Jawless Fishes of the World

Jawless Fishes of the World:

Volume 2

Edited by

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PART 3:

DEMOGRAPHY, STOCK ASSESSMENT, FISHERIES AND CONSERVATION

CHAPTER FIFTEEN

LAMPREYS IN CENTRAL EUROPE: HISTORY AND PRESENT STATE

LUBOMIR HANEL AND JAN ANDRESKA

Introduction

Lampreys do not belong to the groups of vertebrate animals in Central Europe (an area of about 1 million sq km) (Fig. 15-1, centerfold, page i), examined in detail in the past, in particular due to their cryptic way of life (larvae are sediment dwellers) and relative minor economic importance. Some partial historical information is only known from Poland (Cios 2007, 2014), Germany (Thiel et al. 2005; Fullner et al. 2009) and Bohemia (present-day Czech Republic); more important economic value of lampreys was registered in Poland and from other countries around the Baltic Sea (Stora, 1978; Sjoberg, 2011). Nevertheless, there are relatively few historical sources, both about their presence and abundance. Only in the last decades, the attention has been shifted to this ancient group of vertebrates, mainly in the context of increased interest of biologists in protection of biodiversity. Two anadromous species of lampreys (*Lampetra fluviatilis* and *Petromyzon marinus*), a parasitic potamodromous (*Eudontomyzon danfordi*) and three potamodromous non-parasitic species (*Lampetra planeri*, *Eudontomyzon mariae* and *Eudontomyzon vladykovi*) were recorded in Central Europe. Besides other Central European countries (Austria, Germany, Hungary, Liechtenstein, Poland, Slovakia and Switzerland), attention was paid especially to the region of Bohemia, which is sometimes called “the roof of Europe” since its only sources of water are atmospheric rain and snowfall. All the rivers which have their source in the area drain into neighboring countries. Parts of three river basins (the Elbe, the Oder and the Danube river basins) are located in the Czech Republic (Fig. 15-1, centerfold, page ii).

Historical importance of lampreys

Historical information has been obtained by studying various historical files and works, from catch records and from fish collections in museums (Hanel 1996c; Witkowski & Kotusz 1998b). Only fragmentary and often non-specific references are known about the occurrence of lampreys and their utilization by man in Central Europe. Catches of lampreys were probably never too frequent in Central Europe, they played a significant role only in Poland in the river Vistula, especially from autumn till early spring. Nevertheless numerous recipes for their preparation were published in cookery books and manuscripts. Presumably the oldest known record evidencing the presence of lampreys in Central Europe is in a rhymed verse dictionary called Glossary (dated about 1360) by Master Bartholomew of Chlumec, also called Claret (Magister Bartholomaeus de Bohemarius Solencia dictus Claretus (cca 1320-1370). The works of Master Paulus de Praga (1413-1471) also contain notable mentions of lamprey. A brief description of the lamprey body is presented in a Latin-written encyclopedic Book of Twenty Arts originating in the middle of the 15th century (Flajshans 1926, 1928).

Another author, Georg Handsch von Limus (1529-1578), described three lamprey species (sea lamprey, river lamprey and European brook lamprey) in his unfinished work *Historia naturalis*. He also mentioned the absence of bones in lampreys, parasitism on salmon and culinary use. He pointed out stomach disorders or poisonings as a consequence of the incorrect cooking of lampreys. The mucus and serum of lampreys were considered toxic (Handsch von Limus 1933). Indeed, even German biologist Marcus Elieser Bloch (1785) warned against eating of "summer" lampreys, which are not tasty, while he recommended "winter" individuals. Daniel Adam of Veleslavin (1546-1599), in his dictionary *Nomenclator quadrilinguis* issued in one volume, better known as *Silva Quadrilinguis* (1598) also describes the lampreys. Bohuslav Balbinus (1621-1688) dealt with Bohemian ichthyofauna including lampreys. In his major work (*Miscellanea Historica Regni Bohemiae*) published in Latin, he provided information about lamprey, including a number of specific habitats in this country (Balbinus 1679-1687). In his school textbook *Orbis sensualium pictus* (published in Germany in 1658), Jan Amos Comenius (1592-1670), called „The Teacher of Nations“, presented also lamprey as typical water animal (Comenius 1658). A remarkable record is related to 1700, when Herman Jakub Czernin (1659-1710), who served for some time as Chief burgrave of the Kingdom of Bohemia, bought *pisces lampretam* from Cologne for his wife Maria Josefa (Teply 1937). Detailed

scientific information about lampreys, including determination, descriptions and habitats, can be found in the publications of famous Czech zoologist Antonin Fric (1832-1913), who was the last who personally experienced and described spawning migrations of sea and river lampreys in Bohemia. Sea lamprey had been found there in various fish traps (especially wooden wicker baskets), or attached on different subjects in water in the past (Fric 1872). Fric (1908) believed that the sea lamprey reached Prague (the city on the river Vltava, the Elbe river basin) sucked on tug boats drawn from the port of Hamburg (Germany) or on salmon. He noted that lampreys sold in the markets caused antipathy among buyers due to their toothed oral disc. Spawning grounds of the sea lamprey were documented up to 850 km from the mouth of the river Rhine in Germany. Sea lampreys reached South Bohemia (to the town of Pisek) via the river Elbe and then its tributary the river Vltava. This route covered a distance of 1035 km from the mouth of the river Elbe. It is the longest known migration route undergone by lampreys into the heart of the European continent.

