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TRANSFERABILITY OF FISH HABITAT MODELS: THE NEW 5M7 APPROACH APPLIED TO THE MEDITERRANEAN BARBEL (*BARBUS MERIDIONALIS*)

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The Mediterranean barbel, *Barbus meridionalis* (Risso, 1827), is currently classified as a near threatened species by the IUCN. For the purpose of instream habitat management and in order to determine the environmental flows requirements of this species, we recently developed univariate Category Three preferences curves (Bovee *et al* [1]) for use within the Instream Flow Incremental Methodology (IFIM). In two Mediterranean rivers of southern France, a total of 883 Mediterranean barbel (BAM) was collected at 406 electrofishing units, and measurements of local substrate and hydraulic features were performed. The 5M7 model was used to build the river-specific trajectories of the Mediterranean barbel in the (depth, mean velocity, total fish length) space, hereafter (D,V,TL). This model was then improved with the inclusion of a new system of species-environment equations. This revealed that the river-specific trajectories can be predicted by applying preferences curves related to the mean total length of each life stages to the river specific hydrosignatures. Results also indicated that the preferences curves of another barbel (BAF) species, *Barbus barbus* (Linnaeus, 1758), were compatible with the Mediterranean barbel trajectories. This new approach represents a valuable tool to assess the transferability of preference curves and in a general way to assess the efficiency of fish habitat models.

1 INTRODUCTION TO FISH TRAJECTORIES IN 5M7 MODEL

On the basis of a dataset combining electrofishing samples and measurements of mean depth (D) and mean velocity (V), several methodological steps are required to build a trajectory for a given species. First, a set of size classes (SC) of total length must be defined for the considered fish species. For each size class, a sub-dataset is then extracted from the units containing at least one fish of the considered size class (i.e. presence of the specific size-class, potentially reflecting suitable environmental conditions). For each of these units, the mean total length (TL) of each size class is calculated. A single set of coordinates (D,V,TL) is obtained for each size class by averaging the three variables of this sub-dataset, each electrofishing units being eventually weighted by the density of individuals. The trajectory of the fish species in the (D,V,TL) space is finally defined by the polyline passing through the coordinates of the different size classes, from smallest to largest size classes.

This trajectory can be projected onto the three individual planes (V,D), (TL,D) and (TL,V), usually for one single campaign of electrofishing performed at stable hydraulic conditions. One specific relationship exists between each couple of variables. For most of the species, the relationships between D and TL and between V and the square root of TL are linear, while some species are following a Froude number in the (V,D) plane. The application of this approach to French rivers has resulted in trajectories which were rather different (i) between species in a same river, and (ii) from one river to another for a given species. For instance, the Figure 1 illustrates these results for two species of barbel (BAM and BAF).

