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Rapid Communication

Updating the distribution data of recently introduced freshwater fish in the Guadalquivir River Basin (Spain)

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Abstract

We report new distribution data on four recently introduced species in the Guadalquivir River basin: chameleon cichlid (*Australoheros facetus* Jenyns, 1842), North American black bullhead (*Ameiurus melas* Rafinesque, 1820), European catfish (*Silurus glanis* Linnaeus, 1758) and a minnow species of unknown origin (*Phoxinus* spp.). A compilation of records is used to update the distribution range of these species. The information collected reinforces the evidence on the establishment and expansion of these non-native species. We recommend new field sampling to identify the dispersal pathways and to clarify their current statuses.

Key words: exotic species, Mediterranean rivers, invasive, *Australoheros facetus*, *Ameiurus melas*, *Phoxinus* ssp., *Silurus glanis*

Introduction

Introductions of non-native species are recognized as one of the main threats for freshwater biodiversity worldwide (Gozlan et al. 2010). The impacts caused by the arrival of new species are highly diverse and depend primarily on the introduced species and habitat features (Ribeiro and Leunda 2012). In arid and semi-arid regions (e.g. Mediterranean basin) where water demand for human uses is high (Cowx and Collares-Pereira 2002), the number of reservoirs has reached almost a maximum, and consequently, the number of non-native species and their distribution range is increasing. Thus, Iberian inland waters are among the most invaded ecosystems within the Mediterranean region and fish introductions are considered a major threat to native ichthyofauna which comprise a high proportion of endemic species (Ribeiro and Leunda 2012).

Guadalquivir River basin is highly important in terms of biodiversity and number of threatened taxa (Doadrio 2001), as around 50% of the native species recorded in the basin are included in an IUCN-2015 category. Yet, the current ichthyofauna of the basin contains large proportion of introduced species. Fernández-Delgado et al. (2014) detected up to 14 non-native species showing a higher richness than natives ones

(13 species). A recent study also determined high non-native species richness (10 *vs*. 9 for native and introduced species respectively; see Ramos-Merchante and Prenda 2018). These and other studies (García de Lomas et al. 2009; Moreno-Valcárcel et al. 2013) revealed the recent detection of several species with high invasive potential such as chameleon fish (*Australoheros facetus* Jenyns, 1842), North American black bullhead (*Ameirus melas* Rafinesque, 1820) and European catfish (*Silurus glanis* Linnaeus, 1758). These species are included in the rank lists of the most invasive alien species (IAS) because their potential threat to biodiversity (Clavero 2011; van der Veer and Nentwig 2015; Carboneras et al. 2018). Therefore, updated knowledge about new introductions and their distribution ranges is essential to detect new threats and implement appropriate conservation strategies.

Here we provide new distribution data on the three recently introduced species: *Australoheros facetus*, *Ameirus melas* and *Silurus glanis* in the Guadalquivir River basin (South Spain) and also report the first record of an invasive species belonging to the genus *Phoxinus* in this basin.

Materials and methods

The Guadalquivir is the fifth longest river in the Iberian Peninsula, situated in the south of Spain, running in a dominant east-west direction to the Atlantic Ocean. The main channel is 680 km long, with a drainage area of 57439 km^2. Based on non-native species distribution data from other studies (García de Lomas et al. 2009; Moreno-Valcárcel et al. 2013; Fernández-Delgado et al. 2014) we compiled information from two data sources (field sampling and anglers' records) in order to update the current distribution of *Australoheros facetus*, *Ameirus mel*as, *Silurus glanis* and *Phoxinus* spp. in the basin.

Firstly, during the course of a research project on fish fauna distribution in Guadalquivir River basin (see acknowledgements for details) we conducted a field sampling at 285 locations over the entire basin (216 in rivers and 69 in reservoirs) between June 2007 and July 2008 (Figure 1A). Depending on location width and depth, two alternative sampling methods were used. Typical stream sites with low salinity (< 1.5 mS cm^{-1}) and shallow depth (< 1.2 m) were electrofished by wading upstream along a channel length of 100 m during approximately one hour. The equipment comprised a control box delivering a pulsed direct current, 300/600 V, 4–6 A without block nets (Electracatch International, Honda EU 20i motor with a WF6 rectifier and a landing net with a 30 cm diameter and a 4 mm mesh size). When the salinity and depth conditions did not allow electrofishing, mainly in large rivers and reservoirs, we used four types of passive traps: trammel nets, fyke nets, minnow traps and plastic bottle minnow traps. Two trammel nets (10 m × 2 m, 175 mm × 25 mm and 200 mm × 20 mm