As mentioned above, the lampreys played a relatively important role in the Bohemian gastronomy in the past. River lampreys were probably consumed for a long time in the Elbe and Vltava river basins. Lampreys were mentioned in the writings of Master Pavel Zidek (Paulus de Praga or Paulerinus, 1413-1471). The first direct record of the consumption of lampreys is written in Czech in *Spravcovna* (1471), in which master Paulus de Praga wrote a popular guide to governance (including appropriate meals) for King George (George of Podebrady, 1420-1471). An order of 600 pieces of river lamprey as food in the lenten period for the court of Ferdinand of Tirol (1529-1595) in Austrian Innsbruck was documented in 1572 (Grossingova 1993). The first specific recipes, handwritten or printed, relating to Elbe lampreys were recorded in the 15th and 16th centuries. Various ingredients, such as cinnamon, cloves, ginger, pepper, cumin, mace, small raisins, saffron, almonds, honey and gingerbread played a very important role in preparing meals from lampreys. Red wine was a replaceable component used in lamprey cooking. Lampreys were cooked in sauce, smoked, pickled in brine or vinegar and jellied or just salted. Lamprey grilling over charcoal is still popular in some European regions.

Recipes for lamprey cooking in cookbooks have gradually completely disappeared. This coincided with the demise of anadromous lampreys migrating to the Czechian waters. Besides being used in gastronomy, brook lampreys (larvae as well as adults) have been used as bait in commercial or sport angling for a long time (see reports from earlier times within Czechian territory). The European eel (*Anguilla anguilla*), the chub

(*Squalius cephalus*) or the burbot (*Lota lota*) were often successfully caught by anglers in this way (Bubenicek 1898).

Occurrence of lampreys in Central Europe

The distribution of six lamprey species in river basins reaching to Central Europe is presented in Table 15-1.

Table 15-1. The occurrence of lampreys in Elbe, Oder and Danube River Basins within Central Europe

Species	Elbe River Basin	Oder River Basin	Danube River Basin
Sea lamprey (*Petromyzon marinus*)	+	+	-
River lamprey (*Lampetra fluviatilis*)	+	+	-
European brook lamprey (*Lampetra planeri*)	+	+	+
Ukrainian lamprey (*Eudontomyzon mariae*)	-	+	+
Vladykov´s lamprey (= Danubian brook lamprey) (*Eudontomyzon vladykovi*)	-	-	+
Carpathian brook lamprey (*Eudontomyzon danfordi*)	-	-	+

Anadromous lampreys

Sea lamprey (Petromyzon marinus)

The sea lamprey has never been a commercial species in the Baltic Sea. However, it is commercially important in Western Europe, France, Spain and Portugal (Maitland & Campbell 1992). The sea lamprey has been found since the past to the present in Poland and Germany. The oldest sea lamprey record dating back to the year 1855 is known from the Greifswald Bodden (54° 13′ 22″ N, 13° 32′ 48″ E, Pommeranian Coast,

south of the island Ruegen) in the Southern Baltic Sea. The analysis of relevant records resulted in 11 observations of sea lamprey in the considered area in the time period from 1855 to 1939. From 1940 to 1989, sea lamprey was recorded 29 times. Fourteen records of sea lamprey were obtained in German and adjacent Polish waters in the 1990 to 2005 period (Thiel et al. 2009). One specimen of the sea lamprey (57 cm in length) was captured in the river Vistula in 1963 (a 15 cm-long dace *Leuciscus leuciscus* was found in its alimentary canal, see Penczak 1964), its catches in 1999-2001 are also known from the Szczecin Lagoon (53° 48′ 16″ N, 14° 8′ 25″ E) and the Dabie Lake (53° 27′ 57″ N, 14° 39′ 11″ E) (Raczynski et al. 2004). Kazmierczak (1965) describes that he was attacked while swimming by the sea lamprey (the length of about 70 cm) near the Ustronie Morskie (54° 12′ 55″ N, 15° 45′ 17″ E) (Polish seaside). Jokiel (1983) presents that only a few sea lamprey specimens with a length of 90 cm and a weight of 2 kg were observed in catches in the Vistula Bay (54° 27′ 0″ N, 19° 45′ 0″ E) and the Gdansk Bay (54° 22′ 50″ N, 18° 39′ 30″ E) in several years. The sea lamprey was caught in the river Rega flowing into the Baltic Sea in 2012. This is the first record of sea lamprey from the Polish coastal rivers (Skora et al. 2014).

There is only sparse data on the distribution (spatial as well as seasonal) of sea lamprey in the German part of the North Sea because this species is caught only accidentally by commercial fisheries or scientific fishing surveys. According to historical references from around 1900, sea lamprey seemed not to be abundant in the catchments of the rivers Ems, Weser, Elbe and Eider and, as a result, was characterized as “rare”. The occurrence (or spawning) of this species was also documented for several major tributaries in the tidal reaches of the above-mentioned rivers. Meanwhile, by the 1980s the sea lamprey had become almost extinct in the northern German tributaries to the North Sea, due to heavy water pollution (especially in the estuaries), building of migration barriers and the alteration of water courses in the adjacent river systems. However, since 1995 the stocks of sea lamprey have remarkably increased again (especially in the catchment of the tidal part of the river Elbe), probably due to the improved water quality following the political changes in Central Europe after 1990 (the rivers Elbe and Weser) and the restoration of water courses (e.g. the improvement of fish passage facilities) following the commencement of the programme for management of water courses of Lower Saxony in 1992 (Curd 2009). The breeding of sea lamprey in Lower Saxonian rivers was described by Meyer & Beyer (2002) whereas Curd (2009) described breeding in the river Treene (the tributary of the river Eider). Rare occurence of sea lamprey was noticed in the Rhine

