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Scientific Editors

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Global Importance of Local Experience

Coimbra • Imprensa da Universidade

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THE SPAWNING MIGRATION OF THE SEA LAMPREY (*Petromyzon marinus* L.) IN THE RIVER MONDEGO

Abstract

Presently, sea lampreys (*Petromyzon marinus* L.) are confined to the last 35 km of the River Mondego, downstream from the Açude-Ponte dam. Their spawning migration occurs between December and May-June, with a peak in February-March. During that period, this cyclostome presents a nocturnal behaviour, performing their upstream migration during the night, dawn and early morning periods.

Although the physical obstacles present in the freshwater zone of River Mondego retard the upstream movement, the submerged stone weirs create riffles, used by the sea lampreys as resting areas during the day.

The concentration of nests is higher in the first 2 km downstream from the Açude-Ponte dam. After hatching, the ammocoetes spend four years in freshwater habitats, the higher densities being located near the nest area.

Apart from habitat destruction, resulting from dam construction and channelisation, intense fishing and poaching are the major threats to the survival of the sea lampreys in the River Mondego.

Introduction

The River Mondego watershed is one of the most important Portuguese river basins for the diadromous fish. Four species are commercially exploited in this region, the sea lamprey (*Petromyzon marinus* L.), the allis shad (*Alosa alosa* L.), the twaite shad (*A. fallax* Lacépède) and the eel (*Anguilla anguilla* L.).

Assis et al. (1992) point out that the economic value of the diadromous species is directly related with the predictability of the migratory season and movement route, as well as with the occurrence of large concentrations of animals in a short time-space scale, which makes them an easy target for fishermen and natural predators.

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The sea lamprey is a migratory species whose anadromous form is exploited as a commercial fishery in most of the major rivers in Portugal, particularly in the Central and Northern regions of the country. Sea lampreys are mostly captured when entering the estuaries to initiate their upstream reproductive migration, corresponding to the terminal phase of their life cycle (Beamish 1980, Ducasse and Leprince 1980, Guimarães 1987). As the species is considered a delicacy, its commercial value is rather high, attaining market values of 9500 PTE (≅ € 47) per unit.

P. marinus is considered a "Vulnerable" species in the Portuguese Red Book of Endangered Species (Vários 1991), and the literature is unanimous in stating that the sea lamprey's populations are decreasing in all major Portuguese rivers (Guimarães 1987, Alexandrino 1990, Almaça 1990, Assis et al. 1992, Assis 1994, Ferreira and Oliveira 1996).

The human activities that promote significant changes in the physical and chemical characteristics of running water ecosystems can have major impacts in the sea lamprey population dynamics. Several authors have stressed the direct and indirect impacts on the conservation of diadromous species in general, and on the sea-lamprey in particular, resulting from the construction of dams, land recovery (drainage and flood protection), pollution (agricultural, forestry, industrial and urban use), dredging and gravel extraction, overfishing and poaching (Ducasse and Leprince 1980, Assis et al. 1992, Witkowski 1992, Young et al. 1990).

This paper describes the spawning migration of the sea lamprey in River Mondego, based on information gathered from previous works, and from the data obtained by the authors in a recent research project, involving the study of the migratory behaviour observed by ultrasonic tracking in estuarine and freshwater environments. The major threats to the survival of this species in the River Mondego watershed are identified and discussed.

The spawning migration and freshwater phase of the sea lamprey life cycle

Before dam construction, anadromous fish used to migrate into the upper reaches of River Mondego, entering some of the tributaries, namely the rivers Ceira and Alva. Since the construction of the Açude-Ponte dam, at Coimbra, in the early 80's, the migratory species are unable to pass this obstacle, and are forced to complete their life cycle in the last 35 km of the river (Fig. 1). This lower portion of the river runs in open valleys, in a plain area, has two main tributaries, the rivers Arunca and Pranto, and can be divided into two ecologically different stretches: an estuarine, and a freshwater environment. The separation between this two zones results from the presence of a 3 m height blockstone weir, the Formoselha weir, located 11 km downstream from the Açude-Ponte dam. The tidal effect is no longer visible upstream from this weir, and therefore the estuary is limited to the final 24 km of the river. The 11 km freshwater stretch between the Formoselha weir and the Açude-Ponte dam has 11 riffle areas, resulting from partially submerged stone weirs (transversal sediment retention platforms) installed across the river to avoid downstream sediment transportation.

