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PHOTOTACTIC RESPONSE AND MORPHOMETRIC CHARACTERISTIC OF CLIMBING PERCH *Anabas testudineus* (Bloch, 1792) UNDER CULTURE SYSTEM

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ABSTRACT

Phototaxis in climbing perch (*Anabas testudineus*) was investigated by subjecting fish to LED light traps (blue, green, yellow, orange, red, white) and control (total 13 traps). The trap was constructed of polyamide (PA) nylon monofilament (31.75 mm mesh size), fastened around two wire ring frames (∅ 490 mm) with a net height of 270 mm. A lamp was placed on the bottom of the trap. 96 individuals, consisting of 34 males and 62 females, were analysed. Both continuous and blinking light traps were considerably higher in the number of catch compared to the control. The body size of catch ranged from 76-135 mm TL and 8.00-55.00 g W. The mean YPUEs (yield per unit effort) for male and female were 4.00 ± 2.25 and 7.00 ± 4.50 g trap^{-1} trial^{-1}, respectively. The CPUEs (catch per unit effort) for continuous, blinking light traps and the control ranged from 0.43 to 0.93, 0.21 to 0.86, and 0.21 fish trap^{-1}night^{-1}, respectively. The mean condition factor (*K*) values of 2.10 ± 0.40 for males and 2.13 ± 0.34 for females indicate fish with better condition. Positive group responses of fish were more pronounced in the middle size classes between 90 and 109 mm TL. Negative allometric growth pattern (*b*) (1.7271-1.8828) was observed, indicating that the culture system should be refined. *A. testudineus* showed positive phototaxis to the "colors of light". In addition, efforts to collect climbing perch from the wild for breeding and commercial purposes may benefit from this study.

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INTRODUCTION

Climbing perch (*Anabas testudineus* Bloch, 1792) is an economically important freshwater species in Southeast Asia and other countries, e.g. Vietnam (Van and Hoan, 2009), southern Thailand (Chotipuntu and Avakul, 2010), Malaysia (Zalina et al., 2012), the Philippines (Bernal et al., 2015), Bangladesh (Begum and Minar, 2012) and India (Kumar et al., 2013) due to delicious and high-quality meat fish. In nature, climbing perch inhabit freshwaters such as rivers, streams, lakes, reservoirs, irrigation canal and paddy field (Sarkar et al., 2005; Rahman and Marimuthu, 2010) and can be cultured in cages, tanks and ponds (Long et al., 2006; Mondal et al., 2010; Kumar et al., 2013). Culture strategies of *A. testudineus* are currently being developed (Trieu et al., 2001; Phu et al. 2006; Chotipuntu and Avakul, 2010; Hossain et al., 2012). *A. testudineus* is also well-known as a unique fish species because it can breathe air and is capable of spending 4-6 days out of water (Storey et al., 2002) because of the presence of the labyrinth organ (Rahman et al., 2015). In Australia, Papua New Guinea and India, the presence of climbing perch is expected to result in competition between wild birds, reptiles, animals and predatory fish from river or reservoir by using their sharp dorsal and opercular spines (Storey et al., 2002; Hitchcock, 2007; Paliwal and Bhandarkar, 2014). All the above research publications describe the culture potential and possible ecological effect of this species. *A. testudineus* exhibits a unique feeding behaviour. As a fierce predator, climbing perch can eat other fish, invertebrates and aquatic plants. They appear to be visual feeders, feeding primarily during the day (Patra, 1993), and become active at night in search of prey. Local fishermen take advantage of their feeding behaviour to coerce them into traps or nets either with or without the use of bait (Iwata et al., 2003; Irhamsyah et al., 2017). At the same time, light-induced behavioural response in *A. testudineus* has not been explored in these publications. By expanding from previous studies (Ahmadi, 2012; Ahmadi and Rizani, 2013) and combining the present study, we believe that trapping with lights shows a promising option to harvest *A. testudineus* from aquaculture ponds and from the wild. Therefore, the use of lights in harvesting climbing perch is encouraged to improve the harvesting procedures. Thus, the present study investigated phototactic responses in *A. testudineus* by subjecting fish to different colored lights and a pattern of LEDs in the pond experiment, while comparing size distribution, length-weigh relationships and the condition factor of this species.