catchment area (the region of Hessen) in 1999 (Anonymus 2003). On the base of historical reports, Petermeier et al. (1996) confirmed the occurrence of the sea lamprey in the middle reaches of the river Elbe before the year 1900, and also later in the first half of the 20th century, but not yet in the period 1980-1993. After 1960, the species was registered in the tidal part of the river Elbe . Sea lamprey was also observed in artificial fish passes in the tide weir in Geeschacht (more details in the paragraph regarding the river lamprey). The estimated by-catch of the sea lamprey by commercial fyke netting in the tidal area of the Elbe River near Hamburg reached approximately 500 specimens on average. Spawning ascent and/or spawning is regularly documented in all major tributaries of the tidal Elbe in the federal states Lower Saxony (Oste, Schwinge, Aue-Luhe, Este, Seeve, Luhe, Ilmenau) and Schleswig-Holstein (Stor, Pinnau, Kruckau and some smaller tributaries of the Nord-Ostsee-Kanal), see Curd (2009). Sea lampreys are also annually documented in the middle reaches of the river Elbe by stow netting about 100 or 200 km respectively upstream of the tidal weir at Geesthacht (53°26′17″ N, 10°22′29″ E). Additionally, a number of not more than 100 individuals of the sea lamprey are annually documented from the known spawning sites in the tributaries of the tidal part of the river Weser (Hunte, Wumme, Ochtum, Delme). The estimated number of sea lampreys annually ascending through the estuary of the river Ems documented by stow net fishery is small (less than 100 specimens on average) compared to the estuaries of rivers Elbe and Weser, due to problems connected with temporary deficits in oxygen saturation and extremely high turbidity. There were 2227 lampreys caught in the Elbe estuary in northern Germany from 1989 to 1995. In total, 99.5% of this amount was the river lamprey and only 0,5% the sea lamprey during the whole study period (Thiel & Salewski 2003).

Regarding individual findings of sea lamprey, one specimen was mentioned from the river Havola in Germany (= Havel, the tributary of the river Elbe) near Berlin (Barus & Oliva 1995). Lelek & Kohler (1989) mentioned rare findings of the sea lamprey in the river Rhine, in the river km 458.9 (Hammer Aue, 49° 43′ 45″ N, 8° 25′ 50″ E) in July 1988. Bubenicek (1898) wrote, that in the rivers Elbe and Vltava it is not uncommon and added that local fishermen fear of its sign of misfortune. In the past, sea lamprey arrived in the territory of the Czech Republic through the river Elbe. At the time of their migration, they were found in fyke nets and basket traps, sticking to tugs going to Bohemia from Hamburg (53° 33′ 1″ N, 9° 59′ 34″ E**,** Germany), or on salmon. The occurrence of this species has been confirmed in the rivers Elbe, Vltava and Otava as far as the town of Pisek (49° 18′ 32″ N, 14° 8′ 52″ E)**.** A sea

lamprey female was caught in the river Vltava downstream of the town of Orlik (49° 30′ 39″ N, 14° 9′ 53″ E) and is reported to measure 120 cm and to weigh 2.3 kg (Anonymous 1900). The last registered specimen in Bohemia was caught in the river Elbe near the town of Decin (50° 46′ 25″ N, 14° 11′ 46″ E) in 1902 (Oliva 1953, 1958). Two specimens (690 mm and 714 mm) are deposited in the Zoological Department of the National Museum in Prague. Nevertheless, sea lamprey can reappear in the Bohemian territory, as there are recent reports of their findings in the river Elbe at Bad Schandau (Germany, 50° 55′ 0″ N, 14° 9′ 0″ E) not far from the Czech border.

River lamprey (Lampetra fluviatilis)

Witkowski (1996a) summarized data on the occurrence of the river lamprey in Poland. This species inhabited the rivers Oder, Vistula and Elbe, as well as the many tributaries of the Baltic Sea at the beginning of the 19th century. All in all it was found in two rivers in the Elbe river basin, in 16 rivers in the Oder river basin and in 6 locations along the Baltic coast. The gradual population decline was evident in the upper stretches of the largest rivers in Poland at the end of the 19th century. After 1900, this species has not been detected in the river Oder, upper section of the river Rudawa (tributary of the river Vistula near the town of Krakow) and in middle sections of the river Vistula. According to this author this fact was caused by the contamination of water and the existence of hydro-technical structures (weirs and dams). The spawning run of the river lamprey was observed in the river Drweca (left tributary of the river Vistula) near Lubitz (53° 01' 52" N, 18° 44' 46" E), see Witkowski & Jesior (2000) and in rivers Wda and Parseta (Kuszewski & Witkowski 1995). This lamprey is mentioned in the river Grabowa by Witkowski & Kuszewski (1995). It is also known from the Dabie Lake (53° 27' 57" N, 14° 39' 11" E), connected to the river Odra estuary (Sobecka et al. 2000).A fundamental population decline was recorded in Poland in the period 1901-1975. Currently, reduced populations of river lamprey have been found only in 9 rivers and other aquatic ecosystems in Poland. River lampreys were caught to wickerwork fish basket in the lower river Vistula before the Second World War (Staff 1950) and they were mostly sold salted. The largest catches were achieved in November. The catches also declined after the construction of the dam in Wloclawek (52° 39′ 0″ N, 19° 5′ 0″ E) downstream of Warsaw in 1968. River lamprey were offered in the Polish town of Torun (53° 2′0″ N, 18° 37′ 0″ E) till 1960s; in the 1950s there was even a larger consignment of fresh lamprey

imported to Prague (50° 5′ 0″ N, 14° 25′ 0″ E) for sale once (Oliva 1953). While in the post-war period the catches in lower river Vistula were about 60 tons of adult river lamprey per year, at the end of the 1980s they was only 0.75-1 ton per year. Currently only sporadic specimens migrate to this river. River lampreys only rarely appear in the Baltic Sea tributaries now, and only in a few rivers. Owing to this fact, river lamprey was included in the Polish Red list, the list of fish and lampreys that are endangered in this country, in the category of strict protection (however, this applies to larvae only).

