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Note

Common duckweed (*Lemna minor*) consumption by blue tilapia (*Oreochromis aureus*) in feeding trials

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INTRODUCTION

Aquatic plants frequently create problems for farming operations using pond water for irrigation. Free-floating aquatic plants commonly clog irrigation pumps, plumbing, and emitters. Disruption of normal water flow in irrigation systems can be time consuming and expensive to repair. When undetected, disrupted irrigation systems can flood crops or supply insufficient water and ultimately lead to crop failure. In addition to irrigation problems, duckweed (*Lemna* spp.) populations frequently reach densities that interfere with other water uses (i.e., swimming or fishing). High-density growth can even lead to hypoxia-related fish kills. Farmers using pond water for irrigation need aquatic weed treatment options that prevent or reduce interruptions to their daily irrigation operations. Time spent on herbicide applications and manual removal of aquatic weeds prevents farmers from performing their normal farm duties. Water-use restrictions after aquatic herbicide usage may temporarily prevent use of water for irrigation. Herbicide and manual removal techniques rarely provide long-term results, and frequent applications are needed to maintain aquatic plants at low enough densities to support irrigation practices (Pieterese 1977).

Biological control of aquatic plants has been used throughout much of the United States (Andres and Bennett 1975, Andres 1977, Sutton 1977, Langeland 1996, Sutton et al. 2012). Andres and Bennett (1975) reviewed use of herbivorous fish, insects, snails, crayfish, manatees (*Trichechus manatus* L.), and plant pathogens for aquatic plant control. Biological control of aquatic weeds using herbivorous fish may be a more efficient method for irrigation waters than herbicides or manual removal. Sutton et al. (2012) suggested the advantages of using herbivorous fish to manage aquatic plants were long-term control, "low long-term costs," and potential for a harvestable fish.

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The aquatic plant species to be controlled are a major factor in determining which species of herbivorous fish to use for control. Another factor to consider when selecting an herbivorous species for biological control is local availability. Whetstone and Watson (2004) reported that triploid grass carp (*Ctenopharyngodon idella* Cuvier and Valenciennes) and tilapia (*Oreochromis* Günther sp. and *Tilapia* A. Smith spp.) were effective and easy to obtain in South Carolina. Triploid grass carp have been found to be ineffective at controlling duckweed in open water-pond systems under normal stocking rates of 12 to 50 fish ha^{-1} (Lynch 2004, Whetstone and Watson 2004, Lembi 2009). However, tilapia (*Oreochromis* spp., *Tilapia* spp., and crosses) have been reported to consume duckweeds (*Lemna* spp. and *Spirodela* Schleid spp.) in various parts of the world (Mbagwu et al. 1990, Hassan and Edwards 1992, Leng et al. 1995, El-Sayed 1999, Fasakin et al. 1999). These studies, similar to others in the literature, were focused on the culture of tilapia, rather than its use as a biological control agent, and they report using 5 to 100% duckweed in feeds to satisfy dietary needs. Current literature is lacking in the potential of tilapia as a means of biological control for duckweed. Whetstone (2002) reported blue tilapia (*Oreochromis aureus* Steindachneri) stockings (1,000 ha^{-1}) were able to control watermeal (*Wolffia* spp.), a member of the duckweed family, in 3 mo, when stocked in a South Carolina pond. However, that study was limited to a single pond with no replication. In addition, that study did not quantify the *Wolffia* spp. biomass present at the initiation of the trial.

The purpose of this research project was to serve as an initial investigation into the potential of blue tilapia as a biological control agent for control of common duckweed (*Lemna minor* L.) populations in irrigation ponds. The specific objectives of this study were to determine whether blue tilapia would feed on common duckweed and to quantify rate of common duckweed consumption. Currently, the literature on blue tilapia lacks quantitative consumption measurements for duckweeds and many other aquatic macrophytes. Results of this study are intended to supplement field studies in an effort to evaluate the potential of blue tilapia as a means of biological control of duckweed in agricultural impoundments.

MATERIALS AND METHODS

Common duckweed used in feeding trials was collected from a private pond in Chester County, near the town of Lowrys, SC. Duckweed was held in a 38-L fish tank for the duration of the study. Tilapia fingerlings used in this study ($n = 20$) were purchased from Orangeburg Aquaculture (3488 Neeses Highway, Neeses, SC 20115). Tilapia fingerlings were held in 38-L fish tanks ($n = 2$) before trials. Health of tilapia was assessed through observation of physical condition and behavior before initiation of trials and throughout the duration of trials. Each tilapia fingerling was used only one time during the study.

