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Conservation status of Northern Hemisphere lampreys (Petromyzontidae)

C. B. Renaud

Research Division, Canadian Museum of Nature, Ottawa, Canada

Summary

Among the 34 nominal lamprey species in the Northern Hemisphere, ten are endangered; nine are vulnerable at least in part of their range, and one is extinct. The major cause is habitat degradation through pollution and stream regulation. Four conservation priorities are recommended: 1. The protection of all lamprey species or populations thereof listed as endangered; 2. where needed, the rehabilitation of the spawning streams of non-parasitic species and the removal or circumvention of any barriers preventing access to the spawning sites; 3. the protection of permanent freshwater resident populations of anadromous species, specifically of *Entosphenus tridentatus*, *Lampetra ayresi*, *L. fluviatilis*, *Lethenteron japonicum* and *Petromyzon marinus*; 4. the study of the conservation status of Asian lampreys.

Major characteristics of family

There are some 34 species in the Northern Hemisphere lamprey family Petromyzontidae (Table 1). Of these, six are anadromous and the remainder are permanent freshwater residents. All but one of the anadromous species have developed permanent freshwater resident populations: *Entosphenus tridentatus* in Cultus Lake and the Columbia River, British Columbia; Sprague River, Oregon; Goose Lake, Oregon/California; Klamath and Shasta rivers and Copco Lake, California; *Lampetra ayresi* in Morrison Creek, Vancouver Island, British Columbia; *L. fluviatilis* in Loch Lomond Basin, Scotland; Lake Mjøsa, Norway; Finnish lakes and basins of lakes Ladoga and Onega, Russia; *Lethenteron japonicum* in Slave, Hay and Mackenzie rivers, Northwest Territories; and *Petromyzon marinus* in the Laurentian Great Lakes, Finger Lakes, Oneida Lake and Lake Champlain, Canada/USA. There are 14 parasitic and 19 non-parasitic species; the latter do not feed as adults. *Caspiomyzon wagneri* is a special case, as indirect evidence suggests that it feeds exclusively as a scavenger in the adult stage. All lampreys have migratory habits; in the case of parasitic lampreys, especially those that are anadromous, the feeding and spawning migrations can be quite extensive. In *Caspiomyzon wagneri*, migrations used to be in the order of 1500 km; now they are less than 450 km. In *Lethenteron japonicum*, migrations vary between 200 and 2100 km. In *Petromyzon marinus*, they vary between 20 and 850 km. In non-parasitic lampreys, migrations are quite localised, in the order of a few to tens of km.

Distribution of family

Northern Hemisphere lampreys occur across North America and Eurasia roughly between 20° and 72° lat. N. The zoogeographic nomenclature and limits used here follow Bănărescu (1992). The Northern Hemisphere lampreys inhabit the Holarctic and Sino-Indian regions (Bănărescu 1990). Within the Holarctic region, they inhabit the Arctic, Western and Eastern North American subregions and the central Mexican, Euro-Mediterranean and Siberian subregions. Within the Sino-Indian region, they occur only in the East Asian subregion.

Brief history of research on family

Much of what is known about lampreys is summarized in a five-volume work edited by Hardisty and Potter (1971–1982). Hardisty (1979) devoted a book to lampreys and hagfishes and their relationships. The Proceedings of the Sea Lamprey International Symposium (1980) assembled much information on lampreys in general; eight of the 34 recognized lamprey species were described by Vadim D. Vladykov and colleagues, notably Edward Kott. Coad et al. (1988) provided a complete bibliography of Vladykov's work. Holčík (1986) covered virtually all aspects on the biology of the European lampreys. A comprehensive bibliography on lampreys was compiled by Selley and Beamish (1977), with three supplements by Tandler et al. (1979), Healey and Beamish (1984) and Beamish et al. (1989).