The catch of the river lamprey in Germany in the 1950s was economically insignificant (Sterba 1952). Tesch (1967) recorded this species in the estuary of the river Elbe. Sterba (1962) mentioned that the annual catch in the river Rhine was in the range of 1.0 to 6.9 tons during 1910-1913. Thiel et al. (2005) registered 310 reports of total catches of almost twenty million individuals in the German waters of the southern Baltic during the period from 1649 to 2005. The number of findings per year was twice as high in the period between 1649 and 1939 than in 1940 and1998. Only 1 % of the total number of individuals was found in the period 1990-2005. An average 14 377 kg of river lamprey per year were caught in the years 1887-1999. Most individuals were caught in the Szczecin Lagoon (53° 48′ 16″ N, 14° 8′ 25″ E) and the adjacent waters, also in the lower section of the river Vistula, the Gdansk Bay (54° 28′ 59″ N, 18° 57′ 31″ E) and in the Curonian Lagoon (55° 5′ 34″ N, 20° 54′ 59″ E). These authors registered a total of 9 spawning places of the river lamprey, i.e. in Peene, Warnow and Stepenitz river basins. Overall, the current state of the river lamprey populations in this region is classified as critical and therefore a modification of the principles of the rescue program is needed. Lelek & Kohler (1989) mentioned findings of river lamprey larvae in the river Rhine, in river kilometer 759.8 in August 1987.

Anadromous migration of ichthyofauna was monitored in artificial fish passes in the tide weir in Geeschacht on the Elbe (river km 585.9). During one year (August 2010-July 2011) 73 111 specimens of lampreys were caught here. In the total catch, the river lamprey was prevailing (72 924 individulas, i.e. over 99%), the sea lamprey was caught only sporadically (186 individuals) and very rarely the European brook lamprey was observed (one specimen only). The evident preference of the double slit pass over bypass was confirmed (from the totally caught river lamprey were 98 % found in the double slit pass), Adam et al. (2012); Adam & Neumann (2012); Schwevers & Neumann (2012). Pedroli et al. (1991) and Kirchhofer et al. (2007) summarized the occurrence of lampreys in

Switzerland. The occurrence of the river lamprey there is a thing of the past.

In the current territory of the Czech Republic, river lamprey occured mostly in the Elbe river drainage area. The last records of the occurrence of this lamprey species in the rivers Vltava, Divoka Orlice (the tributary of the river Orlice, the Elbe river basin) and Oder are available from the late 19th century. According to Fric (1872) the river lamprey was not abundant in the Bohemian Elbe river in the past. Bloch (1785) published an interesting detail about the catch of river lamprey in the river Oder as far as the town Bohumin (49° 54' 14 N, 18° 21' 27 E). Last direct evidence of the occurrence of river lamprey in Bohemian rivers comes from 1897 (Hanel & Lusk 2005). Nowadays, the river lamprey is not present in the Czech Republic. However, it is probable that it will reappear in the Bohemian section of the river Elbe, as there are recent reports of its findings at Bad Schandau (50° 55′ 0″ N, 14° 9′ 0″ E) in Germany. This fact was caused by the improvement of the permeability of the river Elbe in Germany and improvement of water quality. Although the first record of river lamprey from the river Danube dates before the first (known) stocking of eels in 1881 (Haack 1882), this species has most likely been introduced into the Danube system that way. A total of 2.4 million eels were introduced into water bodies within the area of what is now Baden-Wurttemberg (Germany) between 1893 and 1906 (Sieglin 1892). Assuming that 30 % of these fish went into the Danube system, and that the proportion of lamprey mixed in with the eels was 0.5 %, then approximately 4000 lamprey were accidentally introduced into this river system within 13 years. A further 1000 lampreys can be estimated to have entered the Danube in the vicinity of the city of Ulm (Germany, 48° 24′ 0″ N, 9° 59′ 0″ E), where eels were stocked at the beginning of the 20th century (Kappus et al. 1995). For now, these unintentional activities cannot be considered successful introduction.

Potamodromous non-parasitic lampreys

European brook lamprey (Lampetra planeri)

The occurrence of this species in Europe is similar to ocurrence of the river lamprey, the difference being that the brook lamprey inhabits waters which are more inland. Some authors believe that both mentioned species are an example of ancestral and satelitte-type (ecotype), see e.g. Espahnol et al. (2007); Docker et al. (2009). The European brook lamprey belongs to the most abundant species of lampreys in Central Europe. Hardisty

(1986) pointed out the findings outside previously known European area (the rivers Volga, Tisa, Morava, Drava and Pescara). It is not exactly known, how this lamprey colonizes previously unocuppied river basins. Accidental introduction as attested by Kappus et al. (1995) for transmission of the river lamprey to the Danube basin is not excluded.