MATERIAL AND METHODS

Pond experiment

Trapping experiments were undertaken in a concrete pond (11.5 x 10.0 x 1.55 m, 0.50 m deep) at the Faculty of Marine and Fisheries, Lambung Mangkurat University. *A. testudineus* were fed twice a day with commercial pellets at feeding ratio of 5% body weight/day. Pond water transparency was 28.35 cm, observed from the surface using a secchi disk, while turbidity of the water was 40.9 NTU (Nephelometric Turbidity Unit). The water surface temperature ranged between 29.0-30.5°C at 25 cm throughout the trials. The fishing trials were conducted for 14 sampling days during September 2017.

Trap and lamp setup

A total of 13 circle-shaped traps were constructed with the same dimensions and materials (Fig. 1). Six continuous light traps, six blinking light traps and a control (trap without lamp) were simultaneously tested in the concrete pond at the beginning of trials. The trap made of polyamide (PA) nylon monofilament (31.75 mm mesh size) was fastened around two wire ring frames (wire dia. 2 mm); 1540 mm perimeter was placed on the top and bottom (490 mm diameter). The net height was 270 mm with a hanging ratio of 0.45. Each trap had four entry holes located on each side of the trap with about ~5 cm opening mesh. A sheet of polyethylene (PE) nylon multifilament was placed on the top, allowing for catch removal, and another was placed on the bottom where the lamp was attached.

Fig 1. Climbing perch sample, the traps and lamps used in the pond experiment

Each of the light traps was assigned with 0.9 W LED (Light Emitting Diode) Torpedo light (215 x 50 mm, Fishing Net Industry Co. Ltd. China) containing blue (8.4 ± 1.65 lx), orange (42.5 ± 2.68 lx), yellow (332.0 ± 37.14 lx), red (376.4 ± 93.40 lx), white (1282.6 ± 91.35 lx) and green (3116 ± 342.74 lx), powered by 3 V dry-cell batteries, respectively. The intensity of each lamp was measured using a light-meter LX-100 (Lutron, Taiwan) at Basic Laboratory of Faculty of Mathematic and Natural Science, Lambung Mangkurat University.

Trapping experiment

Trapping experiments with the lights were carried out under an ambient light environment. Each trap was placed on the bottom of pond, 1.5 m apart from each other and collected the following morning. The traps were rotated each night with soaking time of 10 h. After retrieval, the catches were counted, identified for sex, measured for total length (TL) and weight, and released back into the pond. TL was measured to the nearest 0.1 mm using a 30 cm ruler as the distance from the tip of the most anterior part of the body to the tip of the caudal fin. Digital balances with precision of 0.01 g (Dretec KS-233, Japan) were used to record body wet weight. The size distribution of the fish was set at 10-interval class for TL and 5-interval class for weight grouping.

Length-weight relationship and condition factor

The relationship of length-weight of *A. testudineus* was expressed in the allometric form:

$$W = {}_{a}L^{b} \qquad (1)$$

or in the linear form:

$$\text{Log } W = \text{Log } a + b \text{ Log } L \qquad (2)$$

where W is the total weight (g), L is the total length (mm), *a* is the constant showing the initial growth index and *b* is the slope showing growth coefficient. If fish retains the same shape and growth increases isometrically, it is $b = 3$. When weight increases more than length ($b > 3$), positive allometry is exhibited. When the length increases more than weight ($b < 3$), this indicates negative allometry (Morey et al. 2003). If scaling is isometric, fish weight (equal to the volume if constant density is assumed) will vary with the length cubed (i.e. $b = 3$), while the standard length will show linear correlation with total length, i.e. $b = 1$ (Froese, 2006). If the observed value of *b* differs from these expectations, the relationship is allometric and growth is non-isometric. Furthermore, an examination of the contributing growth factors can shed light on species biology and physiological ecology. The condition factor (K) of male and female was calculated using formula (Wootton, 1998):

$$K = 100W/L^3 \qquad (3)$$

where L is total length (cm) and W is weight (g). The *YPUE* (yield per unit effort) was calculated using the following equation (Godoy et al., 2003), which is adapted for this study:

$$YPUE = \frac{\sum weight}{\sum number\ of\ nets * \sum fishing\ trials} \qquad (4)$$

Statistical analysis

The Mann-Whitney test was utilized to identify significant differences in the number of catches between continuous and blinking light traps, and between the experimental light traps with the control. The Kruskal-Wallis test, analysis of variance by ranks, was employed to determine whether there were significant differences in the total catches of each trap group. Tukey's post-hoc analysis test was performed using multiple comparisons to see which catch differed significantly among the traps. All statistical tests were evaluated at a 95% confidence level using SPSS 16.0 software.

