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Short communication

A novel method using light for increasing fry yield in guppy breeding tanks

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ABSTRACT

A novel method for increasing fry yield in guppy breeding tanks was tested in the laboratory and commercial farms. It is based on lighting the fry collecting net baskets to attract newborn guppies into these safe refuges, which in turn reduces their exposure to cannibalism. A laboratory experiment revealed a significantly higher fry yield (by 30.2%) using illuminated net baskets than baskets without light. No significant effect of the timing of fry collection (08:00, 12:00 or 16:00) was found. Under commercial culture conditions in two farms, fry yields significantly increased by 13–28% in various guppy strains, using illuminated baskets. Overall, the results of this study demonstrated the efficacy and high economic potential of the proposed method in increasing fry yield in commercial-size breeding tanks.

1. Introduction

Cannibalism, the killing and complete or partial consumption of conspecific individuals, is a common phenomenon among fish (Smith and Reay, 1991; FitzGerald and Whoriskey, 1992). In aquaculture, it may be a major cause of mortality of larvae and early stage fry (Hecht and Pienaar, 1993; Baras and Jobling, 2002). Most reports on cannibalism concern intra-cohort cannibalism, which is particularly prevalent in piscivorous species under intensive nursery conditions (Hecht and Pienaar, 1993; Baras and Jobling, 2002). In contrast, inter-cohort cannibalism received little attention in aquaculture-related studies, although it may be common in breeding tanks or ponds where brood fish prey upon eggs or fry (Toledo and Gaitan, 1992; Watanabe et al., 1992). The effect of such cannibalistic behavior on the production of fry in hatcheries may be significant in fish with low fecundity and no parental care such as the livebearing ornamental fish of the family *Poecilidae*, which are notorious for their cannibalistic nature (Loekle et al., 1982; Meffe and Snelson, 1989; Magurran, 2005). Substantial loss of fry to cannibalism in breeding tanks of poecilid fish, which may exceed 50% of the population, has been reported (Baldwin, 1980; Jones et al., 1998, 2007).

One of the most important tropical species in the global trade is the guppy fish, *Poecilia reticulata* (Kachel, 2009; Monticini, 2010). Modern guppy farming is carried out in intensive systems in circulated crystal-clear water (e.g. in Israel, where this study was conducted, personal observations, all authors). Owing to the low fecundity of livebearing females, a significant proportion of the farm's volume must be allocated for breeding tanks. Thus, improvement of fry production in these tanks may increase the profitability of guppy farms. To date, guppy growers in Israel are using baskets made of small-mesh plastic netting, into which the small fry can escape from cannibalistic adults. The newborns are collected daily from these baskets for ongrowing. Nevertheless, the growers estimate that at least half of the fry are lost to cannibalism (A. Antignus, personal communication). Thus, our goal was to develop a method of decreasing loss of fry due to cannibalism by attracting the newborns into the small-mesh baskets by light. The suggested method is based on the innate attraction of newborns to light, which was found and demonstrated in a previous stage of the study (Barki et al., 2012). The actual effect of light on the refuge seeking behavior of newborns was further demonstrated in aquaria (Barki et al., 2013); illuminating a safe section of the aquarium enhanced the passage of newborns through a small-mesh net separating it from the predation section (inhabited by adults).

The aim of the current study was to demonstrate the efficacy of illuminating the net basket used in commercial breeding tanks in increasing fry yield. Specifically, we tested the effects of illuminating the net baskets and fry collection time on fry yield in breeding tanks in the laboratory and validated the laboratory findings in farms with various guppy strains under commercial culture conditions.

2. Materials and methods

2.1. Laboratory experiment

The experiment was conducted indoors in 24 circular polypropylene tanks (250 l in volume, 85 cm in diameter) arranged

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in 4 identical sets of 6 tanks connected to a bio-filter tank through which the water was circulated. Water temperature was maintained at 25.6 ± 0.5 °C and dissolved oxygen above 7.2 mg/l, ammonium (NH_4^+) was undetectably low, nitrite (NO_2^-) levels did not exceed 0.25 mg/l and water pH averaged 7.7 ± 0.1. Fluorescent tubes placed on the ceiling provided a 12:12 h light:dark daily illumination cycle between 06:00 and 18:00. Each tank contained a cylindrical plastic mesh basket (3 mm black mesh, 40 cm in diameter, 26 cm water depth), which allow solely the passage of newborns and serve as a safe sanctuary for them. A waterproof 4-LED (light-emitting diode) module (0.6 W) was installed 8 cm above the water surface, facing the center of the mesh basket. Cool-white light was used, as it had been found to be as best attractant to newborn guppies (see for the LED's spectral output, Barki et al., 2012). The average light intensity of the LED module, as measured with the light-meter's sensor (Lutron LX-1128SD) directed toward the LED, was 66.7 ± 13.1 and 24.1 ± 4.5 lx at the basket's bottom inside and outside the basket, respectively.

Each tank was stocked with 130 adult guppies of a Double Sword strain obtained from a commercial farm (13 males: 117 females), similarly to the density and sex ratio used in commercial farms. Mean wet mass of females and males at stocking was 1.71 ± 0.14 and 0.69 ± 0.04 g, respectively. The fish were fed twice a day dry feed (Ocean Nutrition™ Breeder line) at a daily ration of 4% of their mass, supplemented once a week with frozen cultured blood worms (20 g wet weight). Mortality of adults during the experiment ranged between 2.4 and 3.2% and dead fish were replaced by individuals of the same batch to maintain constant density and sex ratio.

