

The effects of habitat restoration in river floodplains on fish diversity and behaviour

Les effets de la restauration de l'habitat sur la diversité et le comportement des poissons dans les plaines inondables

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RÉSUMÉ

Dans cette étude, des séquences vidéo ont été collectées pour observer directement le comportement des poissons dans différents habitats d'un canal secondaire reconstitué dans la rivière Waal, un défluent du Rhin inférieur (Pays-Bas) en août-octobre 2019. Dans un total de 34 déploiements d'environ 45 minutes dans quatre types d'habitat, le nombre, la composition des espèces et le comportement de tous les poissons de moins de 15 cm ont été enregistrés. Au total, 13 espèces de poissons ont été trouvées, parmi lesquelles l'ide (*Leuciscus idus*), le gardon (*Rutilus rutilus*) et l'aspw (*Leuciscus aspius*) étaient les plus abondants. C'était le cas pour tous les habitats, mais l'ide était plus abondant dans les habitats contenant des rochers, tandis que le gardon était plus abondant près des débris ligneux. Ici, les poissons présentaient également la plus grande diversité comportementale, avec un nombre substantiel montrant un comportement de repos ou de grattage. En général, la natation, solitaire ou groupée, suivie de la recherche de nourriture benthique étaient les comportements les plus observés, bien qu'il y ait eu des différences entre les espèces, l'ide nageant en groupe plus souvent et le gardon montrant plus de comportement de grattage. Différents habitats remplissent apparemment différentes fonctions dans le cycle de vie des juvéniles de poissons de rivière, ce qui devrait être pris en compte dans la restauration des canaux des plaines inondables des rivières.

ABSTRACT

In this study video footage was collected to directly observe the behaviour of fishes in different habitats of a reconstructed secondary channel in the river Waal, a tributary of the lower river Rhine (The Netherlands) in August-October 2019. In a total of 34 deployments of ca. 45 minutes at four habitat types numbers, species composition, and behaviour of all fish <15 cm were recorded. A total of 13 fish species were found, of which ide (*Leuciscus idus*), roach (*Rutilus rutilus*), and asp (*Leuciscus aspius*) were the most abundant. This was the case for all habitats, but ide was most abundant in habitats containing boulders, while roach was more abundant near woody debris. Here fishes also had the greatest behavioural diversity, with a substantial numbers showing resting or scraping behaviour. In general swimming, either solitary or grouped, followed by benthic foraging were the most observed behaviours, although there were differences between species, with ide swimming in groups more often and roach showing more scraping behaviour. Different habitats apparently serve different functions in the life cycle of juvenile river fishes which should be considered in the restoration of river floodplain channels.

KEYWORDS

behaviour, floodplain restoration, lowland rivers, nursery habitat, rheophilic fishes

1 INTRODUCTION

The large rivers of western Europe have been heavily modified, resulting in the impediment of natural processes and degraded river ecology and habitats. This also led to a severe decline of diadromous fish species, typical for European lowland river systems, such as Atlantic salmon (*Salmo salar*) and European sturgeon (*Acipenser sturio*). Also, potamodromous, rheophilic species, such as European barbel (*Barbus barbus*), nase (*Chondrostoma nasus*), and dace (*Leuciscus leuciscus*) have significantly reduced (Birnie-Gauvin et al., 2017). To improve the ecological quality of the river systems, authorities in the Netherlands have initiated restoration projects in the floodplains of these rivers, e.g. in the Rhine river and its distributaries. In most cases restoration projects include either the one- or two-sided reconnection of existing floodplain channels, or the construction of new ones. The projects mostly led to positive changes in water quality and an increase in natural habitats, but not to the expected recovery of rheophilic fish species.