RESULTS

A total of 96 individuals of *A. testudineus* (2 155 g total weight), consisting of 34 males (791 g) and 62 females (1 364 g total weight), were collected from the pond experiment using the continuous, blinking light traps and the control (Table 1).

Table 1. Number of catches, weight, YPUE and mean condition factor (K) of A. testudineus by the sex collected from the pond experiments

Light Trap	Treatment	Number of catches			Weight (g)			YPUE			Mean ± SD of *K*	
		Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Without lamp	Control	2	1	3	57	15	72	4.07	1.07	5.14	2.31±0.73	2.44±0.00
Blue	Continuous	5	2	7	117	42	159	8.36	3.00	11.36	2.03±0.73	2.10±0.04
	Blinking	1	5	6	25	161	186	1.79	11.50	13.29	2.29±0.00	2.14±0.35
Green	Continuous	4	3	7	101	56	157	7.21	4.00	11.21	2.34±0.41	2.07±0.13
	Blinking	1	2	3	30	41	71	2.14	2.93	5.07	1.74±0.00	1.74±0.08
Yellow	Continuous	4	7	11	74	150	224	5.29	10.71	16.00	2.43±0.58	2.11±0.61
	Blinking	4	8	12	76	197	273	5.43	14.07	19.50	1.70±0.00	2.12±0.37
Orange	Continuous	2	4	6	39	90	129	2.79	6.43	9.21	1.78±0.19	2.22±0.35
	Blinking	3	6	9	70	133	203	5.00	9.50	14.50	1.67±0.30	1.85±0.58
Red	Continuous	3	11	14	90	208	298	6.43	14.86	21.29	2.17±0.49	1.99±0.20
	Blinking	3	4	7	68	77	145	4.86	5.50	10.36	1.78±0.76	2.55±1.06
White	Continuous	1	6	7	22	135	157	1.57	9.64	11.21	2.57±0.00	2.11±0.40
	Blinking	1	3	4	22	59	81	1.57	4.21	5.79	2.41±0.00	1.94±0.63
Total		34	62	96	791	1,364	2,155	56.50	97.43	148.79	-	-
Mean ± SD		3±1.39	5±2.80	7±3.36	61±31.49	105±62.99	166±71.36	4±2.25	7±4.50	12±5.10	2.10±0.40	2.13±0.34

There were more females caught than males (p<0.05), indicating that females were more attracted to color than males. The body sizes of *A. testudineus* ranged between 76-135 mm TL and 8-55 g. There were significant differences in the number of fish caught among the three trap treatments (p<0.001). Both continuous and blinking light traps captured more *A. testudineus* than the control (p<0.001), but no significant difference in the number of fish caught between them was observed. Similarly, no significant difference was found in the weight of the catch and YPUE, consequentially. On the other hand, the use of continuous light traps was found to be as effective as the blinking light traps in catching *A. testudineus* from a pond. The YPUEs for continuous, blinking light traps and control ranged from 9.21 to 20.63, from 5.07 to 19.50 and 5.14 g trap^{-1} trial^{-1}. The mean YPUEs for males and females were 4.0 ± 2.25 and 7.0 ± 4.50 g trap^{-1} trial^{-1}, respectively. The mean *K* values of 2.10 ± 0.40 for males and 2.13 ± 0.34 for females indicated fish in better condition. No significant differences were observed in the number of catches and CPUE for each light trap (blue, green, yellow, orange, red and white), as shown in Table 2.

The CPUEs for continuous, blinking light traps and control ranged from 0.43 to 0.93, from 0.21 to 0.86 and 0.21 fish trap^{-1} night^{-1}, respectively. It should be noted that *A. testudineus* is able to differentiate between various colors of light, as exhibited in this analysis.