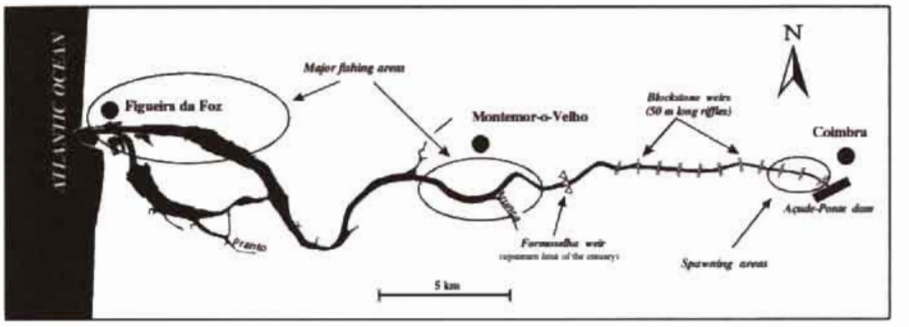

Figure 1. Schematic representation of the River Mondego downstream from the Açude-Ponte dam (adapted from Almeida et al. 2000)

The professional fishermen's activity is restricted to two river stretches (Fig.1) and is only allowed between the 15 January and the 15 April (Anonymous 1972, 1988).

Although the spawning migration of *P. marinus* in the River Mondego starts in late December (Guimarães 1987, Almeida et al. 2000), the period of time spent by these animals in the estuary or in the coastal vicinity, before they engage in their upstream migration, is still unknown. The migration continues until May-June, with a peak in February-March (Guimarães 1987, Alexandrino 1990, Machado-Cruz et al. 1990, Almeida et al. 2000). According to the information obtained from local fishermen, some spawning activity can still be observed in early August.

During their spawning migration, sea lampreys entering River Mondego present a daily migratory behaviour characterised by an alternation between resting periods and continuous upstream movements Almeida et al. (2000). According to these authors, the dusk hours are also associated with an increase in the activity of sea lampreys, but the upstream migration occurs during the night, dawn and early morning periods (*i.e.* between one hour after sunset to 9 a.m.). This nocturnal behaviour has already been observed by Hardisty and Potter (1971), Hardisty (1979, 1986) and Stier and Kynard (1986).

In the studies performed in the River Mondego, Almeida et al. (2000) found that both in the estuarine and in the freshwater environments, the movements of the sea lampreys present identical speeds. The apparently better performances showed by the animals in the estuary probably resulted from the existence of longer river stretches free from physical obstacles, enabling them to present a cruising ground speed of 16.5 body-lengths min^{-1}. This migratory behaviour can be kept for, approximately, nine hours of continuous movement (Almeida et al. 2000).

In freshwater, longer periods of continuous movement resulted in a reduction in the movement speed. The presence of numerous obstacles, namely, sand banks, shallow water sections, riffles and aquatic vegetation, significantly increased the difficulty to reach the upstream stretches of the river (Almeida et al. 2000)

The submerged stone weirs, present in the freshwater section between the Açude-Ponte dam and the Formoselha weir, are responsible for a considerable delay in the upriver progression of the sea lampreys and consequently for an extra energy

consumption. On the other hand, these weirs provide the necessary disruption in the habitat continuity, with the formation of riffles, used by these animals as preferential resting areas during the day (Almeida et al. 2000).

The spawning migration ends with the arrival at the spawning site, nest building, and finally, matting and fertilisation. Nest building is mainly performed by males, usually the first to arrive at the spawning sites (Hardisty and Potter 1971, Hardisty 1979). However, Hardisty and Potter (1971) refer that, late in the spawning season, females may assist males in the construction of the nests.

The choice of spawning sites may be influenced by some abiotic factors, specially the existence of an unidirectional water flow, and the presence of a substrate with adequate characteristics to the nest construction (coarse gravel, pebbles and sand) (Ducasse and Leprince 1980, Manion and Hansen 1980, Hardisty 1986). In the River Mondego, besides these factors, the existence of a barrier that cannot be transposed, the Açude-Ponte dam, plays an important role in determining the concentration of nests in the 2 km downstream from the Açude-Ponte dam. These nests are usually located in relatively deep water (50 cm), in the river stretches between the submerged stone weirs.

