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Diet partitioning, habitat preferences and behavioral interactions between juvenile yellow perch and round goby in nearshore areas of Lake Erie

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ABSTRACT

Ecological interactions between native and non-indigeneous species depend on interspecies dietary and habitat overlap and species-specific behavior. In the Great Lakes, the exotic round goby (*Apollonia melanostoma*) is very abundant in littoral areas used by the native yellow perch (*Perca flavencens*). We examined yellow perch-round goby interactions using multiple approaches. Field surveys analyzing dietary overlap among three size classes of yellow perch and round goby detected significant overlap only between juvenile perch (<95 mm TL) and gobies (<60 mm TL). Laboratory experiments using juvenile stages tested for habitat preference differences (open sand, macrophytes and dreissenids) in solitary, intraspecific (2 perch) and interspecific (1 perch, 1 goby) treatments. In macrophyte and dreissenid habitats, we tested for treatment differences in fish behavior (intraspecific vs. interspecific) and yellow perch growth (solitary, intraspecific and interspecific). Round goby consistently preferred complex habitats. Yellow perch showed diurnal preference of complex habitats, but increased nocturnal use of sand in the solitary and interspecific treatments. Activity was greater in dreissenid than macrophyte habitat, but prey attacks showed the opposite trend. Activity and prey attacks were greater in the intraspecific than interspecific treatments. The trend was due to lower prey attacks executed by round goby. In macrophytes, individual yellow perch growth was lower in the intraspecific than in the solitary and interspecific treatments. In dreissenids, intraspecific and interspecific competitors equally decreased yellow perch growth. Our results suggest differences in diet, habitat preference and behavior between juvenile round goby and yellow perch may allow their coexistence in nearshore areas.

Introduction

Predicting the outcome of biotic interactions among natives and non-indigenous species can be difficult because the interaction strength may depend on their dietary (Bøhn and Amundsen, 2001) and habitat (Li and Moyle, 1999) overlap, which depends on ontogenetic diet and habitat shifts (Huckins et al., 2000). Habitat structure can also differentially influence prey capture rates (Crowder and Cooper, 1982), aggression (Breau and Grant, 2002), and territory size (Sundbaum and Näslund, 1998) of native and non-indigenous species. Here, we examine the interaction between yellow perch, *Perca flavenscens* and the non-indigenous round goby, *Apollonia melanostoma* (formerly *Neogobius melanostomus*; Stepien and Tumeo, 2006).

Yellow perch is a common species in northern USA (Carlander, 1997) and an important component of fish communities in the Laurentian Great Lakes (Fielder and Thomas, 2006; Ohio Division of Wildlife (ODW), 2006). Yellow perch undergo ontogenetic diet shifts from zooplanktivory to benthivory when the young-of-year (YOY) reach 30–35 mm (Wu and Culver, 1992) and from benthivory to piscivory at about 150–200 mm (Truemper et al., 2006). Severe fluctuations in yellow perch abundance in the Great Lakes have been linked with the introduction of non-indigenous fish species such as alewife and white perch (Brandt et al., 1987; Parrish and Margraf, 1994).

The round goby has successfully spread to all five Great Lakes and many tributaries since first reported in 1990 (Jude et al., 1992), reaching higher abundances in nearshore areas (Bergstrom et al., 2008). Round gobies may reduce recruitment of lake trout and smallmouth bass by consuming eggs and fry (Chotkowski and Marsden, 1999; Steinhart et al., 2004), interfere with spawning of mottled sculpin (Janssen and Jude, 2001) and compete for habitat with native darters (Jude et al., 1995; Balshine et al., 2005) and sculpins (Dubs and Corkum 1996). Round gobies can also reduce the density of benthic invertebrates (Lederer et al., 2008) consumed by benthivorous stages of yellow perch such as amphipods, dipterans and tricopterans (Tyson and Knight, 2001; Truemper et al., 2006).

Bottom trawl surveys in Lake Erie indicate the co-occurrence of yellow perch and round goby (Ohio Division of Wildlife, 2006) but their interactions are not well studied. Although the yellow perch

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population in Lake Erie has recovered during the last decade following a drastic abundance decline during the 1990s, yellow perch is not as abundant as during their peak in the late 1980s (Lake Erie Committee Great Lakes Fishery Commission, 2004). In addition, during the last decade, the overall conditions in Lake Erie have substantially changed due to drastic alterations in littoral food web structure due to the successful establishments of zebra and quagga mussels (*Dreissena polymorpha, D. burgensis*), the amphipod *Echinogammarus ischinus,* and round goby (Vanderploeg et al., 2002). Finally, ontogenetic diet shifts and the high degree of omnivory showed by yellow perch (Tyson and Knight, 2001) can make yellow perch-round goby interactions complex. For example, round goby has negatively affected several benthic fish consumed by yellow perch such as mottled sculpin and johnny darter (Jude et al., 1995; Janssen and Jude, 2001), but round goby has become a dominant diet item for the piscivorous stages of yellow perch (Truemper et al., 2006). However, relatively little is known about the potential interactions between the benthic stages of round goby and yellow perch.

Round gobies and benthic stages of yellow perch have shown strong preferences for rocky substrates (Ray and Corkum, 2001; Janssen and Luebke, 2004) and macrophytes (Weaver et al., 1997; Jude et al., 1992), and observational data has shown them to overlap in both habitats. No study has quantified the degree of dietary overlap between yellow perch and round gobies collected in the same geographic area in the Great Lakes, but published diets of yellow perch (Parrish and Margraf, 1994; Tyson and Knight, 2001; Truemper et al., 2006) and round goby (Jude et al., 1995; Charlebois et al., 1997; French and Jude, 2001) suggest a size-dependent dietary overlap due to the consumption of benthic invertebrates by juvenile stages of both species. However, habitat structure and species-specific behavior may mediate interactions between juvenile yellow perch and round goby.