Results of the experiments also showed no significant differences in terms of average total catch, weight and ratio of body sizes between males and females, as described in Table 3.

The size classes of *A. testudineus* caught using the continuous and blinking light traps are displayed in Fig. 2 and Table 4. It

Table 2. The summary of number of catches, CPUE, YPUE and weight of *A. testudineus* obtained from the pond experiments

Light Traps	No. Trials	Number of catches and values of the test							Weight (g) and values of the test					
		Blue	Green	Yellow	Orange	Red	White		Blue	Green	Yellow	Orange	Red	White
Continuous	14	7	7	11	6	13	7		159	157	224	129	285	157
CPUE		0.50	0.50	0.79	0.43	0.93	0.50	YPUE	11.36	11.21	16.00	9.21	20.36	11.21
Blinking	14	6	3	12	9	7	4		186	71	273	203	145	81
CPUE		0.43	0.21	0.86	0.64	0.50	0.29	YPUE	13.29	5.07	19.50	14.50	10.36	5.79
Control	14	3	3	3	3	3	3		72	72	72	72	72	72
CPUE		0.21	0.21	0.21	0.21	0.21	0.21	YPUE	5.14	5.14	5.14	5.14	5.14	5.14
Total		16	13	26	18	23	14		417	300	569	404	502	310
Significance test		p>0.05	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05		p>0.05	p>0.05	p>0.05	p<0.05	p>0.05	p>0.05
Chi-square (χ^2)		1.65	0.52	0.51	1.36	1.60	0.32		1.57	1.57	0.49	0.49	1.30	0.35

Table 3. Mean ± standard deviation, total length, weight and ratio of body sizes of male and female *A. testudineus*

Light Trap	Treatment	Mean±SD of TL (mm)		Mean±SD of Weight (g)		W/TL	
		Male	Female	Male	Female	Male	Female
Without lamp	Control	108±23.33	85±0.00	28.5±9.19	15.0±0.00	0.26±0.03	0.18±0.00
Blue	Continuous	107±13.96	100±2.83	23.4±15.84	21.0±1.41	0.22±0.13	0.21±0.01
	Blinking	103±0.00	112±13.04	25.0±0.00	32.2±15.83	0.24±0.00	0.28±0.10
Green	Continuous	102±17.45	96±2.89	25.3±9.74	18.7±1.53	0.24±0.06	0.19±0.01
	Blinking	120±0.00	106±7.78	30.0±0.00	20.5±3.54	0.25±0.00	0.19±0.02
Yellow	Continuous	92±3.00	101±15.99	18.5±3.79	21.4±6.43	0.20±0.04	0.21±0.04
	Blinking	110±17.15	105±6.78	19.0±4.08	24.6±4.00	0.18±0.05	0.23±0.03
Orange	Continuous	103±0.00	101±5.68	19.5±2.12	22.5±2.08	0.19±0.02	0.22±0.02
	Blinking	112±10.02	107±12.42	23.3±2.08	22.2±7.08	0.21±0.21	0.21±0.05
Red	Continuous	112±12.50	98±5.12	30.0±3.46	18.9±2.36	0.27±0.02	0.19±0.02
	Blinking	110±10.00	92±12.30	22.7±8.33	19.3±7.14	0.21±0.08	0.17±1.42
White	Continuous	95±0.00	102±6.41	22.0±0.00	22.5±4.68	0.23±0.00	0.22±0.04
	Blinking	97±0.00	102±12.86	22.0±0.00	19.67±0.58	0.23±0.00	0.19±0.02

