

# BIOGEOGRAPHY OF THE FRESHWATER FISH OF THE IBERIAN PENINSULA

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## ABSTRACT

This paper reviews and presents new data on the composition and distribution of fish species in the continental waters of the Iberian Peninsula, and proposes a division of the Peninsula into three subregions: the Ebro-Cantabrian, the Atlantic and the Betico-Mediterranean, based on the distribution of the 45 species (native and endemic) in the 22 river basins with surface areas of 990 square kilometres or more.

## INTRODUCTION

The Iberian Peninsula is enormously interesting from an ichthyological point of view. Located at the Southwestern tip of Europe, it is a point of contact between North Atlantic and tropical coastal fish fauna. Much of its coastline is on the Mediterranean, the Straits of Gibraltar, which separate the Mediterranean from the Atlantic, have always been more of a bridge than a barrier for North African and Iberian fauna.

The epicontinental fish fauna has also been affected by the geological history of the Peninsula. Possibilities for dispersion have been, and still are, limited, due to the isolation caused by the Pyrenees and the Straits of Gibraltar. The number of species relative to the surface area is lower than in the rest of Europe, leading to a comparatively less diverse ichthyofauna. Isolation, along with the orographic and climatic peculiarities of the Peninsula, has led to the development of endemisms. Most of the large rivers flow East-West, to the Atlantic, and the variable rainfall means that many of the rivers are torrential, while others are confined to small survival areas in the long dry season (June - October). All of this means that extreme life conditions are imposed on the animals which live in the rivers, favouring the development of adaptation mechanisms.

From the point of view of the ecological characteristics of the rivers, the ecosystems forming a frontier between sea and freshwater should not be forgotten: estuaries, wetlands, coastal lagoons, marshlands and salt marshes, which for different periods, experience the alternating influences of

sea and freshwater. The ecosystems of variable salinity lead us to consider marine species as forming part of the Iberian continental fauna.

## THE ICTHYOFAUNA OF THE IBERIAN PENINSULA

MYERS (1960) classified freshwater fish into three categories: primary, secondary and peripheral (vicariant, diadromous, sporadic and complementary). Under this classification, the continental fauna of the Iberian Peninsula consists of 64 species in 24 families (table 1). Of these, 45 are autochthonous (native or endemic) and 19 allochthonous, with differing degrees of acclimatization (SOSTOA *et al.*, 1984; ICONA, 1986). To these we should add 18 sporadic or sedentary marine species which thrive in the estuaries, marshlands, coastal lagoons, marshes and salt flat ecosystems, and belong to 16 marine families (table 2), raising the number of species to 98.

The taxonomy of the species has been studied by ALMAÇA (1964, 1967, 1972), COLLARES-PEREIRA (1983), DOADRIO (1984, 1987) and ELVIRA (1987), and their distribution in some river basins by HERNANDO (1975a, 1975b), DEMESTRE *et al.*, (1977), GARCIA DE JALON & GONZALEZ DE TANAGO (1983), GARCIA DE JALON & LOPEZ (1983), FERNANDEZ-DELGADO *et al.*, (1986), LOBON-CERVIA *et al.*, (1989) and SOSTOA & LOBON-CERVIA (1989).

Table 1. Freshwater fish fauna of the Iberian peninsula. Type is the character of the specie (N: native; E: endemic; I: introduced, with date of introduction in brackets). Con. is the present preservation according to ICONA (1986) and LOBON-CERVIA & ELVIRA (1989); here we have used the IUCN categories. (I: indeterminate; IC: insufficient knowledge; NA: not endangered; P: endangered; R: rare; V: vulnerable). A: anadromous; C: catadromous; F and B: fresh and salt water.

