Application of large wood in Rhine habitats rapidly facilitates both native fish and macroinvertebrate communities

L'utilisation du bois mort dans les habitats du Rhin favorise rapidement les communautés indigènes de poissons et de macroinvertébrés

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RÉSUMÉ

Les gros débris ligneux sont devenus rares dans les cours d'eaux régulés des Pays-Bas. Au cours d'une étude pilote de trois ans, de grands morceaux de bois ont été réintroduits dans le système fluvial du Rhin, cette mesure de restauration ayant pour but d'améliorer la biodiversité aquatique. Les communautés de poissons et de macroinvertébrés ont été étudiées pendant trois ans au moyen d'une combinaison de méthodes d'échantillonnage sur les grands morceaux de bois et par rapport à des sites dépourvus de cette structure d'habitat (enrochement). Les résultats indiquent que les effets sont divers. Premièrement, l'apport de gros morceaux de bois facilite une colonisation rapide des espèces de poissons et de macroinvertébrés sur le nouvel habitat, la composition des espèces reflétant ainsi les conditions locales d'écoulement de l'eau. Deuxièmement, les densités de poissons étaient significativement élevées autour des morceaux de bois, avec de grandes concentrations de poissons indigènes en comparaison avec les enrochements. Les espèces étrangères, telles que les gobies vivant au fond des cours d'eau, utilisent beaucoup moins ces morceaux de bois mort. En ce qui concerne les macroinvertébrés, le nombre d'espèces sensibles qui se sont installées sur les morceaux de bois a été significativement plus élevé que sur les enrochements, et comprenait des espèces localement éteintes. Troisièmement, les résultats indiquent que ces grandes structures de bois ont diverses fonctions écologiques, de la pépinière au catalyseur de la chaîne alimentaire, fournissant une source d'alimentation importante pour les macroinvertébrés et les poissons. En conclusion, l'utilisation de gros morceaux de bois peut être un outil de gestion rentable pour stimuler la faune aquatique, et contribuer ainsi à la fois au réseau trophique fluvial et aux indices de qualité de la directive-cadre sur l'eau.

ABSTRACT

Large woody debris has become scarce in Dutch regulated rivers. In a three-year pilot study, large wood was reintroduced in the River Rhine system, as a restoration measurement to enhance aquatic biodiversity. Fish and macroinvertebrate communities were surveyed for three years by a combination of sampling methods at the large wood and compared to sites without this habitat structure (riprap). Results indicate various effects. Firstly, application of large wood facilitates a rapid colonisation of both fish and macroinvertebrate species on the new habitat, the species composition hereby reflecting the local water flow conditions. Secondly, fish densities were significantly elevated around large wood with large aggregations of native fish in comparison with riprap. Alien species such as bottom dwelling gobies only use large wood to a small extent. For macroinvertebrates a significant higher number of sensitive species settled on large wood in comparison with riprap, among them species that were locally extinct. Thirdly, results indicate the large wood structures have various ecological functions, from fish nursery to food-web catalyst, providing an important feeding source for macroinvertebrates and fish. In conclusion, the application of large wood may be a cost-effective management tool to stimulate aquatic fauna, thereby contributing to both the riverine food web and Water Framework Directive quality indices.

KEYWORDS

Large woody debris, habitat restoration, macroinvertebrates, fish, navigable river

1 APPLICATION OF LARGE WOOD IN RHINE HABITATS RAPIDLY FACILITATES BOTH NATIVE FISH AND MACROINVERTEBRATE COMMUNITIES

1.1 Introduction

Aquatic diversity of western European regulated rivers strongly declined over the past centuries. Pollution, normalization, canalization and embanking of rivers and floodplains have attenuated aquatic habitat quality and diversity. In consequence, associated riverine communities dominated by characteristic fish and macroinvertebrates made room for communities dominated by generalistic and alien species. Since (organic) pollution is no longer the main stressor it is hypothesized that the reintroduction of natural complex three-dimensional structures in the river channel, such as (pieces of) large wood (e.g., trees that fell into the river, which were common habitattypes before the 20th century) can partially restore this characteristic riverine species composition (Roni *et al.* 2015). This study questions whether this restoration measurement significantly contributes to aquatic species diversity and density in a strongly regulated, navigable part of the Dutch Rhine river system.

1.2 Method

Reintroduction of large wood structures (entire trees) was applied in 2014 to four locations in the Dutch Rhine river system, e.g., the rivers Lek, Nederrijn and IJssel. Subsequently, colonisation of the structures by fish and macroinvertebrates was surveyed in the period 2014 - 2016. Within this survey, comparisons of species communities were made between large wood structures and adjacent control habitats (riprap, unvegetated water bottoms). Different sampling methods were combined to provide a broad insight in the functioning of the large wood structures for aquatic species.

1.3 Results

1.3.1 Fish

The large wood structures were rapidly colonised by fish. Total species richness and density of native fish species were significantly higher in large wood than in adjacent control habitats (figure 1a). The species community reflected the community of the corresponding river stretch. As a result, large wood in river parts with low stream velocity (river Lek) were dominated by ubiqistic species (e.g., pearch, *Perca fluviatilis*; roach, *Rutilis rutilis*), whereas large wood in stretches with a higher stream velocity (river IJssel) showed higher densities of rheophilic species (e.g. common barble, *barbus barbus;* ide *Leuciscus idus*). Interestingly, densities of bottom dwelling alien gobies (e.g., round goby, *Neogobius melanostomus*) were significantly lower at large wood compared with control habitats (riprap) (Dorenbosch *et al.* 2017).