In littoral zones, the abundance and species richness of benthic freshwater macroinvertebrates also increases with habitat complexity (Gilinsky, 1984). Furthermore, interactions among fish species are affected by habitat complexity (Werner, 1986). Fish foraging efficiency typically declines in submerged vegetation (Savino and Stein, 1982; Diehl, 1988) and in dreissenid colonies (Cobb and Watzin, 2002) as habitat structural complexity increases. However, the effect of increased habitat complexity may be species-specific. For example, the number of prey captured by European perch, bream, and roach decreased as habitat complexity increased. European perch were less affected than the other species (Diehl, 1988). Additionally, visually oriented animals, such as yellow perch, may find it more difficult to detect intruders and defend their territories in highly complex habitats. Thus, as habitat complexity increases, fish territory size, time allocated to patrolling, and aggression rate decline (Breau and Grant, 2002; Sundbaum and Näslund, 1998).

The outcome of biotic interactions between yellow perch and round goby may depend on species-specific behavioral responses. Previous studies suggest that interference competition can cause intraspecific variability in YOY yellow perch growth (Post et al., 1997), and a negative relationship exists between growth and activity in yellow perch (Rennie et al., 2005). Thus, increases in yellow perch activity level, such as bouts of aggressive behavior in the presence of round goby, may reduce yellow perch growth rate (Westerberg et al., 2004). However, the intensity of behavioral responses of both species may vary between macrophyte and dreissenid habitats due to the greater vertical structural complexity provided by macrophytes.

In this study, we compared diet overlap and composition of three size classes of yellow perch and round goby during summer in Hatchery Bay, western Lake Erie. In laboratory experiments, we also tested differences in habitat preference, behavior and the potential effect of round goby on yellow perch individual growth. Interspecific differences in habitat preferences were tested among open sand, macrophyte and dreissenid colonies. We predicted that both species would prefer complex habitats (dreissenids or macrophytes) to open sand, but that yellow perch would prefer macrophytes to dreissenids, while round goby would prefer dreissenids to macrophytes.

Behavioral differences between intraspecific and interspecific treatments were tested in dreissenid and macrophyte habitats. Within habitats, we predicted fish to be less active, less aggressive and closer together, and have lower prey attack rates in the interspecific than in the intraspecific treatment based on round gobies' stronger association with substrate. Among habitats, it is expected that fish would be less active, less aggressive and closer together in the macrophyte than in the dreissenid habitat due to the reduction of visual encounters provided by macrophytes' vertical structure. Finally, based on previous feeding experiments (González and Burkart, 2004; Duncan, unpublished data), we anticipated greater prey attack rates in the macrophyte than in the dreissenid habitat.

Lastly, the individual growth of yellow perch was compared under solitary conditions, in the presence of a conspecific and in the presence of a round goby in both habitats. We expected greater yellow perch growth in macrophytes than in the dreissenid habitat, and that yellow perch growth would be greatest under solitary conditions. Lower yellow perch growth in the presence of round goby than a conspecific would indicate a negative ecological effect of round goby on yellow perch populations.

Methods

Diet composition and overlap in the field

Samples for gut content analysis were collected from June 14 to July 2, 2002 and July 30 to August 16, 2002 in the western basin of Lake Erie near Hatchery Bay, South Bass Island, Ohio. We established three 10-m transects oriented perpendicular to shore, parallel to each other and 10 m apart, in two sites, representative of shallow nearshore habitats in of the western basin. The Peach Point (PP) site was steeply inclined, ranging between 1 and 3 m in depth. The substrate was rocky and widely interspersed with dreissenid colonies and macrophytes. The Perry's Monument (PM) site was less steep, ranging between 2 and 3 m in depth with a mainly sandy substrate and scattered rocks. Macrophytes were dominant at the PM site, with dreissenid colonies interspersed in the deeper, rockier areas. We collected fish only at PP in June, and at both sites in August. Fish were collected using cast nets, seines, electrofishing and hook-and-line. In general, smaller fish were collected with cast nets and seines, while larger fish were collected using electrofishing and hook-and-line. Fish were sacrificed and frozen for later analysis.

In the laboratory, fish were thawed, total length (TL) was measured to the nearest millimeter, and wet mass was measured to the nearest 0.1 g. Fish stomachs were removed and stomach content volume was determined using a graduated cylinder. Prey items were counted under a dissecting microscope and identified to order and their percent contribution to total volume was calculated (Jude et al., 1995). Fish collected in PP and PM in August showed similar trends in diet composition; therefore we calculated mean diet composition (% of gut volume) for June and August.

Yellow perch and round gobies undergo ontogenetic diet shifts (Wu and Culver, 1992; French and Jude, 2001); therefore, we divided the data set into three size classes based on discriminant analysis of gut contents using SAS software. Maximum possible discrimination between three size classes of fish was used to create objectively defined categories based on similarity of diet. For each size class of yellow perch and round goby, we calculated an average proportion of each prey category in the diet. We used the Schoener index (SI) based on prey abundance to compare dietary overlap (Schoener, 1970):

$$\alpha = 1 - 0.5\left(\sum_{i=1}^{n} |P_{xi} - P_{yi}|\right)$$