Scientific name			Common name	Type	Con.
<b>Familia Petromyzontidae</b>	3.12%				
<i>Lampetra planeri</i>	(LN)	F	Lamprea de río	N	R
<i>Petromyzon marinus</i>	(PM)	A	Lamprea marina	N	I
<b>Familia Acipenseridae</b>	1.56%				
<i>Acipenser sturio</i>	(AS)	A	Esturión o sollo	N	P
<b>Familia Clupeidae</b>	3.12%				
<i>Alosa alosa</i>	(AA)	A	Sábalo	N	V
<i>Alosa fallax</i>	(AF)	A	Saboga	N	V
<b>Familia Anguillidae</b>	1.56%				
<i>Anguilla anguilla</i>	(AG)	C	Anguila	N	V
<b>Familia Salmoidae</b>	7.81%				
<i>Hucho hucho</i>	(HH)	F	Huchón	I (1968)	R
<i>Salmo fontinalis</i>	(SF)	F	Salvelino	I (XIX)	R
<i>Salmo gaidneri</i>	(SG)	F	Trucha arco iris	I (XIX)	NA
<i>Salmo salar</i>	(SS)	A	Salmón	N	V
<i>Salmo trutta trutta</i>	(STT)	F	Trucha común	N	NA
<i>Salmo trutta fario</i>	(STF)	B	Trucha marisca o reo	N	NA
<b>Familia Esocidae</b>	1.56%				
<i>Esos lucius</i>	(ES)	F	Lucio	I (1949)	NA
<b>Familia Cyprinidae</b>	35.94%				
<i>Anaecypris hispanica</i>	(AH)	F	Jarabugo	E	R
<i>Barbus bocagei bocagei</i>	(BBB)	F	Barbo ibérico	E	NA
<i>Barbus bocagei graellsii</i>	(BBG)	F	B. ibérico de Graells	E	NA
<i>Barbus bocagei sclateri</i>	(BBS)	F	B. ibérico de Sclater	E	NA
<i>Barbus comiza</i>	(BC)	F	Barbo comiza o comiza	E	NA
<i>Barbus haasi</i>	(BH)	F	Barbo culirroyo	E	NA
<i>Barbus meridionalis</i>	(BM)	F	Barbo de montaña	N	NA
<i>Barbus microcephalus</i>	(BP)	F	Barbo cabecicorto	E	IC
<i>Carassius auratus</i>	(CP)	F	Carpín dorado	I?	IC
<i>Carassius carassius</i>	(CA)	F	Carpín	I (XVII)	NA
<i>Cyprinus carpio</i>	(CC)	F	Carpa	I (II b C)	NA
<i>Chondrostoma polylepis polylepis</i>	(CPP)	F	Boga de río	E	NA
<i>Chondrostoma polylepis willkommi</i>	(CPW)	F	Boga del Guadiana	E	NA
<i>Chondrostoma toxostoma toxostoma</i>	(CTT)	F	Madrilla	N	NA

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Scientific name			Common name	Type	Con.
<i>Chondrostoma toxostoma arrigonis</i>	(CTA)	F	Madrilla	N	NA
<i>Gobio gobio</i>	(GG)	F	Gobio	I (XIX)	NA
<i>Iberocypris palaciosi</i>	(IP)	F	Bogardilla	E	IC
<i>Leuciscus carolitertis</i>	(LT)	F	Cacho	E	IC
<i>Leuciscus cephalus</i>	(LC)	F	Bagre	N	NA
<i>Leuciscus pyrenaicus</i>	(LP)	F	Cachuelo	E	IC
<i>Phoxinus phoxinus</i>	(PP)	F	Piscardo	E	NA
<i>Rutilus alburnoides</i>	(RB)	F	Calandino	E	NA
<i>Rutilus arcasii arcasii</i>	(RAA)	F	Bermejuela	E	NA
<i>Rutilus arcasii macrolepidotus</i>	(RAM)	F	Bermejuela	E	NA
<i>Rutilus lemmingii</i>	(RL)	F	Pardilla	E	NA
<i>Rutilus rutilus</i>	(RR)	F		I (1910s)	NA
<i>Scardinius erythrophthalmus</i>	(SE)	F	Gardí	I (1910s)	R
<i>Tinca tinca</i>	(TT)	F	Tenca	N	NA
<b>Familia Cobitidae</b>	3.12%				
<i>Cohitis calderoni</i>	(CD)	F	Lamprehuela	E	IC
<i>Cohitis maroccana</i>	(CM)	F	Colmilleja	E*	V
<b>Familia Homalopteridae</b>	1.56%				
<i>Noemacheilus barbatulus</i>	(NB)	F	Lobo de río	N	NA
<b>Familia Siluridae</b>	1.56%				
<i>Silurus glanis</i>	(SN)	F	Siluro	I (1970s)	NA
<b>Familia Ictaluridae</b>	1.56%				
<i>Ictalurus melas</i>	(IM)	F	Pez gato	I (1910s)	IC
<b>Familia Cyprinodontidae</b>	4.69%				
<i>Aphanius iberus</i>	(AI)	FB	Fartet	E*	P
<i>Fundulus heteroclitus</i>	(FH)	FB		I (1960s)	NA
<i>Valencia hispanica</i>	(VH)	FB	Samaruc	E	P
<b>Familia Poecillidae</b>	1.56%				
<i>Gambusia affinis</i>	(GF)	FB	Gambusia	I (1921)	NA
<b>Familia Atherinidae</b>	1.56%				
<i>Atherina hoyeri</i>	(AY)	FB	Pejerrey	N	NA

