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Historical Changes in the Fish Fauna of the River Duero Basin

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INTRODUCTION

The River Duero rises in Los Picos de Urbion (Soria) at about 2080 m above sea level, and flows westwards through the flat lands of Old Castile, Leon and Portugal. After about 937 km the river flows into the Atlantic Ocean close to Porto (Figure 1). Its drainage basin of 98 375 km² is shared between Spain (80 per cent) and Portugal (20 per cent). The central area is high at about 800 m above sea level. Rain and snow combine to generate an average discharge of 570 m³ s⁻¹ with a maximum recorded discharge of 20 000 m³ s⁻¹ and a minimum of 1 m³ s⁻¹. Other general physiographic and biological data are given in Sole-Sabaris (1978), Lobon-Cervia *et al.* (1986) Garcia de Jalon and Lopez Alvarez (1983) and Garcia de Jalon and Gonzalez del Tanago (1983). Although sharing a topographic divide, the fish fauna of the Duero and Ebro differ markedly (Sostoa and Lobon-Cervia, this volume). Moreover, unlike the Ebro, there is a valuable taxonomic record for assessing historical change.

THE FISH FAUNA

For the purposes of this study, the fish species of the River Duero can be classified into three groups; (1) freshwater species (*sensu strictu*), (2) migratory species, both catadromous and anadromous, and (3) eurihaline species. In this paper, the major concern is with the freshwater species because this group has been subjected to more important historical changes than any other group. Some migratory and eurihaline species have also been severely damaged and have declined in numbers dramatically.

Freshwater species

A list of fish species living in the River Duero catchment area together with their origin, is given in Table 1. Only 20 species comprise the freshwater group, i.e. 77 per cent of the

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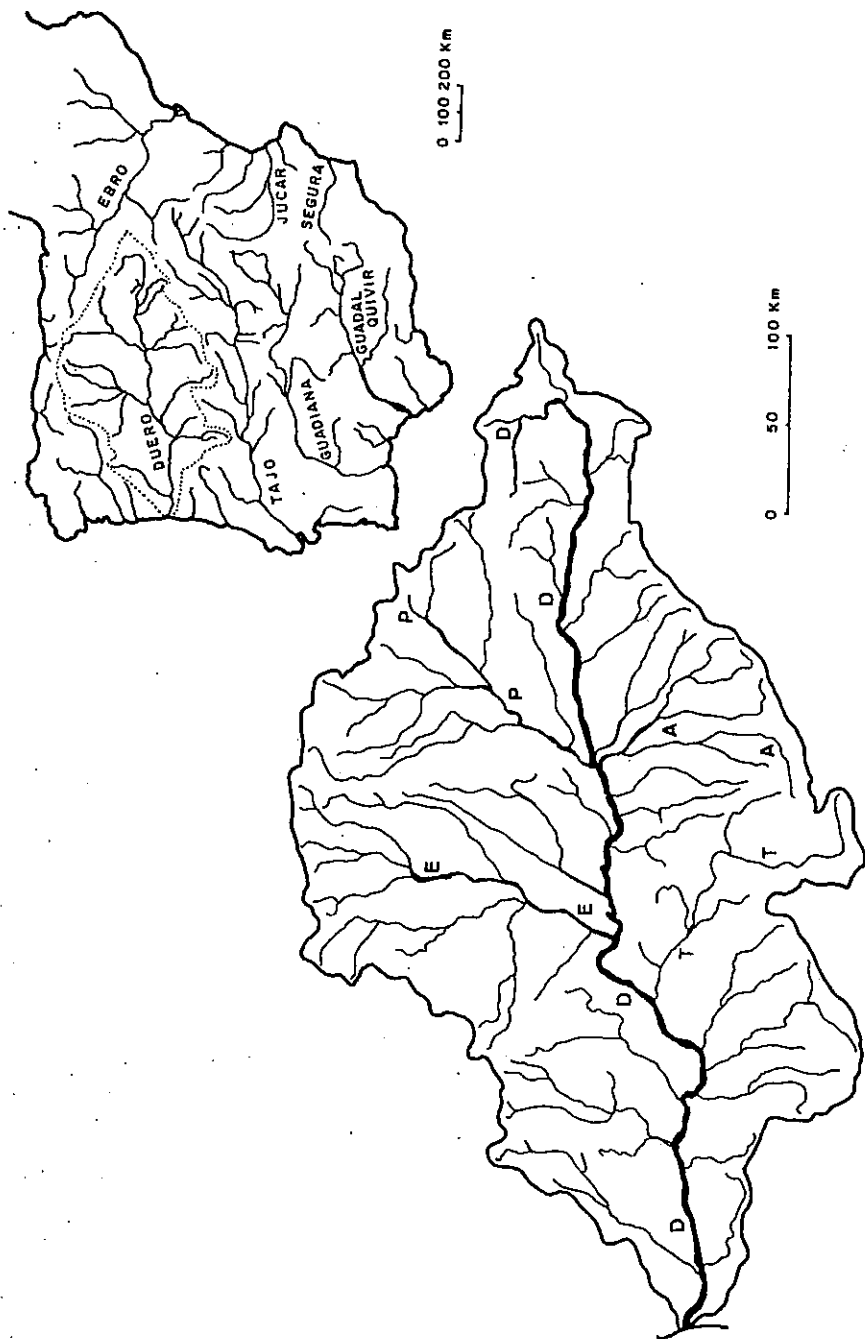


