EFEITO DA ILUMINAÇÃO NO CRESCIMENTO E COMPORTAMENTO DO
BARRIGUDINHO, *POECILIA RETICULATA*

EFFECT OF ILLUMINATION ON GROWTH AND BEHAVIOUR OF GUPPY, *POECILIA
RETICULATA*

ВЛИЯНИЕ ОСВЕЩЕННОСТИ НА РОСТ И ПОВЕДЕНИЕ ГУППИ, *POECILIA
RETICULATA*

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RESUMO

O barrigudinho, *Poecilia reticulata*, é um modelo para muitos estudos ictiológicos. Foi estudado o efeito da luz no crescimento juvenil da *Poecilia reticulata*. Estudos foram realizados em aquários de vinte litros. Para experimentos sobre a escolha arbitrária da intensidade da luz (comportamento da transmissão da luz), foram utilizados aquários radiantes de vidro orgânico medindo 150x15x15 cm, divididos com semi-divisórias transparentes em dez compartimentos de comunicação. A taxa de crescimento específica foi determinada após as experiências. A taxa de crescimento eleva-se com o aumento do nível de luz. A taxa de crescimento é mínima em 0 lx em todas as séries de experimentos. Foi demonstrado que o aumento mais acentuado na taxa de crescimento específico dos barrigudinhos ocorreu quando a iluminação mudou de 0 para 200 lx. Um aumento adicional na intensidade da iluminação praticamente não afetou o crescimento dos barrigudinhos. Além disso, o comportamento juvenil dos barrigudinhos foi estudado em bandejas especiais com luz diferente de 3200 a 5900 lx. A atividade motora dos barrigudinhos aumenta em 30% em condições de gradiente de luz. A frequência (25 s) e a duração dos barrigudinhos (28,3 s) são as mais altas do compartimento, com 4700 lx. A zona de luz preferencial se expande se os jovens estiverem passando fome. À medida que o período de fome aumentava, os barrigudinhos começaram a nadar com frequência quase igual e a permanecer em diferentes zonas de luz. Assim, condições de alta luminosidade estimulam o comportamento de busca e a atividade dos barrigudinhos. Para criar barrigudinhos em condições de produção, é necessária alta iluminação.

Palavras-Chave: Luz, Iluminação, *Poecilia Reticulate*, Crescimento, Comportamento.

ABSTRACT

The guppy, *Poecilia reticulata*, is a model for many ichthyological studies. The effect of light on juvenile growth has been studied on the *Poecilia reticulata*. Studies have been conducted in twenty-liter aquariums. For experiments on the fish arbitrary choice of light intensity (light transmission behavior), it was used radiant pans of organic glass 150 x 15 x 15 cm divided by transparent semi-partitions into ten communicating compartments. The specific growth rate has been determined after the experiments. It increases with the light level increasing. The growth rate is minimal at 0 lx in all series of experiments. It was shown that the sharpest increase in the specific growth rate of guppies occurred when the illumination changed from 0 to 200 lx. A further increase in the intensity of illumination practically did not affect the growth of guppies. Also, the guppy juvenile behavior has been studied in special trays at different light from 3200 to 5900 lx. The motor activity of guppies increases by 30% in light-gradient conditions. The frequency (25 sec) and length of guppies stay (28.3 sec) are the highest in the compartment with 4700 lx. The preferential light zone expands if the juveniles are starving. As the period of starvation increased, guppies began to swim almost equally often and linger in different light zones. Thus, high light conditions stimulate the search behavior and activity of guppies. To grow guppies in production conditions, high illumination is necessary.

Keywords: Light, Illumination, *Poecilia Reticulate*, Growth, Behaviour.