\* Endemism Iberian North-African

Table 1. Freshwater fish fauna of the Iberian peninsula. Type is the character of the specie (N: native; E: endernic; I: introduced, with date of introduction in brackets). Con. is the present preservation according to ICONA (1986) and LOBON-CERVIA & ELVIRA (1989); here we have used the IUCN categories. (I: indeterminate; IC: insufficient knowledge; NA: not endangered; P: endangered; R: rare; V: vulnerable). A: anadromous; C: catadromous; F and B: fresh and salt water.

Scientific name			Common name	Type	Con.
<b>Familia Gasterosteidae</b>	1.56%				
<i>Gasterosteus aculeatus</i>	(GA)	FB	Espinoso	N	V
<b>Familia Syngnathidae</b>	1.56%				
<i>Syngnathus abaster</i>	(SA)	FB	Aguja de río	N	V
<b>Familia Cottidae</b>	1.56%				
<i>Cottus gobio</i>	(CG)	F	Cavilat	N	P
<b>Familia Percidae</b>	3.12%				
<i>Perca fluviatilis</i>	(PF)	F	Perca	I (1970s)	IC
<i>Stizostedion lucioperca</i>	(SL)	F	Lucioperca	I (1970s)	IC
<b>Familia Moronidae</b>	3.12%				
<i>Dicentrarchus labrax</i>	(DL)	FB	Lubina o Robálo	N	NA
<i>Dicentrarchus punctata</i>	(DT)	FB	Baila	N	NA
<b>Familia Centrarchidae</b>	3.12%				
<i>Lepomis gibbosus</i>	(LG)	F	Perca sol	I (1910s)	NA
<i>Micropterus salmoides</i>	(MS)	F	Perca americana	I (1955)	NA
<b>Familia Mugilidae</b>	7.81%				
<i>Chelon labrosus</i>	(CL)	FB	Lisa	N	NA
<i>Liza aurata</i>	(LA)	FB	Galupe	N	NA
<i>Liza ramada</i>	(LR)	FB	Morragute o albur	N	NA
<i>Lizu saliens</i>	(LS)	FB	Galúa o Cachorreña	N	NA
<i>Mugil cephalus</i>	(MC)	FB	Capitán o pardete	N	NA
<b>Familia Blennidae</b>	1.56%				
<i>Blennius fluviatilis</i>	(BF)	F	Fraile	N	E
<b>Familia Gobiidae</b>	3.12%				
<i>Pomatoschistus microps</i>	(PC)	FB	Cabuxino enano	N	NA
<i>Pomatoschistus minutus</i>	(PT)	FB	Cabuxino	N	NA
<b>Familia Pleuronectidae</b>	1.56%				
<i>Platichthys flexus</i>	(PF)	FB	Platija	N	NA
<b>Familia Cichlidae</b>	1.56%				
<i>Cichlasonza facetum</i>	(CF)	F	Chanchito	I (1930s)	IC

The Cyprinidae genera which inhabit the southern provinces originated in Siberia, and arrived in Europe through the drying out of the Sea of Obi during the Holocene period, the time of Alpine orogenesis, when the Pyrenees were formed. During the same period, the Oligocenic transgression divided Europe allowing communication of the North Sea and the Tethys Sea via Southern Russia (TERMIER, 1960).