was clearly demonstrated that the light traps collected more individuals of *A. testudineus* at the size distribution between 90 and 109 mm TL as well as between 16 and 25 g (weight) of the interval classes used. On the other hand, positive group responses of *A. testudineus* were more pronounced in the middle size classes compared to the lower or higher classes. The highest number of fish captured for both males (26.47%) and females (41.94%) was found in the size class of 100-109 mm TL. To facilitate the largest amount of fish caught, weight was recorded at the interval class of 16-20 g (45.16%) for females and of 21-25 g (33.33%) for males. Figure 2 clearly demonstrates that male (n = 34) and female (n = 62) *A. testudineus* had a negative allometric growth pattern, which means that length increased more than weight. The b values obtained for males and females were 1.7271 and 1.8828, respectively. No significant difference in the slope was observed between captured males and females (p>0.05). Such relationships of length and weight were expressed as: $W = 7.2x10^{-4}\ TL^{1.7271}$ and $W = 3.5x10^{-4}\ TL^{1.8828}$. The coefficient of determination (R^2) values for males and females were 0.3723 and 0.4955, respectively. The index of regression (r) obtained demonstrates that for every mm of length, weight increases by 0.6101 g in males, and by 0.7039 g in females. The trendlines of curves intersected each other, indicating an identical growth pattern between

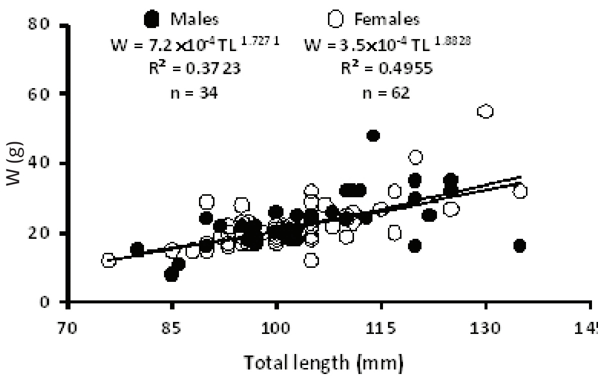

Fig 2. The length and weight relationship of *A. testudineus* obtained from the pond experiment using continuous and blinking light traps

Table 4. The size classes of total length and weight of males and females *A. testudineus* are taken from the pond using the light traps

Interval Class	Number of catches				Interval Class	Number of catches			
of Total length	Male	%	Female	%	of Weight	Male	%	Female	%
60 - 69	0	0.00	0	0.00	1 - 5	0	0.00	0	0.00
70 - 79	0	0.00	1	1.61	6 - 10	1	3.03	0	0.00
80 - 89	3	8.82	2	3.23	11 - 15	1	3.03	5	8.06
90 - 99	9	26.47	21	33.87	16 - 20	10	30.30	28	45.16
100 - 109	9	26.47	26	41.94	21 - 25	11	33.33	17	27.42
110 - 119	6	17.65	8	12.90	26 - 30	3	9.09	7	11.29
120 - 129	6	17.65	2	3.23	31 - 35	6	18.18	3	4.84
130 - 139	1	2.94	2	3.23	36 - 40	0	0.00	0	0.00
140 - 149	0	0.00	0	0.00	41 - 45	0	0.00	1	1.61
150 - 159	0	0.00	0	0.00	46 - 50	1	3.03	0	0.00
160 - 169	0	0.00	0	0.00	51 - 55	0	0.00	1	1.61
Total	34	100	62	100	Total	33	100	62	100

Table 5. Comparative length-weight relationships of *A. testudineus* from different geographical areas

Locations	Country	n	W/TL	a	b	R^2	r	Allometric pattern	Mean *K*	References
Banjarbaru, South Kalimantan	Indonesia	96	0.2161	0.0005	1.8049	0.4339	0.6587	A-	2.115	Present study
Kuttanad, Kerala	India	246	0.363	0.0003	2.8452	0.9556	0.9775	A-	2.060	Kumary and Raj, 2016
Kausalyaganga, Orissa	India	544	0.390	-1.432	2.7201	0.0821	0.9264	A-	2.070	Kumar et al. 2013
Deepar Beel, Assam	India	120	0.162	-2.540	3.645	0.850	0.9220	A+	1.000	Rahman et al. 2015
Chandpur, Matlab, Kalipur	Bangladesh	73	0.069	-1.518	2.423	0.9660	0.9828	A-	1.085	Begum and Minar, 2012

males and females. Regarding relative fishing efficiency, there was no significant difference in the ratio of YPUE to mesh size between continuous and blinking light trap used (p>0.05), as given in Figure 3.