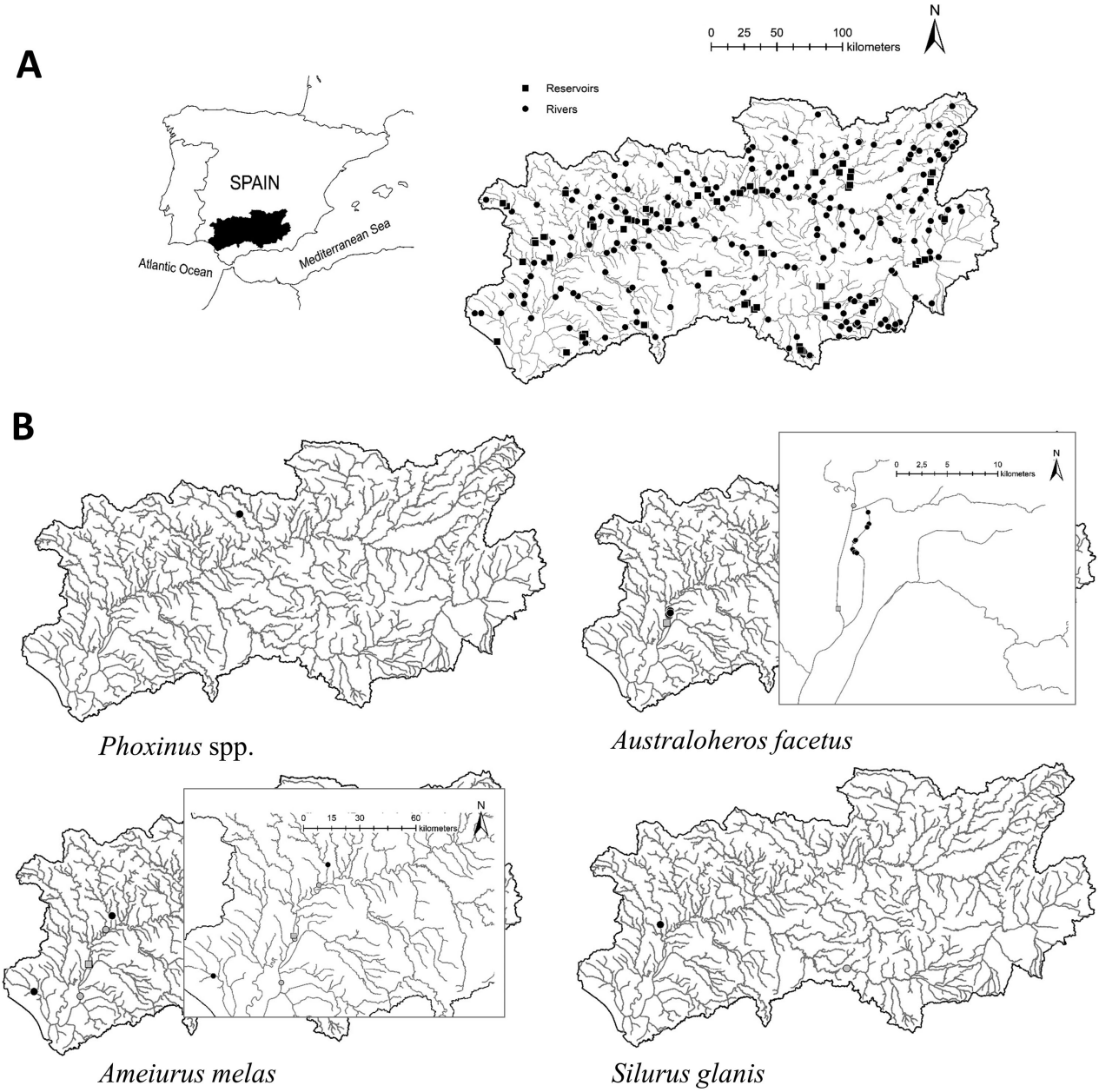

Figure 1. Map of the Guadalquivir River Basin and geographical locations of the records for each species. Dark circles represent the new records described in this study. Grey circles and squares correspond to the previous records reported by Fernández-Delgado et al. 2014 and García de Lomas et al. 2009 respectively. Fine-scale is shown for *Australoheros facetus* and *Ameiurus melas*. For details see Supplementary material Table S1.