Both of these created a great barrier to the arrival of freshwater fish in the Iberian Peninsula (MYERS, 1960; BANARESCU, 1972), and therefore the colonization of the Peninsula must have happened before the end of the Oligocene.

The Siberian immigrants (BANARESCU, 1973a, 1973b) are of the genera *Pseudophoxinus* (*Phoxinellus*), *Tropidophoxinellus*, *Tinca*, *Chondrostoma*, *Rutilus* and *Leuciscus*; and the *Barbus* from East Asia. The differentiation of species such as *Barbus meridionalis* appears to arise in to this period, while the Iberian endemisms of post-Oligocenic formation, possibly during the Pontienne, form two groups. The first, with geographical and ecological incompatibilities with the North African Cyprinidae, comprises the species *Barbus bocagei graellsii*, *Barbus bocagei bocagei*, *Chondrostoma polyepes polyepes* and *Chondrostoma toxostoma arrigonis* and the second group, possibly formed well into the Pontienne, and which is geographically and ecologically compatible with the North African Cyprinidae, includes *Barbus barbus sclateri*, *Barbus comiza*, *Barbus microcephalus*, *Chondrostoma polyepes willkommi*, *Leuciscus pyrenaicus*, *Rutilus arcasi*, *Rutilus lemmingii* and *Rutilus alburnoides*.

According to ALMAÇA (1976) and ELVIRA (1986), the *Rutilus* genus, still of uncertain taxonomy due to the intermediate features of the population at both species and genus levels, may represent a speciation or sub-speciation.

Cobitidae and Homalopteridae are of Euro-Mediterranean origin. In the case of Cobitidae a speciation may have occurred in the Peninsula, in such a way that one species is related to the Euro-Mediterranean and the other endemism to the North African fauna (*Cohitis maroccana*), underlining the fact that both are considered endemisms, the former Iberian and the latter Iberian-North African.

## THE CYPRINIDAE GENERA

The *Barbus* genera has been considered to include *Barbus barbus*, *Barbus comiza* and *Barbus meridionalis*, considering the first and last having two subspecies: *B. h. bocagei*,

*B. h. sclateri*, *B. m. meridionalis* and *B. m. graellsii* (LOZANO, 1935). Later, ALMAÇA (1967), revising the genera, considered that it was necessary to raise some subspecies such as *B. sclateri*, *B. bocagei*, *B. graellsii*. *B. comiza* was maintained, and two new species were defined: *R. microcephalus* and *B. steindachneri*. Finally, DOADRIO (1984) changed the taxonomy, classifying five species, *B. bocagei*, *B. comiza*, *B. haasi*, *B. microcephalus* and *B. meridionalis*, all without subspecies except for the first, the Iberian barbel, which he divided into 3 subspecies: *B. h. bocagei*, *B. h. graellsii* and *B. h. sclateri*.

As for zoogeographical origin, ALMAÇA (1984) divides Iberian barbels into two groups: I (*bocagei*, *graellsii* and *sclateri*), together with North African and Asian barbels, and II (*comiza*, *microcephalus* and *steindachneri*) related to Western Asian and North African barbels.

There are two species of the *Chondrostoma* genus in the Iberian Peninsula, *Ch. polyepes* and *Ch. toxostoma*. The first is endemic, and is distributed throughout the Atlantic river basins, while the second is native, with a Cantabrian-Mediterranean distribution.

Each is divided into two subspecies: parental (*Ch. p. polyepes* and *Ch. t. toxostoma*) and *Ch. p. willkommi* and *Ch. t. arrigonis*. They have very different distributions: the parental subspecies (*Ch. p. polyepes* and *Ch. t. toxostoma*) are to be found in the north, and *Ch. p. willkommi* and *Ch. t. arrigonis* in the south (ELVIRA, 1987).

