

## Additional records of non-native freshwater fishes for the Ebro River basin (Northeast Spain)

Rafael Miranda<sup>1\*</sup>, Pedro M. Leunda<sup>2</sup>, Javier Oscoz<sup>1</sup>, Antonio Vilches<sup>1</sup>, Ibon Tobes<sup>1</sup>, Javier Madoz<sup>3</sup> and Jaime Martínez-Lage<sup>3</sup>

<sup>1</sup>Department of Zoology and Ecology, University of Navarra, PO Box 177, E-31080, Pamplona, Navarra, Spain

<sup>2</sup>Gestión Ambiental Viveros y Repoblaciones de Navarra S.A., C/ Padre Adoain 219 Bajo, 31015 Pamplona/Iruña, Navarra, Spain

<sup>3</sup>Flumen estudios y proyectos ambientales, C/ Errotazar 23, bajo, 31014 Pamplona, Navarra, Spain

E-mail: [rmiranda@unav.es](mailto:rmiranda@unav.es) (RM), [pedro.leunda@gavrn.com](mailto:pedro.leunda@gavrn.com) (PML), [joscoz@alumni.unav.es](mailto:joscoz@alumni.unav.es) (JO), [avilches@alumni.unav.es](mailto:avilches@alumni.unav.es) (AV), [itobes@alumni.unav.es](mailto:itobes@alumni.unav.es) (IT), [jmadarb@alumni.unav.es](mailto:jmadarb@alumni.unav.es) (JM), [jmlage@telefonica.net](mailto:jmlage@telefonica.net) (JML)

\*Corresponding author

Received: 10 February 2010 / Accepted: 7 July 2010 / Published online: 5 August 2010

### Abstract

This paper extends the knowledge of the geographical distribution of non-native freshwater fishes in the Ebro River basin (Spain). More than two hundred surveys were carried out since 2000, and thirteen non-native fish species were collected on fifty-eight occasions. The spread of most of the recorded non-native species seems to be a consequence of illegal introductions related to sport fishing activities and the subsequent natural dispersal. Their presence could impact natural populations of Iberian native—mostly endemic—freshwater fish species, through direct predation and competition for niche and/or trophic resources.

**Key words:** distribution, fish introductions, range expansion, exotic species, Iberian Peninsula

### Introduction

Invasive species constitute a major threat to biodiversity and ecosystem integrity and cause substantial economic damage (Allan and Flecker 1993; Vitousek et al. 1997; Kolar and Lodge 2001). Freshwaters are considered one of the most severely degraded ecosystems in industrialised countries (Oberdorff et al. 2002) and have been the recipient of many invasions, in particular by fish species (see Copp et al. 2005; García-Berthou et al. 2005 for review). The success of non-native fish has been widely studied and attributed to several factors including specific life history traits (Olden et al. 2006), phylogeny (Alcaraz et al. 2005) and environmental characteristics including abiotic factors or human use (Moyle and Light 1996; Alcaraz et al. 2005).

Impacts on native aquatic fauna are considerable and a cause of concern especially in those places that have suffered constant introductions along the course of history, such as in developed European countries (Panov and

Gollasch 2006). Within the European continent, Mediterranean areas have the highest biodiversity but also the highest number of threatened species (Medail and Quezel 1999; Smith and Darwall 2006). Many ecosystems in these European Mediterranean areas are also especially susceptible to invasions by introduced species (Clavero et al. 2004).

Spain is the European Mediterranean country with the peak value of species diversity and, similarly, has the highest number of threatened species according to the International Union for Conservation of Nature Red List of Threatened species (IUCN 2010). Among the 1,136 native species (71 freshwater fish species) catalogued by the IUCN Red List in Spain, 120 species (14 freshwater fish species) are considered endangered, critically endangered or extinct, representing more than 10% (18% of freshwater fish species) of the registered biodiversity for this organisation (IUCN 2010).