Economic and social value of family

Lampreys together with the exclusively marine hagfishes (Myxinidae) represent the most primitive extant vertebrates. This characteristic makes lampreys phylogenetically interesting, and they are used extensively in comparative anatomy courses. Fossil lampreys (order Petromyzontiformes) are known from Montana and Illinois dating to the Carboniferous Period, 280–310 million years ago (Bardack and Zangerl 1968, 1971; Janvier and Lund 1983). Lamprey eggs are preyed upon by a wide variety of fishes. The larvae or ammocoetes are used as food by various fishes and birds. Adults are preyed upon in fresh waters by fishes, snakes, birds and mammals, and in the sea by fishes and mammals. Ammocoetes and adults were used, and in some areas are still used, as bait for various sport and commercial fishes. Lamprey fisheries in Europe data back to the Romans who are said to have considered them a regal food (Thomas 1961). A number of species (*Caspiomyzon wagneri*, *Lampetra fluviatilis*, *Lethenteron japonicum* and *Petromyzon marinus*) are still consumed by humans, especially in the Baltic States, France, Japan, Portugal, Scandinavia and Russia. For example, in Finland in 1983, about 100 t of *Lampetra fluviatilis* were harvested for an estimated value of 800 000 US dollars (Dill 1990). The author has eaten lampreys of this species and can attest to their excellent taste. *Entosphenus tridentatus* and *Lethenteron japonicum* were used into the 20th century as food by natives along the west coast of North America from Alaska to California. During the 19th and early 20th centuries, *Petromyzon marinus* was consumed in the United States, particularly

Table 1
Northern Hemisphere lampreys, their common names (Robins *et al.*, 1991), broad geographic distribution, adult mode of life and presence or absence of an anadromous phase

Species	Common name	Geographic distribution	Mode of life	Anadromous phase
Caspiomyzon wagneri	Caspian lamprey	Caspian Sea Basin	scavenger	present
Entosphenus folletti	Northern California brook lamprey	Klamath River Basin, California	non-parasitic	absent
Entosphenus hubbsi	Kern brook lamprey	Friant-Kern Canal and Merced River, California	non-parasitic	absent
Entosphenus lethophagus	Pit-Klamath brook lamprey	Klamath River Basin, Oregon and Pit River, California	non-parasitic	absent
Entosphenus macrostomus	Vancouver lamprey	Lake Cowichan Basin, Vancouver Island, British Columbia	parasitic	absent
Entosphenus minimus	Miller Lake lamprey	Miller Lake, Oregon	parasitic	absent
Entosphenus similis	Klamath lamprey	Upper Klamath Lake, Oregon and Klamath River Basin, California	parasitic	absent
Entosphenus tridentatus	Pacific lamprey	river basins of the western coast of Mexico, USA (including Alaska) and Canada and in Japanese rivers	parasitic	present; some populations permanent freshwater residents
Eudontomyzon danfordi	Carpathian lamprey	Danube River Basin principally Tisza River Basin	parasitic	absent
Eudontomyzon hellenicus	Greek brook lamprey	Strymon and Loúros river basins, Greece	non-parasitic	absent
Eudontomyzon mariae	Ukrainian brook lamprey	rivers of the Baltic, Azov, Black, Adriatic and Aegean sea basins	non-parasitic	absent
Eudontomyzon morii	Korean lamprey	Yalu River Basin, People's Republic of China and North Korea	parasitic	absent
Ichthyomyzon bdellium	Ohio lamprey	Ohio River Basin, USA	parasitic	absent
Ichthyomyzon castaneus	Chestnut lamprey	Hudson Bay, Laurentian Great Lakes and Gulf of Mexico basins	parasitic	absent
Ichthyomyzon fossor	Northern brook lamprey	Hudson Bay and Laurentian Great Lakes basins and Mississippi and St. Lawrence river basins	non-parasitic	absent
Ichthyomyzon gagei	Southern brook lamprey	Gulf of Mexico Basin, USA	non-parasitic	absent
Ichthyomyzon greeleyi	Mountain brook lamprey	Ohio River Basin, USA	non-parasitic	absent
Ichthyomyzon unicuspis	Silver lamprey	Hudson Bay and Laurentian Great Lakes basins and Mississippi and St. Lawrence river basins	parasitic	absent
Lampetra aepyptera	Least brook lamprey	rivers of Atlantic coast and Gulf of Mexico Basin, USA	non-parasitic	absent
Lampetra ayresi	River lamprey	rivers of Pacific coast of USA (including Alaska) and Canada	parasitic	present; one population of permanent freshwater residents

in the New England states. The only remaining commercial lamprey fishery in North America was still in operation in 1960 on the Saugeen River at Southampton, Ontario, Canada (Thomas 1961).