Tap water (dechlorinated by aeration) was used for all trial and holding tanks. Water-quality parameters were measured at the beginning of the study: pH (7.6), alkalinity (56 mg calcium carbonate [$CaCO_3$] L^{-1}), and hardness (72 mg $CaCO_3$ L^{-1}). No adjustments were made to pH, alkalinity, or hardness. Water temperature was measured at the same time daily to ensure consistency throughout the study. Water temperatures (mean ± standard deviation [SD] = 25.33 ± 0.45 C) did not differ statistically throughout the feeding trials ($\alpha = 0.05$; $P = 1.0000$).

Feeding trials were conducted in 38-L fish tanks (n=5). Before the initiation of trials, one tank was randomly assigned to be a control. The remaining four tanks were assigned to treatment. Fish were randomly assigned to one of four treatment tanks at the start of each trial. Before stocking in their respective tank, fish were weighed and measured. Once stocked in study tanks, fish were not fed for 48 h. At the end of the 48-h purge, 25 g of common duckweed was stocked into each of the study tanks. Before stocking in study tanks, common duckweed was hand pressed and towel dried to obtain a wet mass (Missouri Botanical Garden 2003). Feeding-trial duration was 48 h after the stocking of common duckweed. At the end of each trial, the remaining common duckweed was collected, hand pressed, towel dried, and weighed. Fish were weighed (in grams) with a digital scale, and length was measured to the nearest millimeter at the end of each trial. Feeding trials were replicated five times.

Measurements collected during this study were analyzed with JMP 11 Statistical Software.[1] Normally distributed, homogeneous data were analyzed by one-way ANOVA. Pairwise comparisons were used to identify differences among test replications.

RESULTS AND DISCUSSION

Tilapia fingerling lengths did not statistically differ ($\alpha = 0.05$; $P = 0.6184$). Mean ± SD fish length was 75.65 ± 4.92 mm. Fish weights did not differ ($\alpha = 0.05$; $P = 0.7910$). Mean ± SD fish weight was 6.95 ± 1.54 g.

Common duckweed weight decreased during the 48-h trials in the treatment tanks ($\alpha = 0.05$; $P < 0.0001$). Mean ± SD common duckweed weight change in treatment tanks was −8.15 ± 1.69 g (range = 5 to 12 g). One-way ANOVA for treatment tanks indicated there was no difference among replications with respect to observed common duckweed weight change ($\alpha = 0.05$; $P = 0.6071$). Observed weight change in common duckweed was different between treatment and control tanks for each replication ($\alpha = 0.05$; $P < 0.0001$). Common duckweed weight in the control tanks remained constant at 25 g in all but one trial, in which a 1-g increase in common duckweed weight was observed. Mean ± SD common duckweed weight change for the control tanks was 0.2 ± 0.45 g.

Feeding trial results indicate that blue tilapia will consume fresh common duckweed. Common duckweed consumption was calculated as a percentage of tilapia body weight. Mean consumption was 117.87% of fish body weight per 48 h (range = 75 to 200%, median = 114.29%). During this series of trials, common duckweed consumption ranged from 5 to 12 g $fish^{-1}$ (mean = 8.15 g $fish^{-1}$ 48 h^{-1}). Mean fish weight was 6.95 g at the initiation of trials (range = 4 to 9 g).

Common duckweed growth rates in fish ponds are between 3.14 and 3.54 g dry wt m^{-2} d^{-1} (Rejmánkova 1975). Landolt and Kandler (1987) reported duckweeds were between 86 to 97% water. That translates to approximately 22 to 118 g fresh wt m^{-2} d^{-1} or 220 to 1,180 kg ha^{-1} d^{-1}. Diana et al. (1991) suggested maximum carrying capacity for Nile tilapia (*Oreochromis niloticus* L.) in fertilized ponds was between 2,000 and 3,000 kg ha^{-1}. Comparative carry capacity for blue tilapia in ponds is poorly defined in the literature. Nile tilapia are closely related members of the *Oreochromis* genus, and carrying capacity in ponds would be expected to be similar for the two species. In our study, we observed mean common duckweed consumption of 117.87% of tilapia body weight 48 h^{-1}. Consumption rates observed in tank trials suggest blue tilapia have the potential to serve as a biological control agent for duckweed.

Tank trials did not address the consumption of common duckweed in the presence of additional food resources. Consumption rates of duckweeds may differ in pond stockings because of the availability of additional or alternative food resources. Schwartz and Maughan (1984) reported feeding preference for blue tilapia for five aquatic plants. Results of their study indicated tilapia consumed 64% of stocked, preferred, plant species mass, whereas they refused to eat less desirable plant species stocked in the same tank. Additional research is needed to determine field effectiveness of blue tilapia for duckweed control. Research that focuses on determining appropriate stocking rates and identifying environmental conditions that influence effectiveness of control would also benefit the topic.

SOURCE OF MATERIALS

[1]JMP 11 statistical software, 2013, SAS Institute, Inc., 100 SAS Campus Drive, Cary, NC 27513).

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