

# New parasites and predators follow the introduction of two fish species to a subarctic lake: implications for food-web structure and functioning

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**Abstract** Introduced species can alter the topology of food webs. For instance, an introduction can aid the arrival of free-living consumers using the new species as a resource, while new parasites may also arrive with the introduced species. Food-web responses to species additions can thus be far more complex than anticipated. In a subarctic pelagic food web with free-living and parasitic species, two fish species (arctic charr *Salvelinus alpinus* and three-spined stickleback *Gasterosteus aculeatus*) have known histories as deliberate introductions. The effects of these introductions on the food web were explored by comparing the current pelagic web with a heuristic reconstruction of the pre-introduction web. Extinctions caused by these introductions could not be evaluated by this approach. The introduced fish species have become important hubs in the trophic network, interacting with

numerous parasites, predators and prey. In particular, five parasite species and four predatory bird species depend on the two introduced species as obligate trophic resources in the pelagic web and could therefore not have been present in the pre-introduction network. The presence of the two introduced fish species and the arrival of their associated parasites and predators increased biodiversity, mean trophic level, linkage density, and nestedness; altering both the network structure and functioning of the pelagic web. Parasites, in particular trophically transmitted species, had a prominent role in the network alterations that followed the introductions.

**Keywords** Non-native species · Pelagic community · Species additions · Topology · Trophic interactions

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## Introduction

Food webs depict ecological communities via networks of trophic relationships, and the structure and complexity of these networks influence community dynamics and stability (Bascompte et al. 2003; Dunne et al. 2005; Allesina and Pascual 2008). Beyond their importance in addressing general ecological questions, food-web analyses of species additions and deletions can also shed light on the impact of invasions and extinctions (Dunne et al. 2002; Srinivasan et al. 2007; Petchey et al. 2008). In particular, species introductions, in addition to increasing species richness, can alter food-web topology because a new species can act as a consumer or resource for existing species, or might be the critical resource needed for other consumers to invade the web. Introduced or invading species are furthermore likely to have hitchhiking parasites (Prenter et al. 2004; MacLeod et al. 2010), and parasites may also be affected