The experiment tested the effects of light (i.e. net baskets with light on vs. light off) and time of fry collection (i.e. in the morning (08:00), noon (12:00) or afternoon (16:00)) on fry yield. The 6 combinations of light × collection-time were randomly assigned to tanks in each of the 6-tank sets (n = 4). Newborn guppies were collected from the mesh baskets and counted once every 24 h during 14 consecutive days. Newborns that occasionally escaped outside the basket during collection were captured and counted as well.

An additional laboratory experiment was conducted to test the effect of light on fry yield in another guppy strain, the Red Snake Skin (RSS) (mean wet mass 0.78 ± 0.06 and 0.52 ± 0.06 g, females and males, respectively). This experiment included only two treatments, continuously illuminated baskets vs. non-illuminated baskets. The experiment was conducted in two of the 6-tank sets described above, each including 3 replicates of each treatment (i.e. n = 6). The experiment lasted 18 days and newborns were collected once a day in the morning.

2.2. On-farm experiments

Experiments testing the effect of light on fry yields were conducted in two farms in the south region of Israel (hereafter farm A and farm B) and involved several guppy strains. The breeding tanks in both these farms are similar to those of the aforementioned laboratory experimental system in terms of shape and dimensions. The same LED modules as described above were installed above the center of the mesh baskets.

The experiments compared the number of fry collected from the tanks with illuminated baskets and non-illuminated baskets. Owing to constraints associated with experimentation under working conditions of a commercial farm, notably possible differences among breeding tanks in the number and size/age of brood fish, the experimental design involved paired comparisons in which the two treatments are tested in each tank. In farm A, the Lemon and RSS strains were independently tested (n = 15 tanks, each). Collection of newborns was performed once a day in the morning, while counting and noting the number of newborns collected from inside and outside the basket. The experiment lasted four weeks, in two of which the light was switched on and in the other two switched off. The order of the treatments was balanced among the tanks. In farm B, the Flame strain and RSS strain (from which the RSS guppies of the laboratory experiment were taken) were tested (n = 8 and 7 tanks, respectively). This experiment lasted six weeks and the light was alternately switched on and off on a weekly basis. The first day after each shift of lighting regime (on to off or vise versa) was not counted to allow the brood fish to adjust to the new conditions.

2.3. Statistical analysis

Main and interaction effects of light and collection time on Double Sword fry yield in the laboratory were tested using two-way ANOVA and the effect of light on RSS fry yield was tested using one-way ANOVA. In both analyses the set of tanks was included as a blocking variable assigned a random effect. Paired t tests were used to test for the effect of light in the farm experiments. All analyses were performed with the JMP 8 statistical software (SAS Institute, 2008, Cary, NC). Significance was considered at $P < 0.05$.

3. Results

3.1. Laboratory experiment

In the experiment conducted with the Double Sword strain, a significant effect of light on fry yield was found (P = 0.0016). No significant effect of collection time (P = 0.12) or interaction effect (P = 0.34) was found. Overall, the average daily number of newborns per tank was by 30.2% higher in the presence of light than in its absence (69.1 ± 3.4 vs. 53.1 ± 3.5, respectively) (Fig. 1). No effect of light was revealed in the RSS strain in the laboratory (16.8 ± 1.6 and 16.9 ± 0.6 newborns in the presence and absence of light, respectively, P = 0.94).

3.2. On-farm experiments

The number of fry collected from the net baskets in the breeding tanks was significantly higher when the baskets were illuminated than when they were not, for each of Lemon and RSS strains in farm A (paired t tests, P = 0.027 and P = 0.043, respectively). The daily numbers of fry per tank with and without light were, respectively, 63.2 ± 9.0 vs. 49.2 ± 6.9 for Lemon, and 71.0 ± 7.2 vs. 61.2 ± 6.9 for RSS (Fig. 2). These values correspond to increases of 28.2% and 15.9%

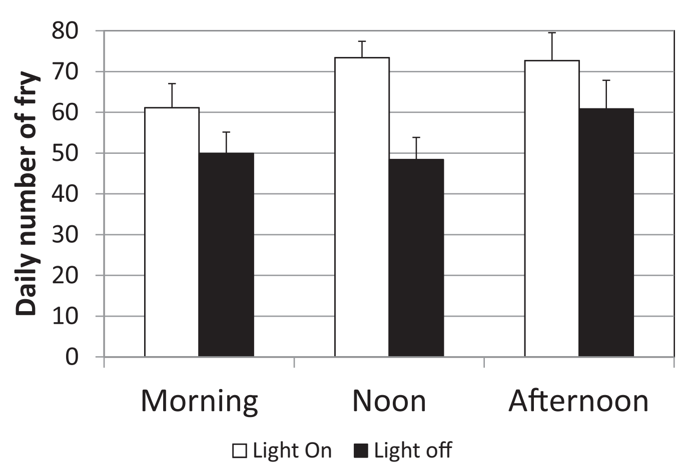

Fig. 1. Mean daily number of Double Sword guppy fry collected in the morning (08:00), noon (12:00) or afternoon (16:00) from tanks with light and without light illuminating the net basket. Error bars represent SE. The effect of light was found significant at $P < 0.01$.