АННОТАЦИЯ

Гуппи (*Poecilia reticulata*) является модельным объектом многих ихтиологических исследований. На этом объекте изучали как воздействует освещенность на рост мальков. Исследования проводили в 20-литровых аквариумах. Для экспериментов по произвольному выбору рыбой интенсивности света (светогradientного поведения) мы использовали прозрачные лотки из органического стекла 150*15*15 см, разделенные прозрачными полуперегородками на десять сообщающихся отсеков. После экспериментов определяли скорость роста. Скорость роста повышалась при увеличении уровня освещенности. При 0 лк скорость роста была минимальной во всех сериях экспериментов. Было показано, что наиболее резкое возрастание удельной скорости роста мальков гуппи происходило при изменении освещенности от 0 до 200 лк. Дальнейшее увеличение интенсивности освещения практически не оказало воздействие на рост гуппи. Также исследовали поведение мальков гуппи в специальных лотках при различной освещенности от 3200 до 5900 лк. Двигательная активность гуппи в светогradientных условиях возрастала на 30%. Частота и длительность пребывания гуппи были наивысшими в отсеке с освещенностью 4700 лк 25 и 28.3 с, соответственно. У голодных особей преферентная зона освещенности расширялась. По мере увеличения периода голодания особи гуппи начинали практически одинаково часто заплывать и задерживаться в различных по освещенности зонах. Таким образом, высокая освещенность стимулирует поисковое поведение и активность гуппи. Для выращивания гуппи в производственных условиях необходима высокая освещенность.

Ключевые слова: Свет, Освещенность, *Poecilia reticulata*, Рост, Поведение.

1. INTRODUCTION

The *Poecilia reticulata*, popular aquarium fish, is a traditional subject of laboratory studies. Guppies live in freshwater both in mountain rivers and in muddy warm water) and in the saltish waters of Venezuela, Guyana, Trinidad, Barbados, Martinique as well as in some parts of northern Brazil (Echevarría and González, 2018). According to Ahmed et al. (1985), it has been found to establish itself in both fresh and polluted waters. In particular, it is used to conduct ethological studies (Fraser and Gilliam, 1987; Abrahams and Dill, 1989; Morrell et al., 2008), to study color and light perception (Smith et al., 2002; Sakai et al., 2016) as well as reproductive behavior (Reeve et al., 2014) and parasitological studies (Gotanda et al., 2013).

Light creates the necessary existence conditions, makes it possible to orient oneself in the environment for many aquatic organism species (Konstantinov et al., 2000; Ruchin et al., 2005; Ruchin, 2007, Ruchin, 2020). Illumination is an important environmental factor that affects different aspects of aquatic animals' existence. Specific environmental conditions have a positive effect on fish and amphibians (Boeuf and Le Bail, 1999). For example, growth of *Epinephelus coioides* yearlings improves with 320-1150 lx illumination (Wang et al., 2013), growth of juvenile *Megalobrama amblycephala* improves with 400 lx (Tian et al., 2015), growth of *Acipenser baerii* juveniles improves with 30-800 lx (Ruchin, 2008), growth of *Salmo salar* juveniles improves with 21-650 lx illumination (Handeland et al., 2013).

According to Toledo et al. (2002), Bădiliță et al. (2010), Ruchin (2016), Ruchin (2018), the embryonic development of fish and amphibians needs specific illumination parameters. Russian biologists such as Ruchin (2000), Ruchin (2004), Kuznetsov, and Ruchin (2001) proved that the larval development of several amphibian species accelerates with illumination above 1000 lx. Inhibition of growth, development, and survival of many species of aquatic vertebrate animals is observed outside of this illumination. Our research is aimed to study the light effect on the guppy growth and behavior.

2. MATERIALS AND METHODS

The experiments were conducted in 20 L aquariums. Fluorescent lamps emitted illumination. The intensity of illumination was measured with the U-116 lux meter. In the darkness (0 lx), aquariums were closed with an opaque cover. In each series of experiments, we used one female juvenile. Every time we placed 10–20 juveniles and weighed them at the beginning and the end of the experiment with an accuracy of 0.01 mg (Figure 1). We fed them continuously with zooplankton, and *Artemia* decapsulated eggs. The duration of the experiments ranged from 10 to 20 days. Experiments were repeated from five to nine times. Growth parameters were calculated as follows (Eq. 1):

$$\text{SGR } (\% \text{ day}^{-1}) = \frac{\ln W_f - \ln W_i}{t} \times 100 \quad (\text{Eq. 1})$$

where SGR is the *Specific Growth Rate*.

