BIOLOGY AND BIODIVERSITY OF RIVER SYSTEMS

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Contents

Summary

In this chapter several approaches towards zonation and continuity of biocommunities in streams are analyzed. In older literature, rivers were described in well defined stretches from source to mouth. The biocommunities were described as entities in those stretches. Later, American scientists claimed that a river is a continuum with gradually changing conditions and henceforth gradually changing biocommunities with much overlap.

This chapter offers a solution between both approaches. There are places along rivers where the physical conditions change—the so-called transition areas. The most important characteristic of these areas is that they produce hydraulic stress, and this creates circumstances for suitably adapted species. Species from the stretches upstream and downstream of transition areas overlap and thus create high biodiversity in the transition areas. It is claimed that hydraulic factors are the main determinants for invertebrate zonation patterns. This is illustrated with examples, where multivariate analysis is an important help. There is a clear relationship between the presence of certain (not all) species and well-defined hydraulic conditions.

In the lower courses of large rivers there are connections with floodplains, connected side-arms, oxbow lakes and ephemeral waters. These waters form an extension of the river proper and the total biodiversity of the lower course is potentially the highest of the total river. Because lower courses are among the most polluted and physically changed parts of rivers, biodiversity in these parts of modern rivers is frequently much lower than it could be.

1. Introduction

Rivers are among the oldest waterbodies in the world. Many species evolved in running waters and subsequently invaded stagnant waters. Biodiversity in river systems is therefore the most diverse and complex of the world’s fresh water bodies. As a consequence of human development, nature has been adapted to our needs, and rivers are foremost among the habitats to have been conquered. First, rivers have been used for drinking water and as a means of transportation. Large cities have been built on estuaries and deltas because of the advantageous position for harbours and the presence of fresh water. For the same reasons, cities have been erected alongside rivers and in the course of time the detrimental effects of the growing population became apparent in reducing water quality and in physical modification of rivers.

The original flora and fauna of rivers suffered from human impacts like pollution, damming, embankments and deforestation of the catchment area. It is now very difficult to find pristine situations where rivers are free-flowing and contain a natural biocenosis. In many places, the upper courses are still undisturbed but downstream stretches get more and more influenced by agriculture, forestry and human settlements. Knowledge of the ecology of natural rivers, therefore, is an amalgam of remnants of more or less undisturbed (parts of) river in many parts of the world.

2. Ecological characteristics along the course of running waters.

In *Biogeochemical Processes in River Systems*, the different stream sources are described and an indication is given of the stream types resulting from them. This has been elaborated in more detail in Table 1 for Central European rivers. This is a synoptic overview containing the most important ecological characteristics.

Part of river	**Characteristics**	
Source:	Glacier	t<7 °C, high turbidity in summer, no canopy, very few species
	Hot spring	t>30 °C, often high turbidity by sulphur, no canopy, very few species
	Lake	temperature and turbidity depend on origin, number of species and organisms in accordance with trophic status and origin
	Limnocrene	groundwater of low temperature follows annual temperature, clear water, in natural conditions canopy, lentic organisms
	Helocrene	as limnocrene, but temperature tends to be lower and with lotic organisms in addition
	Rheocrene	t 5 to 12 °C, clear water, in natural conditions under timberline canopy, lotic and specialised organisms
	Seepage area	groundwater of low temperature follows annual temperature with smaller amplitude, clear water, generally canopy, species composition comparable to helocrene but more adapted to semi-permanent conditions.
Note: the last four types depend on slope and terrain		
Upper course	Temperature and turbidity depend on source,	
	P/R<1 (=production generally lower than respiration, but allochtonous production from the bank vegetation is not considered here),	
	Sometimes these courses can be temporary,	
	Stream order 1-3, dimensions small (standard type) or large (e.g. lake outlet),	
	Slope related to source is an important ecological factor,	
	Canopy results in allochtonous organic matter and shredders dominate,	
	If there is no canopy, grazers and predators dominate at high current velocities, but usually no filtering collectors, grazers and predators at low velocities	

	Fish species like trout and bullhead.
Middle course	Extreme temperatures of glacier streams and hot springs tend to stabilize, the others have larger amplitudes than in upper courses
	P/R≅ or P/R>1
	Stream order 4-7, dimensions and slope are important ecological factors
	High numbers of species (in "modern" streams highest numbers)
	Primary producers are algae on stones and beginning production of plankton
	Invertebrates are: filter feeders, collectors, grazers and predators
	Fish species typical for grayling/barbel zones (in temperate streams)
	Higher nutrient content than in upper course by input from the upstream part of the drainage area
Lower course	Daily temperatures have been stabilized, annual temperature follows air temperature
	P/R>1 or P/R<1 (generally by disturbances), under natural conditions many stagnant and periodically overflown waters in the winter-bed can add to high production
	Depth is the most important dimension variable
	Sedimentation of sand and silt in last stretch
	Generally low numbers of species in "modern" streams by pollution and weirs
	Highest numbers of species in natural conditions by backwaters, pools, etc.
	In "modern" streams predominantly collectors, under natural conditions all types of functional groups according to local variation
	High nutrient content: plankton and aquatic macrophytes,
	Fish species typical barbel/bream zones (in temperate streams).

Table 1. Ecological characteristics along the course of running waters in Central Europe.
Source: Higler and Statzner, 1988..

The sequence of source, upper, middle and lower course is a rough division and is not meant as a realistic zonation with defined boundaries. In the twentieth century, however, such zones were often described, with associated biocommunities and with major faunistic changes in relatively short stream reaches (e.g. Huet 1949, Illies & Botosaneanu 1963, and Botosaneanu 1979). In contrast to a strict zonation, American scientists developed a system without strict boundaries—the River Continuum Concept (Vannote *et al*, 1980). This concept claims a gradual change in morphological and physical circumstances and in relation to that a gradual change in the occurrence of plankton, fish and macroinvertebrates. The biocommunities are not separated from each other, but gradually change along the course of the stream.

Statzner & Higler (1986) commented on the RCC and created a system that combines elements from both approaches (see Figure 1). In their paper, they cite examples from studies all over the world and conclude that hydraulic factors are the main determinants for invertebrate zonation patterns.

Fittkau & Reiss (1983) made a reconstruction of the ecological characteristics of large rivers and their floodplains. In addition to the main channel, there can be many types of freshwaters supporting a rich fauna: "lotic and lentic, static and astatic, summer-cold and summer-warm, small and large". These waters form an extension of the river proper and the total biodiversity of the lower course is the highest of the total river. At the same time, lower courses are among the most polluted and physically changed parts of rivers. Today, therefore, river biodiversity is generally much more impoverished than it could be.

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Biographical Sketch

Bert Higler investigated macroinvertebrate associations in relation to vegetation structure in standing waters and in relation to hydraulics in running waters. His primary research took place in The Netherlands. His results are being used by water managers.
His international activities comprise research and education, both in developed and in developing countries. The latter has resulted in a manual on water quality monitoring for use in developing countries.
He retired as head of the department of Aquatic Ecology of the Institute for Forestry and Nature Research (now ALTERRA, Research Institute for the Green World), which comprised freshwater and marine research. His present activities as a senior scientist include work for the European Water Framework Directive, nature restoration projects and biodiversity research on macroinvertebrates and fish.