FIGURE 1. Geographical situation of the River Duero drainage basin within the Iberian Peninsula. Letters by the map denote the main tributaries: P is River Pisuerga; E, Esla; A, Adaja and T, Tormes, D is the main Duero corridor

TABLE 1. Native (N) and introduced (I) species living in the River Duero drainage basin and their present status. A and C refer to anadromous and catadromous species and F is freshwater species (*sensu strictu*). Ab is abundant; C, common; R, rare; V, vulnerable; E, extinct and ? is undocumented. Note that eel (*A. anguilla*) is extinct throughout most of the basin (Figure 2) but is abundant below the reservoirs of the central corridor. Notations are used as recommended by ICONA (1986)

Petromizontidae			
<i>Petromizon marinus</i>	N	A	R
Acipenseridae			
<i>Acipenser sturio</i>	N	A	E
Clupeidae			
<i>Alosa alosa</i>	N	A	V
<i>Alosa fallax fallax</i>	N	A	V
Anguillidae			
<i>Anguilla anguilla</i>	N	C	E & Ab
Salmonidae			
<i>Hucho hucho</i>	I	F	?
<i>Salmo gairdneri</i>	I	F	C
<i>Salmo salar</i>	N	A	E
<i>Salmo trutta</i>	N	F	Ab
<i>Salvelinus fontinalis</i>	I	F	R
Esocidae			
<i>Esox lucius</i>	I	F	C
Cyprinidae			
<i>Barbus bocagei</i>	N	F	Ab
<i>Chondrostoma polylepis</i>	N	F	Ab
<i>Carassius auratus</i>	I	F	C
<i>Cyprinus carpio</i>	I	F	C
<i>Gobio gobio</i>	I	F	Ab
<i>Leuciscus sp.</i>	N	F	Ab
<i>Phoxinus phoxinus</i>	I	F	Ab
<i>Rutilus arcasii</i>	N	F	Ab
<i>Rutilus arburnoides</i>	N	F	Ab
<i>Rutilus lemmingii</i>	N	F	C
<i>Rutilus macrolepidotus</i>	N	F	C
<i>Tinca tinca</i>	N	F	Ab
Cobitidae			
<i>Cobitis calderoni</i>	N	F	C
Poeciliidae			
<i>Gambusia affinis</i>	I	F	Ab
Centrarchidae			
<i>Micropterus salmoides</i>	I	F	C

total number of species, with 50 per cent of them being native whilst 50 per cent have been introduced.

The taxonomy of the native species has been recently reviewed and is rather well documented (Collares-Pereira, 1983; Doadrio, 1984; Elvira, 1987a, 1987b). The only exception seems to be the population of chub. For many years (Lozano-Rey, 1935; IFIE, 1952; Almaca, 1965; and others), their populations were considered as belonging to the taxonomic group of *Leuciscus cephalus cabeda* but recently they have been found to be a new species although its description has not been published yet (Doadrio, 1987); in this

paper, we deal with the species as *Leuciscus* sp. Native freshwater species are the following: brown trout (*Salmo trutta*), Iberian barbel (*Barbus bocagei bocagei*), Iberian nase (*Chondrostoma polylepis polylepis*), duero's chub (*Leuciscus* sp.), four species of roach (*Rutilus alburnoides*, *R. arcasii*, *R. macrolepidotus* and *R. lemmingii*), tench (*Tinca tinca*) and calderon's loach (*Cobitis calderoni*).

