Limnologica 51 (2015) 63–69

Contents lists available at ScienceDirect

Limnologica

journal homepage: www.elsevier.com/locate/limno

Live bait capture and crayfish trapping as potential vectors for freshwater invasive fauna

Filipe Banha*, Pedro Manuel Anastácio

MARE – Marine and Environmental Sciences Centre, Departamento de Paisagem, Ambiente e Ordenamento, Escola de Ciências e Tecnologia, Universidade de Évora, Rua Romão Ramalho, no. 59, 7000-671 Évora, Portugal

ARTICLE INFO

Article history:
Received 15 October 2014
Received in revised form
26 December 2014
Accepted 29 December 2014
Available online 7 January 2015

Keywords:
Biological invasions
Human vectors
Dispersal
Fishing activities
Desiccation survival
Fishing methods

ABSTRACT

Fishing activities strongly contribute to biological invasions in freshwaters. The purpose of this study was to investigate the potential risks of live bait capture using dip nets and of crayfish trapping as vectors for invasive freshwater macrofauna dispersal. In the Tagus river basin (Portugal), where both activities are common, we evaluated the probability of capture and the electivity of the local aquatic macrofauna according to the method used. During the compulsory removal of the invasive species captured we also quantified fish desiccation survival capacities. We found, for both vectors, that the species exhibiting the highest probability of capture and the highest electivity were invasive, respectively, *Gambusia holbrooki* and *Crangonyx pseudogracilis* with the dip net, *Procambarus clarkii* and several invasive species with special relevance for *Ameiurus melas* with the crayfish trapping. Moreover, the desiccation survival capacities, of all invasive fishes analyzed, are compatible with long distance dispersal out of water, with special relevance to *G. holbrooki*. This study demonstrates that fishing activities contribute to long-distance dispersal of invasive fauna. Therefore, according to our findings, it is important to update the fishing regulation and simultaneously to raise fishermen awareness of this problem.

Introduction

The introduction and spread of invasive species is currently considered one of the major drivers in biodiversity loss worldwide (Moyle and Light, 1996; Pimentel et al., 2000; Strayer, 2012). In freshwater environments, this problem plays a crucial role (Ricciardi and MacIsaac, 2000) since these habitats are one of the major biodiversity reservoirs (Costanza et al., 1997). Thus, since the eradication of invasive species is rarely achieved (Costanza et al., 1997; Moyle, 2001; Simberloff, 2001, 2003), the prevention of invasion by acting on vector management is decisive. Therefore, the knowledge of the dispersal mechanisms is very important (Bohonak and Jenkins, 2003; Crooks and Soulé, 1999). Intentional introduction of aquatic organisms is the most important dispersal process in vertebrates, while the majority of the introductions are accidental in invertebrates (García-Berthou et al., 2007).

Many economical and recreational activities such as sport fishing and professional crayfish trapping, are closely associated with inland aquatic systems and act as possible vectors for invasive fauna. Angling is connected to biological invasions due to the deliberated introduction of sport fish (Dextrase and Mandrak, 2006), due to the use of live bait (Ludwig and Leitch, 1996) and potentially due to accidental transport by gear related to fishing activities, such as for example, dip nets for bait capture. Consequently, many species of fish, crayfish, and of other invertebrates have become established in aquatic and terrestrial ecosystems outside of their native ranges (Hobbs et al., 1989; Keller and Lodge, 2007; Picco and Collins, 2008). Crayfish traps are also potential vectors for accidental transport of invasive species since these are not thoroughly cleaned and are frequently moved among different locations. Both in the case of crayfish traps and of dip nets, the transport to another location involves tolerating exposure to air. Actually, this trait (i.e. desiccation survival capacity) is fundamental for passive overland dispersal of freshwater fauna (Banha et al., 2014; Figuerola and Green, 2002; Vanschoenwinkel et al., 2008).

The Sorraia River is the major Portuguese tributary of the Tagus river basin, occupying a large part of Central Portugal. Fishermen activities are very important in this area with numerous national and international competitions (FPPD, 2013). One of the most appreciated sports fishing species, is the non-native Largemouth bass (*Micropterus salmoides*, *Lacepède*) (Godinho and Castro, 1996). *M. salmoides* is traditionally fished using the native stone loach (*Cobitis paludica, DeBuen*) as live bait (Collares-Pereira et al., 2000). Although the Portuguese law has forbidden the capture and

* Corresponding author. Tel.: +351 266745385; fax: +351 266745395.
E-mail address: filipebanha@hotmail.com (F. Banha).

http://dx.doi.org/10.1016/j.limno.2014.12.006
0075-9511/

use of stone loach as bait in 2010 by the Portaria no. 624/2010, this technique is still used due to its efficacy for bass capture and low authorities' control. The capture of this bait involves the use of small-mesh nets (Collares-Pereira et al., 2000), a bucket with water and frequently vegetation to keep fish in good conditions. Consequently several invasive species can also be inadvertently transported by this process, both in the buckets and by the small-mesh dip nets while browsing for bait. Another fishermen activity that occurs frequently in this basin is red swamp crayfish (*Procambarus clarkii*) trapping. In fact, in the year 2000, more than 88 t of this species were captured in the Tagus river basin (Rodrigo et al., 2006). The capture of this species is legal, but may result in the transport of this or other invasive species to other locations. Since it is very difficult to obtain field data on illegal activities, such as intentional transport of non-native species or accidental transport on bait buckets, an indirect approach to assess the non-native aquatic fauna dispersal potential of these vectors was adopted. In this context, this work studies the electivity and the rate of capture of each species by crayfish trapping and by stone loach dip net capture. Due to its importance for the success of accidental transport, the desiccation survival capacity of the non-native fauna captured was also assessed.

