Pellet-reared Largemouth Bass Competitive Ability at Various Levels of Exposure to Live Forage

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Abstract: We investigated the effects of exposing pellet-reared, advanced-fingerling largemouth bass (*Micropterus salmoides*) to live forage on the ability of bass to capture live forage (competitive ability). Wild and pellet-reared largemouth bass were paired in competitive trials in 75-L aquaria and offered live fathead minnows (*Pimephales promelas*). Prior to competitive trials, pellet-reared largemouth bass were placed into trial groups and fed fathead minnows daily for 0, 2, 4, 8, and 16 days among groups. Pellet-reared largemouth bass without exposure to live forage captured the fathead minnow in 9% of competitive events against wild fish and captured significantly fewer fathead minnows than pellet-reared largemouth bass with exposure to live forage (logistic regression; $P < 0.05$). Pellet-reared largemouth bass with exposure to live forage before competitions were similar to wild largemouth bass in competitive ability. Regression analysis predicted pellet-reared largemouth bass with nine days of prestocking live forage exposure would have a similar ability to compete for food as wild largemouth bass. Providing pellet-reared largemouth bass with live forage for nine days before stocking may provide the benefits of both pellet and live-forage rearing.

Key words: largemouth bass, hatchery, competition, feed trained, stocking

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Supplemental stocking programs are a management tool commonly used for the enhancement of largemouth bass (*Micropterus salmoides*) populations. According to Halverson (2008), 35 fisheries management agencies stock largemouth bass in the United States. Goals of such stocking programs have included improving year-class strength (Hoffman and Bettoli 2005, Heitman et al. 2006), increasing angler harvest (Boxrucker 1986, Buynak and Mitchell 1999), or influencing genetic composition (Maceina et al. 1988, Dunham et al. 1992, Buckmeier et al. 2003).

Although largemouth bass stocking programs often utilize fingerling (~50 mm) fish, stocking larger sizes can improve the likelihood of stocking success (Diana and Wahl 2009). Propagating largemouth bass to advanced sizes (e.g., ≥75 mm) can be relatively inefficient. Advanced-fingerling largemouth bass are commonly reared on commercially available feed to increase yield and reduce hatchery expense (Sloane and Lovshin 1995). However, Heidinger and Brooks (2002) found that poststocking survival of pellet-reared largemouth bass to age 1 was 1.5–7.7 times less than that of minnow-reared largemouth bass during a five-year stocking program. Pellet-reared largemouth bass fed minnows for 14 days prior to stocking had similar survival to fish reared exclusively on minnows. Pouder et al. (2010) compared survival and diet composition between wild and pellet-reared largemouth bass that were fed eastern mosquitofish (*Gambusia holbrooki*) for five days prior to stocking. Stocked fish had higher incidence of empty stomachs at seven days poststocking than wild fish, but mortality was similar between wild and stocked fish after 90 days poststocking. Providing live forage to pellet-reared largemouth bass for 5–14 days prior to stocking may produce hatchery-reared fish that are functionally similar to wild conspecifics.

Hatchery propagation can result in fish that are behaviorally different from wild conspecifics (see Weber and Fausch 2003 for review). Evidence suggests hatchery-reared fish demonstrate a higher frequency of aggressive displays than wild fish (e.g., Berejikian et al. 1996, Einum and Fleming 1997). Stocking programs would be more efficacious if hatchery-produced fish were functionally equivalent to wild fish. The objectives of this research were to 1) describe pairwise competitive ability between wild and pellet-reared largemouth bass with varied exposure to natural forage, and 2) determine the amount of exposure to live forage required to produce hatchery-reared, advanced-fingerling largemouth bass that are functionally similar to wild conspecifics.

Methods

Age-0 largemouth bass were acquired from a commercial fish producer in August 2011 and maintained in 250-L tanks with recirculated water at approximately 20 C. Fish were fed 1.5- to 3.5-mm pellets (Silver Cup, Nelson and Sons Inc., Murray, Utah) ad libitum daily for 8 mo. In April 2012, largemouth bass (range 16–73 g) were divided into groups of six fish and offered fathead minnows (*Pimephales promelas*) once daily for 2 days, 4 days, 8 days, or 16 days. Additionally, one group of 12 largemouth bass was not exposed to live forage, but continued to be offered pelleted feed. All hatchery-reared largemouth bass were marked by partially clipping the lower lobe of the caudal fin.

