MOVEMENTS OF ENDEMIC AND EXOTIC FISH IN A LARGE RIVER ECOSYSTEM (RHÔNE, FRANCE)

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The aim of this study is to characterise the mobility templates of two patrimonial species of rheophilic cyprinids (*Barbus barbus* and *Squalius cephalus*) and of a species of exotic fish, the catfish (*Silurus glanis*), in an area of the upper Rhône River characterised by significant disruptions of flow and thermal regimes (caused by hydroelectric and nuclear power plants). Results reveal contrasted mobility patterns, habitat uses and home-range sizes between endemic and exogenous fish species, but with a high interindividual variability.

1 INTRODUCTION

Fish mobility (i.e., diel migration, home-range, spawning migration, homing behaviour, seasonal variability) is a major component of the ecology of fish communities and fisheries management. (Ovidio [1]; Lucas and Baras [2]). Technological advances over the past two decades enable scientists to carry out telemetry studies in a wide variety of aquatic environments using radio and acoustic biotelemetry techniques with manual or automatic detection. Despite that, there is a lack of knowledge about life strategies and patterns of seasonal mobility of holobiotic fish species in large European rivers. Hydrologic and nuclear power plants fragment habitat and change flow and thermal regimes causing drastic declines in endemic fish populations (De Leeuw and Winter [3]; Ovidio and Philippart [4]). By contrast, it appears that the exogenous catfish (*Silurus glanis*) is adapted to these altered conditions to the detriment of endemic species (Britton *et al.* [5]; Castaldelli *et al.* [6]).

The objective of this study is to characterize the mobility patterns of two species of endemic rheophilic cyprinids, barbel (*Barbus barbus*) and chub (*Squalius cephalus*) and of the exogeneous catfish in a section of the upper Rhône River. This study intend (1) to develop an active scanning protocol, using acoustic mobile tracking equipment (HTI-Sonar ©), adapted to the fast flowing conditions and allowing the simultaneous monitoring of a high number of fish, (2) to determine the seasonal ranges (breeding included), (3) to analyse the influence of the environmental conditions (discharge, temperature) on the intensity of movements and (4) to evaluate a large scale habitat selection.

2 MATERIAL AND METHODS

Our study site was 35 km long section of the upper Rhône River, between Lyon and Geneva characterized by severely altered flow and thermal regimes. In this section (Figure 1), flow are mainly regulated by storage dams which are located upstream (hydropeaking production) and a nuclear power plant (Electricité de France), located in the median part, which discharges warm water (ca 100 $m^3.s^{-1}$; + 10°C).

We selected and tagged (Model 795 Acoustic Tags: frequency of 307khz; transmit power level of 155dB relative to 1 µPa at a distance of 1m, Hydroacoustic Technology Inc., Seattle, Washington) adults fish of three species: barbels (452-650 mm, n = 37), chubs (382-536 mm, n = 23) and catfish (640 to 1265 mm, n = 13). From April to October 2010, we carried out weekly localisation campaigns, with a boat equipped with a mobile system of acoustic telemetry (active scanning). Each fish was identified by the implanted tag's sound emission period. The studied section was divided in 500-m long areas (Figure 2) and for each of these areas we assessed the morphology, modelled hydraulic conditions for low (150 $m^3.s^{-1}$) and medium (500 $m^3.s^{-1}$) flows (with software Modeleur V1.8, INRS-ETE, Québec, Canada), and recorded daily flow (Compagnie Nationale du Rhône) and water temperature (Electricité de France) along the study section.