Materials and methods

Data were collected in the winter and summer of 2013, using similar crayfish traps and dip nets to the ones used by local fishermen. During dip net searches for live bait and during crayfish trapping it is very common to capture other species and these were quantified. Additionally, in this study, none of the invasive species captured was released back to water, fulfilling the Portuguese law (decreto-lei no. 565/99 de 21 de Dezembro) and ICNF (Instituto de Conservação da Natureza e da Florestas) dispositions. Indeed, we obtained data concerning the desiccation resistance of the invasive fish species. The desiccation resistance of other detected invasive species, namely crustaceans (*P. clarkii* and *Crangonyx pseudogracilis*), is already available from previous studies involving the authors of this paper (Banha and Anastácio, 2014; Rachalewski et al., 2013).

We selected 4 locations in the Sorraia River and tributaries (Tagus river basin) because these places are commonly visited by fishermen using both techniques (Fig. 1), but also because of its accessibility and permanence of water flow during all year. A quadrangular dip net was used, with a 1 mm mesh, 60 cm × 40 cm frame and a 120 cm cable. In each location 8 one meter long drags were performed, to quantify organisms from all different microhabitats present. Eight galvanized steel wire crayfish cylindrical traps (1 cm mesh; 42 cm long; two 5 cm openings; 23 cm diameter) were used and placed in 8 different locations. Traps were baited with 50 g of sardines (*Sardina pilchardus*) immediately before dusk and checked the next morning. The non-native fish fauna captured by these two techniques was measured and the time to death was registered since according to the Portuguese legislation it is forbidden to return them to the water. We did not quantify the loss of invasive fauna during the transfer of live bait to the bait bucket or during cleaning of the traps or of the dip nets since this is highly dependent on each fisherman options and skills. Fishes were considered dead if no movement or reaction to manipulation was present. The relative humidity and air temperature were measured using a thermo-hygrometer and water temperature was measured using a multiparameter probe (Multiline-WTW). Wind direction and velocity were taken from the nearest meteorological station (Geophysical Center, University of Évora).

To obtain the species' densities in each location, fish fauna was electro fished in 3 areas of 5 m^2, using a CPUE of 5 min. For invertebrates we used 3 areas of 1 m^2 isolated by mesh (1 mm), thoroughly sampled using a dip net until no more fauna was found, using the catch-success method (Leslie and Davis, 1939). Densities were estimated in both seasons (winter and summer).

Statistical analysis

Ivley's electivity index (*Ei*; Ivlev, 1961) was used to determine the vector preference for each species caught:

$$Ei = \frac{r_i - p_i}{r_i + p_i}$$

where r_i is the proportion of organism species i in the catch composition, and p_i is the proportion of the same species in the environment. E_i ranges between −1 and +1. Positive values indicate selectivity of the fishing gear, with a species overrepresented in the catch composition in relation to its availability in the environment. Negative values signify avoidance, with a species underrepresented in the catch composition in relation to its availability (Lechowicz, 1982).

For each species in each sampling station, the probability of capture by a type of fishing gear is the number of captured individuals of that species divided by the number of individuals of all species captured. Confidence intervals (95%) for the Ivlev's index values were calculated according to Strauss (1979). Ivlev's index values were considered significantly different from zero ($p < 0.05$) if its confidence interval did not include zero. The same protocol was applied to the probability of capture for each gear and season.

A Kaplan–Meier analysis was used to calculate the mean survival time for the captured non-native fish species. Except for *G. holbrooki*, we captured few individuals of the majority of fish species and therefore the latter were not subjected to further analyses. An ANCOVA was performed in order to analyze the effects of the covariate *G. holbrooki* total length (mm) and the factor season (winter and summer) on the desiccation survival time of *G. holbrooki*. Before applying this analysis, total length and time survival data were transformed $\left(\sqrt{x}\right)$, in order to meet the assumptions of homogeneity of variances and normality. We also confirmed the homogeneity of the regression slopes before running the analysis. All statistical analyses were performed using PASW version 18.

Results

In this study, 540 faunal organisms were captured, 64% of which were non-native. The total number of specimens captured slightly increased from winter to summer, from 34 to 43 specimens for crayfish trap, and 210 to 253 for the dip net. In fact, the faunal composition captured by each gear was different between seasons (Dip net: $\chi^2 = 125.320$; df = 12; sig. < 0.001; Crayfish trap: $\chi^2 = 14.163$, df. = 5, sig. = 0.015). The dip net allowed the capture of 13 different taxa, from which 7 were native. Nevertheless, the crayfish trap only allowed the capture of 7 taxa, with only 2 natives. So, the two types of fishermen vectors tested allowed the capture of 9 invasive species in the study area, namely 1 freshwater gastropod (*Physa acuta*), 1 amphipod (*C. pseudogracilis*), 1 crayfish (*P. clarkii*) and 5 fish species (*Alburnus alburnus*, *Ameiurus melas*, *G. holbrooki*, *Gobio lozanoi*, *Lepomis gibbosus*). The most abundant species found was the invasive amphipod *C. pseudogracilis* with a mean density of 12 individuals per square meter (Table 1) and its density was much higher in winter than in the summer. This species was one of the most captured by the dip net, having high values of probability (Fig. 2) and electivity in the summer (Fig. 3). Not surprisingly, due to its small size, no individual of this species was captured with crayfish traps and therefore, its electivity was −1 (Fig. 3). Although the dip net method is used by fishermen to capture *C. paludica* we obtained a very low capture rate. Actually, the crayfish trap had