Community structure and genetic structure of aquatic insects inhabiting alpine and sub-alpine ponds of the Japanese mountains

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Alpine and sub-alpine ponds are considered that they pay some roles as important habitats and/or environments in mountain ecosystem. For example, they have functions as water resources for terrestrial organisms, and habitats for aquatic organisms. Alpine and sub-alpine ponds have various origins, and their environments differ greatly for each origin (e.g. vegetation, pH). For aquatic animals inhabiting these ponds, differences of their environments are thought to directly effect in biota, so their environments' diversity may contribute to the creation of mountainous biodiversity. However, despite the importance of alpine and sub-alpine ponds, studies focusing on the relationship between the ponds' environments and their biodiversity have only a few cases even in high mountainous areas of Europe. Especially in ponds on the Northern Japan Alps, there are not yet study cases. Under these circumstances, In this present study, we focused on the Kamikochi area and the Yari-Hotaka Mountain Ranges in the Northern Japan Alps, and we have conducted analyses for the relationship between their aquatic insect fauna and the ponds' environments in alpine and sub-alpine ponds. Quantitative samplings of aquatic insects was at 23 ponds in the alpine and subalpine zones of the Northern Japan Alps. And, various environmental factors were measured in each pond. In addition to comparing and examining the obtained community, population structure data and environmental data as habitats, the cluster analysis, the NMDS analysis, and the CCA analysis were also performed. As the result of conducting our studies, community structures were categorized into 4 groups largely in all of our analyses. Also it was suggested that the alpine and sub-alpine aquatic insects' fauna is influenced by altitude, abundance of herbaceous plants around the shore, amount of gravels, sands and soil at the bottom of ponds. Therefore, the aquatic insect fauna of mountain ponds differs depending on such ponds' environments. Alpine ponds with divergent environments may have important roles in the creation of mountainous biodiversity. In addition, for some representative species of aquatic insects inhabiting these isolated and scattered ponds, we focused on their genetic structure. Genetic analysis of the mtDNA COI region (DNA barcoding region) were performed on the small diving beetle Agabus japonicus and mountain caddisflies Pseudostenophylax spp. It was confirmed that the genetic structure of A. japonicus in the Northern Japan Alps corresponds to a widespread lineage observed from the Northeastern Japanese region. However, different lineage was observed in only one pond, i.e., Shoga-ike at the summit of Mt. Yake-dake. This haplotype was positioned in the lineage observed from the Southwestern Japanese region. This way be due to the Northern Japan Alps being a border area between the Northeastern and the Southwestern Japan. As a result, A. japonicus , in addition to that we observed individuals of the same lineage as widely distributed (i.e., from Hokkaido to Nagano), we revealed that individuals of largely genetically different lineage inhabit some alpine ponds. As for the results of genetic structure analyses of Pseudostenophylax caddisflies, the genetic differentiation of each mountain range was clearly remarkable. In addition the correlation between their geographical distances and their genetic differentiation was extremely high. These results suggest that the genetic structure of Pseudostenophylax caddisflies is considered to strongly reflect the history of the formation of the Japanese Archipelago and mountains.

Keywords: alpine zone, mountain ponds, biodiversity, benthic invertebrates