mesh size), three pairs of fyke nets (12 mm and 3 mm mesh size), fifteen metal minnow traps (6 mm mesh size) and ten pairs of plastic minnow traps (25 mm inlet) were set for a minimum of 8 h (see Clavero et al. 2006 for more details). After capture, fish were identified to species level, counted, measured and returned live to the river.

Secondly, we completed the information obtained in the field samplings with extensive searches on different social media websites (e.g. YouTube, Facebook), recreational fisheries forums, blogs and search engines (i.e. Google) to obtain records of the studied species. In addition, we sent a request for information on records of the species under study to fisheries

websites. Following the Gago et al. (2016) criteria, we performed a Boolean search between July 2010 and October 2015 using a combination of different keywords, including scientific and common names in Spanish (i.e. chanchito, pez gato, siluro, piscardo) and river name (Guadalquivir). Species records were accepted only when it included the locality, year and accompanying media (picture or video) (see Gago et al. 2016 for details). We interviewed, whenever possible, the angler who reported the information to confirm this and avoid double counting. The geographical coordinates were extracted from Google Earth Pro. Finally, we added to the database a remarkable sighting of North American black bullhead that we made in the Doñana National Park, a highly protected area in the lower section of the basin.

Results and discussion

A total of 18 records were obtained in the Guadalquivir River basin (Supplementary material Table S1), with fishing forum websites representing the main source of information with 46.2% of the total records. A single record was never detected in more than one data source (i.e. duplicate records). Chameleon cichlid was the species with the highest number of records (69%) and the species with the highest number of specimens registered was the North American black bullhead (> 2000) (Table S1). During the fish sampling, other 8 non-native species well known in previous studies were also collected (Doadrio 2001; Vinyoles et al. 2007): *Oncorhynchus mykiss* (Walbaum, 1972), *Alburnus alburnus* (Linnaeus, 1758), *Carassius auratus* (Bloch, 1782), *Cyprinus carpio* (Linnaeus, 1758), *Gobio lozanoi* (Doadrio and Madeira, 2004), *Gambusia holbrooki* (Girard, 1859), *Lepomis gibbosus* (Linnaeus, 1758) and *Micropterus salmoides* (Lacépède, 1802).

Phoxinus *spp.*

Traditionally, minnow populations from the Iberian Peninsula have been identified as *Phoxinus phoxinus* (Linnaeus, 1758) (Doadrio 2001). However, Kottelat (2007) reclassified these populations as *P. bigerri*. Since the author did not analyse samples from Iberia he suggests caution identifying these populations. The Iberian distribution includes some rivers in the Cantabrian Mountains and the Ebro River basin (Kottelat and Freyhof 2007). However, the origin (native or introduced) of Atlantic populations is unknown due to continuous introductions carried out by anglers (e.g. Cantabrian Rivers and Douro basin) who use the species as live bait or as food for trout (Doadrio and Garzón 1986; Doadrio 2001; SIBIC 2014). Moreover, species from *Phoxinus* genus can reproduce and generate hybrids, even intergeneric hybrids (Eisenhour and Piller 1997). For this reason, identifications based on morphometric characteristics can be misleading and genetic analysis represent the most reliable tool. Three individuals from *Phoxinus* genus were collected on May 1st 2008 (Table S1) in a right bank tributary of the

Figure 2. Minnow (*Phoxinus* spp.) specimens captured in the Guadalquivir basin (only two are shown) during the field session with emerging spawning characteristics: bright colours, reddish base of fins, darker band on the flanks, and yellow spots on the operculum.

