（第３号様式）(Form No. 3)

学 位 論 文 要 旨
Dissertation Summary

氏　　名 (Name) 東垣 大祐 (Daisuke TOGAKI)

論　文　名：魚類群集形成における外部および内部要因：

下流域における水域ネットワークと上流域における種間相互作用

(Dissertation Title)

(Regional and local processes in fish assemblage organisation:
habitat network in a lowland river and species interactions in headwater streams.)

Processes of assemblage organisation in a local habitat are roughly classified into regional and local processes. Both processes are important for all communities and their relative contribution changes depending on characteristics of the target local habitat *per se*, its connectivity to surrounding habitats and dispersal characteristics of organisms. In river systems, environmental conditions change along the course of streams from headwater to the mouth. Such longitudinal environmental gradients affect the relative importance of regional and local processes in fish assemblage organisation. In general, lowland river systems consist of various habitats, such as main channels, tributaries, ponds, wetlands, paddies and ditches, forming highly complex networks. In such systems, frequent movements of fishes can mask effects of biotic interactions and local habitat conditions on fish assemblages. In contrast to lowland river systems, headwater streams are characterised by small and isolated habitats with low productivity. In such systems, effects of local processes (e.g. biotic interactions) on fish assemblage organisation can override those of regional processes. In this dissertation, I explored mechanisms underlying fish assemblage organisation in a lowland braided river and upper, headwater streams, focusing on regional and local processes, respectively.

<u>Effects of fish movement in lowland freshwater systems</u>
In lowland river systems, I focused on effects of fish movement on assemblage organisation as a regional process. During dispersal or movement through a river network, fish have to select their way at each junction (i.e. the confluence of two channels) in the network, and their channel selection (route selection) would be reflected in the spatial variations in fish assemblage composition. First, I examined channel selection by fish during movement and its effects on local fish assemblage using braided channels. The channel-selection survey showed that fat minnow (*Rhynchocypris oxcycephala*) and spined loach (*Cobitis* sp. BIWAE type A) selected channels with lower flow volume. In pools in the braided channels, strong positive correlations were found between the density of the two species. These results suggest that the fish assemblage composition of local habitats in our braided river reflected channel selection by fish during their movement. Route selection by fish during dispersal or movement can be a notable factor determining the assemblage composition of freshwater fish.

Next, I explored seasonal movement of fishes at a confluence of surface-water and groundwater channels. In braided rivers, networks of groundwater-fed and surface-water dominated channels cause a high variability in stream water temperature in space and time. Fishes in braided channels may exploit such spatiotemporal thermal heterogeneity through seasonal movement. I surveyed seasonal habitat use by fishes at a confluence of groundwater and surface-water channels. The seasonal survey revealed that pale chub (*Opsariichthys platypus*) density was higher in the groundwater channel than in the surface-water channel in winter and *vice versa* in summer. These spatial variations of pale chub density were related to water temperature both in winter and summer, suggesting their seasonal movement between the two channels to seek better thermal conditions. Thus,

groundwater seeps can provide important winter habitats for warmwater fishes and the close proximity of channels having contrasting thermal regimes is an important aspect of braided rivers for persistence of diverse fish assemblages. Overall, the results of these two studies using a braided-channel network suggest the importance of habitat connectivity for maintenance of fish assemblage. This importance found in the braided channels can be applied also to larger networks, such as river-floodplain systems, in lowland rivers.

Interspecific interactions in headwater streams

In headwater streams, I focused on interspecific interactions as a local process in assemblage organisation. In upper reaches of rivers, longitudinal species replacement has often been reported for various pairs of stream salmonids. White-spotted charr (*Salvelinus leucomaenis* subspp.) and masu salmon (*Oncorhynchus masou* subspp.) are common stream salmonids in Japan. In southwestern Japan where white-spotted charr is not originally distributed (i.e. Shikoku and Kyushu), introduced white-spotted charr populations have established in several streams inhabited by native masu salmon. In the Kurokawa River, introduced white-spotted charr has created the common longitudinal pattern (upstream and downstream dominance by white-spotted charr and masu salmon, respectively), by displacing native red-spotted masu salmon in upper reaches. For salmonids, size-dependent dominance hierarchies strongly affect growth and survival of individuals within each local habitat. Because age-0 white-spotted charr is smaller than age-0 red-spotted masu salmon due to late spawning timing, white-spotted charr seems to be inferior to red-spotted masu salmon. However, introduced white-spotted charr has displaced native red-spotted masu salmon in upper reaches, suggesting that white-spotted charr has some advantages to red-spotted masu salmon in upper reaches. I explored mechanisms of displacement of native red-spotted masu salmon by introduced white-spotted charr in upper reaches.

First, I focused on spawning timing, and hypothesised that smaller channels of upper reaches would have higher potential of redd superimposition owing to lower availability of spawning habitat. The high risk of redd superimposition in upper reaches can provide a competitive advantage to late-spawning white-spotted charr and may cause displacement of native red-spotted masu salmon. Spawning-habitat survey showed that 1) the habitat availability decreased upstream as channel size decreased, and 2) characteristics of spawning habitat highly overlapped between the two species in small channels, whereas those differed significantly between the two species in larger channels, suggesting that redd superimposition can be a potential mechanism causing displacement of red-spotted masu salmon in the upper reaches.

Next, I explored differences in growth along streams between the two species. Considering their size-dependent dominance hierarchy, differences in growth can be an important factor affecting their competitive superiority. If white-spotted charr grow faster than red-spotted masu salmon in upper reaches whereas *vice versa* in lower reaches, this longitudinal reversal of growth can be a cause of displacement of red-spotted masu salmon in upper reaches. I conducted a three-year monitoring survey to examine whether 1) the longitudinal reversal of growth occurs between white-spotted charr and masu salmon, and 2) white-spotted charr negatively affect growth and persistence of red-spotted masu salmon. Although no longitudinal reversal of growth between the two species was observed, my monitoring survey revealed that white-spotted charr grew faster and became larger than red-spotted masu salmon at age 2, despite their smaller initial body size. After age 1, when white-spotted charr caught up in size with red-spotted masu salmon, white-spotted charr negatively affected persistence and growth of red-spotted masu salmon. Thus, high growth of white-spotted charr would be one major factor facilitating the establishment and dominance of its population. Overall, my results suggest that the introduced white-spotted charr in the study area has advantages in growth and spawning habitat use, which could be important factors facilitating the displacement of red-spotted masu salon. These explorations may be applied also to the longitudinal replacement of salmonids in general.