Wild age-1 largemouth bass (range 20–95 g) were collected from the Arkansas River using electrofishing. These fish were immediately transported to the lab, housed in 250-L tanks, and offered fathead minnows once daily for two days. Wild largemouth bass were observed during feeding to ensure they had prey recognition and capture abilities. Food was withheld from hatchery-reared and wild largemouth bass for approximately 36 h prior to trial initiation to ensure gastric evacuation.

Separate trials were conducted for each level of hatchery-reared largemouth bass exposure to live forage (e.g., 0, 2, 4, 8, or 16 days). Trials were conducted at 22 C to stimulate feeding behavior while reducing acclimation stress on wild and hatchery fish. Trials were initiated by placing a different fathead minnow into each of 6 or 12 (in the case of the trial with no hatchery-reared largemouth bass exposure to fathead minnows) 75-L aquaria. Hatchery-reared and wild largemouth bass were weighed to the nearest gram, matched to obtain pairs of similar size (i.e., smallest hatchery fish paired with smallest wild fish), and placed into one of the aquaria. Aquaria were observed 24 h after largemouth bass introduction to determine if the fathead minnow had been eaten. Gastric lavage was performed on both wild and hatchery-reared largemouth bass to determine which bass captured the fathead minnow. Largemouth bass were euthanized and gut contents examined if results of gastric lavage were inconclusive. Using gastric lavage, we were unable to determine consumption of the fathead minnow in the trial using hatchery-reared largemouth bass with no pre trial exposure to live forage. We reduced the amount of time between trial initiation and observing for fathead minnow consumption to 6 h in subsequent trials.

For each trial, multiple logistic regression (SAS PROC LOGISTIC; SAS Institute 2004) was utilized to determine if fish weight and fish source (i.e., wild or hatchery-reared) significantly influenced the probability of fathead minnow capture. Proportion of wild fish capturing the fathead minnow was regressed against exposure duration of the hatchery-reared largemouth bass to live forage in order to determine the amount of exposure required before likelihood of minnow capture was similar between hatchery and wild fish. A significance level of $\alpha = 0.05$ was used for all statistical tests.

Results

Fish weight did not significantly influence which largemouth bass captured the fathead minnow in any trial (Table 1). One replicate in the trial using hatchery largemouth bass with no pre trial exposure to live forage was removed from consideration because of inability to determine which fish captured the minnow. Fish source significantly influenced ($\chi^2 = 9.347$, df = 1, $P = 0.002$) which largemouth bass captured the fathead minnow when hatchery fish were not exposed to live forage prior to the trial; wild fish consumed the minnow in 91% of these trials. However, fish source did not significantly influence which largemouth bass captured the fathead minnow in trials with hatchery-reared largemouth bass that had pre-trial exposure to live forage (Table 1).

As exposure time of hatchery-reared largemouth bass to fathead minnows increased, proportion of wild fish capturing the minnow decreased exponentially (Figure 1). The relationship was expressed as:

$$y = 0.81e^{-0.053x}$$

where x was the days of hatchery-reared fish pre-trial exposure to fathead minnows and y was the proportion of wild fish that captured the fathead minnow during a trial. This model explained 69% of the variation in proportion of wild fish capturing the fathead minnow ($F = 53.54$; n = 5; $P = 0.005$). The model estimated wild and hatchery-reared fish were equally likely to capture the fathead minnow when hatchery-reared fish were exposed to fathead minnows for nine days before the trial.

Table 1. Test statistics and probability values resulting from multiple logistic regression.

