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## **Notes on the Biology of the Miller Lake Lamprey *Lampetra (Entosphenus) minima*<sup>1</sup>**

### **Abstract**

Biology and life history of the extinct Miller Lake lamprey were studied by examination of field notes and preserved specimens. The life span was approximately 36 months. About 30 months were spent in the larval stage, with metamorphosis to the adult stage in the fall and spawning in late spring and early summer. Although the adults fed voraciously on trout and chubs, and were involved in cannibalism and scavenging, the shrinkage in length from full-term larvae to spawning adults was about 4.5 percent. Speciation of this dwarf lamprey apparently required less than 6600 years, for fish life of Miller Lake is thought to have been destroyed by the explosion of Mount Mazama, only 38 km distant. Reduced food supply for lampreys reinvading the lake, relatively short generation time, and the "founder effect" are thought to have been involved in the rapid speciation.

### **Introduction**

*Lampetra (Entosphenus) minima* is a dwarfed parasitic lamprey formerly found only in Miller Lake, Klamath County, Oregon. Fish control operations during the 1950s caused the apparent extinction of this species (Bond and Kan, 1973). Subsequent intensive investigation of the lake and outlet stream by the Oregon Department of Fish and Wildlife has disclosed no specimens (Harry Lorz, ODFW, pers. comm.). The location of Miller Lake is T27S, R6 1/2E, Secs. 11-14, about 16 km northeast of Mt. Thielsen.

### **Biology**

Bond and Kan (1973) described and named *L. minima* and Kan (1975) discussed the species briefly. The objective of this paper is to examine the life history of *L. minima* and to relate the biology of the species to its apparently rapid rate of speciation. The biology of this species can be studied only in retrospect, based on preserved specimens mostly in the Fish Collection, Department of Fisheries and Wildlife, Oregon State University (OS), and notes and observations made in the early 1950s.

Unlike other parasitic species of lampreys, *L. minima* was considerably larger in total length in late larval stage and the feeding stage than in the spawning stage (Bond and Kan, 1973) (Fig. 1). Shrinkage from the feeding stage is about 13 per-

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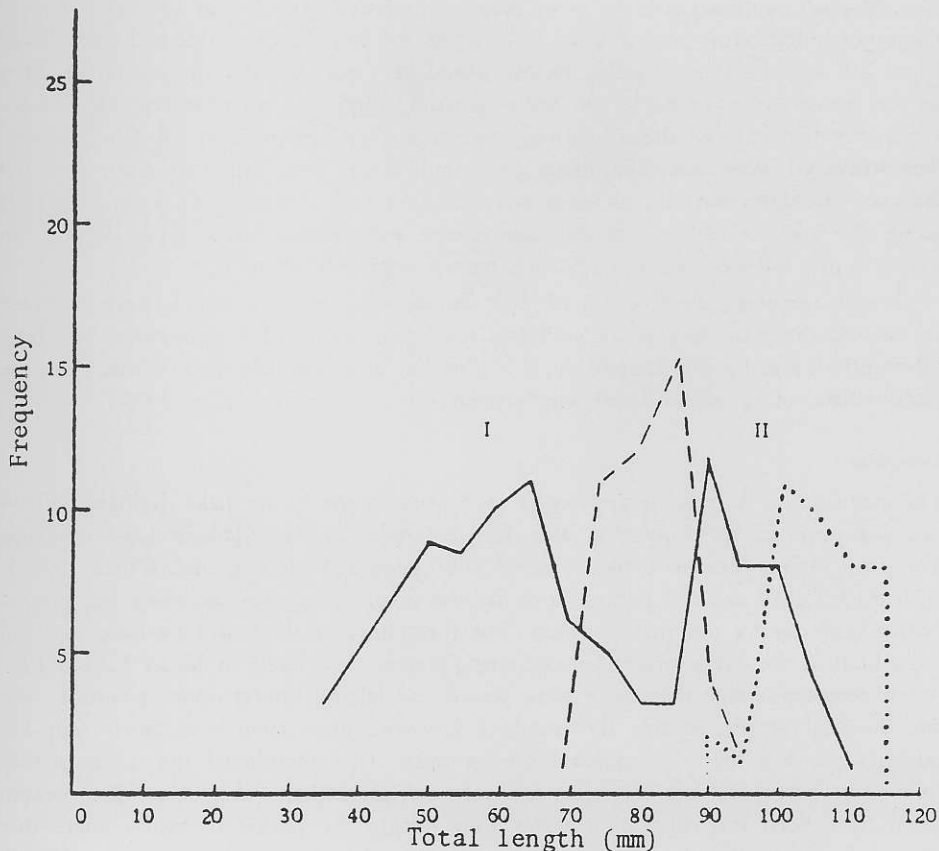