For experiments on the fish arbitrary choice of light intensity (light transmission behavior), we used radiant pans of organic glass 150 x 15 x 15 cm divided by transparent semi-partitions into ten communicating compartments (Ruchin, 2019). There was emitted a light gradient from 3200 lx at the beginning of the tray to 5900 lx at its end. The illumination in the control corresponded to the average value of the illumination in the experimental tray (4550 lx). We conducted observations in the morning at a temperature of 24 °C. We placed there three or four immature females weighing 9–12 g. We were watching one fish for 10–20 minutes a day. The experiments were repeated ten times. We also conducted research on well-fed and starving individuals. We investigated the options: 1 – well-fed, 2, 3, and 4, respectively, 0.5, 2, and 24 hours after the food's withdrawal.

Based on statistical data, we calculated the average duration of a single fish stay in a particular compartment (τ , sec), the swims' number in each compartment (n), and the total time of fish stay in each compartment ($\sum \tau$, min). All values were reduced to one hour (Ruchin, 2001a). The swimming distance from the beginning of the movement to the turn in the opposite direction was called "single-vector" and was designated as S_v . We calculated the duration of the continuous single-vector displacement (τ_v) because the motion in the gradient is discrete. Moreover, we noted the total number of single-vector displacements (N). Knowing their average length (S_v), we calculated the total path traversed by fish per hour as well as calculated the speed of movements (S_v/τ_v), the total time of movements, and the total time of fish delays in the compartments. According to Konstantinov and Zdanovich (1993) and Ruchin (2019), the use of these indicators makes it possible to characterize the fish behavior in gradient conditions more differentiated.

Data between treatments and sampling times were compared by analysis of variance (ANOVA). The data were statistically processed using a standard method with Student's Test.

3. RESULTS AND DISCUSSION

Figure 2 shows that the growth rate of guppy juveniles gradually increases with the light increase. Earlier, Ruchin (2001b) obtained similar results in experiments on carp larvae. As we can

see, the specific growth rate of guppy juveniles appeared when the illumination changes from 0 to 200 lx. A further increase in the intensity of illumination had practically no effect on the growth. In some experiments, the maximal increments were noted with 4500 lx and 11500 lx. There was no significant difference between them. In other experiments, in the absence of light (0 lx), the increments were minimal. The survival rate in all experiments was 100%, and we did not register the death.

Analysis of the fish behavior in the light gradient field showed that the juveniles stayed principally in areas with a certain light level. However, they often swam for short periods in compartments with different light values (Table 1).

The frequency (25 s) and duration (28.3 s) of guppy's stay were highest in the compartment with illumination 4700 lx. Table 1 shows that juveniles moved without a definite pattern in the control with balancing illumination, but they lingered in the last compartments. In other words, the "edge" effect appeared in the control. This effect was not registered with light gradient conditions. Individuals began to swim almost equally often and lingered in zones with different illumination as the starvation period increased. For example, the duration of one-time stay of starvation (0.5 hours) individuals with an illumination 4100–5300 lx was 35.3–21.2 s. Two hours after the food absence, the preferential zone expanded to 3800–5600 lx ($t = 25.0$ –36.3 s), and after 24 hours of fasting, the juveniles stayed almost the same time in all compartments.

Table 2 shows that the motor activity of juvenile guppies in light-gradient conditions was higher in control by 30%. If the number of vector displacements did not differ, in the light gradient, the average displacement distance and the total path were higher by 15% and 18% than the corresponding values in the control with uniform illumination. Consequently, the total time of movement in the experiment exceeded this value with balancing illumination.

Thus, fish motor activity increased due to the increase in the range of movement and swimming speed in a gradient field. Juvenile behavior analysis in the gradient field of the factor shows that the preferential zones vary depending on the period of lack of food. The zone of the preferendum is shifted towards higher illumination values.

