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Density of juvenile brown trout and Atlantic salmon in natural and man-made riverine habitats

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Abstract – The density of juvenile brown trout (*Salmo trutta* L.) and Atlantic salmon (*Salmo salar* L.) was significantly higher along river bank areas protected against erosion than along natural river banks in the River Gaula, Central Norway. A habitat shift appeared in Atlantic salmon, and a behavioural shift was demonstrated by brown trout from August to October. The effect of habitat on densities of juvenile salmonids should be taken into account as mitigation measures on eroded river banks and when assessing fish production in rivers.

Key words: erosin protection; trout; salmon; density; river habitat

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Un resumen en español se incluye detrás del texto principal de este artículo.

Introduction

Estimation of fish density within rivers and lakes is crucial in production assessment. The most widely used methods to estimate fish densities in running water are the mark-recapture and the removal. The precision of production assessment is, however, dependent on several factors such as size of sampling area, number of sampling areas, age/size distribution, and spatial distribution of species (Bohlin et al. 1989).

Sympatric juvenile Atlantic salmon (*Salmo salar* L.) and brown trout (*Salmo trutta* L.) segregate in running waters. Juvenile brown trout is most common in the shallow parts of the river with low water velocities, whereas juvenile Atlantic salmon are more common at higher water velocities in midstream (Heggberget 1984; Heggenes & Saltveit 1990; Hvidsten & Johnsen 1992). However, little information on segregation of salmon and trout in relation to bottom substratum is reported.

Results and discussion

In the natural Atlantic salmon-producing streches of the River Gaula, Central Norway (63°20′N), thirteen stations between Melhus (9.9 km from river outlet) and Rognes (53.7 km from river outlet) were sampled. Four stations were situated in areas with river bank protection embankments. These consisted of large boulders (diameter>1 m), forming a steep slope. The nine natural stations had low gradients and a substrate dominated by pebbles and cobbles (diameter 10–30 cm). Each station was electrofished in August and October 1986. The population sizes were estimated by the removal method with three successive removals (Zippin 1956). Age of 230 brown trout and 1020 Atlantic salmon juveniles was determined from otoliths.

The density of all age groups of juvenile brown trout and Atlantic salmon (except 1+ salmon) were significantly (*t*-tests, $P<0.001$) higher in erosion-protected river bank areas than around natu-

Table 1. Mean density (n±SD 100 m^{-2}) of juvenile brown trout and Atlantic salmon in the River Gaula, 1986. Number of sampling stations are given in brackets

		Brown trout		Atlantic salmon	
River bank	Period	1+	>1+	1+	>1+
Natural	Aug.	1.2±1.5 (6)	1.0±2.1 (7)	18.1±11.2 (8)	15.4±12.4 (9)
	Oct.	0.5±1.0 (8)	0.3±0.5 (9)	7.1±5.0 (7)	5.2±4.8 (8)
Erosion protected	Aug.	13.3±17.6 (3)	29.0±21.3 (4)	9.1±5.4 (4)	35.5±27.6 (4)
	Oct.	5.4±4.5 (4)	16.5±10.5 (4)	45.8±31.6 (3)	25.5±18.0 (3)

ral river banks during both sampling periods (Table 1). Along both habitats and in both sampling periods, the density of all age groups of juvenile Atlantic salmon were significantly (t-tests, $P<0.01$) higher than that of corresponding age groups of juvenile brown trout, except for 1+ in August where the reverse was the case (t-test, $P<0.05$).

The data indicates that a habitat or behavioural change takes place between the two sampling periods. The estimated density for brown trout was reduced in October compared to August, and significantly (t-tests, $P<0.001$) in erosion-protected areas. The water temperature at the two sampling periods were 12.5 and 0.5°C in August and October, respectively. Thus, the decline in population density may be a consequence of inactivity during daytime, as trout demonstrate nocturnal activity and hiding in the substrate during daytime at water temperature below 9°C (Heggenes et al. 1993). The salmon data, on the other hand, indicates a change in habitat use. A significant (t-tests, $P<0.001$) reduction in density of both age groups of salmon was found in natural areas from August to October, whereas a significant ($P<0.001$) increase was simultaneously recorded in erosion-protected areas. Juvenile Atlantic salmon also become nocturnal at low water temperatures (Heggenes & Saltveit 1990), so the actual increase in density is probably even higher than recorded. One reason for the observations may be that as high water velocity is more important for juvenile Atlantic salmon (Karlström 1977; Heggenes & Saltveit 1990), they may congregate in swift, deep areas along the river to prevent being frozen up during winter. In his study of habitat selection and population densities of Atlantic salmon and brown trout parr in Swedish rivers, Karlström (1977) found a similar increase in juvenile density in habitats with coarse substrate during winter compared to summer conditions. He considered this preference for blocky areas to be of adaptive value, as the habitat may protect the parr against predators and bottom ice.

The recorded densities of juvenile Atlantic salmon were in accordance with previous studies in comparable Norwegian rivers (Jensen & Johnsen 1989). In rivers with coexisting Atlantic salmon and brown trout, the density of juvenile brown trout is usually low and at a similar level as in our study (Johnsen & Jensen 1988; Jensen & Johnsen 1989).

During the last decades a number of studies demonstrate that brown trout prefer lower water velocities than salmon and, under conditions with high water velocity, will seek shelter in stable stony areas. The present study gives support to these general acceptances for habitat use in juvenile brown trout. However, our results indicate that juvenile brown trout avoid natural river banks and prefer river banks that have been protected against erosion. The rationale for such complexity in density relationships of brown trout is difficult to interpret. One reason may be the territorial behaviour of brown trout (Kalleberg 1958). In stony areas increased visual isolation apparently reduces the agonistic behaviour. Thus, the holding capacity of the area increases. Furthermore, the food availability in this habitat may be more profitable compared to river habitats of finer substrate and lower water velocities, as brown trout and salmon are chiefly feeding on drifting invertebrates in rivers (Kalleberg 1958).

It is, however, very important to distinguish between the man-made erosion-protected river banks in this study and those which are naturally stabilized by vegetation, particularly trees. Such river habitats provide cover and allochtonous food for fish. The density of juvenile salmonids in these areas may be considerable. Studies have demonstrated the paramount importance of an intact riparian vegetation for the fish production in running waters (Martin et al. 1986; Murphy et al. 1986). Thus, natural stabilized river banks can by no means be compared with man-made erosion protected river banks. The latter can only be considered as an option when the river bank becomes unstable for some reason.

Our results indicate that the distribution of juvenile brown trout and Atlantic salmon within a river is complex and dependent on both spatial and temporal conditions. The habitat effect on densities of juvenile Atlantic salmon and brown trout should be taken into account when assessing fish production in rivers.

Resumen

1. La densidad de juveniles de Trucha (*Salmo trutta* L.) y Salmón (*S. salar* L.) del río Guala (Noruega central) fueron significativamente más altas a lo largo de las orillas del río en áreas protegidas contra la erosión que en las orillas naturales. Desde Agosto a Octubre, detectamos un cambio en el habitat de los Salmones y un cambio en el comportamiento de las Trucha.
2. Los efectos del habitat sobre las densidades de juveniles de salmónidos deberían ser tenidas en cuenta tanto al tomar medidas para mitigar las erosiones sobre las orillas de los ríos como al determinar la productividad de las poblaciones de peces.

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