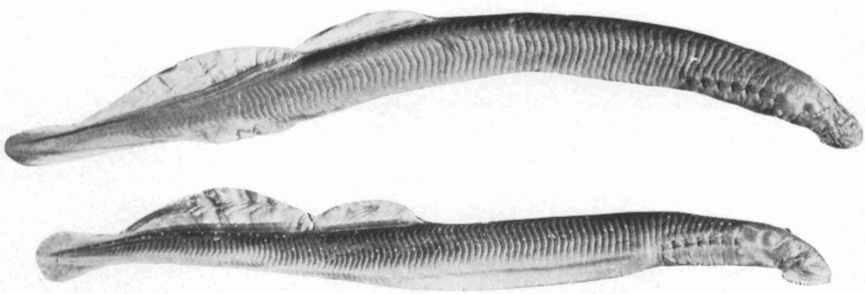

PLATE II.

UPPER FIGURE. Evans Creek, near Redmond, Washington, showing a curve in the stream overhung by bushes where the larvae of *Lampetra planeri* have been taken in abundance.

MIDDLE FIGURE. A typical coarse gravel riffle where many adults were observed spawning in May and June.

LOWER FIGURE. A typical habitat in Evans Creek, where sand and silt have settled in quiet stretches of the stream, is occupied by larvae of all sizes.