Knowledge regarding impact mechanisms and risk evaluations of non-native species is, without doubt, one of the pertinent issues and a key issue

in the conservation of the native fauna (Leunda 2010). The aim of this paper is to document additional records of non-native freshwater fishes in the River Ebro basin, north-eastern Spain, obtained from different monitoring studies carried out by the authors during the last decade.

## Methods

The Ebro River is the largest river in Spain, draining an area of 86,100 km<sup>2</sup> in the north-eastern Iberian Peninsula (Figure 1). From the year 2000 until 2009, 238 surveys were carried out in this basin for several technical reports and research projects.

Most surveys were undertaken by electro-fishing using backpack units (300-600 V, 0.2-2 A) (CEN EN 14011:2003). Different sampling designs were carried out (i.e. three-run depletion between two stop-nets, qualitative surveys, semi-quantitative surveys) depending on the original purpose of the survey. Surveys in reservoirs were carried out with multimesh gillnets (CEN EN 14757:2005). Finally, specimens of non-native fishes were captured in some monitoring surveys of biological water quality assessment by macro-invertebrate hand-netting, and we were included in this study.

The caught fish were anaesthetized with 2-phenoxyethanol before being measured to the nearest 1 mm, and weighted, when possible, to the nearest 0.01 g. Some of caught specimens were stored immediately on ice but not frozen and transported to the laboratory where the specimens were fixed in 4% formaldehyde solution for 48 h and afterwards preserved in 70% ethanol solution in order to be catalogued in the Museum of Zoology, University of Navarra (MZNA) collection (Salinas and Ariño 2000).

Taxonomic review of scientific names and the common names were validated according to the William N. Eschmeyer's Catalogue of Fishes (Eschmeyer 2010) and Kottelat and Freyhof (2007).

## Results and discussion

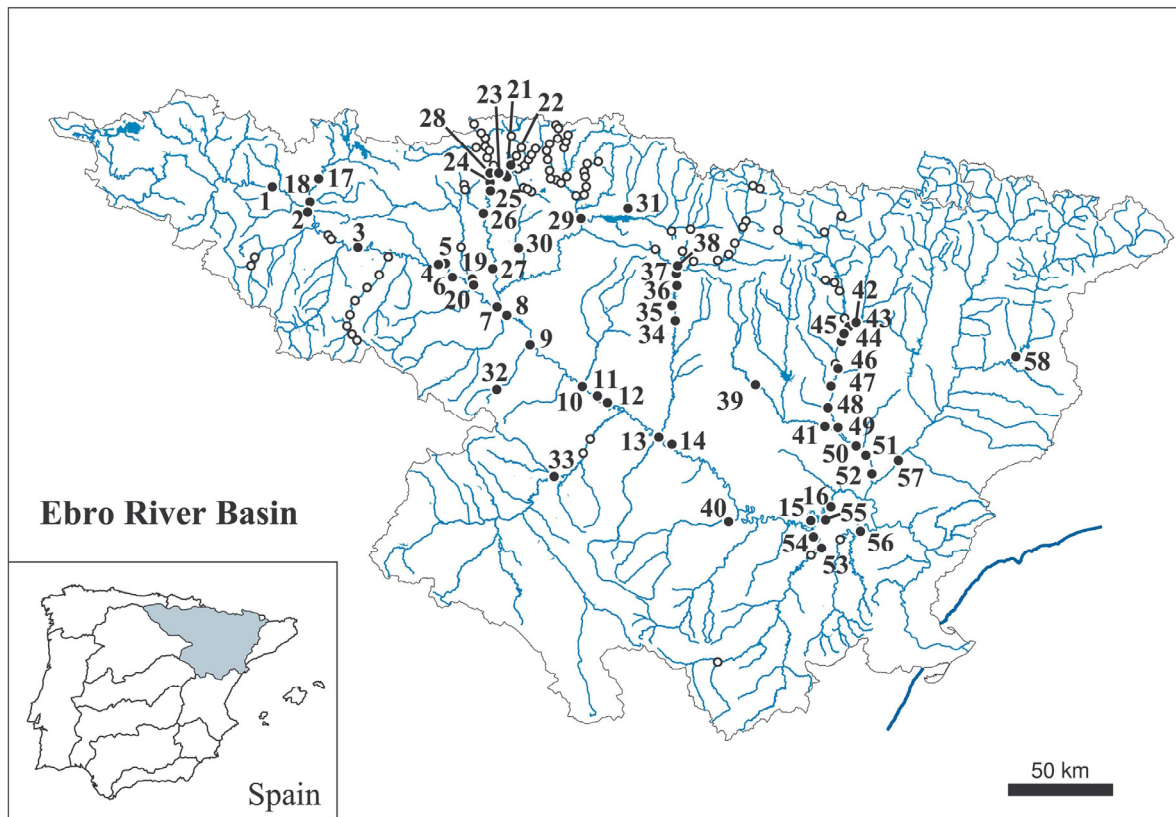
Thirteen non-native fishes were collected in 58 of the 238 surveys carried out in 146 places (Annex 1, Figure 1): five cyprinids (*Alburnus alburnus* (Linnaeus, 1758), *Carassius auratus* (Linnaeus, 1758), *Cyprinus carpio* Linnaeus, 1758, *Rutilus rutilus* (Linnaeus, 1758) and