Some parasitic species, *Petromyzon marinus* in the Laurentian Great Lakes being the most infamous example, pose a serious threat to fisheries. *P. marinus* was in part responsible for the collapse of the lake charr (*Salvelinus namaycush*) and whitefish (*Coregonus* spp.) fisheries in the Great Lakes. According to Miller et al. (1989), parasitism by *P. marinus*, along with other factors (overfishing and introgressive hybridization) caused the extinction of the commercially important *Coregonus alpenae* (=*zenithicus*), *C. johannae* and *C. nigripinnis*. Fetterolf (1980) reported that between 1958 and 1980, 54.5 million US dollars were spent to control the populations of *P. marinus* in the Great Lakes. A lampricide, 3-trifluoromethyl-4-nitrophenol or TFM, used in conjunction with a synergist, Bayer 73, was developed for this purpose.

Larval and adult lampreys have been used as biomonitors of organochlorine contaminants in fresh water (Kaiser and Valdmanis 1978; Kaiser 1982; Renaud et al. 1995a, b).

Legislation relevant to family

The purpose of the Bern Convention ratified by 23 European countries is to protect wildlife and natural habitats; the lampreys *Lampetra fluviatilis*, *L. planeri* and *Petromyzon marinus* are in Appendix III which lists protected species. In France, *Lampetra fluviatilis*, *L. planeri* and *Petromyzon marinus* are protected by law (Keith et al. 1992). In the Netherlands, *Lampetra fluviatilis* and *L. planeri* are protected by law (Lelek 1987). In the Czech Republic, lampreys are protected by law (Anonymous 1993). In the former German Democratic Republic, lampreys were protected by law (Waterstraat 1990b). In Canada, the Fisheries Act offers the prevention of pollution and protection of fish habitats. In the USA, the Endangered Species Act of 1973 states that species, subspecies and genetically distinct populations of vertebrates listed as endangered or threatened (the latter equivalent to the vulnerable category of IUCN 1990, 1996) are to receive broad protection from actions of government agencies and are protected from significant habitat modification, capture or kill by government agencies and private individuals (Williams and Miller 1990). At present no lamprey appears on the official List of Endangered and Threatened

Table 1 *-continued*

Species	Common name	Geographic distribution	Mode of life	Anadromous phase
Lampetra fluviatilis	European river lamprey	rivers of European Atlantic Ocean Basin	parasitic	present; some populations of permanent freshwater residents
Lampetra lanceolata	Turkish brook lamprey	Iyidere River, Turkey	non-parasitic	absent
Lampetra pacifica	Pacific brook lamprey	Columbia River Basin, Oregon and Sacramento-San Joaquin River Basin, California	non-parasitic	absent
Lampetra planeri	European brook lamprey	rivers of European Atlantic Ocean Basin and Danube and Volga river basins	non-parasitic	absent
Lampetra richardsoni	Western brook lamprey	rivers and lakes of the Pacific Ocean Basin of British Columbia, Washington and Oregon	non-parasitic	absent
Lethenteron alaskense	Alaskan brook lamprey	Brooks River Basin and Chatanika River, Alaska and Mackenzie River Basin, Northwest Territories	non-parasitic	absent
Lethenteron appendix	American brook lamprey	rivers of North American Atlantic coast, Laurentian Great Lakes Basin, St. Lawrence and Mississippi river basins	non-parasitic	absent
Lethenteron japonicum	Arctic lamprey	Arctic Ocean Basin and Asian and North American coasts of the North Pacific Ocean Basin	parasitic	present; some populations permanent freshwater residents
Lethenteron kessleri	Siberian brook lamprey	Ob' River Basin to Anadyr River Basin, Russia and rivers on Sakhalin Island, Russia and Hokkaido Island, Japan	non-parasitic	absent
Lethenteron reissneri	Far Eastern brook lamprey	Amur River Basin, rivers on Sakhalin Island and the Kamchatka Peninsula, in South Korea and Japan	non-parasitic	absent
Lethenteron zanandreai	Po brook lamprey	Adriatic Sea Basin, Italy	non-parasitic	absent
Petromyzon marinus	Sea lamprey	North American, European and North African Atlantic Ocean basins and European Arctic Ocean Basin	parasitic	present; some populations permanent freshwater residents
Tetrapleurodon geminis	Mexican brook lamprey	Celio and Duero rivers, and Río Grande de Morelia Basin, Mexico	non-parasitic	absent
Tetrapleurodon spadiceus	Mexican lamprey	Celio, Duero, Zula and Lerma rivers and Lake Chapala, Mexico	parasitic	absent