The presence of the European brook lamprey has been confirmed in many locations in Poland, Germany and the Czech Republic (especially in the Oder and Elbe river basins). Witkowski & Kotusz (1998a) summarized the reports on occurrence of this lamprey in Polish Silesia in southwestern Poland. In the last 50 years they have confirmed it in 43 localities, including 38 in the Oder and 5 in the Elbe. The largest number of sites were registered in the left-sided tributaries of the river Oder (26) with mountain and foothill character. Right tributaries lie more in the lowlands and are also affected by improper modifications and pollution. Witkowski & Kotusz (1998b) presented the collection of specimens of the European brook lampreys (from river basins of Vistula, Oder, Elbe and Baltic coastal rivers) stored at the Museum of Natural History, Wroclaw. Obolewski (2008) studied the incidence of lamprey on the river Slupia in Slupsk (54° 28′ 0″ N, 17° 2′ 0″ E) and noticed regular migration to places with more natural character of the river bed.

The European brook lamprey was registered in 276 German brooks and rivulets in 1999 (Anonymous 2011). The presence of this lamprey was confirmed in the Weser river catchment area (e.g. in rivers Lethe, Delme, Grosse Aue, Ilme, Schwulme, Oker, Sieber, Ortze, Lachte, Bohme, Lehrde, Wumme), in the Elbe river catchment area (e.g. in rivers Oste, Schwinge, Aue-Luhe, Este, Seeve, Luhe, Ilmenau) and in the Ems river catchment area (e.g. in rivers Hase and Dute), LAVES (2011). From the river Rhine it is mentioned by Schreiber & Engelhorn (1998), from some tributaries of the river Oder by Fechner (1851). Krappe et al. (2012) found this species within monitoring of the ichtyofauna in the Mecklenburg-Vorpommern region (Libnower Muhlbach, Ziemenbach, Hellbach, Augraben, Kosterbeck, Tribohmer Bach, Beke, Schaale, Schwanheider Muhlbach). The closest locality to Bohemian borders is the brook Flajsky potok (Floeha) in the territory of Saxony (Kuschka & Meyer 1981). Mueller (1986) reported the occurrence of brook lamprey in 24 streams in the Saxonian Ore Mountains. In addition, its presence was cited in the river Mulde rooted in Bohemia between the towns of Teplice and Hermsdorf Frauenstein at Illigmuhle (Waterstraat 1989a). Other Saxon sites are stated by Brockhaus (1993). Lelek & Kohler (1989) mentioned its presence in the river Rhine in 1987-1988. European brook lamprey population was studied in detail in the brook Ziemenbach (Northern

Germany) by Waterstraat (1989b). The overall map of the occurrence of the brook lamprey in Northern part of Germany is presented by Waterstraat et al. (2007). The populations of the brook lamprey are clasified in German waters in the last decade as stabilized everywhere (Freyhof 2009).

European brook lamprey is within Slovakia only known from the Baltic basin (Dunajec and Poprad rivers and their tributaries), see Holcik (1970) and Kosco et al. (2006). The number of sites (11) is lower than in adjacent countries (Kosco et al. 2006). This lamprey was found in the past in the catchment area of the river Dunajec near the border with Poland (Kux & Weisz 1960), mainly in the river Poprad and its tributaries (Velicky potok, Lucivianka, Lubicky potok), see Kux & Weisz (1960); Kirka et al. (1978). Present occurrence in the river Dunajec and its tributaries was not confirmed (Kosco et al. 2006), the evidence is known only from the river Poprad catchment area (Zontag 2006). According to recent monitoring within system Natura 2000 (network of nature protected areas in the territory of European Union) in 2013-2014, the European brook lamprey was also found in following locations: the brook Beliansky potok at Spisska Bela (49° 12' 3.24" N; 20° 24' 53.28" E), the river Poprad at Spisska Teplica (49° 3' 15.48" N; 20° 16' 46.56" E) and the brook Velicky potok above Velka (49° 4' 3.36" N; 20° 15' 9.72" E).

Spindler (1997) states that the occurrence of the European brook lamprey in Austria is rare. It penetrates here within the basin of the river Drau (= Drava, Drave, the tributary of the river Danube) in Lower Austria (see also Mrakovcic et al. 2006). Ratschan & Guttmann (2013) confirmed the occurence of the European brook lamprey in examined Austrian brooks nearby Czechian border (Igelbach, Schwarze Runse, Schrollenbach and Rotbach). Pedroli et al. (1991) and Kirchhofer et al. (2007) reported that the European brook lamprey is the only species of lamprey in Swiss waters nowadays.

The occurrence and biology of the European brook lamprey was studied in detail in the Czech Republic. The originally very abundant occurrence of this species in this country belongs to the past. Bubenicek (1898) noted that "this lamprey is excluded from protection and it can be caught whenever and in any size". Lohnisky (1984) and Zitnan (1985) pointed out the permanent loss of populations in Eastern Bohemia due to pollution and inappropriate modifications of riverbeds and classify it as an endangered species, sensitive to pollution and decrease in oxygen content. Hanel & Lusk (2005) counted over 400 findings of the brook lamprey in the Czech Republic during 1961-2005 and therefore this species is the most common lamprey in this country. The species occurs in the Elbe and