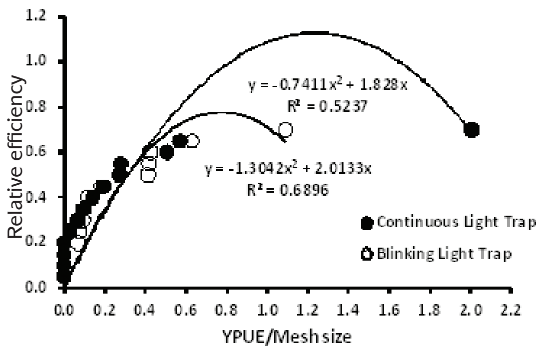

Fig 3. The ratio of YPUE to mesh size showing no significant difference in relative fishing efficiency between continuous and blinking light traps tested (p>0.05)

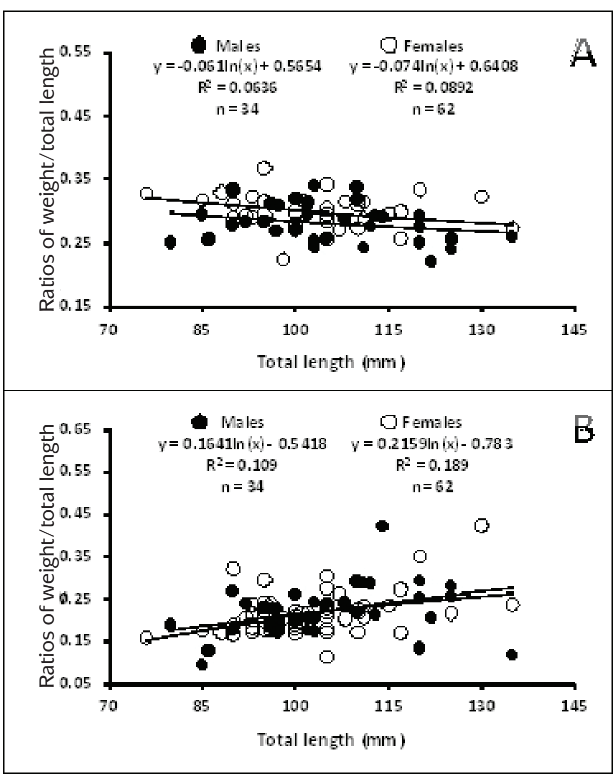

Fig 4. **A:** The mean ratios of body weight/total length of females were considerably higher than males (p<0.01) **B:** No significant difference in the mean ratios of body weight/total length between males and females was observed (p>0.05)

DISCUSSION

When considering attracting fish with artificial light sources, thus taking advantage of the phototaxis behavior in fish, it should be taken into account that fish have color receptors in their eyes. These receptors can recognize various intensities of light, which leads fish aggregation in lighted areas (Arimoto et al., 2010). The LED lamp is one of the most recent light-based technologies promoted in light-based fisheries (Yamashita et al., 2012; Mills et al., 2014; Puspito et al., 2015), instead of incandescent, halogen and metal halide illuminations (Baskoro et al., 2002; Matsushita et al., 2012) or chemical light sticks (Kissick, 1993; Marchetti et al., 2000). According to Hua and Xing (2013), LED fishing lights should meet the following requirements: A) the light source should have wide lighting range and sufficient illumination that can be applied to trap fish, B) the starting operation should be easy and quick, C) lights should be sturdy, shock-proof, pressure-proof and durable. It should be noted that the LED light spectrum is almost entirely concentrated in the visible light frequency bandwidth, with the optical efficiency up to 80-90%.

As fishing gear auxiliary, LED light is not only applicable for marine fish species, but also for freshwater fish species. Currently, research on the design of LED fishing light is being developed (Li, 2010; Kehayias et al., 2016). Regarding practical applications, it is a great challenge for us to provide more scientific information on phototaxis for other endemic fish species in this area of study (e.g. *Channa striata, C. mircopeltus*, *Helostoma temmincki, Trichogaster trichopterus* and *T. pectoralis*). This research is imperative in an effort to support aquaculture and fisheries conservation of these species. In South Kalimantan, the inland fishery has not been optimally utilized, thus the characteristics of endemic fish species that exhibit positive or negative phototaxis are still being poorly studied.