Figure 1. Length-frequency distribution for *Lampetra minima* ammocoetes (102 specimens, indicated by solid line), feeders (44, dotted line), and spawners (40, broken line) from Miller Lake, Oregon.

cent; spawners are about 4.5 percent smaller than the ammocoetes of age class II. Thus, the postlarval period of *minima* was shortened compared to landlocked *L. tridentata* of the Klamath Basin. *L. minima* metamorphosed in fall and spawned in June and July. The feeding period was therefore less than a year. During this short period, *L. minima* fed voraciously when prey animals were available. Lamprey marks were observed on tui chubs, *Gila bicolor*, and the planted fingerlings of brown trout, *Salmo trutta*, and brook trout, *Salvelinus fontinalis*. Cannibalism (see Davis, 1967) also played a part in the nutrition of *minima*, for scars and mined-out holes were found on specimens in collections of *minima* at feeding stage (OS 2811 and 2879). Scavenging was seen on several occasions. Dead tui chubs and lampreys were continuously attended by feeding lampreys until all soft material was removed. Chubs were sometimes reduced to a perforated skin surrounding the skeleton.

Egg counts for 10 *L. minima* range from 503 to 727, with a mean of 604.40. Relative fecundity (no. of eggs per g of egg mass/total body weight in g) varies from

432 to 596 (mean 525). Compared with other lampreys as listed by Hardisty (1971), the absolute fecundity of *minima* is the lowest, apparently a consequence of its extremely small adult size. On the other hand, the relative fecundity of *minima* is among the highest, indicating that a large fraction of the lipid reserves accumulated during larval life and the short parasitic period would be incorporated into gonadal products so that little reserve would be left for a spawning migration up tributaries. *L. minima* apparently had reduced the migration considerably; all spawners in the OS collection were collected along the lake shore. Few ammocoetes were collected from the cold tributary streams, but ammocoetes were common in deposits of organic detritus along the lake shore. Presumably ammocoetes were present in organic deposits in deeper water, but we have no collections from deeper than about 1 m.

Length-frequency distribution of 102 ammocoetes, most of which were collected in the fall along the lake shore, indicates the larval period of *L. minima* to be about 30 months (Fig. 1). By comparison, this duration is at least one year shorter than the larval period of *L. tridentata*, of which *minima* is a derivative (Kan, 1975).

### Evolution

The evolution of *L. minima* apparently took place in the Miller Lake drainage following disruption of its connection with the remainder of the Klamath Lake drainage. The great Mount Mazama exploded about 6600 years ago (Powers and Wilcox, 1964), with thick fall of ash and pumice covering the surrounding area including the present Miller Lake district (Williams, 1942). The forerunner of *minima* must have survived the ashfall in the outlet stream or connecting waters (less likely in Miller Lake itself), but it seems probable that there were severe and lasting effects upon spawning sites and on food supply, so that the numbers surviving must have been small. Our hypothesis requires that the ancestral species must have abandoned the outlet stream following reinvasions of, or population rebound in, Miller Lake. A possible reason could have been interruption of water flow during the period of arid climate that prevailed during the time about 8000 to 4000 years before the present (Hansen, 1947; Heusser, 1966).