Exposure to minnows (days)	Wild fish minnow captures (Captures/total replicates)	Fish weight		Fish source	
		χ^2	*P* - Value	χ^2	*P* - Value
0	10/11	0.051	0.821	9.347	0.002
2	4/6	0.244	0.622	1.398	0.237
4	3/6	0.907	0.341	0.121	0.728
8	4/6	0.059	0.808	1.317	0.251
16	2/6	0.003	0.958	1.152	0.283

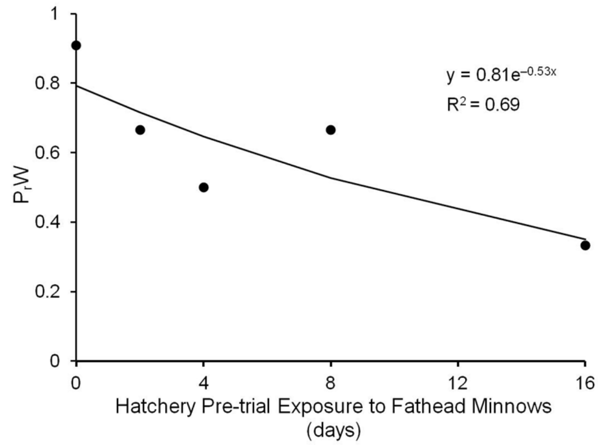

Figure 1. Relationship between proportion of wild largemouth bass capturing the fathead minnow (P_rW) and duration of hatchery-reared largemouth bass pre-trial exposure to fathead minnows (days).

Discussion

Our data revealed substantial differences in competitive ability between wild and hatchery largemouth bass reared exclusively on pellets. Wild fish captured the minnow in 10 of the 11 pairwise comparisons. These results illuminate a mechanism that potentially contributes to the high mortality observed in stocking programs conducted with pellet-reared largemouth bass (e.g., Heidinger and Brooks 2002, Porak et al. 2002, Janney 2006, Thomas and Dockendorf 2009). Even if pellet-reared fish are able to learn to identify natural food items post-stocking, they may continue to be outcompeted by wild fish. Individuals that lose a competition have a lower probability of winning future competitions than individuals that have established dominance or individuals without previous competition experience (Beacham and Newman 1987). Tiira et al. (2009) found individuals that lost initial competitions grew less over 8 mo than the individuals that won competitions. They also found relative dominance was stable over long periods, with initial competition winners maintaining dominance over losers after 8 mo. If food is limiting and pellet-reared largemouth bass are poor competitors, as demonstrated in this study, they might contribute little to the population in which they are stocked.

By learning prey recognition before being introduced into an unfamiliar environment, hatchery-reared fish became proficient foragers. The results of our study agreed with previous studies as hatchery-reared fish with minnow exposure performed better than fish reared only on pellets (Heidinger and Brooks 2002), and similar to wild fish (Pouder et al. 2010). Our results suggested that prestocking exposure to live forage may not have to exceed nine days for hatchery-reared fish to have equivalent abilities to compete for food at the time of stocking. Interestingly, fish size had no effect on which largemouth bass captured the fathead minnow. Fish size is commonly the determinant factor in pairwise fish competitions, but aggression and phenotype may also be factors (Szabo 2002, Ward et al. 2006). Although competitive ability between hatchery-reared largemouth bass with pre-trial exposure to minnows and wild largemouth bass appeared similar, there was a general negative relationship between proportion of wild largemouth bass capturing the fathead minnow and exposure time of hatchery-reared fish to fathead minnows.

Experiments of this type have obvious limitations. Fish behavior in an artificial environment may not characterize fish behavior in natural environments (Johnsson et al. 2006). Individual differences in prey recognition may have influenced fathead minnow capture due to the small sample size in this study. Since fathead minnows were the only prey item used, these results do not represent the variety of prey types that are available in the wild, with each prey type differentially influencing predator capture success. Also, wild largemouth bass may have been more stressed than hatchery-reared largemouth bass due to their capture (via electrofishing) and change from a natural environment to an artificial one. These factors may have influenced the results of our study. However, we believe that these results demonstrate that exposure to live forage increases competitive ability of stocked largemouth bass.

Although competition for food resources can be a factor affecting poststocking mortality, other biotic interactions warrant consideration. Conditioning hatchery-reared fish to structurally complex habitat (Berejikian et al. 2000) and predators (Brown and Smith 1998, Buckmeier et al. 2005) could also improve overall competitive ability. Stocking program managers should consider performance of the hatchery-reared fish being stocked as well as interactions between hatchery-reared fish and native biota.

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