Wildlife in the USA, although the Ohio Department of Natural Resources (1990) designated *Ichthyomyzon bdellium* as endangered in Ohio; the Illinois Endangered Species Protection Board (1994) designated *I. fossor* and *Lampetra aepyptera* as endangered in Illinois; Miller (1972) designated *I. castaneus* as endangered in Nebraska and *I. unicuspis* as endangered in Nebraska and South Dakota; Roosa (1977) designated *I. castaneus* and *Lethenteron appendix* as threatened in Iowa; Burr et al. (1990) designated *I. greeleyi* as threatened in Kentucky; and Rohde et al. (1994) designated *L. appendix* as threatened in North Carolina.

Endangered species within family

Caspiomyzon wagneri (Kessler, 1870): vulnerable in Europe generally (Lelek 1987, Maitland 1991); sharply declining numbers in Russia (Pavlov et al. 1985); extirpated from the Sefid River and rare in Anzali Lagoon and tributaries, Iran (J. Holčík, pers. comm.)

Entosphenus folletti Vladykov and Kott, 1976: no designated conservation status

Entosphenus hubbsi Vladykov and Kott, 1976: rare (IUCN 1990); near-threatened (IUCN 1996)

Entosphenus lethophagus (Hubbs, 1971): rare in Oregon (Miller 1972)

Entosphenus macrostomus (Beamish, 1982): vulnerable (Campbell 1994), downgraded from rare (Beamish 1987, IUCN 1990); data deficient (IUCN 1996)

Entosphenus minimus (Bond and Kan, 1973): extinct (Miller et al. 1989; IUCN 1990, 1996). The state of Oregon purposely eradicated this species with ichthyocides during the 1950s because of its parasitism of introduced trout (Miller et al. 1989)

Entosphenus similis Vladykov and Kott, 1979: no designated conservation status

Entosphenus tridentatus (Gairdner in Richardson, 1836): the populations in Clear Lake, California (Moyle 1976) and Elsie Lake Basin, Vancouver Island, British Columbia (Beamish and Northcote 1989) are extinct; an undescribed subspecies from Goose Lake, Oregon/California is rare (IUCN 1990)

Eudontomyzon danfordi Regan, 1911: vulnerable in Europe generally (Lelek 1987, Maitland 1991); sharply declining numbers and rare in the Ukraine (Pavlov et al. 1985); near-threatened (IUCN 1996)

Eudontomyzon hellenicus Vladykov, Renaud, Kott and Economidis, 1982: vulnerable in Europe generally (Lelek 1987, IUCN 1996)

Eudontomyzon mariae (Berg, 1931): endangered in Poland (Witkowski 1992), downgraded from rare (Głowaciński 1992); vulnerable in Europe generally (Lelek 1987) and endangered

in the Czech Republic specifically (Hanel 1994); sharply declining numbers in the Ukraine and Moldavia (Pavlov et al. 1985); data deficient (IUCN 1996)

Eudontomyzon morii (Berg, 1931): no designated conservation status

Eudontomyzon vladykovi Oliva and Zanandrea, 1959: near-threatened (IUCN 1996); however, according to Renaud (1982) and Salewski et al. (1995), this species is synonymous with *E. mariae*.