Additional surveys showed high densities of juvenile fish in large wood in summer, whereas large differences were observed between the species community in the structures during day and night.

1.3.2 Macroinvertebrates

Large wood structures were also rapidly colonised by macroinvertebrate species. On the contrary to the fish community, the observed species community on large wood did not significantly differ in species richness or density from adjacent control habitat (riprap, figure 1b). In all investigated samples the species community was dominated by alien species. However, when focussing on specific groups of species (i.e., sensitive native species associated with hard substrates and higher stream velocities such as Chironomidae and Trichoptera), large wood harboured significant higher number of these species than control habitats (riprap, figure 1b). Among these species were also species that were thought to be extinct in Dutch rivers (e.g. *Brachycentrus subnubilus* and *Stenochironomus*.).

1.4 Conclusion

The observation of this three-year survey of the colonisation pattern of large wood structures by aquatic species in the Dutch Rhine enables various conclusions. Firstly, application of large wood in a strongly regulated river results in a rapid colonisation of both fish and macroinvertebrates species of

the new habitat. Here, the species assemblage on large wood reflects the species assemblage of the river, including species with more sensitive life-history tactics (such as rheophilic fish and macroinvertebrates associated with hard substrates and higher water flow velocities). Secondly, for fish a clear density-enhancing effect of large wood was observed. Large aggregations of native fish were observed around large wood in comparison with control habitats, whereas alien species such as bottom dwelling gobies only use large wood to a small extent. Although for macroinvertebrates this density-effect was not detected, large wood structures facilitate the settlement of rare species, including species that were thought to be extinct in the Dutch Rhine.

Thirdly, results indicate the large wood structures have various ecological functions: aggregation of juvenile fish indicate a nursery function, high density of macroinvertebrates provide an important feeding source for fish whereas day-night shifts of fish assemblages indicate diurnal connectivity of large wood habitats with other nearby habitats.

In conclusion, the application of large wood may be a cost-effective management tool to stimulate aquatic fauna on a local scale. Applied on a larger scale, large wood structures may improve habitat quality for fish and macroinvertebrates, thereby contributing to both the riverine food web and Water Framework Directive quality indices.

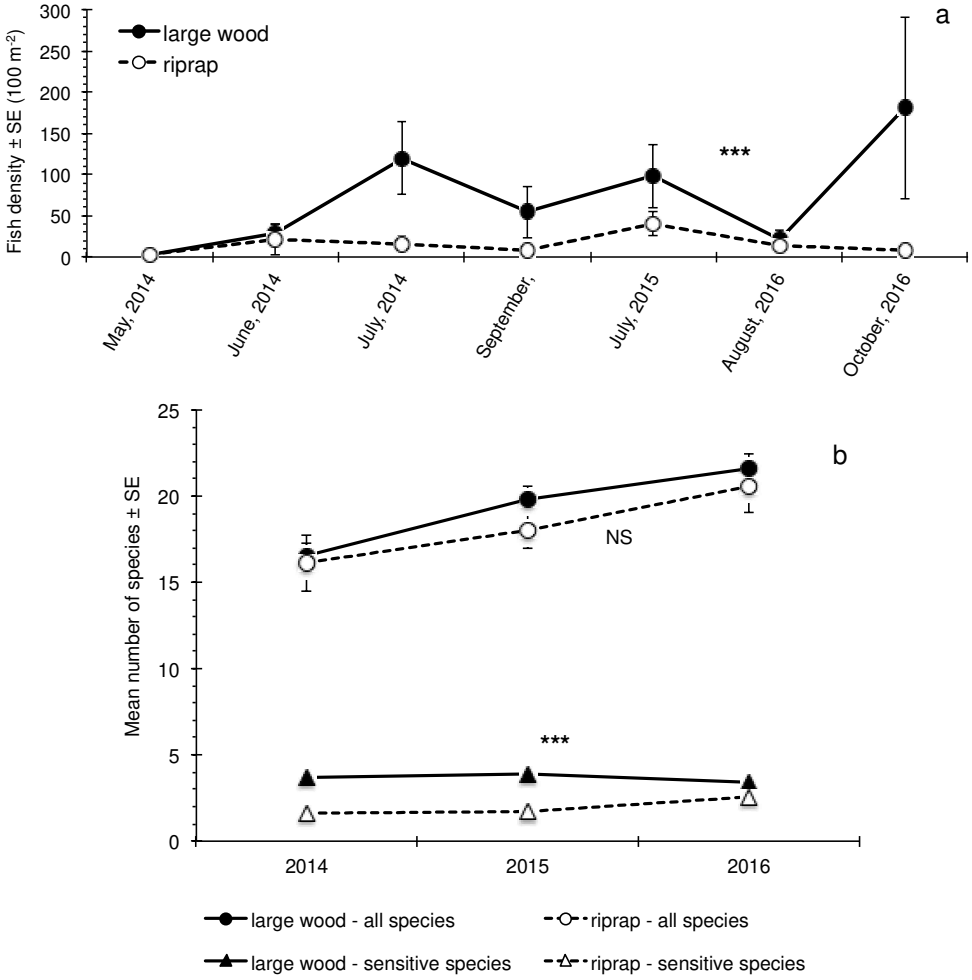

Figure 1. A) Development of native fish densities on large wood in comparison with adjacent riprap (2014 – 2016). B) Development of macroinvertebrate species richness on large wood structures in comparison with adjacent riprap (2014 – 2016) for the entire community and sensitive species. NS; no significant difference; *** P<0.001

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