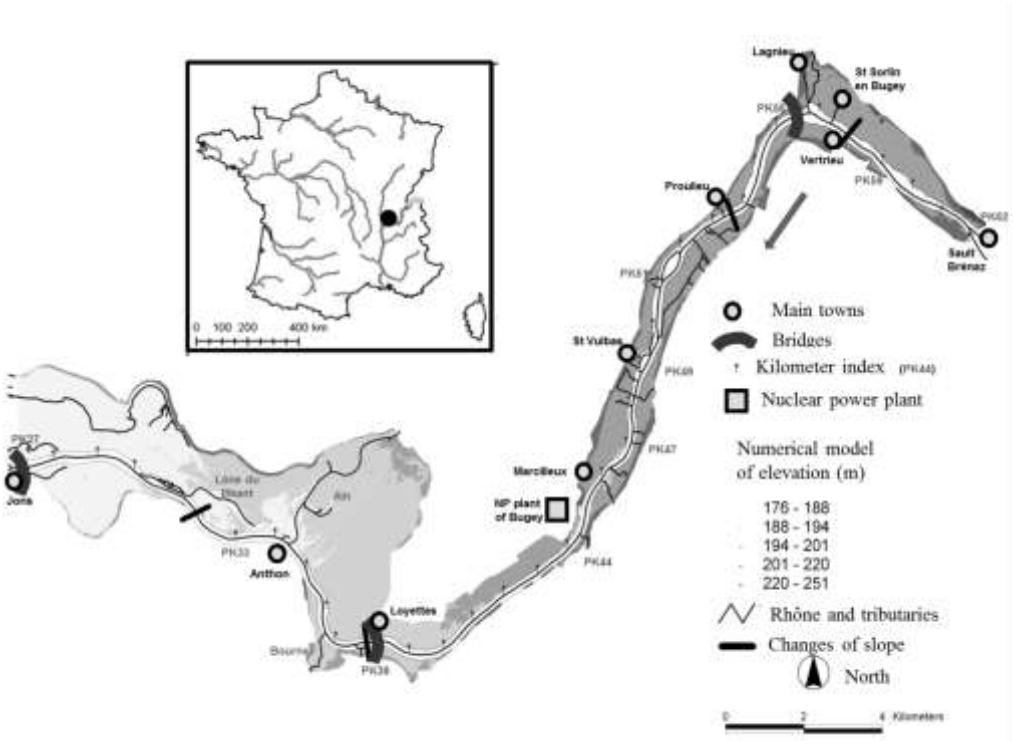

Figure 1. The study site is the section of the upper Rhône River located upstream of Lyon, between Sault-Brénaz (kilometre landmark 62) and Jons's (kilometre landmark 27) hydroelectric facilities. The main riverbed is shown within a digital elevation model (elevations in m) in order to illustrate the section's 15-m level difference.

3 RESULTS AND DISCUSSION

We recorded 1572 localisations of fish (n = 828 (barbels), 457 (chubs), 287 (catfish)) between April 1st 2010 and October 19th 2010 (29 sampling days; Figure 2). The number of fish localised during each campaign varied from 43 to 63 individuals. The acoustic portable detection system was an effective technique to follow fish throughout the river, despite its large size and high flow velocity. The combination of the active-scanning acoustic system with a precise geolocalisation tool provided a high detection rate of the tagged fish (74% on average) and a sufficient accuracy on the fish's home-range scale, without going up to the microhabitat scale.

The barbel and the chub show a high interindividual variability in migrations patterns, Along a continuum of resident (max displacement < 1 km) to highly mobile individuals that migrated between the upstream and downstream limits of the study area. It appears that 27% of the barbels and 30% of the chubs were residents. The catfish displayed lower individual variability in mobility pattern with a majority of its subjects showing a rather flat mobility pattern illustrated by 54% of individuals categorized as resident. Only two catfish travelled more than 5 km between two localisations. The median home ranges of the cyprinids were not significantly different (barbels, 3045 m and chubs, 2355 m) but they were significantly higher than the catfish's median home range (1295 m; $p = 0.031$). The number of tagged fish in our study is one of the most important ever seen in literature dealing with such topic (cyprinids and catfish mobility in large rivers), and the high number of detections for each fish enable to be confident with our results of the non-parametric tests.

The rheophilic cyprinids selected multiple lotic channels while the catfish exploited more homogeneous and lentic habitats. The barbel also selected habitats with a lot of woody debris compared to the chub or the catfish. The catfish significantly used part of the Rhône heated by the Bugey nuclear power plant.