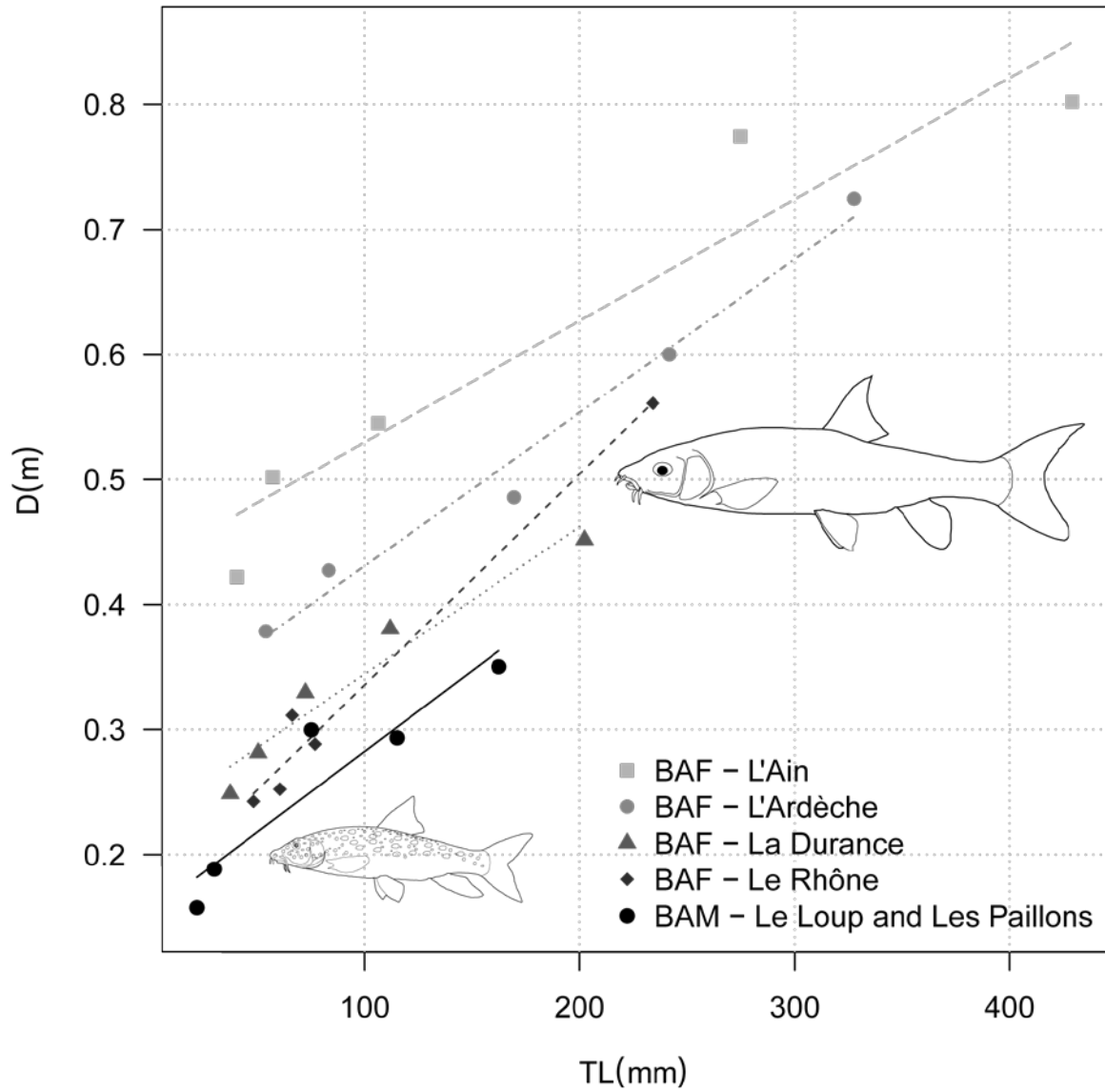


Figure 1. Trajectories of two barbels species in different French rivers in the (TL,D) plane (Le Coarer [2]).

2 MATERIAL AND METHODS

2.1 Determining the preference curves for the Mediterranean barbel

In two Mediterranean rivers of southern France (Le Loup and Les Paillons) a total of 883 BAM was collected at 406 electrofishing units. Depth and mean velocity were spatialized at nine hydraulic verticals by topographic measurements. A triangular irregular network was built in the horizontal plane for each sampling unit using these hydraulic verticals as nodes, which has allowed finite element calculations. The local substrate was estimated for the entire unit, and average values for the three variables (D,V,TL) were calculated for each unit. Regarding the hydrosignatures (Le Coarer [3]) of the two campaigns realized on both rivers, we have grouped them into one single dataset as their hydraulic conditions were very similar. Figure 2 gives the overall hydrosignature of the two campaigns.