Guadalquivir (Guadalbarbo River; Figure 1). Morphological measures taken from the sampled specimens (e. g. distance between the end of the first and last ray branched of the anal fin, see Kottelat 2007) did not allow unambiguous identification of the species since they could correspond to both *P. phoxinus* and *P. bigerri* as well as commercial hybrids. On this basis, we consider this population as *Phoxinus* spp. until additional studies based on genetic analysis can clarify this issue. The fish exhibited bright colours and emerging spawning characteristics, such as a reddish abdomen and base of fins, a darker band on the flank, yellow spots on the operculum with intensive colour and head tubercles (Figure 2), and thus reproduction is highly likely. After the capture, individuals were measured to the nearest 1 mm and weighed to the nearest 0.01 g. Length and weight measurements were: 44, 56 and 55 mm and 0.83, 1.70 and 1.60 g, respectively. Three native species: Iberian arched-mouth nase (*Iberochondrostoma lemmingii* – Steindachner, 1866), southern Iberian barbel (*Luciobarbus sclateri* – Günther, 1868), and calandino (*Iberocypris alburnoides* – Steindachner, 1866) and one non-native species, bleak (*Alburnus alburnus* – Linnaeus, 1758), were also captured in the same locality. Subsequent sampling has confirmed the establishment of a minnow population in this location (referred to as *P. phoxinus*, see Fernández-Delgado et al. 2014). The specimens were preserved in the ichthyological collection of the Department of Integrative Sciences (University of Huelva, Spain).

Chameleon cichlid – Australoheros facetus *(Jenyns, 1842)*

Chameleon cichlid was identified in the Guadalquivir River for the first time in 2007 during the implementation of control measures on non-native

Chinese mitten crab (*Eriocheir sinensis*) (see García de Lomas et al. 2009). Between 7 Oct. 2010 and 10 Mar. 2015, we have compiled in the same river section 9 new records, via angler captures, corresponding to 12 individuals (Table S1). These new records provide evidence on the survival and establishment of an emerging population in this locality (Seville city, Guadalquivir dock; Figure 1). Specimens of *A. facetus* captured coincide with identification characters reported by Doadrio (2001) and Fernández-Delgado et al. (2014); the dorsal fin is composed by 15–17 hard and 9–11 soft rays, the anal fin shows 5–6 hard rays and the caudal fin is rounded with a dark spot at the base. Some of these captures corresponded to reproductive individuals (> 20 cm) building nests in shallow areas (PS, *pers. obs.*). The chameleon cichlid is a highly valued species by aquarist, lacking any sporting value.

North American black bullhead – Ameiurus melas *(Rafinesque, 1820)*

The species was first detected in the lower part of the Guadalquivir River basin in 2007 (García de Lomas et al. 2009) and subsequently it has dispersed both upstream and downstream from this location (Fernández-Delgado et al. 2014). We report data from two new localities (Table S1). The first locality corresponds to the Viar River, a right bank tributary of the Guadalquivir (Figure 1) where the species first appeared in the spring of 2009 via angler captures. This species is currently reproducing in this location and has been observed performing parental care behaviours (*i.e.* guarding; PS, *pers. obs.*).

The second sub-basin corresponds to the Doñana National Park. On the 26th of July 2016 we observed a large shoal of bullhead individuals in the "La Rocina", a shallow freshwater inland marsh (Figures 1, 3). During the sighting we were able to capture by hand some specimens for identification purposes and we estimate, based on field observation, abundance around several thousands of individuals (Figure 3).

Specimens of *A. melas* collected in the Guadalquivir basin coincide with identification reported by Elvira (1984) and Cucherousset et al. (2006): D I/6, P I/7, V 8, A 19–21 and C 19–20. Its presence in Doñana has been known since 2010 (MA Bravo, *pers. comm.*), however, during the last few years the species is spreading throughout the lower sections of the basin (Fernández-Delgado et al. 2014), where environmental conditions are most appropriate for the species (*i.e.* lentic or low-flow habitats with a mud substrate).