Males are the first to arrive at the spawning grounds, establishing and protecting a nesting territory (Manion and Hansen 1980). In the River Mondego, poachers take advantage of this behaviour to capture the animals while they are engaged in mating activities (unpublished data).

Like other lampreys, *P. marinus* spends most of its life in freshwater environment (migratory phase and larval stage). Hardisty (1979) believes that the marine phase of the lampreys' life cycle representing only 1/3 to 1/4 of the animal's life, is probably a secondary introduction in the life cycle of a group which primarily lived in freshwater environments.

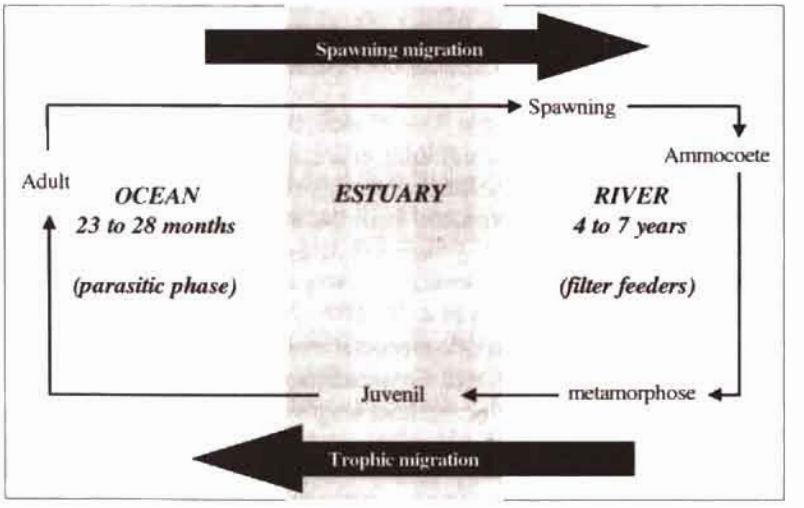

Figure 2. Sea lamprey (*P. marinus* L.) life cycle (adapted from Hardisty and Potter 1971).

The duration of this larval stage depends on the abiotic conditions of the river, and varies between 4 to 7 years (Hardisty and Potter 1971, Sousa 1988, Afonso 1989) (Fig. 2). In the case of the River Mondego, the ammocoetes spend, at least four years in freshwater habitats, before they undergo a process of metamorphosis that will lead them through a macrophtalmic stage to a juvenile form, identical to the adult (Quintella 2000). As a result, the success of a lamprey population is highly dependent on the quality of the freshwater environment, which should provide the appropriate conditions to ensure the spawning success, the development of the eggs and the survival of the ammocoetes.

The authorities responsible for the management of the River Mondego watershed should keep in mind the peculiarities of the sea lampreys' migratory behaviour. From December to June, and at least during the period between dusk and early morning (*i.e.* 1 h before sunset to 3 h after sunrise), the freshwater flow should allow the sea lampreys to reach the upstream spawning grounds with less effort. Furthermore, it is important to maintain the riffle areas. However, some of the physical obstacles (e.g. extensive shallow areas) present in the freshwater zone, upstream from the Formoselha weir, should be eliminated.

Downstream the Açude-Ponte dam the major impacts of man's activities on the aquatic environment result from agriculture-generated wastes, dam construction and channelisation. Among these three factors, dam construction induces the worst consequences to the sea lamprey population. The blocking of longitudinal connectivity drastically reduced the river basin area accessible to the migratory species. Besides, the disturbance of flow regimes downstream from the dams can attenuate the abiotic cues that are usually associated with the entering of the adult sea lampreys in a specific river (Hardisty 1979).

Although eutrophication caused by agriculture-generated wastes and domestic sewage could promote disturbances in the riverine ecosystem, the resulting increase in the phytoplankton production and in the accumulation of particulate organic matter in the sediment, might have been responsible for the good condition factor and fast growth rate of the ammocoete populations (Quintella 2000).

Finally, but by no means less important, the fishing effort from professional fishermen and poachers should be reduced, at least while there is no scientific evidence that the sea lamprey population is recovering.

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