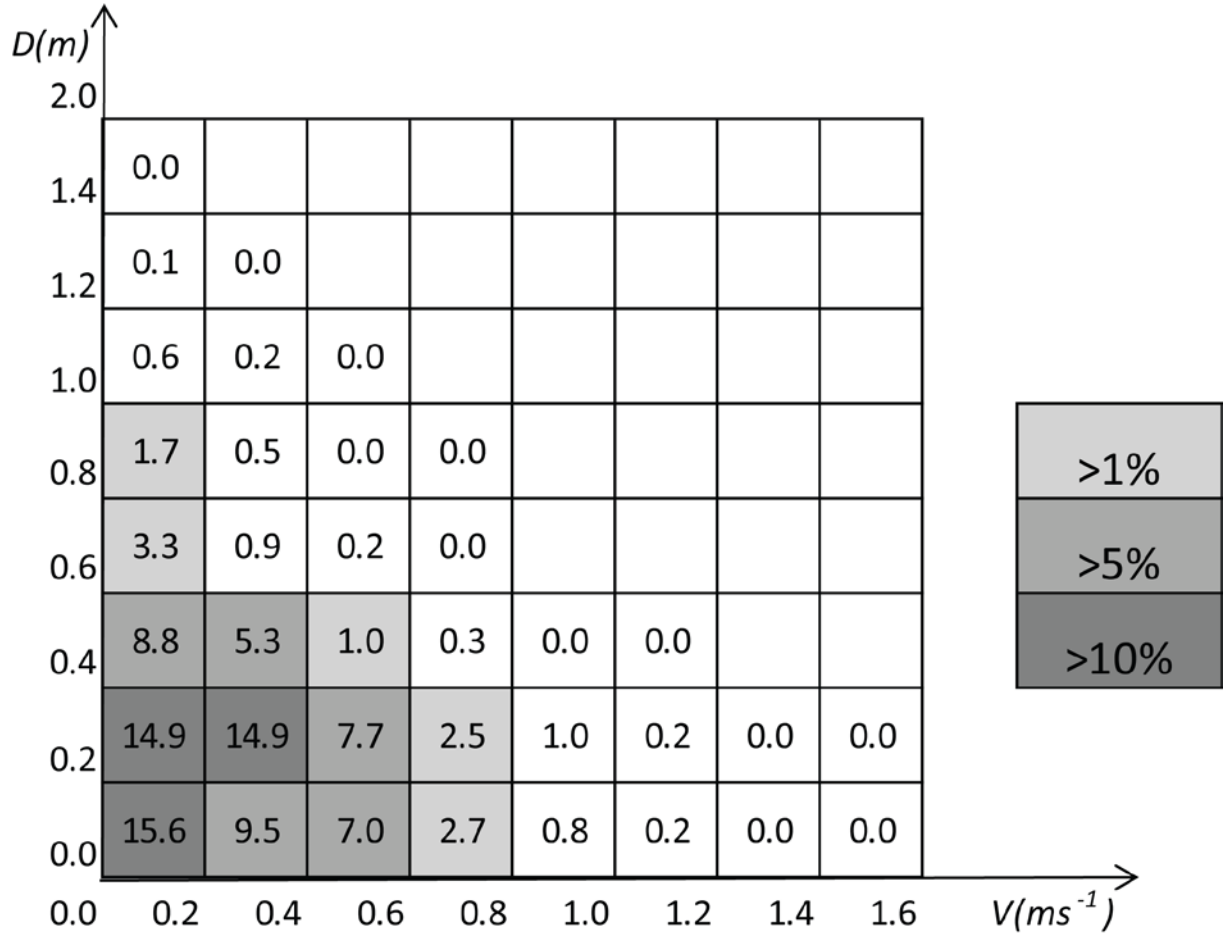


Figure 2. Overall hydrosignature for Le Loup and Les Paillons rivers, quantifying hydraulic conditions during electrofishing campaigns, represented by the areal percentages of concomitant conditions of depth (D, m) and mean velocity (V, m/s) in a grid of depth and velocity cross-classification.

We define three fish size classes corresponding to fry, juvenile, and adult fish of TL(mm) $\in [0,45[, [45,120[, [120, \infty[$, respectively. Then we built univariate Category Three preferences curves for each size class by computing the local Log- density (LLD) (Lamouroux [3]), using the following equation where d is the density of individuals:

$$LLD = \ln(1 + 1000 \cdot d) \quad (1)$$

2.2 Linking fish habitat suitability models to 5M7 trajectories

To estimate the BAM trajectory directly from the preference curves of the three life stages, we also used LLD to compute a mean total length TL(Tax) by size class, which were fry=33mm, juvenile=100mm and adult=168mm, respectively. In order to calculate the two other coordinates, depth D(SC) and mean velocity V(SC) for each life stage, we used the overall hydrosignature giving the distribution of areal depth and velocity:

$$D(SC) = \frac{\sum_{id=1}^{id=ID} D_{id} \cdot pd(SC, D_{id}) \cdot CC_{id}}{\sum_{id=1}^{id=ID} pd(SC, D_{id}) \cdot CC_{id}} \quad V(SC) = \frac{\sum_{iv=1}^{iv=IV} V_{iv} \cdot pv(SC, V_{iv}) \cdot CC_{iv}}{\sum_{iv=1}^{iv=IV} pv(SC, V_{iv}) \cdot CC_{iv}} \quad (2)$$

where:

ID=number of depth classes; id=index of depth class, CCid=areal percentage of the depth class, Did=central depth value of the depth class, pd(SC,Did)=preference value of the size class for the Did central depth; IV=number of velocity classes; iv=index of velocity class, CCiv=areal percentage of the velocity class, Viv=central velocity value of the velocity class, pv(SC,Viv)=preference value of the size class for the Viv central velocity.

This has allowed the calculation of the trajectory connecting the three life stage coordinates in the (D,V,TL) space.

3 MAIN RESULTS AND DISCUSSION

Figure 3 gives the projections onto the three planes (V,D), (TL,D), (TL,V) of (i) the 5M7 BAM trajectory, (ii) the BAM trajectory modelled using preference curves, and (iii) the BAF trajectory modelled using preference curves (Lamouroux [4]) applied to the overall hydrosignature of Le Loup and Les Paillons rivers. Regarding the BAF species, we used the original data provided by Irstea colleagues, and the LLD calculation of the three life stages of the BAF was used to estimate the TL(Tax).

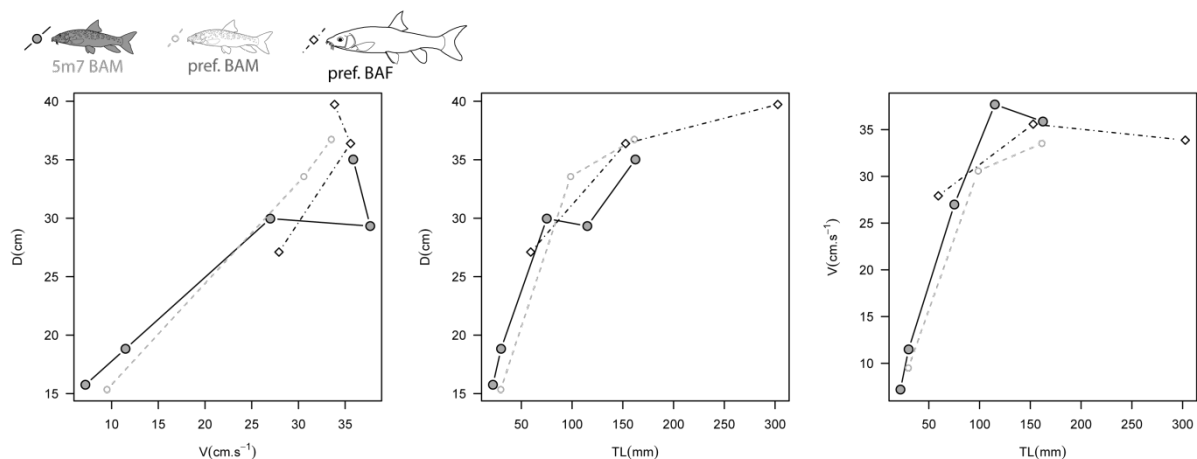


Figure 3. For Le Loup and Les Paillons rivers: 5M7 BAM trajectory, BAM and BAF trajectories modelled using preference curves.

It appears that both BAM and BAF trajectories fit the 5M7 trajectory. It is noteworthy that the BAF trajectory fits well the 5M7 trajectory despite the fact that the preference curves have been built on rivers presenting hydraulic conditions quite different from Le Loup and Les Paillons rivers, and also that, at similar age, the BAF is larger than the BAM.

This new approach represents a valuable tool to:

- assess the transferability of preference curves,
- compare the performance of fish habitat models,
- validate the definition of fish guilds.

We recommend that future fish hydraulic habitat models should be designed in terms of (D,V,TL), and without separating life stages.

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