Oder rivers drainage areas (98% of known localities). Only several isolated populations are found in the Morava river drainage area (the Danube river system), see Merta (2000). This lamprey inhabits brooks and rivulets in trout and grayling zones at the elevation of 130-895 m above sea level, but most of the findings come from 300-600 m a.s.l. Most findings were made in rather short streams less than 40 km in length. In total 2/3 of the findings were recorded in natural streams, the rest in those modified to a various extent. The stream gradient was mostly about 1.5-2 $m.km^{-1}$, the prevalent annual average flow rate in the river mouth of the registered watercourses was lower than 1 $m^3.s^{-1}$. The observed abundance of larvae varied between 311 and 7067 exx. per hectare. In the Czech Republic, both sexes participate in the nest construction usually in shady areas of streams that are 1-8 m in width and a few centimeters to 0.8 m in water depth. The spawning occurs usually in May/June in the water temperatures 9-19.5 °C. The actualized saprobic index (Si), i.e. indication of the level of organic pollution, using analyzes of diatoms and benthos from water streams inhabited by the brook lamprey, was calculated. Its value was calculated as Si = 1,3 (indicator weight = 4, oligosaprobic zone - 7, β-mezosaprobic zone - 3), Hanel (1997). It turned out that this lamprey larvae can survive even a water pollution accident when other ichtyofauna die. Such example was observed in detail in the creek Polanka (Central Bohemia, Sazava/Elbe river basin, 49° 41′ 51″N, 14° 51′ 14″ E) in 1992. At that time the quantity of oil substances in water reached values of 0.3 $mg.l^{-1}$ and content in the upper layers of bottom sediments ranged between 155 to 363 $mg.l^{-1}$ (Hanel 1996a, 1996b, 2004). Ammocoetes of this species survived because of their cryptic way of life, as they are continuously buried in soft sediments of the creek bed during their larval stage. The lamprey still exists in the brook Polanka (ammocoetes were confirmed there in 2014 as well). The strategy of larvae during water pollution is therefore to remain in the substrate as long as possible. Only if toxicants penetrate into the substrate, then the larvae leave it and tend to get in more convenient locations (Hanel, own observations). The brook lamprey seems to be a good bioindicator with respect of long-term good quality of water environment, but its larvae can sometimes survive short-term pollution.

Ukrainian lamprey (Eudontomyzon mariae) and Vladykov´s lamprey (Eudontomyzon vladykovi)

Some authors did not distinguish the taxon *Eudontomyzon vladykovi* as a valid species (e.g. Renaud 1982; Holcik & Renaud 1986; Vida 1993; Barus & Oliva 1995; Holcik 1995, 1996; Salewski et al. 1995; Holcik & Soric 2004; Kosco et al. 2006; Levin & Holcik 2006; Ahnelt 2008); others accepted this lamprey as a separate valid species (e.g. Balon 1966; Oliva & Hrabe 1968; Kottelat 1977; Freyhof & Brooks 2011; Eschmeyer 2014). According to Froese & Pauly (2014), this species is questionably a junior synonym of *Eudontomyzon mariae* (Berg, 1931) or in subspecies taxonomic category. They state that more studies are required. The newest opinions accept *E. vladykovi* as a valid species (Eschmeyer 2014). Nevertheless a detailed study of these taxa is necessary, especially within Central Europe. Considering many authors did not distinguish between these species in the past, there has been only little sufficiently detailed information about the variability of morphometric characters, occurrence and genetics (see Lang et al. 2009) separately for either taxa so far. The presumptive area of distribution of the Vladykov´s lamprey includes upper and middle Danube drainage: the Sava and Drava systems (Majer 2001) and the upper Danube north and west of the Drava (Holcik & Delic, 2000), locally in the Timis and Olt systems (lower Danube drainage), see Freyhof & Kottelat (2008). The area of distribution of the Ukrainian lamprey would then include tributaries of the Baltic Sea (the Odra, Vistula, Neman drainages), the northern Black (the Danube to Kuban drainages) and Caspian Seas (the rivers Sura, Volga drainage). In the Danube, its occurrence is restricted to tributaries below the Iron Gate, a gorge on the Danube forming the boundary between Serbia and Romania (Freyhof 2013c). In Poland, the Ukrainian lamprey is reported in several tributaries in the basin of the Vistula (Oliva & Hensel 1962; Wikowski & Kotusz 1998b; Nowak et al. 2010), it is also known in the river Oder; the river Lososna is the only single locality within the Neman river basin (Rembiszewski & Rolik 1975; Witkowski 1996b; Drag-Kozak 2011). Witkowski (1996b) summarized the findings in detail about the current occurrence in Poland. Ukrainian lamprey belongs among the least common there and it is characterized by low abundant population. Marszal (2001) assumed its spreading in Poland in recent decades. The Vladykov´s lamprey was found in the river Czarna Orawa in Poland (Balon & Holcik 1964; Rembiszewski & Rolik 1975; Augustyn & Nowak 2014).

The Ukrainian lamprey was presented in the Szigetkoz (Little Schutt Island) section of the river Danube in Western Hungary (Vida 1993; Col.

aut. 2010). This species has been found also in the river Drava, nearby the mouth of the river Mur (Mura), see also Sallai & Kontos (2005). The occurrence of this species in the river Tisa is mentioned by the WWF (2002). Spindler (1997) and Gumpinger et al. (2011) summarized findings in Austria. Historical occurrence was known in the federal states of Burgenland, Lower and Upper Austria, Vienna, Salzburg, Tyrol, Carinthia and Styria. The current occurrence is known only from Carinthia, Styria and Lower Austria. It is recorded in the basin of the Drava. Ratschan (2015) newly discovered the presence of the Ukrainian lamprey in the Austrian river Pfuda (the Danube river basin). Kaufmann et al. (1991) completed the current state of knowledge of such occurrence from the upper section of the river Mur between the villages of Stadl and Bruck. It is found also in the river Salzach (Schmall & Ratschan 2011). The Vladykov´s lamprey is presented in the river Inn (Reichholf 1989).