All the native Cyprinidae and Cobitidae except tench are endemic to the Iberian Peninsula although none of them is restricted to the River Duero Basin. However, in spite of the large catchment area these families contain a low number of species in comparison to other European basins; a fact that applies to all the rivers of the Iberian Peninsula (Daget, 1968; Sostoa and Lobon-Cervia, this volume). Among many comparative examples in rivers flowing to the Mediterranean Sea Basin, Daget and Economidis (1975) recorded 17 species for the River Evros and 18 for the Strymon, both in the balkan Peninsula, while Gandolfi and Le Moli (1977) reported 13 species for the Italian River Po. A comparison with Central and Northern European rivers flowing to the Atlantic Ocean would increase the difference. In Poland, for much smaller drainage basins, Kolder *et al.* (1974) recorded 32 species for the River Raba and tributaries while Mahon (1984) reported 22 species for the River Nida.

The contemporary distribution of fishes within the Duero reflects a long history of stocking and introduction. The original distribution of brown trout (*S. trutta*) in the River Duero has drastically changed in the last century mainly because of human impacts. The first known trout-farm in Spain was built in 1866 in La Granja (Segovia) taking water from the River Eresma, a southern tributary of the River Duero. As this farm succeeded in raising fish, other farms were established. The progressive development of this industry has had several consequences, including: (1) continuous escapes of individuals from these farms; (2) colonization of new reaches of streams by escaped individuals; and (3) mixing of their genetic pools with those of natural populations. Further, in the 1940s and later years, the Fisheries Services of the State Administration, in order to promote angling and due to its poor facilities to manage fish, used trout from these farms to stock streams, thereby increasing their distribution and genetic mixing.

Throughout the River Duero and its tributaries, four species (*B. bocagei*, *C. polylepis*, *Leuciscus* sp. and *C. calderoni*) are common and widely distributed, while roach (*Rutilus* spp.) show more limited distribution. *R. arcasii* occupies all the central, northern and eastern areas of the basin while *R. macrolepidotus*, its closest relative (Elvira, 1987b), lives only in the westernmost streams. *R. lemmingii* is restricted to the River Huebra-Yeltes drainage basin (lefthand-side tributary), and *R. alburnoides* is known to occur in the southwestern waters (i.e. River Agueda).

Tench (*T. tinca*) has also been traditionally grown in ponds throughout the river basin, although not intensively, and it has been further subjected to river stocking. Today it is not possible to separate accurately its original distribution from that resulting from human manipulation.

Ten species belonging to five families have been introduced in historical times (Table 2). Carp (*C. carpio*) and goldfish (*C. auratus*) have been reported in this river since the 17th century and have been stocked up continuously to the present day. Gudgeon (*G. gobio*) is thought to have been introduced by the mid-19th century and it seems to be associated with the first stages of trout farming. Earliest references are due to Ugarte (1929) and Lozano-Rey (1935). Since these records, its distribution has increased significantly, nowadays occupying most, if not all, the river basin (Figure 2). A similar situation prevails

TABLE 2. Historical changes observed in the fish fauna of River Duero drainage basin in relation to dates of introduction and extinction (—) of species. The top total number of species in each particular period of time is given together with the theoretical number of species (extinctions are taken into consideration) which is given in parenthesis

