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Short communication

Additional records of eastern mosquitofish *Gambusia holbrooki* (Girard, 1859) for the River Ebro basin (Spain)

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Abstract

Since the first authorised introductions to Spain in 1921 of the Eastern mosquitofish *Gambusia holbrooki* (Girard, 1859), this North American freshwater fish species has invaded large parts of several Iberian basins. For the River Ebro basin, we report 24 new records of this exotic species between 2005 and 2007 which represents a considerable expansion. Potential negative implications for aquatic invertebrate and fish communities are discussed.

Key words: aquatic invasive species, biological invasion, range expansion, Iberian Peninsula

Eastern mosquitofish *Gambusia holbrooki* (Girard, 1859) is one of many small-bodied fish species of the family Poeciliidae. Native to North America, it inhabits still or slow-flowing waters, preferably with dense aquatic vegetation and may survive in very polluted waters by taking oxygen from uppermost water layers. Its native North American distribution extends from the Delaware drainage in the North to Florida and Alabama in the South, but it has been introduced to many countries world-wide. In Europe, it was first introduced in Spain 1921 by health authorities in the hope that it would control mosquitoes (vectors of various diseases such as malaria) by preying on their larvae (De Sostoa and Lobón-Cervia 1989; Doadrio 2001; Kottelat and Freyhof 2007). However, there is no evidence that it has had any impact on mosquitoes. Presently, mosquitofish is established in many warmwater systems throughout southern Europe, including the Atlantic coast of France as far north as the Loire estuary, and it is locally present in the southern Caspian basin as well as coastal areas of Black Sea basin (Kottelat and Freyhof 2007).

In Spain, Eastern mosquitofish is widely established (Elvira 1998), and in the River Ebro basin it had been recorded for some Catalonian and Basque rivers (Doadrio 2001) as well as in the lower- and upper extents of the Ebro's drainage but not between them. More recently, its presence and distributions was reported (Zaldivar 2006) from rivers of La Rioja province (Figure 1), although this species was not found in a previous study from the same author (Zaldivar 1994). In different monitoring studies (fish community surveys by electrofishing and biological water quality assessment by macroinvertebrate hand-netting) carried out between 2005 and 2007, individuals of eastern mosquitofish were captured in various rivers and localities within the River Ebro basin (Annex 1). These 24 new records show that Eastern mosquitofish is now widespread throughout most of the River