The shoreline spawning habit may have resulted from limited suitable space in the small tributaries and to their cold temperatures. Studies of the sea lamprey, *Petromyzon marinus*, disclosed that peak spawning and successful hatching took place at temperatures of 15.6° to 21.1°C (Applegate, 1950; McCauley, 1963; Piavis, 1961).

The only other fish species thought to have survived in the system was the tui chub, *Gila bicolor*, which has heavy scales and, except in very young stages, is not easy prey for a small lamprey. Moreover, the lake and environs, smothered by cinders and pumice, probably could not support a large population of either chubs or lampreys. Lampreys are known to respond to diminished food supply by reducing the ultimate body size, but without changing the duration of the feeding stage (Hardisty and Huggins, 1973). Smith (1971) reported a 13 percent reduction in size of *Petromyzon marinus* in the Great Lakes from 1947 to 1970. This change was independent of the abundance of lampreys but reflected a general reduction in food supply. In response to the supposed severe paucity of food, *L. minima* evidently evolved through two seemingly contrasting processes: feeding fiercely on whatever was available, and maturing early and spawning even on a starvation diet. These two processes were

apparently operating in view of its eventual characteristic adult body size and its observed feeding habits such as predation, cannibalism, and scavenging. As a result, *L. minima* remained extremely dwarfed and maintained the short adult life even though introduction of other species provided abundant food. Only one of our preserved specimens, a 129 mm adult (OS 2873), appears to have spent more than a few weeks to a few months in active feeding. The impact of predation upon planted trout fingerlings led to the destruction of the species through chemical control measurements during the 1950s.

#### **Speciation Rate**

The speciation of *L. minima* must have required less than 6600 years. Factors that interacted with genetic processes and played an important role in bringing about this rapid rate include geographical isolation and severe ecological conditions, in particular reduced food supply.

Roles of geographical isolation in the process of gradual speciation have long been a subject of discussion. Mayr (1963) accumulated much evidence indicating that the process of speciation requires geographical isolation, the allopatric model of speciation. *L. minima* appeared to become geographically isolated from a probable landlocked *L. tridentata* type ancestry following the impact of the Mazama volcanism and arid climate. Duration of the isolation, some 6600 years, would seem insufficient to allow for the differentiation of a form to a full species level (see Hubbs, 1940; Miller, 1961); but during this period, *L. minima* accumulated distinctive characters including dwarfism, altered feeding habits, and partial or complete elimination of adfluvial migration, as well as reduced disc size, reduced dentition, and other salient characters (Bond and Kan, 1973).

No doubt the physiochemical makeup of the water in Miller Lake was greatly altered through addition of a large amount of hot volcanic ash and cinders generated by the Mazama eruption only 38 km away. Native fishes, including the lamprey, probably died out because of the sudden drastic environmental changes. Altered ecological conditions that confronted the reinvading or surviving fishes in the Miller Lake system must have played an important part in speciation.

After a sudden drastic environmental change has reduced a species to a very small population, the genotype of a majority has already been proven unsuccessful to meet the changed environment. The remnant of the now decimated species is faced with perishing or adapting. Adaptation can be facilitated through inbreeding in a small population. Population size of the incipient *L. minima* in Miller Lake was apparently very small because of the impact of the Mazama ashfall. By comparison with the supposed parent species, *L. tridentata*, some characteristics of *L. minima* including the dentition and adult body size are remarkably constant (Kan, 1975), suggesting that inbreeding in a small population had indeed occurred.

A short generation time appears to favor a rapid speciation rate in isolated freshwater fishes (Miller, 1961). The three-year generation of *minima* was longer than the generation time of most freshwater teleosts, but was short for a lamprey; this fact may have speeded the rate of speciation.

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