*Scardinius erythrophthalmus* (Linnaeus, 1758)); two centrarchids (*Lepomis gibbosus* (Linnaeus, 1758) and *Micropterus salmoides* (Lacepède, 1802)); one esocid (*Esox lucius* Linnaeus, 1758); one ictalurid (*Ameiurus melas* (Rafinesque, 1820)); one percid (*Sander lucioperca* (Linnaeus, 1758)); one poeciliid (*Gambusia holbrooki* (Girard, 1859)); one silurid (*Silurus glanis* Linnaeus, 1758) and one salmonid (*Oncho-rhynchus mykiss* (Walbaum, 1792)). Records of *Gambusia holbrooki* already published by the authors (Oscoz et al. 2008) will not be considered in this contribution, although new recent records have been included. This species is considered by Eschmeyer (2010) to be a synonym of *Gambusia affinis* (Baird and Girard, 1853), although Kottelat and Freyhof (2007) consider it a different species.

All the species collected have been previously reported in the Ebro River basin, and some species have been previously cited in some of the places recorded in this work (e.g. Doadrio 2001). Specifically, the bleak *Alburnus alburnus* has spread to almost the whole Iberian Peninsula and new records in the Ebro River basin have been reported recently (Vinyoles et al. 2007). In this study, additional new records are reported for the basin. In particular, middle stretches of the Arga and Gállego Rivers (sites 21 to 25 and 35 to 37 in Figure 1 and Annex 1) show the fast spread of the bleak in tributary rivers of the basin.

The pumpkinseed *Lepomis gibbosus* is considered an invasive species throughout the Iberian Peninsula (Gutierrez-Estrada et al. 2000; Doadrio 2001; Hermoso et al. 2008), but there are few records in the north of Spain (Oliva-Paterna et al. 2005). In fact, the pumpkinseed has only been reported in the Mequinenza Reservoir in Doadrio (2001) and from few other sites in the upper Ebro basin (Zaldivar 2006). In this study the pumpkinseed was collected in this Reservoir (sites 15 and 16), two sites close to this Reservoir (sites 52 and 55) and also in additional new localities in the upper Ebro basin (sites 1 and 2).

Regarding zander *Sander lucioperca*, this is the first published record in the Alcanadre River (Site 41), the Segre River (Site 58), or in the lower Ebro and Cinca River (Sites 15 and 52). This species has been recently cited in other Iberian locations (Perez-Bote et al. 2004, Perez-Bote and Roso-Romero 2009). The high piscivorous specialization of the zander could lead to a decline in stock of local endangered species (Doadrio 2001). It has been previously reported



**Figure 1.** Location of the sampled reaches without non-native (○) and with non-native (●) freshwater fishes the Ebro River basin.

in the literature that the zander has depleted stocks of native fishes in some areas where it has been introduced for angling (e.g. Innal and Erk'akan 2006).

