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Global Importance of Local Experience

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INTRODUCING THE MONDEGO RIVER BASIN

General Introduction

The source of the Mondego river is located at the "Estrela" Mountain and extends along 227 Km, draining a hydrological basin of approximately 6670 Km^2, the largest entirely comprised in Portuguese territory (Lourenço 1986) (Figure 1).

The main tributaries of the Mondego are the rivers Dão, Ançã and Foja, in the right margin, and the rivers Alva, Ceira, Cernache, Ega, Arunca, and Pranto, in the left margin (Lourenço 1986). The Pranto river converges with the Mondego already in the estuarine area. The Mondego valley between Aguieira and Coimbra is considerably deep, but the river spreads below this town to form a vast alluvial plain, the Lower Mondego Region, which consists of 15 000 hectares of good agricultural land.

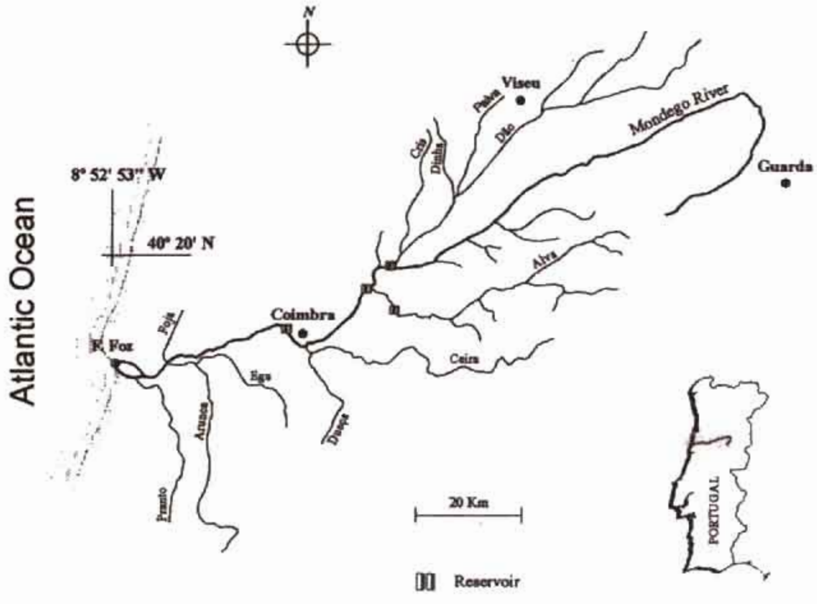

Figure 1. The Mondego river hydrological basin.

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The Mondego river basin plays an important role regarding the activities and day-by-day life of more than half a million people. Nevertheless, in the early sixties, the basin was still under-utilised. From 1962, the "Direcção Geral de Recursos e Aproveitamentos Hidráulicos", prepared a hydro-agricultural plan aiming to improve the use of the basin water resources and alluvial plain by means of the river flow control. The plan had also the objectives of, providing water to populations, industries, and agriculture, and produce electric power.

As a whole, this plan was only partially accomplished, but we shall not utter here any opinion concerning the plan it self or its execution. Floods control was achieved through river margin regularisation and by the construction of several dams ("Aguieira", "Raiva" and "Açude de Coimbra", in the Mondego, and "Fronhas", in the Alva river). Flood control, had doubtless a considerable environmental impact, namely in the Mondego hydrological regimen (Dias and Rebelo 1984).

The Lower Mondego river valley, at the present, consists essentially of agricultural land where the main crop is rice (60% of the valley). Other significant crops are corn and beans (18% of the area). Non-cultivated areas, such as swamps, are usually located in the perimeter of the valley and exhibit a flourishing fauna and flora. Drainage channels, which are widespread across the whole valley, also constitute a biological reservoir (Anastácio et al. 1995).

The drainage of this Lower Mondego Region contributes with an important load of nutrients and several chemical pollutants into the Mondego estuary, located in the western coast of Portugal. Besides, the estuary it self constitutes an important system to support human activities, correspond to a considerable concentration of people and goods. Actually, the estuary is the location of a mercantile harbour, "Figueira da Foz", which has considerable regional importance, namely regarding the export of wood pulp for paper production. Urban waste-waters are still let out into the Mondego without treatment, and besides the harbour facilities, the estuary supports industrial activities, salt-works, and aquaculture farms. Additionally, the city of "Figueira da Foz" constitutes an important centre for tourism activities, which implies a seasonal increase of the human pressure on the system.