It is generally accepted that the color of light used as an attractant is an important variable for light trap use. Of the color wavelengths analyzed in this study, yellow (575 nm) appeared to be the strongest in attracting *A. testudineus*. Such phototactic response is also reported in golden perch *Macquaria ambigua* and silver perch *Bairdiella chrysoura* (Gehrke, 1994). Most teleost retinas contain four types of cone cells, each corresponding to a maximal wavelength of light absorption: red (600 nm), green (530 nm), blue (460 nm) and ultraviolet (380 nm) (Helfman et al., 1997; Moyle and Cech, 2000). The behavioural response of most fish species depends on vision, and visual ability of fish will be affected by the physical conditions of their environment, e.g. illumination, wavelength and turbidity (Utne, 1997). In the present study, the ability of *A. testudineus* to sense different colors of lights at 40.9 NTU was visually acceptable. Our results suggest that *A. testudineus* preferred yellow and red wavelengths compared to other colors in the LED light spectrum. Since *A. testudineus* are able to alter their behavioural responses to different wavelengths, they are considered to have true color vision. Kong and Goldsmith (1977) stated that true color discrimination is only possible when the fish has at least two receptor types with distinct but overlapping spectral ranges. Color discrimination requires inputs of different photoreceptor cells that are sensitive to different wavelengths of light. In this study, *A. testudineus* has a multichromatic visual system between blue and red, suggesting that results of this study were valid.

Experimental evidence demonstrated female-biased attraction to the lights. The sex ratio of male to female was 1 : 1.8, indicating that females (n = 62) were more responsive to colors than males (n = 34) during trapping experiment periods. This implies that light traps could be potentially used for broodstock purposes. Light traps could be beneficial for collecting broodstock from the wild or a culture pond. In the present study, the continuous light trap contributed to 54%, the blinking light trap to 43% and the control trap to 3% of the total catches. Morphometric analysis indicated that the mean ratios of body width and the total length of females were significantly higher than that of males ($p<0.01$). This validates that females develop wider abdomens when they become reproductively mature (Lowery, 1988). No significant difference was observed in the mean ratios of body weight and total length between females and males ($p>0.05$), as shown in Figure 4.

Regression analysis showed that the growth slope of *A. testudineus* was negatively allometric, where the b values (1.7271-1.8828) were significantly lower than the critical isometric value (b < 3). This suggests that the species becomes leaner as the length increases. Negative allometric growth pattern was also reported in *A. testudineus* from paddy fields in Chandpur, Matlab and Kalipur, Bangladesh (Begum and Minar, 2012), from cages, tank and ponds in Kausalyaganga of Orissa, India (Kumar et al., 2013), and from Kuttanad wetlands of Kerala, India (Kumary and Raj, 2016). However, *A. testudineus* caught from the Deepar Beel (wetlands) of Assam, India exhibited a positive allometric growth pattern (Rahman et al., 2015). Variation in slope may be attributed to sample size variation, life stages and environmental factors such as food and space (Kleanthids et al., 1999; Abowei et al., 2009). There is a strong correlation between feeding frequency and response of fish to lights. Since *A. testudineus* in the pond were fed to satiation three times a day with pellet, it may be disadvantageous for light trap use. Therefore, it is not surprising that there was a low catch presented in this study. Similar behavioural responses were also demonstrated in American crayfish (*Procambarus clarkii*) during trapping experiments with lights in the pond (Ahmadi et al., 2008).