Finally, new records of the European catfish *Silurus glanis* should be commented upon. This species has been cited in the Mequinenza Reservoir (Site 15, Doadrio 2001) and more recently in other Iberian rivers (Carol et al. 2003; Benejam et al. 2007). In this study European catfish is reported in the Cinca River (Sites 43, 44 and 52), upstream of the Mequinenza Reservoir, and in the upper Ebro River (Sites 5 to 7 and 11, Zaldivar 2006) more than 200 km northwest from this reservoir. It is supposed that the European catfish is spreading and may be present along this 200-km Ebro River stretch.

The adverse and unpredictable ecological consequences of non-native freshwater fish introductions lead Moyle et al. (1987) to call these impacts the “Frankenstein effect”. From the 28 exotic fish species introduced in European freshwaters, at least 25 are actually threatening

the survival and/or genetic integrity of the native Iberian species (Doadrio 2001). Along with the introduction of exotic invasive fish species, habitat degradation – i.e. via dam and weir construction, water extraction, river channelization, flow regime alteration, gravel extraction – and water pollution is the leading threat to the survival of the native – mostly endemic – Iberian freshwater fishes.

Although some of the non-native fishes mentioned above were originally legally introduced for experimental or sport-fishing purposes in under-controlled populations, the subsequent spread is mostly due to unauthorized and uncontrolled introductions by sport fishermen. Little efforts are being made in Spain for the control or eradication of illegally introduced non-native fishes even when adverse ecological impacts on native fishes are documented. The authors indicate that according to Spanish Law 42/2007, public administrations will act in order to avoid the introduction and spread of non-native (sub-) species since they

could compete with the native ones, alter their genetic integrity or alter the ecological balance.

Prevention measures should be taken by the administration to control the spread of non-native fishes to other river basins and moreover to avoid new introductions. This has not been the case with numerous previous introductions in the Iberian Peninsula, and in fact nowadays several species are being illegally spread by anglers to other waters (Benejam et al. 2005).

Invasive species are recognized as a leading cause of animal extinctions (Clavero and García-Berthou 2005) and subsequently increased attention is beginning to be paid to non-native.

### Acknowledgements

Authors are grateful to the Confederación Hidrográfica del Ebro (Ministerio de Medio Ambiente of Spain) which financed some of the surveys by means of several contracted technical reports. A. Agorreta, A. Amezcua, E. Beriain, M. Díez-León, L. Escuer, X. Esparza, D. Galicia, C. García-Fresca, S. Gaspar, L. González-Urbiola, C. Hurtado, M. Imas, S. Iñigo, A. Irujo, J. Lecumberri, J. Mateo, J. Molina, J. Muerza, O. Palacios, G. Redondo, L. Romeo, P. Verdonck, J.M. Vilches and M. Vilches collaborated during the field surveys.

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**Annex 1.** Additional records of non-native freshwater fishes in the Ebro River basin (Spain). (Aa: *Alburnus alburnus*; Am: *Ameiurus melas*; Ca: *Carassius auratus*; Cc: *Cyprinus carpio*; Se: *Scardinius erythrophthalmus*; Ms: *Micropterus salmoides*; Sg: *Silurus glanis*; Gh: *Gambusia hoolbrooki*; Lg: *Lepomis gibbosus*; Sl: *Sander lucioperca*; Rr: *Rutilus rutilus*; El: *Esox lucius*; Om: *Onchorhynchus mykiss*).