The *Rutilus* genus has so far had a more uncertain classification (COLLARES-PEREIRA, 1984; ELVIRA, 1987) since some of the species included have shifted between *Leuciscus*, *Chondrostoma*, *Pararutilus*, *Rutilus* and *Tropidophoxinellus* genera. At present it is considered to be formed by two species, *R. arcasi* and *R. lemmingii*.

The first has two subspecies, the parental, distributed throughout the northern river basins, and *R. a. macrolepidotus*, found in North West Portugal, between the Limia and the Tajo, and in the Duero basin. Both are endemic to the Peninsula. (LOBON-CERVIA *et al.*, 1989) include the subspecies *R. a. macrolepidotus* as a species in the text and in Table I of a paper, but do not include it in Table 2, referring to its relict distribution in the most westerly streams.

Here we must refer to another endemism, *Tropidophoxinellus alburnoides*, which was included in the same genera as *R. alburnoides*. Due to its peculiar biological characteristics, the presence of two different genotypical groups ( $2n = 50$ ;  $3n = 75$ ) and triploid associated gynogenesis and the production of clonic females, the "*Rutilus alburnoides* Complex" (COLLARES-PEREIRA, 1984, 1985) was created.

Table 2. Marine dependent species found in the estuaries, wetlands, marshes, salt flats, and brackish or salty lagoons of the Iberian Peninsula.

Familia Ammodytidae <i>Ammodytes tobianus</i> <i>Gymnamodytes cicerellus</i>	Familia Pomatomidae <i>Pomatomus saltator</i>
Familia Batrachoididae <i>Halobatrachus didactylus</i>	Familia Sciaenidae <i>Argirosomus regius</i> <i>Umbrina canariensis</i> <i>Umbrina cirrosa</i>
Familia Blennidae <i>Blennius pavo</i>	Familia Soleidae <i>Dicologoglosa cuneta</i> <i>Solea senegalensis</i> <i>Solea vulgaris</i>
Familia Bramidae <i>Brama brama</i>	Familia Sparidae <i>Diplodus sargus</i> <i>Litognathus mormyrus</i> <i>Sparus aurata</i>
Familia Clupeidae <i>Sardina pilchardus</i>	Familia Stromateidae <i>Stromateus fiatola</i>
Familia Engraulidae <i>Engraulis eucrasicholus</i>	Familia Syngnathidae <i>Hippocampus hippocampus</i>
Familia Gobiidae <i>Aphia minuta</i> <i>Gobius niger</i> <i>Gohius paganellus</i> <i>Gobius cruentatus</i>	Familia Trachinidae <i>Echiichthys vipera</i>
Familia Mugilidae <i>Oedalechilus labeo</i>	
Familia Mullidae <i>Mullus barbatus</i> <i>Mullus surmuletus</i>	

It was finally decided (ELVIRA, 1987) to include it in the *Tropidophoxinellus* genus, fully acknowledging the need for a thorough review. Furthermore, LOBON-CERVIA *et al.*, (1989) consider it as belonging to the *Rutilus* genus, and LOBON-CERVIA & ELVIRA (1989) as *Tropidophoxinellus*.

In addition, the Iberian endemism *Anaocypris hispanica* has a complex taxonomy, and has been included in the *Phoxinellus* and *Pseudophoxinellus* genera. Its distribution, limited to the Guadiana basin, has been enlarged since its capture in the River Bembezar (Azuaga, Badajoz), an affluent of the River Guadalquivir (DOADRIO, 1986).

As for the *Leuciscus* genus, similar problems have arisen, although traditionally (LOZANO, 1935; BUEN, 1935) it has been considered as comprising the species *Leuciscus cephalus* with two subspecies: *L. c. cabeda* in the north and *L. c. pyrenaicus* in the south. However, DOADRIO (1987) has revised the genus, concluding that there are three species: *L. cephalus*, *L. carolitertis* and *L. pyrenaicus*. For the time being, and until the distribution of *L. carolitertis* is better known, it is restricted to the Duero basin. This suggests that this is a case of speciation similar to that of *Rutilus*, possibly due to the effect of glaciations.