Brief description of the freshwater systems

Algae and macrophytes are the producers in rivers and streams. At the University of Coimbra there has been a strong tradition in phycological studies. However, most of the studies dealt with cell biology and taxonomy of individuals sampled from streams, lakes, ponds, fountains and terrestrial systems. The ecological studies are therefore scarce. The construction of reservoirs for irrigation and hydro electrical proposes created new environments for plankton taxa. The crescent use of fertilisers leaded to eutrophic conditions in some of those reservoirs, which resulted in blooms of cyanobacteria producing toxins and therefore affecting human populations.

The vegetation of the low Mondego River has been studied from the perspective of plant invasion into channels (Almeida et *al.* 1991, Morais et *al.* 1994). A recent study on the aquatic and riparian species of the artificial Mondego River channel indicated that nearly 10% of the 212 recorded taxa are invading species (Aguiar et *al.* 1999, 2001). The dominant taxa of the Mondego river channel are all exotic: *Eryngium pandanifolium* (piteirão), *Tradescantia fluminensis*, *Paspalum paspalodes* (graminhão) and *Acacia dealbata* (mimosa), among others. *Eryngium pandanifolium*, a South American species was reported for the first time in 1947 near Figueira da Foz (Garcia 1947). The expansion of this specie seems to be related with channel modification (Aguiar *et al.* 2001).

The number of Hidrophyte *taxa* is low. However, the more abundant taxa are the exotic *Azolla filiculoides* e *Myriophyllum aquaticum* (pinheirinha-de-água). The riparian vegetation is dominated by willows, ash, alder and poplar.

Besides primary production, organic matter entering the streams and rivers is an important energy source for aquatic systems. Deciduos and some evergreen trees dominated the original forest in the Mondego basin. Due the canopy cover, many small streams are always heterotrophic: most of their energy consist in organic matter rather than benthic algae. In small streams, invertebrates feeding in fine and coarse particulate organic matter are the most abundant.

As a result of the temperature decrease in autumn, many deciduous trees lose their leaves, leading to an input of organic matter to small streams. The result of this autumnal energy input coupled with a decrease in summer precipitation is a seasonal abundance of many aquatic insects. Many *taxa* have an aquatic stage in autumn-winter (high food in the aquatic system) and an aerial stage in summer (low water level).

One of the high economic activities in the Mondego river basin is the wood extraction for pulp production. The main tree used for such purposes is *Eucalytus globulus*, a species introduced from Australia. Due to the energy linkage between riparian vegetation and the aquatic systems, forest replacement is likely to affect aquatic communities. Studies in the Mondego river basin have shown that leaves of *Eucalyptus* are protected against microbial degradation and therefore they are not readily taken by invertebrates as food source. The plantations with eucalyptus are therefore likely to affect the structure and functioning of aquatic systems.

New water treatment plants were constructed in recent years to decrease organic pollution. On the other hand, there has been a general decrease in the agricultural area in the Mondego river basin. At the same time, the amount of fertilisers has increased and the number of industries increased as well. Those changes affect water quality. Water quality of streams and rivers draining the Mondego basin range from very clean to heavily polluted, as assessed by the use of chemical physical and biological data. Because aquatic communities directly reflect changes in the chemical and physical environment, the use of biological methods for biomonitoring proposes is urgent. Moreover, such methodology will be compulsory by the new EC regulations.

Macroinvertebrates are food for fish and vertebrates. They also impact economic activities or may be resources for human populations. This is the case of the crayfish *Procambarus clarkii*. In the lower Mondego river valley, the introduction of this species had a significant effect on economic activities. For that reason a large effort was made to know the ecology of *Procambarus clarkii*.

Another very important component of aquatic communities are fish communities. Due the biogeographic conditions, cyprinids are very important in the rivers of the Iberian Peninsula. Damming destroys the longitudinal continuity of rivers and create lentic (reservoirs) environments were new species can be established. The Mondego river basin is therefore in a transitional phase and new studies are needed to assess the impact of such modifications. Some effects are already noticed. The creations of reservoirs hamper lampreys of completing their migratory movements. Such species is highly appreciated in the area as food for human populations.

Rice fields in the lower Mondego river also created habitats for new fish species. That is the case of the mosquitofish *(Gambusia affinis)* which can attain large numbers and high production. Marshlands or abandoned rice fields are also ideal habitats for amphibians.

Finally, the Mondego river basin is the home of one mammal with a high protection status in the European Union area: the otter *Lutra lutra*. This species is widely distributed in the Mondego river basin and their survival depends on the preservation of habitat, especially bank river vegetation.