It was found that the growth of juveniles was characterized by an optimal range of illumination. Referring to the researches of Trippel

and Neil (2003), Suzer *et al.* (2006), Ruchin (2008), it was concluded that bottom dwellers needed lower luminance values and pelagic fish, including guppies, needed higher luminance (Ruchin, 2001b; Pereira-Davison and Callan, 2018; Jirsa *et al.*, 2009; Wang *et al.*, 2013). The sharply negative effect of zero light on growth (0 lx) was common to all of these fish species.

Many researchers studied fish behavior in various light conditions. Winslade (1974) proved that the juvenile *Ammodytes marinus* possessed positive phototaxis as well as *Cyprinus carpio* and *Carassius auratus* (Ruchin, 2001a) and the atherin *Leuresthes tenuis* (Reynolds *et al.*, 1977). Meanwhile, Britz and Pienaar (1992) revealed that *Clarias gariepinus* had negative phototaxis. Confer *et al.* (1978), Macy *et al.* (1998), Ryer and Olla (1999) showed that light intensity could influence prey selection and consumption rates. According to Keyler *et al.* (2015), food consumption increases with the light intensity. It means that planktonophagous foraging for food (plankton) is oriented toward illumination. Consequently, differences in illumination stimulate guppies to search for food and increase the juvenile activity. Guppy belongs to planktophagous, so its individuals searching for food focus on the light. Although White *et al.* (2005), did not reveal any peculiarities in food consumption. Jain and Sahai (1994), White *et al.* (2005), Barki *et al.* (2013) also indicated a positive phototaxis of different ages guppies.

4. CONCLUSIONS

The obtained results confirm that the appropriate light intensity is needed for guppies growing. The growth of this juvenile species improves with very high values of illumination in a wide range of illumination from 1500 lx to 11500 lx. However, to save energy resources, the authors recommend lighting up 2000-2500 lx for juveniles growing.

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Figure 1. The scheme of the experiments: A – the first experiment (there is an aquarium with experimental fish, covered with a lid with a lamp that creates a certain illumination); B – the second experience (Side view and top view; it was described in the text).

Figure 2. Specific growth rate of guppy juveniles with different initial mass at different illumination (in the legend, the figure shows the initial mass of fish before the experiments).

Table 1. The frequency of occurrence and the duration of stay of guppy juveniles in various light zones.

Control				Experiment			
Illumination, lx	n	τ , sec	$\Sigma\tau$	Illumination, lx	n	τ , sec	$\Sigma\tau$
4550	13	103.8	22.5	3200	5	4.8	0.4
4550	25	10.3	4.3	3500	18	9.3	2.8
4550	21	8.0	2.8	3800	18	10.0	3.0
4550	18	18.7	5.6	4100	13	21.2	4.6
4550	17	20.8	5.9	4400	18	24.3	7.3
4550	16	10.5	2.8	4700	25	28.3	11.8
4550	14	15.0	3.5	5000	23	27.6	10.6
4550	6	21.0	2.1	5300	23	27.6	10.6
4550	6	27.0	2.7	5600	17	26.8	7.6
4550	4	117.0	7.8	5900	5	15.6	1.3

n – the number of swims in the zone per hour; τ – the average duration of a one-time stay in the zone, sec; $\Sigma\tau$ – the total duration of stay in the zone per hour.

Table 2. Indicators of the motor activity of young fish in light-gradient conditions (experiment) and under uniform illumination (control) *

Parameter	Experiment	Control
The number of vector displacements (N)	72	70
Average distance vector displacement, cm (S_v)	34.0	29.6
Total path, m ($\Sigma S_v \cdot N$)	24.5	20.7
Average duration of vector displacement, sec (τ_v)	15.4	11.8
Travel speed, cm / s (S_v/τ_v)	2.2	2.5
Total travel time, min	18.5	13.8
Total time of delays in the compartments, min	41.5	46.2

* - All values were equalized to one hour.