Ichthyomyzon bdellium (Jordan, 1885): endangered in Ohio (Ohio Department of Natural Resources 1990); rare in Maryland (Miller 1972)

Ichthyomyzon castaneus Girard, 1858: endangered in Nebraska and rare in Kansas (Miller 1972); threatened in Iowa (Roosa 1977); vulnerable in Canada (Lanteigne 1992b)

Ichthyomyzon fossor Reighard and Cummins, 1916: endangered in Illinois (Illinois Endangered Species Protection Board 1994); vulnerable in Canada (Lanteigne 1992a)

Ichthyomyzon gagei Hubbs and Trautman, 1937: rare in Missouri (Miller 1972)

Ichthyomyzon greeleyi Hubbs and Trautman, 1937: threatened in Kentucky (Burr et al. 1990); rare in Pennsylvania (Miller 1972)

Ichthyomyzon unicuspis Hubbs and Trautman, 1937: endangered in Nebraska and South Dakota and rare in West Virginia (Miller 1972)

Lampetra aepyptera (Abbott, 1860): threatened in Illinois (Illinois Endangered Species Protection Board 1994); rare in Maryland (Vladykov 1973)

Lampetra ayresi (Günther, 1870): no designated conservation status

Lampetra fluviatilis (Linnaeus, 1758): endangered in Europe generally (Lelek 1987); extinct in Switzerland (Pedroli et al. 1991) and probably in Spain (Nicola et al. 1994); endangered in Poland (Witkowski 1992), downgraded from vulnerable (Glowaciński 1992); vulnerable in France generally, although endangered in two major hydrographic basins (Artois-Picardy and Rhône-Mediterranean-Corsica) and extinct in one (Rhine-Meuse) (Keith et al. 1992); threatened in Sweden (Nilsson 1975); rare in Portugal (Assis 1990); near-threatened (IUCN 1996)

Lampetra lanceolata Kux and Steiner, 1972: no designated conservation status.

Lampetra pacifica Vladykov, 1973: no designated conservation status. Robins et al. (1991) consider this species to be synonymous with *L. richardsoni* on the basis of a statement in Bond and Kan (1986) that the distinction between the two appears to be slight. Until a rigorous study comparing the two species is made, the author considers *L. pacifica* to be a distinct species

Lampetra planeri (Bloch, 1784): vulnerable in Europe generally (Lelek 1987); endangered in Belgian Flanders (Bervoets et al. 1990), the former German Democratic Republic (Waterstraat 1990a), the Czech Republic (Hanel 1994) and Switzerland (Pedroli et al. 1991); vulnerable in Poland (Witkowski 1992); rare in Spain (Ministerio de Agricultura, Pesca y Alimentacion 1986) and Portugal (Valente and Alexandrino 1990); near-threatened (IUCN 1996)

Lampetra richardsoni Vladykov and Follett, 1965: no designated conservation status

Lethenteron alaskense Vladykov and Kott, 1978: no designated conservation status

Lethenteron appendix (DeKay, 1842): threatened in Iowa (Roosa 1977) and North Carolina (Rohde et al. 1994); rare in Connecticut, Massachusetts and Missouri (Miller 1972)

Lethenteron japonicum (Martens, 1868): vulnerable in Europe generally (Lelek 1987)

Lethenteron kessleri (Anikin, 1905): no designated conservation status

Lethenteron reissneri (Dybowski, 1869): no designated conservation status

Lethenteron zanandreai (Vladykov, 1955): vulnerable in Europe generally (Lelek 1987), downgraded to endangered (IUCN 1996)

Petromyzon marinus Linnaeus, 1758: vulnerable in Europe generally (Lelek 1987) and in Spain (Nicola et al. 1994) and France specifically, although endangered in two major hydrographic basins (Artois-Picardy and Rhône-Mediterranean-Corsica) and extinct in one (Rhine-Meuse) (Keith et al. 1992); endangered in Poland (Witkowski 1992) and Portugal (Valente and Alexandrino 1994); rare in Florida (Gilbert 1992)

Tetrapleurodon geminis Alvarez del Villar, 19[66]: no designated conservation status

Tetrapleurodon spadiceus (Bean, 1887): endangered (Mayden et al. 1992, Lyons et al. 1994)

The conservation status of 11 species has not been designated either due to lack of information or because the species was not in jeopardy. The reason for the lack of a conservation status designation was not ascertained. Additionally, an unnamed anadromous parasitic species from the Black Sea watershed (Holčík and Renaud 1986) and an unnamed non-parasitic species from the Los Angeles River Basin (Hubbs 1967) have become extinct since the beginning of this century.

