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Short Communication

Could electric fish barriers help to manage native populations of European crayfish threatened by crayfish plague (*Aphanomyces astaci*)?

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Abstract

Crayfish plague (*Aphanomyces astaci*) is the main problem that hinders the conservation of European crayfish species. Every year, dozens of native crayfish populations disappear due to this disease. We used an electric fish barrier to block the dispersal of infected crayfish upstream. One of the main objectives of this communication is to transfer our expertise using this equipment for improved conservation outcomes. As a result, we report a detailed description of the experience, as well as requirements, problems and opportunities of using an electric fish barrier to try to control crayfish plague *in-situ*.

Key words: *Autropotamobius, Astacus,* European crayfish, crayfish plague, conservation

Introduction

European native crayfish species are threatened and their populations are declining due to habitat loss, water pollution, and the effects of competition from non-indigenous crayfish species and diseases (Holdich et al. 2009; Füreder et al. 2010). One of the main conservation problems is the crayfish plague, which is caused by the oomycete *Aphanomyces astaci* (Schikora) (Schrimpf et al. 2012). This pathogen lives in the crayfish cuticle, and is spread by asexual swimming zoospores, which serve as infective units (Holdich et al. 2009). Crayfish plague is listed on the top 100 of the "World's Worst" invaders by the International Union for Conservation of Nature (IUCN) (Lowe et al. 2000). This disease is generally lethal for the European crayfish species and it has decimated entire populations (Gherardi and Holdich 1999; Jussila et al. 2011; Viljamaa et al. 2011). In each European country, the number of detected and diagnosed mortalities due to crayfish plague varies from a couple to a dozen cases per year (Diéguez-Uribeondo 2009). The North American crayfish species (e.g. *Procambarus clarkii*, *Pacifastacus leniusculus*, *Orconectes limosus*) introduced the crayfish plague pathogen, *A. astaci,* to Europe and is known to act as a vector of crayfish plague (Diéguez-Uribeondo and Söderhäll 1993; Peeler et al. 2011; Schrimpf et al. 2013).

Since 1992, for conservation purposes we have been monitoring approximately 70 populations of *Austropotamobius pallipes* on three river basins in the northeast of the Iberian Peninsula: Muga, Fluvià and Ter (Montserrat et al. 2004; Benejam et al. 2012) (Figure 1). Many of these populations are in the Garrotxa Volcanic Zone Natural Park. Monitoring occurs because accurate information on crayfish populations is necessary to inform the specialists and managers of protected areas so that conservation goals can be achieved. Every

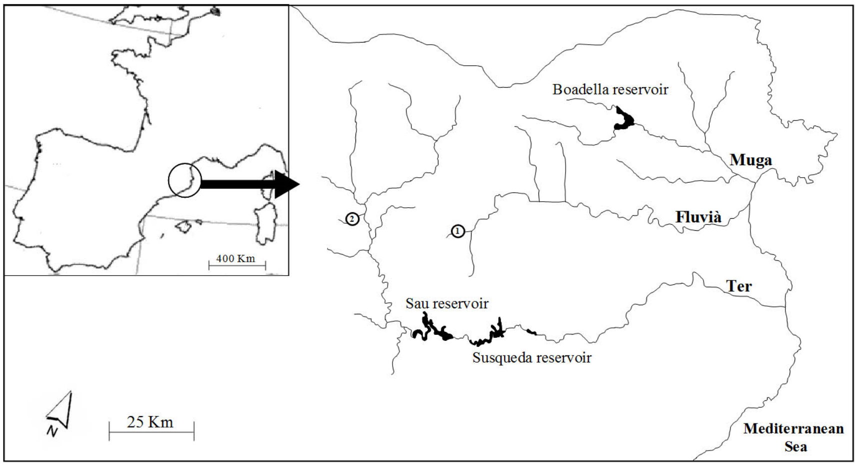

Figure 1. Location of study sites with crayfish plague events: 1. Joanetes stream (UTM: 451518, 46629412) 2. Llosses stream (UTM: 430501, 4669096). Rivers and reservoirs are also indicated.

year, 0–2 crayfish plague outbreaks have been detected in the studied protected area (mean is 1.1 per year). Although the water is the best medium for downstream transmission of zoospores, infected individuals also transport the disease upstream in the river. In some cases during a mortality event of crayfish plague, a part of the native crayfish populations survive upstream due to an important river discontinuity (such as a large waterfall or dam) that interrupts and hence hinders the movement of infected crayfish upstream in the river. Consequently, the current distribution area and the main refuges of the European native crayfish species are low-order mountain streams (Clavero et al. 2008; Füreder et al. 2010). As a result of the apparent effectiveness of these natural barriers, we decided to use an electric fish barrier during an event of crayfish plague to increase the discontinuity of the river to stop the progression of individual infected crayfish upstream.