Freyhof (2013c) cited a single record of the Ukrainian lamprey from the upper Morava river system (Czech Republic). Nevertheless Freyhof & Kottelat (2008) previously presented the same population as *E.vladykovi*. Therefore verification of taxonomic position of this single isolated population on the periphery of the area of its distribution (the brook Racinka, 50º 02' 03" N, 17º 01' 58" E, elevation 406 m above sea level) is needed (taxonomic status of this population was usually designated as *E.mariae* in papers of Czech ichtyologists, see Hanel & Lusk 2005; Lusk et al. 2008, 2011). However, such a more detailed study of morphometrical variability and genetical characteristics is excluded due to the fact that it is an extremely small successively disappearing population. Since the detection of this lamprey in 1968, its population has significantly decreased over the next decades. The original population was distributed throughout a 2 km reach of the brook. In 1999 and 2000, the larvae of this species were found only in a 700 m long section. The state of the population was evaluated as critical with a high probability of extinction (in the examined section of the brook Racinka only about 50 larvae were estimated). The causes for this negative development include inappropriate streambed modifications, abundant brown trout (*Salmo trutta* m. *fario*) populations and the presence of insurmountable migration barriers. Some larvae and adults have been carried downstream to less suitable environments during floods and the adults cannot migrate back to the upper sections of this brook. Impermeable migration barriers divide the small lamprey population into several smaller and isolated parts. The critical situation of the population is further intensified by the high instability of sediments, which are the micro-habitat of larvae of this lamprey. The revitalization measures taken in 2004-2005 turned out to be

insufficient for the expected development of the population (Lusk et al. 2008). The Ukrainian lamprey is quite abundant and widespread in many rivers in Slovakia. Barus & Oliva (1995) summarized its findings in following rivers: the Danube and its branches from Bratislava to confluence with the river Ipel, upper reaches of the Ipel, upper reaches of the river Hron from Bacuch (48° 51' 26" N, 19° 48' 27" E) to Banska Bystrica (48° 44' 8" N, 19° 8' 45" E) and its tributaries (Bystrica, Rohozna, Slatina), upper and middle reaches of the river Vah from Hybe (49° 02' 40" N, 19° 49' 44" E) to Trencin (48° 53' 42" E, 18° 2' 30" E) and its tributaries i.e. rivers Orava (Biela Orava, Cierna Orava, Mutnanka, Hranicny Krivan, Jelesna). Further occurrence was confirmed in the river Turiec, upper reaches of the river Nitra (Nedozery 48° 49' 00" N, 18° 39' 00" E). Kux (1985) presented collections of specimens of this species mostly from the river Rudava at Velke Levare (48° 30' 11" N, 17° 0' 4" E). Ukrainian lamprey was also found within faunistical research in 2013-2014 in following sites: Hron at Lopej (48° 48' 51.48" N; 19° 29' 42.72" E), Rudava at Studienka (48° 30' 5.76" N; 17° 12' 23.76" E), Biely Vah at Vazec (49° 3' 28.44" N; 19° 58' 23.16" E), Hybica at Hybe (49° 2' 43.08" N, 19° 49' 46.2" E).

The taxonomic validity of the Vladykov´s lamprey would have to be taken into account in regional legislation and national Red Lists. Only *E.mariae* is for now presented from this point of view in Central European countries (see Tab. 2). The protection category „least concern“ is suggested for the species *Eudontomyzon vladykovi* within Europe (Freyhof & Brooks 2011).

Potamodromous parasitic lampreys

Carpathian lamprey (Eudontomyzon danfordi)

The Carpathian lamprey is endemic to the Danube System (Black Sea watershed), Renaud & Holcik (1986). This species lives within Central Europe in Slovakia in the Tisa River drainage area, mostly in the Hnilec River and its tributaries, see Holcik & Soric (2004); Kosco et al. (2006). Together 68 localities with the occurrence of Carpathian lamprey is known from Slovakian waters (Kosco et al. 2006), namely from Eastern Slovakia (upper reaches of the river Hnilec and its tributaries: Topla, Ondava, Ubla, Ulicka, Okna). In Hungary, this species is limited to the rivers Tisa, Timis and Szamos (Vasarhelyi l960a, b; Harka 1997, 2006; Gyore et al. 1999, 2013; Antal et al. 2013); in the Koros drainage system it was found by Telcean et al. (2007) and Gyore et al. (2013). The nonparasitic lamprey

Lampetra (*Eudontomyzon*) *gracilis* Kux, 1965 (described from the Tisa river basin), is conspecific with the parasitic lamprey *Eudontomyzon danfordi* Regan, 1911 (Renaud & Holcik 1986).