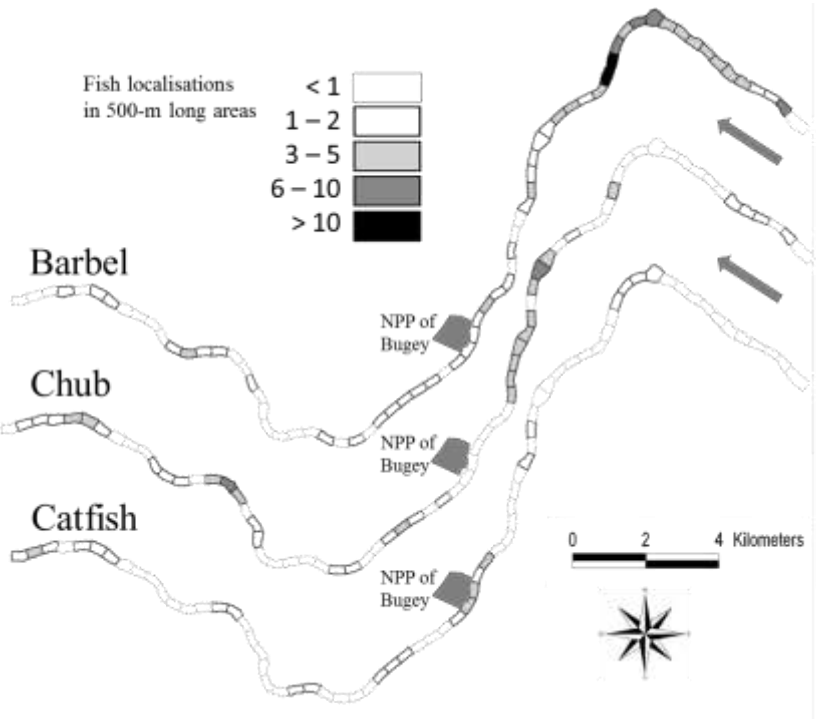

Figure 2. Distribution of the fish localisations recorded during the whole study period (from April to October 2010). The limits of the 500 m-long areas (used for describing the habitat conditions) are marked by lines across the main riverbed. In each area the number of fish localised during the experiment is represented by a color code (see the legend) for the three species. Nuclear power plant (NPP) of Bugey is located in the median part of the study section. The hydro-electric facilities, (i.e. the upstream and downstream limits of the study section), are not represented.

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REFERENCES

[1] Ovidio M., "Cycle annuel d'activité de la truite commune (*Salmo trutta* L.) adulte: étude par radio-pistage dans un cours d'eau de l'Ardenne belge", *Bulletin Français de la. Pêche et de la Pisciculture*, Vol. 352, (1999), pp.1-18.

[2] Lucas M.C. and Baras E., "*Migration of Freshwater Fishes"*, Oxford: Blackwell Science, (2001).

[3] De leeuw J.J. and Winter H.V., "Migration of rheophilic fish in the large lowland rivers Meuse and Rhine, the Netherlands", *Fisheries Management and Ecology*, Vol. 15, (2008), pp.409–415.

[4] Ovidio M. and Philippart J., "The impact of small physical obstacles on upstream movements of six species of fish", *Hydrobiologia*, Vol. 483, (2002), pp 55–69.

[5] Britton J.R., Cucherousset J., Davies G.D., Godard M.J., and Copp G.H., "Non-native fishes and climate change: Predicting species responses to warming temperatures in a temperate region", *Freshwater Biology*, Vol. 55, (2010), pp 1130-1141.

[6] Castaldelli G, Pluchinotta A, Milardi M., Lanzoni M., Giari L., Rossi R., and Fano E.A., "Introduction of exotic fish species and decline of native species in the lower Po basin, north-eastern Italy", *Aquatic Conservation: Marine and Freshwater Ecosystems*, Vol. 23, (2013), pp 405-417.