Our own opinion, however, is in line with that of ALMAÇA (1976) and ELVIRA (1986), in that it is necessary to review thoroughly the *Rutilus* and *Leuciscus* genera, and determine the distribution of each species.

The group of strictly freshwater species is formed by the Cyprinidae, Cobitidae and Homalopteridae, and two vicariant species: *Blennius fluviatilis* and *Cottus gobio*, both with a very concise distribution (table 3). Cyprinidae, Cobitidae and Homalopteridae have the largest number of endemic or native species. Of a total of 26 species (40.62% of fish fauna), 15 are endemic (23.42%), 5 are native (7.8%) and 6 (9.4%) introduced.

## ALLOCHTHONOUS SPECIES

The introduction of allochthonous species in the Iberian peninsula began with the Romans, who acclimatised the carp, *Cyprinus carpio*, which today, with 19 species, makes up 29.7% of the total Iberian continental fish fauna. Their distribution among the river basins is unequal, with the lowest number of introduced species being found in the South of Spain (4) and the highest in the rivers of the Eastern Pyrenees, where 12 species in all have been found. These two areas include the five large river basins: the Ebro, Guadalquivir, Guadiana and Tajo, with 10 introduced species, and the Duero, with 8 (table 3).

The origins of these species, and the reasons for their introduction, are several. Firstly, there are "accidental" introductions, mainly escapes from fish farms, where these fish were raised for sale or as live food for other species (brown trout, rainbow trout, grudgeon). These accidental introductions also include *Scardinius erythrophthalmus*, *Ictalurus melas* and *Silurus glanis*. The government has caused other introductions: *Esox lucius*, *Microterus salmoides*, *Lepomis gibbosus* etc., for angling, and *Gambusia affinis* for health reasons (malaria control). *Esox lucius*, on the other hand, is

Table 3. Distribution of the species in the different river basins. The codes used are those of Table 4 and figure 1.

SPECIES BASINS	VC	RG	M	LM	CV	AV	DR	VG	MG	TJ	SD	MR	AE	GD	GV	SE	SG	JC	TR	MJ	EB	PO
<i>L. planeri</i>	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>P. marinus</i>	1	1	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0
<i>A. sturio</i>	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0
<i>A. alosa</i>	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1	0	0	0	1	0
<i>A. fallax</i>	1	1	1	0	0	0	1	1	0	1	1	0	0	1	1	0	0	1	0	0	1	0
<i>A. anguilla</i>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
<i>H. hucho</i>	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>S. fontinalis</i>	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
<i>S. gaidneri</i>	1	1	1	1	1	1	1	0	0	1	0	0	0	1	1	0	1	1	1	0	0	1
<i>S. salar</i>	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>S. t. trutta</i>	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1
<i>S. t. fario</i>	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>E. lucius</i>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
<i>A. hispanica</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
<i>B. b. bocagei</i>	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0
<i>B. b. graellsii</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
<i>B. h. sclateri</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
<i>B. comiza</i>	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0
<i>B. haasi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1?	1?	0	1	1
<i>B. meridionalis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>B. microcephalus</i>	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
<i>C. auratus</i>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
<i>C. carassius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
<i>C. carpio</i>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
<i>Ch. p. polylepis</i>	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
<i>Ch. p. willkommii</i>	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
<i>Ch. t. toxosostma</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Ch. t. arrigonis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
<i>G. gobio</i>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0
<i>I. palaciosi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>L. carolitertis</i>	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>L. cephalus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
<i>L. pyrenaicus</i>	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
<i>P. phoxinus</i>	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
<i>R. alburnoides</i>	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
<i>R. a. arcasii</i>	1	0	0	0	0	0	1	1	0	1	1	0	0	1	0	0	0	1	0	1	0	0
<i>R. a. macrolepidotus</i>	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>R. lemmingii</i>	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
<i>R. rutilus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>S. erythrophthalmus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>T. tinca</i>	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0

Table 3. Distribution of the species in the different river basins. The codes used are those of Table 4 and figure 1.