	Da.es							Introduced in
	Native	17th	1865	1900	1925	1950	1975– present	
<i>P. marinus</i>	*	*	*	*	*	*	*	
<i>A. sturio</i>	*	*	*	*	*	—	—	
<i>A. alosa</i>	*	*	*	*	*	*	*	
<i>A. fallax</i>	*	*	*	*	*	*	*	
<i>A. anguilla</i>	*	*	*	*	*	*	*	
<i>S. salar</i>	*	*	*	—	—	—	—	
<i>S. trutta</i>	*	*	*	*	*	*	*	
<i>B. bocagei</i>	*	*	*	*	*	*	*	
<i>C. polylepis</i>	*	*	*	*	*	*	*	
<i>Leuciscus</i> sp.	*	*	*	*	*	*	*	
<i>R. arcasii</i>	*	*	*	*	*	*	*	
<i>R. alburnoides</i>	*	*	*	*	*	*	*	
<i>R. lemmingii</i>	*	*	*	*	*	*	*	
<i>T. tinca</i>	*	*	*	*	*	*	*	
<i>C. calderoni</i>	*	*	*	*	*	*	*	
<i>C. auratus</i>		*	*	*	*	*	*	17th cent.
<i>C. carpio</i>		*	*	*	*	*	*	17th cent.
<i>S. gairdneri</i>				*	*	*	*	late 19th
<i>S. fontinalis</i>				*	*	*	*	late 19th
<i>G. gobio</i>				*	*	*	*	19th–20th
<i>P. phoxinus</i>				*	*	*	*	19th–20th
<i>G. affinis</i>						*	*	1926
<i>E. lucius</i>						*	*	1950
<i>M. salmoides</i>							*	1955
<i>H. hucho</i>							*	1968
Number of species	16	18	18	20 (19)	22 (21)	24 (22)	26 (24)	

for minnow (*P. phoxinus*). Some earlier reports (Lozano-Rey, 1935 and references therein) lead us to believe that minnow is native to the northwestern rivers of the Iberian Peninsula and its colonization in the Duero must be due to similar reasons to that of gudgeon. It is likely that its colonization of the River Duero occurred in the early 20th century because the same author (Lozano-Rey, 1919) reported 12 specimens from Vizcainos de la Sierra (Burgos) captured in 1918. Because minnow select very different habitats to gudgeon, their distribution is limited to the uppermost reaches of streams and rivers although they are also spreading rapidly.

Rainbow trout (*S. gairdneri*) was also introduced to Spain and specifically to the Duero Basin by the end of the 19th century. Early references were reported by Ugarte (1929) and Nobre (1932). Actually, their distribution is limited to places where they are frequently stocked and/or to rivers and streams flowing close to trout-farms from where they frequently escape. As with rainbow trout, char (*S. fontinalis*) was brought from North America by the end of the 19th century and was stocked in several places mainly in lakes and reservoirs