An electric fish barrier produces an electrical field and it is widely used to discourage fish movements and to create fish exclusion areas, for example in canals of hydropower stations (Clarkson 2003; Smith-Root 2012). Moreover, not only are fishes affected by the electric field, but all the other aquatic fauna (e.g. amphibians and crayfish) may be sensitive to electric discharges (Alonso 2001; Olson and Rugger 2007). Therefore, if an electric fish barrier is installed, it could be possible to restrict aquatic fauna movement and to avoid the upstream dispersal of infected crayfish. The aim of this paper is to share our expertise and to show requirements, problems and opportunities of using an electric fish barrier in order to help native crayfish population conservation.

Methods

In August 2008 on Joanetes stream (tributary of Fluvià River; UTM: 451518, 4662941) and July 2011 on Llosses stream (tributary of Ter River; UTM: 430501, 4669096), we detected events of crayfish plague in populations of *Austropotamobius pallipes* (Figure 1). We sent samples of dead crayfish to the Department of Mycology of the Real Jardín Botánico CSIC (Madrid, Spain), where they confirmed that crayfish were infected with the plague. Both streams are of secondary order and situated between 800–600 m above sea level. They present a heterogeneous mesohabitat with riffles, runs, pools and some small waterfalls. These streams present a stable streamflow (around 0.2 $m^3 s^{-1}$) and are not affected for extreme drought in summer. Small populations of Mediterranean barbel (*Barbus meridionalis*) are present in both streams.

We installed an "Electric Fish Barrier IG201-1FS" (provided by the Acuitec Company) 200 m upstream of the last dead crayfish detected. Little power was applied (output: 70 volts and 1 ampere; frequency of discharge: 1 pulse per second) because both streams have low conductivity (180 to 320 µS/cm), are only 2–3 m wide, and 20–40 cm deep. The electric fish barrier was connected to a nearby house using a 400m long electric cable. Every 48 hr we sampled the stream to detect dead, or moribund individuals to enable us to monitor the progression of crayfish plague and the efficiency of electric fish barrier. To avoid dispersing the crayfish plague during monitoring, we walked from upstream to downstream and we never went into the water.

Figure 2. Electric fish barrier installation pictures in Joanetes stream. A) Circuit box and display inside a plastic box to protect them from rain. Metallic nets (B) and poster signs (C) were also installed to avoid accidents with wildlife fauna, farm animals or humans. Photographs by Lluís Benejam.

Results and discussion

During the first two weeks, after installing the electric fish barrier in Joanetes stream, dead and moribund crayfish were progressively detected closer to the fish barrier, but never upstream of the electric barrier. After these two weeks, no dead crayfish were detected downstream or upstream of the electric barrier. However, the area was sampled for a further two months to be sure that the crayfish plague was not present in the stream and then the electric fish barrier was removed. The action appeared to be successful in halting the progression of the plague upstream. Consequently, the Joanetes stream population of crayfish is now recovering.

In July 2011 crayfish plague appeared in Llosses stream. The electric fish barrier was installed and monitoring to detect the progression of the crayfish plague upstream was initiated. However, in this case, after only one week of installing electric fish barrier dead and moribund individuals were detected downstream and upstream of the barrier. Our assumption for the plague appearing upstream of the barrier is that it was already present in the whole population of Llosses stream when we installed the electric fish barrier.

After these two experiences, here we list the issues that that might be important to the successful use this technique:

- The electric fish barrier should be installed in a site where a small water discontinuity already exists (e.g. small waterfall that is 2–3 m in height). The electric fish barrier should be established just upstream of this discontinuity to increase the difficulty for crayfish to move upriver. Therefore, it is an important requirement to first detect some river discontinuities (natural or not) and use them to create a double barrier with the inclusion of the electric fish barrier.
- As it is possible for a crayfish to harbor internal infections without showing obvious visual signs. Therefore, it is essential to be sure that the disease is not present in crayfish at the chosen site or close to it before installing the electric fish barrier. As a result, we would

recommend installing the electric fish barrier a minimum of 300 m upstream from the last dead or moribund crayfish.

- This technique should only be used when mortality due to crayfish plague is detected at the beginning of the outbreak; not when the entire population is already infected. For this reason, it is very important to conduct a continuous and intensive monitoring of crayfish populations, particularly those with high probabilities of being infected by crayfish plague (e.g. populations near American crayfish populations).
- Another important aspect is to clearly designate the electric fish barrier area with signs, as well as to close the area (e.g. with metallic net) around the electric fish barrier to avoid accidents with wildlife fauna, farm animals (e.g. cow, sheep) or even humans (Figure 2).
- Sometimes, obtaining the electricity necessary for the electric fish barrier could be a problem because crayfish populations are in isolated places. In this case, solar panels may be an effective solution to power the electric fish barrier.

As a result of our experience using this tool, and being conscious of its limitations, as it has been exposed through our control efforts, we think that the use of an electric fish barrier can be beneficial to stop the progression of infected crayfish upstream and to improve European crayfish populations' conservation.

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