SPECIES/ BASINS	VC	RG	M	LM	CV	AV	DR	VG	MG	TJ	SD	MR	AE	GD	GV	SE	SG	JC	TR	MJ	EB	PO
<i>C. calderoni</i>	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>C. maroccana</i>	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
<i>N. barbatulus</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
<i>S. glanis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>I. melas</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
<i>A. iberus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
<i>F. heteroclitus</i>	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
<i>V. hispanica</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
<i>G. affinis</i>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
<i>A. boyeri</i>	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
<i>G. aculeatus</i>	1	1	1	1	0	1	1	1	1	1	1	0	0	1	1	1	0	1	0	0	1	1
<i>S. abaster</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
<i>C. gobio</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
<i>P. fluviatilis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
<i>S. lucioperca</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>D. labrax</i>	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
<i>D. punctata</i>	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
<i>L. gibbosus</i>	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	1
<i>M. salmoides</i>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
<i>Ch. labrosus</i>	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
<i>L. aurata</i>	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
<i>L. ramada</i>	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
<i>L. saliens</i>	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
<i>M. cephalus</i>	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
<i>P. fluviatilis</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	1	1
<i>P. microps</i>	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
<i>P. minutus</i>	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
<i>P. flexus</i>	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
<i>C. facetum</i>	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0

more of are introduction, as it has been found in the fossil layer of the early Pleistocene in Arganda, Madrid (MORALES, 1980). When more data is available, it may well be considered a native species of the Iberian Peninsula.

At present many changes are occurring, as species are being moved between different river basins. Live bait has been used to catch predator species, which are then released in other river basins, as has been the case with *Lepomis gibbosus*, introduced into the Guadalquivir in the province of Cordoba from the Guadiana. Indiscriminate release by aquarium owners is another cause, and may explain the presence of *Fundulus heteroclitus*, *Cichlasoma facetum*, *Carassius auratus* and *Carassius carassius*.

The Government, to satisfy ever increasing demand from anglers, has made massive introductions of fish from Germany, Italy, France and the USA. The fish involved are brown trout, rainbow trout, pike, largemouth bass and pumpkinseed sunfish.

Some species such as *Hucho hucho*, *Salvelinus fontinalis*, *Ictalurus melas* and *Silurus glanis* show a limited distribution despite having been introduced in several areas. On the other hand, species such as *Esox lucius*, *Micropterus salmoides*, *Lepomis gibbosus* and *Gambusia affinis* are very widely distributed. *Fundulus heteroclitus* and *Cichlasoma facetum* have been found in the river basins of the South of Portugal, the Guadiana and the Guadalquivir, but their



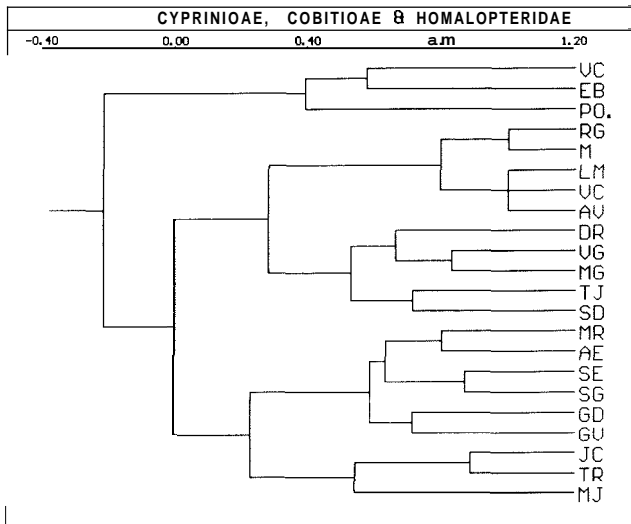


Figure 1: Sectorization of the Iberian Peninsula. The initials of the river basins are those of Table 4.

distribution area is spreading. As for *Cichlasoma facetum*, the first known samples are from the River Mira (HELLING, 1943), spreading later towards the South of Portugal (ALMAÇA, 1964; COLLARES-PEREIRA, 1985), and subsequently to the Guadiana basin (PEIRO, 1987).