Place No. (map ref.)	River	Sample Station	Record coordinates		Record date	Species
			Latitude, N	Longitude, W		
1	Ebro	Sobrón	42°45'26"	03°05'05"	20/08/2008	Lg
2	Ebro	Ircio	42°39'20"	02°53'47"	13/06/2007	Lg
3	Ebro	El Ciego	42°29'43"	02°37'45"	19/08/2008	Aa
4	Ebro	Mendavia	42°25'04"	02°12'02"	12/08/2008	Aa
5	Ebro	Lodosa	42°25'09"	02°04'37"	12/08/2008	Sg
5	Ebro	Lodosa	42°25'09"	02°04'37"	09/07/2009	Aa
6	Ebro	Rincón de Soto	42°14'51"	01°50'03"	11/08/2008	Sg
6	Ebro	Rincón de Soto	42°14'51"	01°50'03"	07/07/2009	Aa
7	Ebro	Milagro	41°14'58"	01°50'05"	05/10/2005	Aa, Am, Ca, Cc, Ms, Sg
8	Ebro	Castejón	42°10'45"	01°41'20"	12/07/2007	Aa
9	Ebro	Tudela	42°03'59"	01°35'57"	27/04/2004	Cc
9	Ebro	Tudela	42°03'59"	01°35'57"	11/07/2007	Ca
9	Ebro	Tudela	42°03'59"	01°35'57"	11/08/2008	Am
10	Ebro	Gallur	41°52'14"	01°18'52"	25/08/2008	Aa, Am, Gh
11	Ebro	Luceni	41°49'54"	01°13'09"	11/10/2008	Aa, Cc, Gh, Sg
12	Ebro	Alagón	41°47'27"	01°08'11"	25/08/2008	Aa, Gh
13	Ebro	Zaragoza	41°39'09"	00°51'05"	25/08/2008	Aa, Gh
14	Ebro	Pina Dam	41°33'38"	00°40'49"	02/07/2009	Gh
15	Ebro	Soto del Pitón (Caspé)	41°14'58"	00°00'32"	12/10/2005	Aa, Cc, Lg, Sl, Sg
16	Ebro	Soto del Buisán (Caspé)	41°16'09"	00°01'55"	12/10/2005	Aa, Cc, Lg
17	Zadorra	La Puebla de Arganzón	42°45'59"	02°49'57"	21/08/2008	Aa
18	Ayuda	Lacorzanilla	42°40'50"	02°53'04"	25/07/2005	Cc
19	Ega	Cárcar	42°24'18"	01°58'58"	26/06/2006	Cc
20	Ega	San Adrián	42°20'11"	01°55'27"	09/07/2009	Aa
21	Arga	Barañain	42°47'53"	01°41'39"	24/10/2008	Aa, Am
21	Arga	Barañain			27/10/2006	Aa
22	Arga	La Magdalena Mill (Pamplona)	42°49'23"	01°38'16"	20/06/2008	Aa