European catfish – Silurus glanis *(Linnaeus, 1758)*

This species, the largest European freshwater fish, reaches sizes up to 5 meters in length and more than 100 kilograms in weight. In the Iberian Peninsula this species was detected for the first time in 1974 in the Ebro River (Doadrio 2001). It is considered a serious threat to aquatic ecosystems (Copp

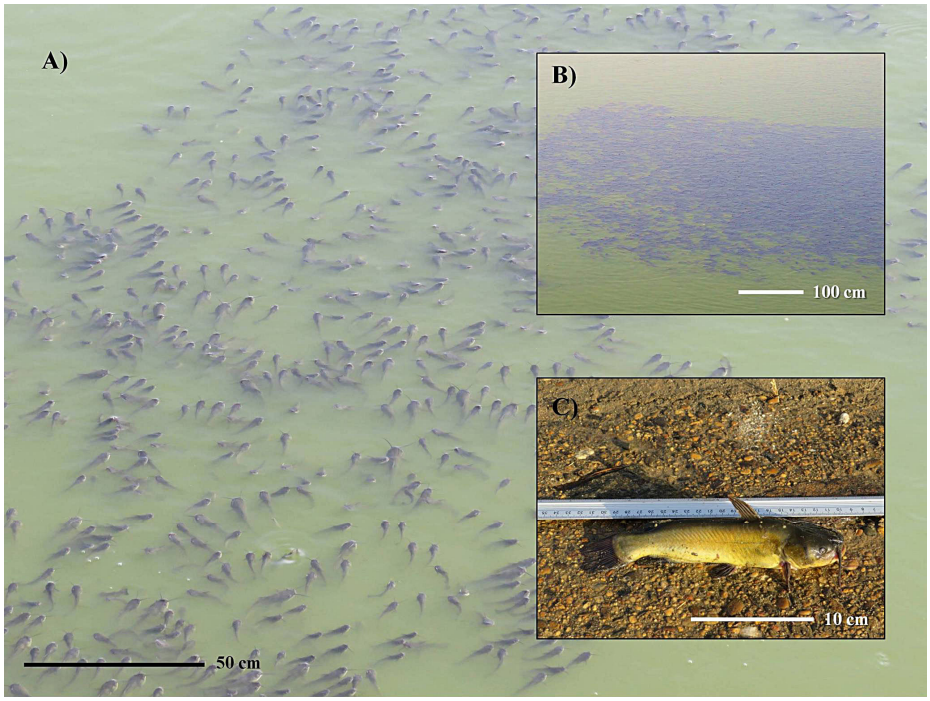

Figure 3. Near (a) and distant (b) views of a large group (> 2000) of young North American black bullheads in Doñana National Park (SW Spain). Many adults (> 20 cm length) were also found in the group (c).

et al. 2009). The first record of this species in the Guadalquivir was in 2011 in Iznájar reservoir, the largest in the basin (Moreno-Valcárcel et al. 2013). We report a new locality located 250 km downstream from Iznájar reservoir, in a lower stretch of a Guadalquivir right bank tributary (Rivera de Huelva; Figure 1). This new record, via angler captures in February 2015, corresponds to 3 adult individuals. Specimens were identified following Kobayakawa (1989) and Kottelat and Freyhof (2007). The weights of these specimens ranged from 3 to 8 kg. Until now, there was no evidence of the European catfish presence outside the Iznájar reservoir.

Concluding remarks

The information collected in this study provides evidence on the reproduction of three non-native species in the Guadalquivir River basin (*Phoxinus* spp., Chameleon cichlid and North American black bullhead). Therefore, the establishment of these species in different sections of the basin is highly likely. The presence of these invasive species (Leunda 2010) in different sections of the basin can be confirmed and their distribution ranges will probably increase in the next few years. Regardless of the taxonomy of *Phoxinus* specimens collected in this study, this genus has a high invasive potential in the Iberian Peninsula (see Clavero 2011). For this reason, the knowledge of this population by researchers and wildlife managers can help to avoid its expansion because there is currently only one population located in a small tributary. At the same time, genetic analyses and new samplings of this population are necessary to set the

taxonomy of this species. European catfish have been detected many kilometres downstream from the first recorded site, and there are no records between the two areas, so their presence there is likely to be due to new introductions. This species constitute a great threat to native fish fauna due to its voracity and wide dietary range, comprising up to 53 freshwater fish species reported by Copp et al. 2009. It is therefore critical to increase sampling effort, to improve our knowledge about the invasion degree by this species of the Guadalquivir basin.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Record list collected for each species including latitude and longitude in decimal degrees (coordinates), number of specimens (N), river name and data source.

This material is available as part of online article from:
http://www.reabic.net/journals/bir/2019/Supplements/BIR_2019_Saez-Gomez_Prenda_Table_S1.xlsx