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Phyto- and zooplankton dynamics in Hachimandaira ponds during the 20 th century: what's happening at the alpine lakes?

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Anthropogenic perturbations such as global warming and nutrient loadings from the watershed are predicted to increasingly affect alpine ponds and lakes. In addition, recent studies revealed that nitrogen input through atmospheric deposition alter these aquatic ecosystems. Long-term monitoring data are necessary to elucidate how, and to what extent the environmental changes affect given aquatic ecosystems. However, biological monitoring data from alpine aquatic ecosystems at time scales of decades or longer has been scarcely reported. To establish an ecosystem management plan for a alpine ecosystem, it is essential to understand how, and to what extent, the plankton community has been altered in response to changes in environmental conditions at local, regional and global scales. Fortunately, in lake and pond ecosystems, the remains of phyto- and zooplankton and their pigments of algae in the past are preserved in the bottom sediments. In this study, therefore, we examined phyto- and zooplankton remains and fossil pigments in the sediments of two Hachimandaira ponds, that is Hourai- and Hachiman-numa, to (a) to uncover historical changes in the phyto- and zooplankton community over the past 100 years, and (b) to identify environmental factors causing such changes.
As a result, the concentrations of total nitrogen (TN) and phosphorus (TP) in Hourai-numa had increased since the 1950s. In parallel with this, the abundance of phytoplankton slightly increased, furthermore, it drastically increased by 5-18 fold after the 1980s when both TN and TP concentrations rapidly increased. Additionally, crustacean zooplankton of Daphnia, which is a keystone species in lake ecosystems, largely increased by 3-6 folds since the 1980s. Other zooplankton, Alona and Chydorus, also slightly increased since the 1950s. These results suggest that the phyto- and zooplankton community in Hourai-numa that exists in national park of Japan have been altered by bottom-up effects of nutrient loading to this lake for the past several decades. Since we did not detect anthropogenic effects in the watershed around this pond after the 1950s, therefore, recent nutrient loading to this lake are thought to be brought by air deposition.
In Hachiman-numa, the abundances of phyto- and zooplankton were entirely low compared to those of Hourai pond. The concentration of TN slightly increased after the 1990s, but that of TP did not increase. The abundance of zooplankton, Alona, Chydorus and Daphnia, have not almost increased since the 1950s, although that of phytoplankton slightly increased by 3-6 folds after the 1990s. As noted above, phyto- and zooplankton dynamics in two ponds during the 20th century are quite different despite only slight distance between them (1.3km).
We report and discuss the causal factors driving contrasting ecosystem changes in these ponds, and the origin of increasing phosphorus input to Hourai-numa through the air deposition, based on the results of lead stable isotopes.

Keywords: paleolimnology, phytoplankton, zooplankton, 20th century, atmospheric deposition, alpine lakes