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Assessment of impacts of invasive fishes on the food web structure and ecosystem properties of a tropical reservoir in India

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ABSTRACT

A network model of trophic interactions in a tropical reservoir in India was developed with the objective to quantify matter and energy flows between system components and to study the impact of invasive fishes on the ecosystem. Structure of flows and their distribution within and between trophic levels were analysed by aggregating single flows into combined flows for discrete trophic levels. The trophic flows primarily occurred in the first four trophic level (TL) and the food web structure in this reservoir ecosystem was characterized by the dominance of low TL organisms, with the highest TL of only 3.57 for the top predator. Highest system omnivory index (SOI) was observed for indigenous catfishes (0.422), followed by the exotic fish Mozambique Tilapia (0.402). Nile Tilapia and Pearl spots show the highest niche overlap which suggests high competition for similar resources. The mixed trophic impact routine reveals that an increase in the abundance of the African catfish would negatively impact almost all fish groups such as Indian major carps, Pearl spots, indigenous catfishes and Tilapines. The other invasive fish Mozambique Tilapia adversely affects the indigenous catfishes. The most interesting observation in this study is that the most dominant invasive fish in this reservoir, the Nile Tilapia does not negatively impact any of the fish groups. In fact it positively impacts the Indian major carps. The direct and indirect effects of predation between system components (i.e. fish, invertebrates, phytoplankton and detritus) are quantitatively described and the possible influence and role in the ecosystem's functioning of the invasive fish species are discussed.

1. Introduction

Exotic species invasion is the most significant worldwide threat to native biota (Hall and Mills, 2000) and can impact ecosystems through competition with predation on native species, and by altering habitats, nutrient cycles, and energy budgets (Mack et al., 2000). Introduction of exotic species has caused extinction of native species in aquatic systems (Moreau et al., 1988; Mills et al., 1993; Pitcher and Hart, 1995; Latini and Petrere, 2004; Dudgeon et al., 2006; Villanueva et al., 2008).

Invasive species homogenize food webs by truncating the frequency distribution of species abundance, eventually turning it into an extremely skewed distribution dominated by the invader. Changes arising from invasion generally end up in local extinctions and decline in species richness. Widespread introductions of non-indigenous species have been categorized as a major cause of natural species extinction in aquatic systems (Moreau et al., 1988; Mills et al., 1993; Pitcher and Hart, 1995; Latini and Petrere, 2004; Puth and Post, 2005; Dudgeon et al., 2006). Cases where introduction of exotics have been reported beneficial are rare in aquatic ecosystems (Gottlieb and Schweighofer, 1996). The importance of considering a trophic network approach is that it can elucidate feeding relationships which occur between species in an ecological community and determine functional roles of species groups in the ecosystem (Yodzis and Winemiller, 1999). Indeed, numerous evidences suggest that food web structures are susceptible to a wide array of human activities, including species introductions or invasions (Van der Zanden et al., 1999), habitat alteration (Wootton et al., 1996) and global environmental warming (Petchey et al., 1999).

Food webs provide the framework for integrating population dynamics, community structure, species interactions, community stability, and biodiversity and ecosystem productivity. Food web interactions ultimately provide the fate and flux of every population in an ecosystem, particularly upper trophic levels of fiscal importance (May, 1973; Pimm, 1982). Additionally food webs often provide a context for practical management of living resources (Crowder et al., 1996; Winemiller and Polis, 1996). The mass-balanced Ecopath with Ecosim (EwE) model is considered as one of the effective and straightforward methods for quantifying the food web interactions and fisheries ecosystem dynamics (Christensen et al., 2000). First built for estimating biomass and food consumption of the elements of an aquatic ecosystem, EwE was combined

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