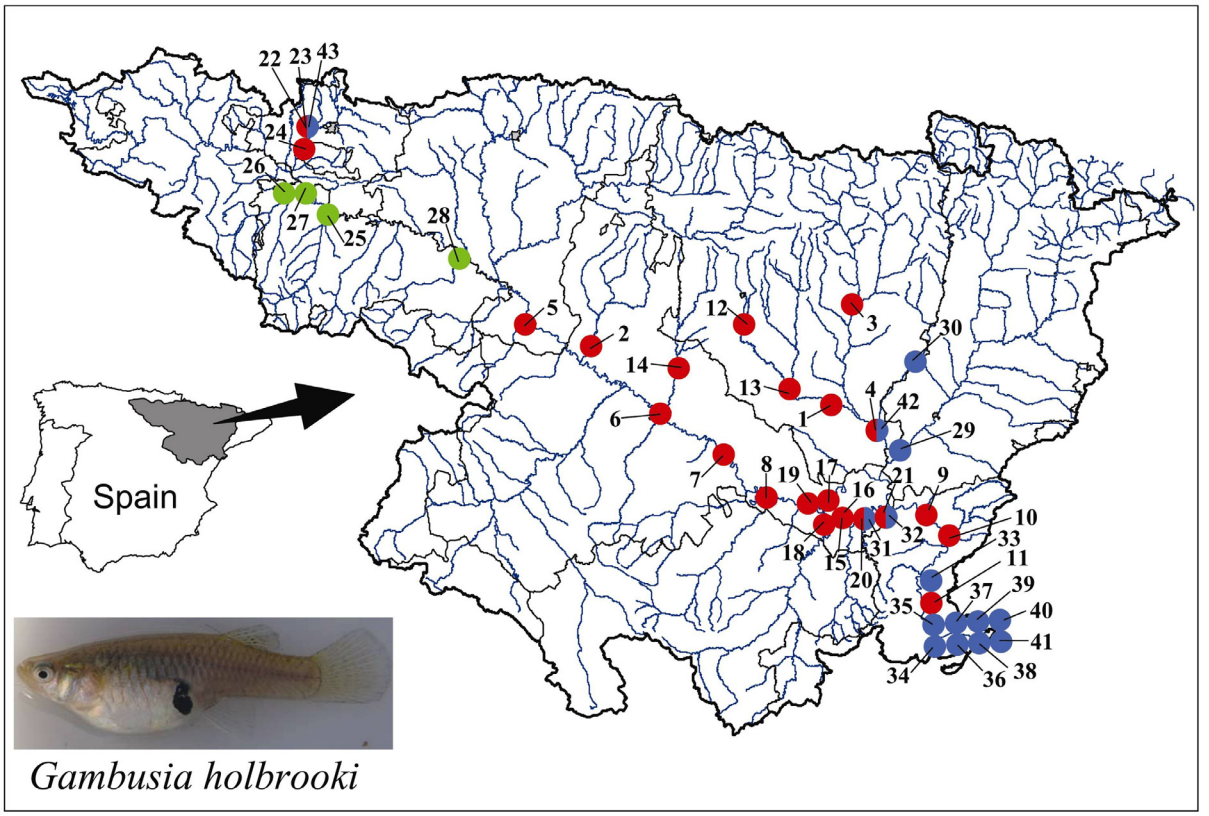

Figure 1. Presence of *Gambusia holbrooki* in River Ebro basin (Blue circles: Doadrio (2001); Green circles: Zaldivar (2006); Red circles: This study. See Annex 1 for additional information).

Ebro basin (Figure 1) and is likely to continue spreading, as it is considered as a superior invader (Rehage and Sih 2004).

Mosquitofish have been demonstrated to have a detrimental impact on native fish species of the genera *Valencia* and *Aphanius*, which are endemic to Iberia (Caiola and de Sostoa 2005). The impacts include predation on eggs and larvae, exploitative competition for food and behavioural interference (direct aggression, disruption of courtship) (Rincón et al. 2002; Alcaraz et al. 2008). The diet of eastern mosquitofish varies both temporally and spatially, but generally consists of aquatic and terrestrial invertebrates, filamentous algae and detritus (Specziár 2004). In lakes, rice fields or wetlands, the diet has been reported to consist mainly of microinvertebrates (copepods, cladoceran, ostracods and rotifers) and adult (imago) chironomids (Garcia-Berthou 1999; Meiro et al. 2001; Blanco et al. 2004). Competitive advantage over native fishes may be due to the mosquitofish's high individual specialisation (Specziár 2004), with the potential for considerable predation impacts on zooplankton community structure when the mosquitofish occurs in high population densities (Margaritora et al 2001; Meiro et al 2001). Changes in the zooplanktonic community could also negatively affect native fish species using this trophic resource, and therefore further research is necessary to evaluate the direct and indirect impacts of the Eastern mosquitofish on the local aquatic invertebrate and fish communities of the Ebro basin in order to inform conservation and management strategies.

Usually, implementing regulations and augmenting control that limit stocking opportunities along with increasing the public's awareness about the negative and unpredictable consequences of releasing exotic species (Elvira and Almodóvar 2001; Rahel 2007) are recom-

mended measures to avoid the spread of exotic fish species. However, such measures unlikely will suffice with highly successful invaders such as Eastern mosquitofish. Unfortunately, biological population control of Eastern mosquitofish is well beyond present capabilities and therefore future research should focus on the most efficient, species-selective and cost-effective tools to conduct mass removals.

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References

Alcaraz C, Bisazza A, García-Berthou E (2008) Salinity mediates the competitive interactions between invasive mosquitofish and an endangered fish. *Oecologia* 155(1): 205-213, http://dx.doi.org/10.1007/s00442-007-0899-4

Blanco S, Romo S, Villena MJ (2004) Experimental study on the diet of mosquitofish (*Gambusia holbrooki*) under different ecological conditions in a shallow lake. *International Reviews in Hydrobiology* 89(3): 250-262, http://dx.doi.org/10.1002/iroh.200310684

Caiola N, de Sostoa A (2005) Possible reasons for the decline of two native toothcarps in the Iberian Peninsula: Evidence of competition with the introduced Eastern mosquitofish. *Journal of Applied Ichthyology* 21: 358-363, http://dx.doi.org/10.1111/j.1439-0426.2005.00684.x

De Sostoa A, de Sostoa FJ, Lobón-Cervia J, Elvira B, Hernando JA, Avila M (1984) Atlas y distribución de los peces de agua dulce de España: El proyecto, métodos y resultados preliminares. *Boletín de la Estación Central de Ecología* 13(25): 75-81