It was expected that insufficient extent or quality of nursery habitat for juvenile fish could be one of the causes for the limited recovery of these fishes (Eick and Thiel, 2013). Although habitat requirements of river fishes are known to some extent (Stoffers et al. 2021), detailed knowledge of the use of floodplain habitat by juvenile fish is mostly limited and often indirect, derived from catches, and not from direct observations. Therefore the objectives of this study were to directly observe the use of different types of floodplain habitat by juvenile fish to gain insight in their function as a nursery area.

2 MATERIALS AND METHODS

The study site, 'De kil van Hurwenen', is situated in the east of the Netherlands (N 51.82, E 5.29). It is a secondary channel of the river Waal, a tributary of the river Rhine, to which it was connected in 2014. The secondary channel is characterised by both fast and slow flowing areas, contains sediment types ranging from silt to boulders, has fields of submerged vegetation, and contains mussel beds and woody debris.

In August to October 2019, video footage was collected using GoPro Hero 6 Black edition cameras, attached to a steel pin. Deployments lasted ca. 45 minutes. Nine deployments were performed at woody debris, fourteen at a sand patch, five at boulders at the inflow of the channel, and six at boulders at the outflow. All fish <15 cm were considered as juveniles and identified to species level if possible. Fish numbers (N_{\max} : the maximum number of fish per species in one video frame) and species composition were recorded per deployment. Fish behaviour was categorised as: benthic foraging, pelagic foraging, scraping, swimming, grouped swimming, resting and agonistic behaviour.

3 RESULTS AND DISCUSSION

In total thirteen fish species were observed (Table 1). The most abundant species was ide, *Leuciscus idus* (79.2% of the total), followed by roach, *Rutilus rutilus* (5.7%) and asp, *Leuciscus aspius* (3.0%), whereas more specialised rheophilic species such as barbel, *B. barbus*, nase, *C. nasus*, and dace, *L. leuciscus* were observed rarely and never more than one individual at a time (Table 1).

Table 1. Maximum number of individuals per fish species registered in one video frame (N_{\max}) from recordings in a floodplain channel of the River Waal in 2019.

Species	Common name	N_{\max}
<i>Leuciscus idus</i>	Ide	15
<i>Alburnus alburnus</i>	Bleak	9
<i>Neogobius melanostomus</i>	Round goby	5
<i>Esox lucius</i>	Pike	4
<i>Leuciscus aspius</i>	Asp	3
<i>Rutilus rutilus</i>	Roach	3
<i>Perca fluviatilis</i>	Perch	2
<i>Abramis brama</i>	Bream	1
<i>Barbus barbus</i>	Barbel	1
<i>Chondrostoma nasus</i>	Nase	1
<i>Leuciscus leuciscus</i>	Dace	1
<i>Neogobius fluviatilis</i>	Monkey goby	1
<i>Platichthys flesus</i>	Flounder	1

The dominance of (rheophilic) ide was consistent in all studied habitats (Figure 1A), with an apparent preference for habitats with boulders at the inflow and outflow of the secondary channel, where the flow velocity was higher than in the other two habitats. Roach, a eurytopic species, was almost as abundant as ide near woody debris, which is a habitat with a smaller flow velocity. In most habitats a substantial

number of juvenile fish were categorised as ‘unidentified cyprinids’, which was caused by limited visibility and by (woody) structures hampering interpretation of the video footage.