Brief description of the estuary hydrographical and ecological conditions

The Mondego estuary is located in a warm temperate region with a basic continental temperate climate. It consists of two arms, north and south (Figure 2) separated by an island. The two arms become separated in the estuarine upstream area, at about 7 Km from the sea, and join again near the mouth. These two arms of the estuary differ in their hydrographic characteristics. The north arm is deeper (5 to 10 m during high tide, tidal range about 2 to 3 m), while the south arm (2 to 4 m deep, during high tide) is almost silted up in the upstream areas, which causes the freshwater of the river to flow essentially by the north arm. The water circulation in the south arm is mostly due to tides and to the relatively small fresh water input of a tributary, the Pranto River, which is artificially controlled by a sluice, located at 3 km from the confluence with the south arm of the estuary. In addition, due to differences in depth, the penetration of the tide is faster in the north arm, causing daily changes in salinity to be much stronger, whereas daily temperature changes are higher in the south arm (Marques 1989, Marques *et al.* 1993a, 1993b, Flindt *et al.* 1997).

Eutrophication is increasing in most estuaries all over the world, probably as a result of excessive nutrient release into coastal waters, and the Mondego estuary is no exception. Seasonal intertidal macroalgae blooms (mainly of *Enteromorpha* spp.) have been reported in the south arm of the estuary for several years (Marques et al. 1993a, 1993b, Pardal 1998, Pardal et al. 2000, Lillebø et al. 1999, Martins et al. 2001). As a pattern, although there is a clear inter-annual variation as a function of hydrological conditions, *Enteromorpha* spp. biomass increases from early winter (February/March) up to July, when an algae crash usually occurs. A second but much less important algae biomass peak may normally be observed in September followed by a decrease up to the winter.

The *Zostera noltii* beds, which represent the richest habitat with regard to productivity and biodiversity, are being drastically reduced in the south arm of the

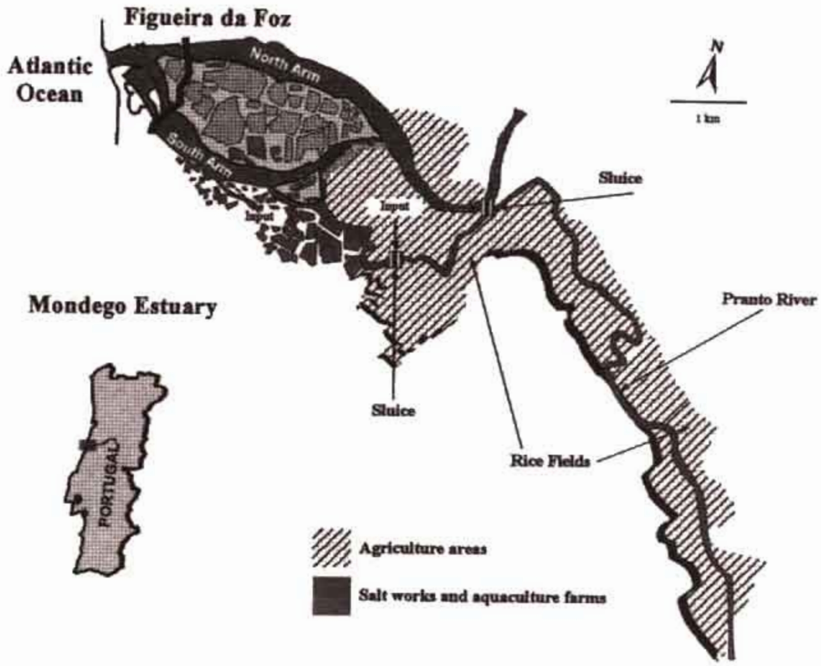

Figure 2. The Mondego estuary consists of two arms, north and south separated by an island. The two arms become separated in the estuarine upstream area, at about 7 Km from the sea, and join again near the mouth. The water circulation in the south arm is mostly due to tides and to the relatively small fresh water input of a tributary, the Pranto River, which is artificially controlled by a sluice, located at 3 km from the confluence with the south arm of the estuary.

Mondego estuary, presumably as a function of competition with *Enteromorpha*. (Raffaelli *et al.* 1991, Hodgkin and Hamilton 1993), resulting from the different strategies of macroalgae and macrophytes to uptake nutrients (Fairweather 1990 *in* Hardy *et al.*1993). Such shift in the benthic primary producers due to eutrophication may probably affect the structure and functioning of the communities, including the species composition (Marques et al. 1997, Pardal 1998), and through time such modifications may determine a selected new trophic structure.

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