De Sostoa A, Lobón-Cervia J (1989) Fish and fisheries of the River Ebro: actual state and recent history. In: G.E. Petts (ed), Historical change of large alluvial rivers: Western Europe, John Wiley and Sons Ltd, pp 233-247

Doadrio I (2001). Atlas y libro rojo de los peces continentales de España. Dirección General de Conservación de la Naturaleza y Museo Nacional de Ciencias Naturales, Madrid

Elvira B (1998) Impact of introduced fish on the native freshwater fish fauna of Spain. In: Cowx IG (ed) Stocking and introduction of fish, Fishing News Books, Oxford

Elvira B, Almodóvar A (2001) Freshwater fish introductions in Spain: facts and figures at the beginning of the 21st century. *Journal of Fish Biology* 59: 323-331, http://dx.doi.org/10.1111/j.1095-8649.2001.tb01393.x

Garcia-Berthou E (1999) Food of introduced mosquitofish: ontogenetic diet shift and prey selection. *Journal of Fish Biology* 55: 135-147, http://dx.doi.org/10.1111/j.1095-8649.1999.tb00663.x

Kottelat M, Freyhof J (2007) Handbook of European Freshwater Fishes. Kottelat Publications, Berlin

Margaritora FG, Ferrara O, Vagaggini D (2001) Predatory impact of the mosquitofish (*Gambusia holbrooki* Girard) on zooplanktonic populations in a pond at Tenuta di Castelporziano (Rome, Central Italy). *Journal of Limnology* 60(2): 189-193

Meiro CL, Cabral JA, Marqués JC (2001) Predation pressure of introduced mosquitofish (*Gambusia holbrooki* Girard), on the native zooplankton community. A case-study from representative habitats in the lower Mondego river Valley (Portugal). *Limnetica* 20(2): 279-292

Rahel FJ (2007). Biogeographic barriers, connectivity and homogenization of freshwater faunas: it's a small world after all. *Freshwater Biology* 52: 696-710, http://dx.doi.org/10.1111/j.1365-2427.2006.01708.x

Rehage JS, Sih A (2004) Dispersal behavior, boldness, and the link to invasiveness: a comparison of four *Gambusia* species. *Biological Invasions* 6: 379-391, http://dx.doi.org/10.1023/B:BINV.0000034618.93140.a5

Rincón PA, Correas AM, Morcillo F, Risueño P, Lobón-Cerviá J (2002) Interaction between the introduced eastern mosquitofish and two autochthonous Spanish toothcarps. *Journal of Fish Biology* 61: 1560-1585, http://dx.doi.org/10.1111/j.1095-8649.2002.tb02498.x

Specziár A (2004) Life history pattern and feeding ecology of the introduced eastern mosquitofish, *Gambusia holbrooki*, in a thermal spa under temperate climate, of Lake Hévíz, Hungary. *Hydrobiologia* 522: 249-260

Zaldivar C (1994) Atlas de distribución de los peces de la comunidad autónoma de La Rioja. *Zubia Monográfico* 6: 71-102

Zaldivar C (2006) Guía de los peces de La Rioja. Gobierno de La Rioja, Consejería de Turismo, Medio Ambiente y Política Territorial, Dirección General de Medio Natural. Logroño

Annex 1. Records of *Gambusia holbrooki* in River Ebro basin (Spain).