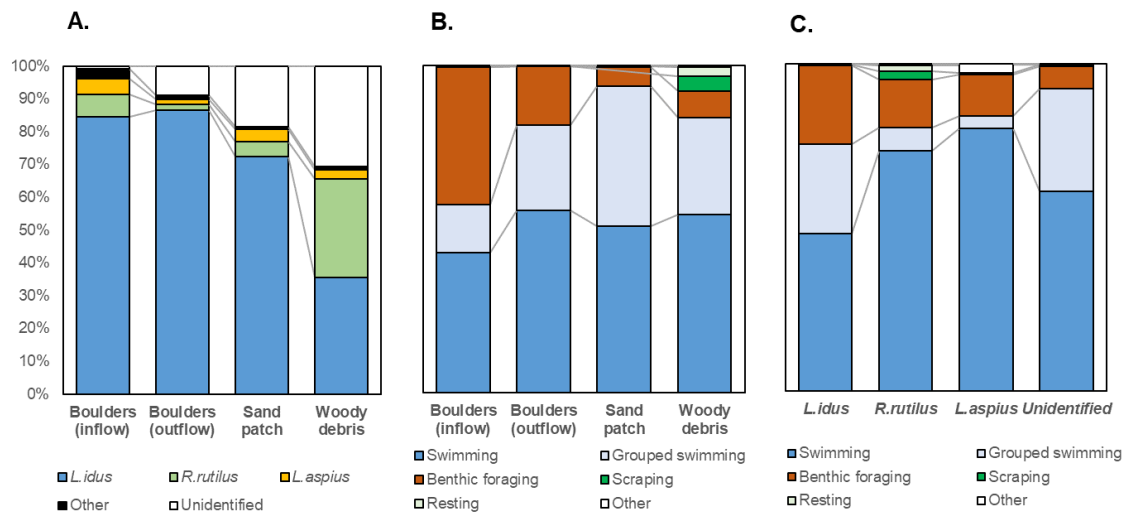


Figure 1. Species composition (A) and behaviour of juvenile fishes in four different habitats (B) and per species (C) in a floodplain channel of the River Waal, a distributary of the Rhine River, the Netherlands, 2019.

The most frequently observed behaviour was swimming, either solitary (57.3%), or grouped (28.3%), followed by benthic foraging (24.0%). Benthic foraging was especially prevalent at boulder habitats (Figure 1B), probably because these contained high densities of dreissenid bivalves (*Dreissena* spp.) that could serve as a substratum for benthic food organisms. Woody debris appeared to be supporting the most diverse behaviours, including a substantial amount of scraping, which was enabled by the presence of woody structures. Also resting fish were seen here more often than in the other habitats, probably because woody structures can provide shelter against predation for juvenile fish.

Fish species differed in the distribution of observed behaviours (Figure 1C), with ide having a stronger tendency to swim in groups, and roach to show more scraping behaviour. Asp was mostly swimming alone, which is in concordance with its predatory behaviour. Whether behaviour is driving habitat preference, or *vice versa* is unresolved, but they are probably interacting.

4 CONCLUSION

Our study shows that both rheophilic (e.g. *L. idus*) and eurytopic (e.g. *R. rutilus*) fish species used a variety of habitats in the secondary channel of the river Waal, although the critical rheophilic species such as *C. nasus* and *B. barbatus* were only observed in small numbers. It was also found that different habitats in the secondary channel serve different functions in the life cycle of juvenile river fishes, with some species being more abundant in particular habitats and showing different behaviours in different habitats, including habitats that are not natural in lowland rivers, such as the boulder habitats. The restoration of river floodplain channels therefore needs close consideration of the role of habitat variability in the nursery of juvenile fishes.

LIST OF REFERENCES

- Birnie-Gauvin, K., Aarestrup, K., Riis, T.M.O., Jepsen, N. and Koed, A. (2017). Shining a light on the loss of rheophilic fish habitat in lowland rivers as a forgotten consequence of barriers, and its implications for management. *Aquatic Conserv.: Mar. Freshw. Ecosyst.*, 27, 1345– 1349.
- Eick, D. and Thiel, R. (2013). Key environmental variables affecting the ichthyofaunal composition of groyne fields in the middle Elbe River, Germany. *Limnologia* 43, 297- 307.
- Stoffers, T., Buijse, A. D., Verreth, J. A. J., and Nagelkerke, L. A. J. (2021). Environmental requirements and heterogeneity of rheophilic fish nursery habitats in European lowland rivers: Current insights and future challenges. *Fish and Fisheries*, 00, 1– 21.