Principles of lamprey protection in Central Europe

Some authors have summarised the main negative factors influencing lamprey populations. Waterstraat & Krappe (1998) studied distribution and abundance of the brook lamprey in the Peene drainage (north-eastern Germany) in relation to isolation and habitat conditions. Waterstraat (1989b) investigated the influence of stream regulation on a population of the European brook lamprey in the brook Ziemenbach in Germany. Besides enhanced larvae mortality during stream regulation, the alteration of the sediment composition of the river bed was the most important impact of human activities on the European brook lampreys. Kappus et al. (1995); Hanel (1996a); Moyle et al. (2009); Foulds (2013); Maitland et al. (2014) summarized specific threats endangering lampreys. The number of identified potential threats ranges between 13 and 18. Their elimination is vital for the survival of lamprey populations. Within Central Europe, following negative factors seem to be the most important (they are not put in order according to their importance, the synergy effect is very significant): unsuitable modification of streambeds (armoring of river banks with breeze blocks, total channelization), migration barriers (weirs, steps, dams), long-term water pollution (water acidification, input of organic nutrients, thermal pollution, eutrophication), removal of muddy or sandy sediment, trampling by livestock, extremely increased flows (floods), extremely decreased water flows (minimum summer flows or incorrect operation of hydroelectrical power stations), extremely high fish stock (in particular of salmonids), predation of lampreys by water fowls. The occurrence of lamprey larvae is also influenced by destruction or relocation of muddy sediments in riverbeds due to heavy rains. Their growing intensity may probably be related to climate changes (Basilico et al. 2009).The number of different threats for each lamprey population can range between 0 and 7 in Germany (Kappus et al. 1995). Generally, the populations in the Swabian Alps area (low mountain range in Baden-Wuerttemberg), face an average of 3.3 identifiable threats, whereas this number is only 2.5 for the populations in the Danube headwaters area. An similar situation has also been found in the Bohemian watercourses (number of threats between 0 and 8) with the occurrence of the brook lamprey, the population of the Ukrainian lamprey in the brook Racinka is affected by 10 negative factors (Hanel, unpublished data).

All observed Central European species of lampreys are included in Annexes II or III of the Bern Convention and the Habitats Directive fish species and in the category least concern (it is average rate of endangering within their European occurence), see also classification according to IUCN categories by Freyhof & Kottelat (2008) and Freyhof (2013a, 2013b, 2013c, 2013d).

In some countries, (or their internal regions) special Acts of nature conservation or Red Lists with registers of endangered species (Austria, Czech Republic, Hungary, Poland, Slovakia, Germany) classified to various categories exist (see Table 15-2). The Vladykov´s lamprey is not accepted in the presented Red Lists.

Table 15-2. Various categories of endangering of lamprey species in Red Lists of countries in the Central Europe. Explanatory notes: Ex – extinct, CR – critically endangered, EN – endangered, VU – vulnerable, NT – near threatened, ○ – the species is not included. Used following literary sources: Austria (A) – Wolfram & Mikschi (2007); Czech Republic (CR) – Lusk et al. (2011); Germany (G) – Wolter et al. (2003, 2005); Hungary (H) – Guti (1995); Poland (P) – Witkowski et al. (2009); Slovakia (Sl) – Kosco & Holcik (2008); Schwitzerland (Sw) – Kirchhofer (2007).

Species	A	CR	G	H	P	Sl	Sw
Petromyzon marinus	○	EX	EN	○	CR	○	○
Lampetra fluviatilis	○	EX	EN	○	CEN	○	EX
Lampetra planeri	EN	EN	EN	○	VU	EN	EN
Eudontomyzon mariae	VU	CR	○	EN	VU	VU	○
Eudontomyzon danfordi	○	○	○	EN	○	NT	○

The basic protection principles of the management of localities with the presence of potamodromous lampreys in Central Europe can be defined as follows:

- Preserve the natural watercourse, including the riparian vegetation. Besides the sandy gravel bottom in the stream bed there must also be places with fine muddy sediments.
- Maintain the diversification of stream water velocity (usual current velocity within the range of 0.1–0.5 $m.s^{-1}$, maximum up to 0.8 $m.s^{-1)}$. The current speed in places above the alluvial deposits with the occurrence of larvae should be 0.3-0.5 $m.s^{-1}$. Higher water velocity

increases the probability of unstable sediments.
- Ensure continuous water flow throughout the year, even in the dry season (keep the minimum residual flow).
- Keep downstream and upstream migration permeability for lampreys in the watershed. If transverse flow obstacles are inevitable, prefer boulder chutes or bypasses.
- Changes to the stream bed, including the removal of deposits, are acceptable only as the last resort, particularly in the context of flood control and restoration of the watershed after the flood. Such cases require rescue transfer of ammocoetes (electrofishing repeated 3–5 times, see Hanel & Mueller 1997).
- Maintain the required water quality (oligotrophic to beta – mezosaprobic class of water quality, the average value of BOD_5 (biochemical oxygen demand in 5 days) is approximately 4).
- Do not tolerate long-term pollution by organic substances (Hanel 1996a, b, 2004).

Biodiversity and its protection has become an important topic of the present time on both the global and regional (country) scale. In Central Europe, it is the lampreys that are considered an endangered vertebrate group. All Central European countries (excluding Liechtenstein remaining outside the European Union) created sites in the Natura 2000 network of protected European sites. The project's focus has been the conservation of rivers or brooks identified as Special Areas of Conservation (SACs) and of relevant habitats and species listed in Annexes I and II of the European Union Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) (the Habitats Directive). Each of countries has to guarantee using this network of special areas of conservation and sustaining prosperity of populations of individual lamprey species. The summary of some LIFE nature projects focusing on lampreys (*Eudontomyzon* ssp., *Lampetra fluviatilis, Lampetra planeri* and *Petromyzon marinus*) with respect to Central Europe is presented by Silva et al. (2015). This financial instrument for the environment is among others focused also on improving of overall condition of river systems and increasing of populations of selected fishes and lampreys.

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