Record No. (map ref.)	River	Sample Station	Record coordinates		Elevation, m	Record date	Reference
			Latitude	Longitude			
1	Alcanadre	Ontiñena	41º40'47"N	00º05'33"E	158	29 August 2005 2 August 2007	This study
2	Arba de Luesia	Tauste	41º54'49"N	01º16'45"W	232	13 July 2005	This study
3	Cinca	Las Pilas Bridge	42º03'56"N	00º12'59"E	334	20 August 2007	This study
4		Fraga	41º31'23"N	00º20'52"E	95	2 August 2007	This study
5	Ebro	Tudela	42º03'59"N	01º35'57"W	246	11 July 2007	This study
6		Zaragoza	41º39'09"N	00º51'05"W	190	20 July 2006	This study
7		Pina de Ebro	41º28'49"N	00º32'10"W	157	4 August 2005 26 July 2007	This study
8		Azud de Rueda	41º17'43"N	00º19'07"W	125	1 August 2005 24 July 2007	This study
9		Flix	41º14'02"N	00º32'53"E	35	20 September 2005	This study
10		Mora de Ebro	41º05'21"N	00º38'55"E	30	20 September 2005	This study
11		Tortosa	40º48'45"N	00º31'06"E	10	20 September 2005	This study
12	Flumen	Barbues	41º58'56"N	00º25'22"W	338	17 August 2005	This study
13		Sariñena	41º45'24"N	00º10'59"W	243	29 August 2005	This study
14	Gallego	Villanueva de Gállego	41º49'23"N	00º47'04"W	245	29 August 2007	This study
15	Guadalope	Salto de la Cierva	41º10'12"N	00º01'47"E	155	14 October 2005	This study
16		Km 64 (A-221)	41º11'54"N	00º02'23"E	145	14 October 2005	This study
17		Mequinenza Reservoir	41º15'08"N	00º00'23"E	135	12 October 2005	This study
18		Caspe	41º12'30"N	00º00'40"W	88	27 July 2005	This study
19		Palanca – Caspe	41º14'33"N	00º02'34"W	85	27 July 2005	This study
20	Matarraña	Fabara	41º12'11"N	00º11'45"E	215	13 October 2005	This study
21		Nonaspe	41º12'41"N	00º15'48"E	140	13 October 2005	This study
22	Zadorra	Villodas	42º50'02"N	02º46'56"W	490	19 June 2007	This study
23		Nanclares de la Oca	42º48'45"N	02º48'50"W	475	6 September 2005	This study
24		La Puebla de Arganzón	42º45'59"N	02º49'57"W	470	6 September 2005	This study
25	Ebro	Cenicero	42º29'04"N	02º38'27"W	410	16 September 2002	Zaldivar (2006)
26	Tirón	Cihuri	42º34'12"N	02º55'01"W	480	21 September 2002	Zaldivar (2006)
27		Haro	42º34'52"N	02º52'37"W	450	21 September 2002	Zaldivar (2006)
28	Highway Pond	Near A-68 Highway	42º17'18"N	01º57'16"W	330	18 August 2004	Zaldivar (2006)

Annex 1 (continued).

Record No. (map ref.)	River	Sample Station	Record coordinates		Elevation, m	Record date	Refefence
			Latitude	Longitude			
29*	Segre	Lower Segre	41º28'37"N	00º25'30"E	-	16 November 1950	Doadrio (2001)
30*	Noguera Ribagorzana	Sta. Ana Reservoir	41º50'22"N	00º31'51"E	500	Before 1989	De Sostoa and Lobón-Cervia (1989) Doadrio (2001)
31*	Matarraña	Near Nonaspe	41º12'05"N	00º11'50"E	-	Before 2001	Doadrio (2001)
32*		Fayón	41º12'15"N	00º18'59"E	95	Before 1989	De Sostoa and Lobón-Cervia (1989) Doadrio (2001)
33*	Ebro	Upstream Tortosa	40º56'22"N	00º33'53"E	-	Before 2001	Doadrio (2001)
34*		Ebro River Delta	40º40'10"N	00º34'29"E	-	Before 1984	De Sostoa et al (1984) Doadrio (2001)
35*		Ebro River Delta	40º45'35"N	00º34'17"E	-	Before 1984	De Sostoa et al (1984) Doadrio (2001)
36*		Ebro River Delta	40º40'19"N	00º41'34"E	-	Before 1984	De Sostoa et al (1984) Doadrio (2001)
37*		Ebro River Delta	40º45'43"N	00º41'23"E	-	Before 1984	De Sostoa et al (1984) Doadrio (2001)
38*		Ebro River Delta	40º40'27"N	00º48'40"E	-	Before 1984	De Sostoa et al (1984) Doadrio (2001)
39*		Ebro River Delta	40º45'52"N	00º48'29"E	-	Before 1984	De Sostoa et al (1984) Doadrio (2001)
40*		Ebro River Delta	40º45'59"N	00º55'35"E	-	Before 2001	Doadrio (2001)
41*		Buda Island (Ebro Delta)	40º40'35"N	00º55'46"E	-	22 January 1972	Doadrio (2001)
42*	Cinca	Lower Cinca	41º33'51"N	00º18'06"E	-	Before 2001	Doadrio (2001)
43*	Zadorra	Downstream Vitoria	42º51'24"N	02º48'59"W	-	Before 2001	Doadrio (2001)

*Record coordinates calculated in the center of the UTM square of 10x10 km given by the reference authors.