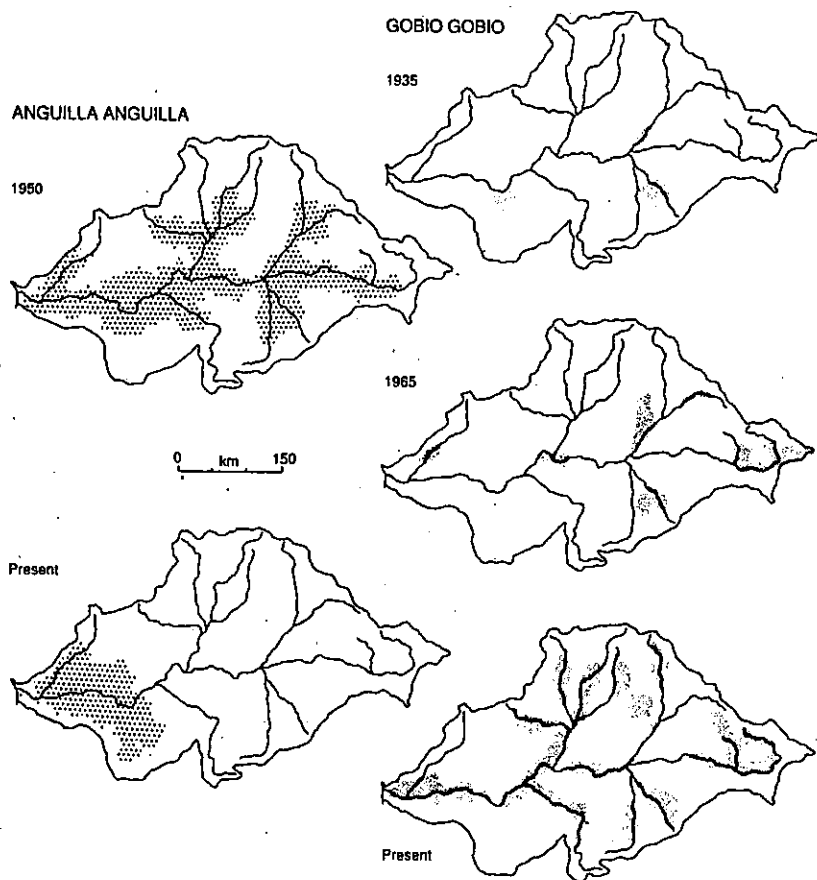


FIGURE 2. Historical changes in the distribution of gudgeon (*G. gobio*) and eel (*A. anguilla*) in River Duero basin

(Lozano-Rey, 1935). Because of recent introductions they occur, at least, in Lake Sanabria (Zamora), Laguna de Beila (Burgos) and Navacerrada (Segovia). One more salmonid, the Huchen (*H. hucho*) originally from Czechoslovakia, was stocked in 1968 in two tributaries of the River Duero; in the River Orbigo where the species rapidly disappeared and in the River Tormes in which the species thrived (Anonymous, 1969, 1973; Mondejar, 1981; Holcik *et al.*, 1984).

Pike (*E. lucius*) was brought from France in 1950 (Calderon, 1955) and spread throughout the basin. A few years later in 1955 the Fisheries Services introduced black-bass (*M. salmoides*). Both species acclimatized very rapidly and today, are common in lowland reaches.

The mosquito fish (*G. affinis*) is perhaps the only case of a fish introduced for purposes other than angling. It was brought from North America in 1926 by the Medical Services

to assist in the struggle against paludism and was, subsequently, stocked in several rivers (Sostoa *et al.*, 1984). Although the effect of *G. affinis* on the mosquito population (host of the paludism virus) was never assessed, or otherwise studied in any way, paludism disappeared years later. However, it is interesting to note that some references on the biometrical features of these introduced populations were published by de Buen (1930). Like the previously mentioned species, mosquito fish spread throughout the lowland reaches of the River Duero and its tributaries where it is still common.

Migratory species

At least six migratory taxa have been reported in the River Duero in historical times, these are: *Anguilla anguilla* (catadromous) and *Petromyzon marinus*, *Acipenser sturio*, *Salmo salar*, *Alosa alosa* and *Alosa fallax fallax* (anadromous). The populations of all these species have sharply declined in this century to the extent that they are either threatened or extinct (ICONA, 1986). In the last 30 years, *A. anguilla* has been reduced both in distribution area and numbers (Figure 2). Before the 1960s eel was really the most common and widely distributed species in all the basin. Its decline is consequent upon the construction of a dam in the main channel of the River Duero.

P. marinus seldom appears in the literature but has experienced similar changes to the eel. Today this species seldom reaches the Carrapatello Reservoir (Portugal) situated 60 km from the river mouth (Eiras, 1977). This reservoir is also the upstream limit of both shads (*A. alosa* and *A. fallax*) although their populations are still abundant enough to support some professional fisheries (Eiras, 1980). Sturgeon (*A. sturio*) were recorded in the River Duero upstream to Barca d'Alva (Portugal) at about 200 km from the Duero mouth. In the last decades, and presumably for the same reasons, no new records have been reported. Salmon (*S. salar*) were once common, but none has been reported in this century. There are also historical records of, at least, *Gasterosteus aculeatus*, *Chelon labrosus*, *Liza ramada*, *Liza aurata*, *Mugil cephalus cephalus* and *Platichthys flesus*. All of these have disappeared from the Duero.

HISTORICAL CHANGES: AN OVERVIEW

Although the construction of main-stream reservoirs since 1940's has confined the distribution of eel and shads, and contributed to the disappearance of Sturgeon and Atlantic salmon, the greatest impact of Man upon the fish fauna of the Duero, over the historic timescale has been stocking with exotic species. The first study of the ichthyology of the River Duero was undertaken by Steindachner (1866a, 1866b) who visited the river between 1864 and 1865. For those years, at least 17 taxa, 11 freshwater (*sensu strictu*) and six migratory species were present in the Duero (Table 2). However, Steindachner failed to record three native (*R. alburnoides*, *R. lemmingii* and *R. macrolepidotus*), two migratory (*P. marinus* and *A. fallax*) and one introduced (*C. auratus*) species. Their absence from Steindachner's work could be due simply to inadequate sampling techniques (fishing with nets, etc). Other studies made during the late 19th century by several Spanish and Portuguese workers (Capello, 1881; Osorio, 1888, 1894, 1895, 1896; Vieira, 1894, 1897) do not offer any new contributions to the statements of Steindachner. Introductions, adaptations and fish farming of foreign species began in these years as Maximiliano de la Paz Graells, a