The reasons for the endangered or vulnerable (= threatened) status of the above species are due to loss of spawning and larval habitats because of pollution and/or alteration of streams in sand extraction, damming or irrigation projects. In the cases of *Caspiomyzon wagneri*, *Lampetra fluviatilis*, *Lethenteron japonicum* and *Petromyzon marinus*, an additional factor is their commercial harvesting for human consumption.

Lampreys are not the object of aquaculture. Some experimental animals are reared in captivity by, for example, Dr F.W.H. Beamish and his students at the University of Guelph, Ontario (*Petromyzon marinus*) and Dr Richard J. Beamish, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, British Columbia (*Entosphenus macrostomus*, *Lampetra richardsoni*). Lampreys are a common experimental animal, especially in neurobiological studies, such as are carried out by Dr Avis Cohen at Cornell University, Ithaca, New York; doubtless there are other captive stocks elsewhere.

Threatened habitats or sites utilised by family

Industrial pollution of spawning streams is particularly prevalent in central and eastern Europe. In North America, the most threatened areas are in California and Maryland (Vladykov 1973). Stream regulation has altered some habitats and prevented access to spawning sites. For example, the building between 1957 and 1959 of five dams on the outlet and in the immediately surrounding area of Elsie Lake, on Vancouver Island, British Columbia, prevented feeding adult *Entosphenus tridentatus* from going to sea and spawning adults from reaching their spawning sites, resulting in the extinction of the population (Beamish and Northcote 1989).

Existing conservation programmes

Two non-parasitic lampreys, *Eudontomyzon mariae* and *Lampetra planeri*, are the object of a long-term conservation programmed in the Czech Republic (Anonymous 1993; Hanel

1994). In the former German Democratic Republic, a conservation programme was developed for all lampreys (Waterstraat 1990b).

Conservation programmes needed for family

Most efforts have so far been directed at controlling the exotic *Petromyzon marinus* populations in the Laurentian Great Lakes through the use of lampricides, rather than conserving any of the non-target native parasitic and non-parasitic species. Although it may be argued that some parasitic lampreys are pests and efforts to control their populations should continue, most parasitic species live in equilibrium with their host species and do not pose a substantive threat to fisheries. Nonparasitic species play an important role in the freshwater environment as a food source for numerous species of fishes, and all should be protected (Vladykov 1973). Most lamprey larvae are notoriously difficult to identify as to species, due to misidentifications their use as bait should be strictly regulated because of the risk of introducing parasitic species.

The following measures are recommended for the family: 1. The first priority is to protect all lamprey species or populations thereof listed here as endangered; 2. The second priority is to rehabilitate where needed the spawning streams of non-parasitic species. Concomitantly, any barriers preventing access to spawning sites should be removed or circumvented; 3. The third priority is the protection of permanent freshwater resident populations of anadromous species, specifically of *Entosphenus tridentatus*, *Lampetra ayresi*, *L. fluviatilis*, *Lethenteron japonicum* and *Petromyzon marinus*, because they may provide insight into the course of lamprey evolution.

In the above three priorities, it is understood that the habitats themselves must also be protected from any deleterious effects such as pollution and stream regulation; 4. Although good overall assessments of the conservation status of lampreys exist for North America and Europe, information is virtually nonexistent for Asia; the fourth priority is that such a study be undertaken.

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Author's address: C. B. Renaud, Research Division, Canadian Museum of Nature, P.O. Box 3443, Station D, Ottawa, Canada K1P 6P4, Canada