## Annex 1 (continued).

Place No. (map ref.)	River	Sample Station	Record coordinates		Record date	Species
			Latitude, N	Longitude, W		
23	Arga	San Pedro Bridge (Pamplona)	42°49'28"	01°38'39"	20/06/2008	Aa
24	Arga	Echauri	42°47'29"	01°47'15"	10/05/2007	Aa, Am, Ca, Cc
25	Arga	Bidaurreta	42°46'03"	01°49'53"	10/05/2007	Aa, Am, Ca, Cc
26	Arga	Señorio de Sarria	42°42'13"	01°50'29"	20/10/2005	Am, Cc
27	Arga	Soto de la Muga(Peralta)	42°21'11"	01°46'37"	12/05/2009	Cc, Se
28	Arakil	Ibero	42°47'51"	01°46'01"	11/08/2008	Cc
28	Arakil	Ibero	42°47'51"	01°46'01"	07/08/2008	Aa, Cc, Ms
28	Arakil	Ibero	42°47'51"	01°46'01"	12/07/2007	Am
28	Arakil	Ibero	42°47'51"	01°46'01"	02/11/2007	Aa, Am, Ca
28	Arakil	Ibero	42°47'51"	01°46'01"	04/07/2007	Aa, Am
28	Arakil	Ibero	42°47'51"	01°46'01"	10/05/2007	Aa, Am, Ca, Cc
29	Irati	Liédena	42°36'16"	01°16'36"	15/06/2005	Aa, Gh
30	Zidacos	Olite	42°29'00"	01°38'28"	08/07/2009	Aa
31	Esca	Sigües	42°38'41"	01°00'44"	09/07/2008	Aa
32	Queiles	Los Fayos	41°52'25"	01°46'48"	18/07/2007	Cc
33	Jalón	Alhama de Aragón	41°18'28"	01°52'32"	05/05/2010	Gh
34	Gállego	Puendeluna	42°08'59"	00°45'20"	01/08/2006	El, Ms, Rr
35	Gállego	Ardisa Reservoir	42°10'48"	00°45'27"	27/07/2006	Aa, Cc, El, Rr
36	Gállego	Murillo de Gállego	42°19'08"	00°45'19"	29/09/2005	Aa, El
37	Gállego	Santa Eulalia	42°16'53"	00°44'56"	26/07/2006	Aa
38	Gállego	De La Peña Reservoir	42°22'60"	00°42'50"	27/09/2005	Cc, El, Rr
39	Flumen	Lalueza	41°50'54"	00°16'34"	10/08/2009	Aa, Rr
40	Aguasvivas	Almochuel	41°16'45"	00°32'57"	23/06/2008	Gh
41	Alcanadre	Ontiñena	41°40'47"	00°05'33"	02/08/2007	Aa
41	Alcanadre	Ontiñena	41°40'47"	00°05'33"	03/08/2009	Sl
42	Ésera	Desembocadura	42°06'05"	00°14'40"	06/08/2009	Aa
43	Cinca	El Grado	42°06'19"	00°13'58"	22/07/2008	Sg
44	Cinca	Puente de Las Pilas	42°03'56"	00°12'59"	21/06/2006	Sg
45	Cinca	Ariéstolas	41°57'48"	00°10'36"	15/11/2004	Cc, Om
46	Cinca	Monzón	41°54'41"	00°10'30"	15/11/2004	Aa
46	Cinca	Monzón	41°54'41"	00°10'30"	22/07/2008	Cc, Gh
47	Cinca	Conchel	41°52'54"	00°08'44"	15/11/2004	Aa, Cc, Ms
48	Cinca	Albalate	41°43'13"	00°08'29"	12/11/2004	Aa
49	Cinca	Chalamera	41°40'01"	00°10'15"	12/11/2004	Aa, Cc
50	Cinca	Zaidín	41°36'07"	00°15'15"	08/04/2003	Aa
51	Cinca	Velilla de Cinca	41°35'27"	00°16'21"	11/04/2003	Aa, Cc
52	Cinca	Fraga	41°32'36"	00°20'02"	12/11/2004	Aa, Cc, Ms, Sg, Lg, Sl
53	Guadalope	Perçuñar	41°10'00"	00°01'41"	14/10/2005	Aa, Cc
54	Guadalope	Miraflores	41°11'41"	00°01'45"	14/10/2005	Aa
55	Guadalope	Guadalope Mouth (Caspe)	41°14'51"	00°00'15"	12/10/2005	Aa, Gh, Lg
56	Matarraña	Nonaspe	41°12'40"	00°14'49"	13/10/2005	Aa
57	Segre	Balaguer Below Rialb	41°47'35"	00°48'27"	08/06/2004	Cc
58	Segre	Reservoir Dam (Gualter) Below Rialb	41°56'17"	01°11'41"	20/10/2006	Aa, Cc, Rr, Sl
58	Segre	Reservoir Dam (Gualter) Below Rialb	41°56'17"	01°11'41"	08/11/2005	Aa, Cc, Rr, Sl
58	Segre	Reservoir Dam (Gualter)	41°56'17"	01°11'41"	03/10/2003	Cc, Sl