well-known naturalist of the time, was appointed as advisor to Queen Elizabeth II. His trips to France strongly influenced the development of natural sciences and fish farming (Graells, 1867).

Notable contributions to the knowledge of the Duero fish fauna were made during the early 20th century. Motivated by the general lack of information, Seabra (1911), Ugarte (1929), Velaz de Medrano and Ugarte (1930), Nobre (1932), de Buen (1930, 1935) and Lozano-Rey (1935) built the base of freshwater ichthyology. Furthermore, from these papers we have been able to infer, among many other things, that gudgeon (*G. gobio*) and minnow (*P. phoxinus*) were introduced and established in this period (Table 2) and that the first specimens of both species probably escaped from trout-farms where they were grown as food for trout. Still earlier, these specimens could originally have come from France as this country was the main supplier of trout for farms and, later on, of pike and black-bass.

Prior to the mid-20th century exotic species generally appeared in rivers as a result of accidents. Since 1950 the colonization of the Duero system by foreign species has been the result of administrative decision. In this way, pike (*E. lucius*), black-bass (*M. salmoides*) and huchen (*H. huicho*) were successively introduced in 1950, 1955 and 1968 respectively by administrative agencies lead by forest engineers. Furthermore, over the same period, these agencies increased and supported intensive stocking of those exotic species formerly introduced: *S. gairdneri*, *S. Fontinalis* and *C. carpio*. Trout-farming used foreign specimens imported from Germany, Italy and France.

No fisheries research at all was undertaken during the mid-20th century partly due to the civil war (1936–1939). Scientists, such as Dr. F. de Buen, left Spain and at this time Institutions devoted to research in these fields, such as the National Museum of Natural Sciences (CSIC, Madrid) were neglected, or were otherwise forced to abandon these branches of science (i.e. Instituto Forestal de Investigaciones y Experiencias, Ministry of Agriculture, Madrid). As a result, in Spain no more than six references on freshwater fish were published between 1940 and 1978 and none of them deal with the Duero fish!

Present and future

Although, since 1970's, the administration has reduced the intensity of stocking, particularly of *E. lucius* and *H. hucho* and, since 1981, of *S. fontinalis* (Figure 3), they are stocking four species (*S. trutta*, *S. gairdneri*, *M. salmoides* and *T. tinca*) in increasing numbers. As an example, data concerning stocking of individuals released in the streams and rivers of the River Duero during the period 1973–1983 are shown in Figures 3 and 4. Numbers of brown trout, rainbow trout and black-bass released in these waters in 1982 were 3.5, 5 and 10 times higher respectively, than in 1973 and 1974; totalling 3.5 millions in 1982.

It is worthwhile mentioning that if biological interactions have occurred after the introduction of these foreign species, they have not occurred to the extent of replacing native species by foreign species by competition or to the extinction of a native-prey by a foreign predator. Although these biological interactions have never been assessed in the River Duero, it appears that native species of the freshwater group (Cyprinidae and Cobitidae) have been, historically, rather stable in their distribution.