## SECTORISATION OF THE IBERIAN PENINSULA

There have been several attempts to divide the Iberian Peninsula into sectors of freshwater fauna. AREVALO (1929) proposed a model based on the presence or absence of salmon and ciprinodontiforms, with three "provinces": Cantabria, the Atlantic and the Betico-Mediterranean. LOZANO (1952), based his model on the presence or absence of Cyprinidae, Cobitidae and Cyprinodontidae, and reduced the number of "regions" to two: Northern and Southern. ALMAÇA (1978) and HERNANDO *et al.*, (1982)

Table 4. Number of species catalogued in the Iberian Peninsula river basins, using those whose surface is equal to or greater than 990 square kilometres. (NAT: native; END: endemic; INT: introduced).

RIVER BASINS	SURFACE AREA (Km <sup>2</sup> )	SPECIES				
		NAT	END	INT	TOTAL	
CANTABRIAN BASINS	VC	24382	23	3	6	32
RIVERS OF GALICIA	RG	11225	19	2	7	28
MIÑO	M	16800	19	2	7	28
LIMIA	LM	2515	6	3	7	16
CAVADO	CV	1680	5	3	7	15
AVE	AV	1520	6	3	7	16
DUERO	DR	97710	9	7	8	24
VOUGA	VG	3150	6	9	6	21
MONDIGO	MG	6350	5	7	6	18
TAJO	TJ	80400	8	10	10	28
SADO	SD	6500	15	8	7	30
MIRA	MR	1530	12	8	8	28
ALGARVE	AE	990	12	7	8	27
GUADIANA	GD	72337	20	11	10	40
GUADALQUIVIR	GV	56528	20	8	11	39
BASINS OF SOUTHERN SPAIN	SE	23121	15	6	4	25
SEGURA	SG	15803	15	5	6	26
JUCAR	JC	22651	17	7	7	31
TURIA	TR	6808	14	8	7	29
MIJARES	MJ	7966	14	5	7	26
EBRO	EB	83000	24	7	10	41
WESTERN PYRENEES	PO	16826	20	4	12	36

propose two different models, both based on the distribution of Cyprinidae and Cobitidae. In the first, there are three "subdistricts" or "subsectors": Ebro-Cantabria, Central and Southern, and in the second there are two subregions: the North Atlantic and the Betico-Mediterranean.

Although HERNANDO (1990) considers this latter subregionalization to be valid, we believe that the new data on Cyprinidae, Cobitidae and Homalopteridae (strictly freshwater species), the description of a new species of the *Leusiscus* genus, the variation in the distribution of *Anaecypris hispanica*, etc., justify a new attempt to clarify the sectorisation or subregionalisation of the Iberian Peninsula.

This will be based on the distribution matrix (presence-absence) of the species and subspecies of these families in the 22 river basins with a surface area of more than 990 km<sup>2</sup> (table 2). The river basins are grouped using the PHI similarity index (ROHLF, 1988) and then a UPGM-type cluster analysis (ROHLF, op. cit.), considering species and subspecies as identical.

Three different models were made to determine which most closely represents the distribution of species in river basins. The first includes species and subspecies of Cyprinidae, Cobitidae and Homalopteridae (fig. 1). The second adds *Blennius fluviatilis*, *Cottus gobio* and *Lampetra planeri* to these families, and the third includes all 35 species and subspecies under consideration (table 3).

The results show three groups of river basins (fig 1). The first group includes the Ebro, Cantabria and the eastern Pyrenees. The second has two subgroups: the Gallegos, Miño, Limia, Cavado and Ave, and the Duero, Vouga, Mondego, Tajo and Sado. The third group includes the South of Spain and the Segura, and the Jucar, Turia and Mijares on the Mediterranean.

This pattern is repeated for the other models, and demonstrates the strong influence of the Cyprinidae, Cobitidae and Homalopteridae families with respect to the other species. It is thus proposed to consider the Iberian Peninsula as being divided into three subregions or subsectors: the Ebro-Cantabrian, the Atlantic and the Betico-Mediterranean.

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