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Food web structure and trophic interactions of the tropical highland lake Hayq, Ethiopia

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ABSTRACT

We generated a mass-balance model to figure out the food web structure and trophic interactions of the major functional groups of the Ethiopian highland Lake Hayq. Moreover, the study lay down a baseline data for future ecosystem-based investigations and management activities. Extensive data collection has been taken place between October 2007 and May 2009. Ecotrophic efficiency (*EE*) of several functional groups including phytoplankton (0.8) and detritus (0.85) was high indicating the utilization of the groups within the system. However, the *EE* of *Mesocyclops* (0.03) and *Thermocyclops* (0.30) was very low implying these resources were rather a 'sink' in the trophic hierarchy. Flows based on aggregated trophic level *sensu* Lindeman revealed the importance of both phytoplankton and detritus to higher trophic levels. The computed average transfer efficiency of 11.5% for the first four trophic levels was within the range for highly efficient African lakes. The primary production to respiration (*P*/*R*) ratio (1.05) of Lake Hayq indicates the maturity of the ecosystem. We also modeled the food-web by excluding Tilapia and reduced phytoplankton biomass to get insight into the mass balance before Tilapia was introduced. The analysis resulted in a lower system omnivory index (SOI = 0.016) and a reduced *P*/*R* ratio (0.13) that described the lake as immature ecosystem, suggesting the introduction of Tilapia might have contributed to the maturity of the lake. Tilapia in Lake Hayq filled an ecological empty niche of pelagic planktivores, and contributed for the better transfer efficiency observed from primary production to fish yield.

1. Introduction

Food webs provide a framework for integrating population dynamics, community structure and ecosystems processes (Kaunzinger and Morin, 1998), and are a central idea in ecology (Wilbur, 1997). Predator–prey interactions provide a means to examine the species' roles in ecological processes, and to understand community and ecosystem functioning (Thapanand et al., 2009). Furthermore, food-web structure also affects primary production through its influence on grazing (Carpenter et al., 1998). For instance, in a three trophic-level food chain, predators can reduce herbivore zooplankton indirectly benefiting the primary producer phytoplankton, which partly explains the variation that otherwise would remain unexplained by the effect of nutrient input experiments (Carpenter et al., 1985; Carpenter and Kitchell, 1993; Bronmark and Hansson, 2005). Moreover, it gives a clue whether the basal trophic groups such as phytoplankton are adequate to sustain the whole ecosystem through estimates of primary production required (Christensen et al., 2005). Experiments and modeling approaches are two ways to study structure and function of an ecosystem, the former being more informative in a whole-lake experiment (Carpenter and Kitchell, 1992). Ecosystem-level experiments, however, are few due to methodological problems, large economic costs and time requirements (Wetzel and Likens, 1991). Among the different hypothesis, trophic cascades are typically strong in aquatic ecosystems particularly in whole-lake experiments (Carpenter and Kitchell, 1992). Nevertheless, trophic interactions in aquatic ecosystems are much more complex and dynamical than thought before (Paine, 1980; Wetzel and Likens, 1991). In biomanipulation research, for example, juvenile predator fish, which are expected to be piscivore, are zooplanktivore and are able to reverse the effect of biomanipulation (Hansson et al., 1998). An alternative to experimental approaches is ecosystem modeling that can be used to describe pathways of organic matter, to predict ecosystem responses of perturbations and to identify higher-level properties of the ecosystem that are not readily measurable, such as the goal functions (Muller and Leupelt, 1998). We used the modeling software Ecopath, which offers a network analysis and provides insights into the structure and dynamics of aquatic ecosystems

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