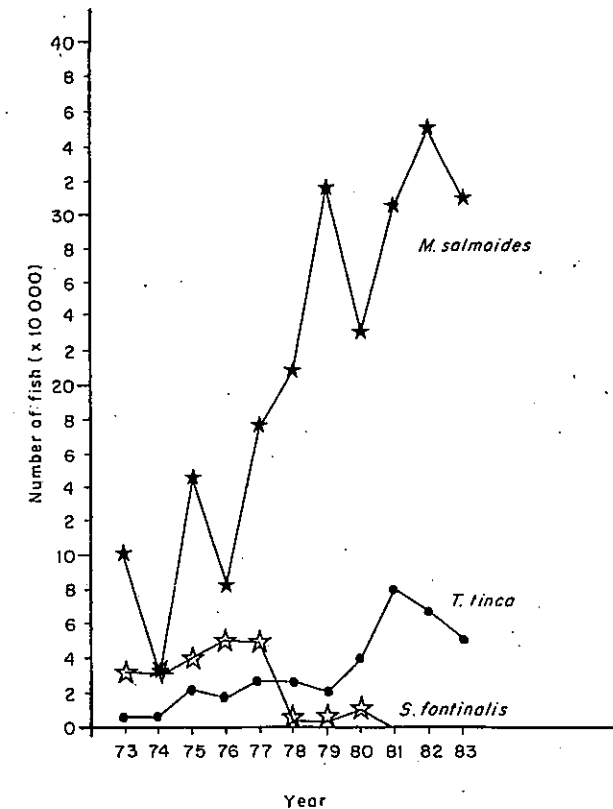


FIGURE 3. Number of black-bass (*Micropterus salmoides*), tench (*T. tinca*) and char (*Salvelinus fontinalis*) released per year in River Duero and tributaries for the period 1973–1983. Note that char (*S. fontinalis*) has not been stocked since 1981

In the 1980s, the problem remains that fish management is not based on scientific arguments but on the stocking of any river or stream without considering the status of the existing population. Moreover, stocking is made from farms, and farms still grow foreign specimens. This is a little surprising because in the last 10 years an important increase in the number of professionals working on fish has resulted in a huge volume of publications, especially on biology, ecology and culture.

This decade has witnessed a new problem: the last six new exotic species recorded in the Iberian Peninsula (Sostoa *et al.*, 1984) are not the result of fish escaping from farms (second half of 19th century) or administrative decisions (first half of 20th century) but of casual introductions. The two most important groups of people acting in this way are anglers and aquarium lovers. Anglers transport fish from one river to another as they use small, live cyprinids, as bait to fish pike, black-bass and trout; they press the administration to improve fisheries by increasing stocking; and they take their own decisions on which

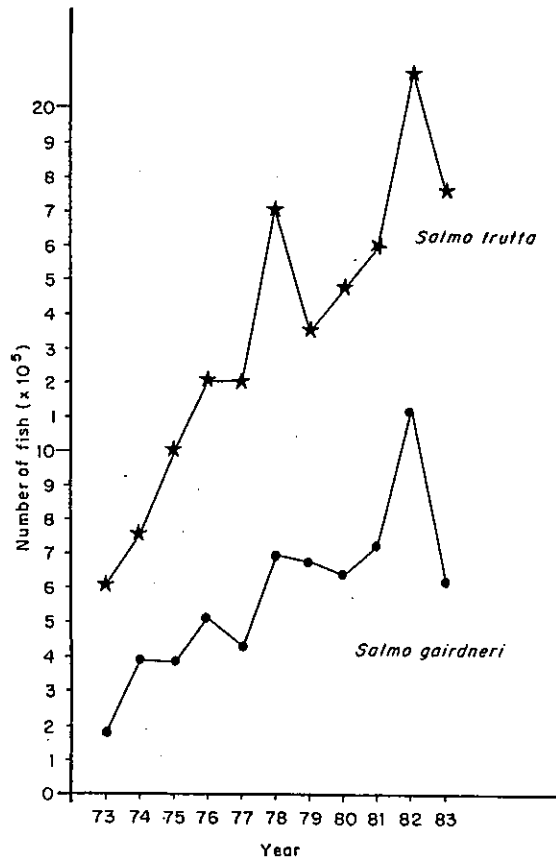


FIGURE 4. Number of individuals of brown trout (*Salmo trutta*) and rainbow trout (*S. gairdneri*) released per year in River Duero and tributaries for the period 1973–1983

species must be introduced to any particular water. Aquarium lovers release fish in any water where they assume fish can survive. Until recently, the River Duero has not been affected by these problems but several species are spreading rapidly in neighbouring rivers: *Lepomis gibbosus* in the River Tajo (Sostoa *et al.*, 1987), and *Ictalurus melas* in the River Ebro (Elvira, 1984). Clearly, such casual introductions are a potential threat in the near future.

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