Regardless of gender, there was a difference in the exponent for smaller length class, as compared to larger ones indicating that the species has two growth levels. The smaller individuals (< 90 mm TL) grew with the exponent significantly smaller than the cubic value ($W = 0.5599\ TL^{0.7064}$ with $R^2 = 0.0269$). The largest individual (^{3} 90 mm TL) grew with exponents significantly higher than the cubic value ($W = 0.0163\ TL^{1.5553}$ with $R^2 = 0.3301$). Table 5 shows the ratio of body weight in comparison to total length of *A. testudineus* in the present study (0.2161) was higher than that of *A. testudineus* captured in the Deepar Beel of Assam, India (0.162; Rahman et al. 2015) or collected from the paddy field in Chandpur, Matlab and Kalipur, Bangadesh (0.069; Begum and Minar, 2012). However, this ratio value was lower compared to *A. testudineus* captured from the Kuttanad wetlands of Kerala, India (0.363; Kumary and Raj, 2016) and in Kausalyaganga of Orissa, India (0.390; Kumar et al., 2013). The mean K values of 2.10 ± 0.40 for male and 2.13 ± 0.34 for female *A. testudineus* in the present study are also commonly found in the same fish species from other regions (Chotipuntu and Avakul, 2010; Begum and Minar, 2012; Kumar et al., 2013). The K value greater than 1 indicates better condition of fish (Le Cren, 1951), suggesting that the result of this study is valid. Variation in the value of the mean K may be attributed to the biological interaction involving intraspecific competition for food and space (Arimoro and Meye, 2007) between species, including sex, stages of maturity, condition of the stomach contents and availability of food (Gayanilo and Pauly, 1997; Abowei et al., 2009; Gupta et al., 2011). Information on condition factor of fish is considerably necessary for aquaculture system management particularly to understand specific condition and the health of fish being cultured. When the fish becomes leaner as the length increases, the manager or fish farmer should improve management strategies, such as improving the quality of feed contents and its feeding ratio, and adjusting the rearing density to reduce competition for food and space.

In normal conditions, *A. testudineus* usually appear on the water surface for air-breathing and can survive on low levels of oxygen because of having the labyrinth organ (Rahman et al., 2015). Climbing perch are even able to walk on the land for some time. When the fish are caught in the net trap by the gills, the probability of mortality quickly increases. The survival ability of fish depends on the individual's health condition and how long the fish was stuck in the trap. In our experiment, it was found that healthy fish can survive for more than 6 h. The more the fish tried to escape from the trap net, the more energy it consumed, leading to eventual mortalities. It is suggested that shortening the residence time of the trap in the water and replacing the nylon material with polyethylene (PE) or black 1.5 cm hexagonal mesh wire (16 gauge PVC-coated wires) may improve fish condition prior to capture. In addition, refining the trap instalment technique in pond culture systems to improve the fish housing ecosystem could improve fish condition.

CONCLUSION

Both continuous and blinking light traps captured more *A. testudineus* than the control trap. There were no significant differences in YPUE and CPUE between continuous and blinking light traps. Positive group responses of fish were widely exhibited in the middle size classes instead of the lower and higher classes. The current aquaculture management system for climbing perch should be improved since *A. testudineus* in the pond displayed negative allometric growth.

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FOTOTAKSIČNI ODGOVOR I MORFOMETRIJSKE KARAKTERISTIKE GRGEČA PENJAČA *Anabas testudineus* (Bloch, 1792) U UZGOJNOM SUSTAVU

SAŽETAK

U radu je istraživana fototaksija kod grgeča penjača (*Anabas testudineus*) izlaganjem riba zamkama uz pomoć LED svjetlosti (plava, zelena, žuta, narančasta, crvena, bijela) uz kontrolnu skupinu (ukupno 13 klopki). Zamke su izrađene od poliamidnog (PA) najlonskog jednostrukog vlakna (veličine oka 31,75 mm), pričvršćenog oko dva žičana okvira (∅ 490 mm) s visinom od 270 mm. Svjetlo je postavljeno na dno zamke. Analizirano je 96 primjeraka, od kojih 34 mužjaka i 62 ženki. U usporedbi s kontrolom, kontinuirane i trepereće svjetlosne zamke bile su znatno uspješnije u broju ulovljenih riba. Dužina i masa tijela riba kretala se od 76-135 mm TD odnosno 8-55 g M. Prosječni YPUE (prinos po jedinici napora) za mužjake su bili 4,00±2,25 odnosno 7,00±4,50 za ženke g zamka^{-1}pokus^{-1}. CPUEs (ulov po jedinici napora) se kretao u rasponu od 0,43 do 0,93 za kontinuirane, 0,21 do 0,86 za trepereće svjetlosne zamke, odnosno 0,21 za kontrolu riba zamka^{-1}noć$^{-1}$. Srednja vrijednost faktora kondicije (K) od 2,10±0,40 za mužjake i 2,13±0,34 za ženke označava ribu bolje kondicije. Pozitivne reakcije riba bile su izražene u skupinama srednjih veličina od 90 do 109 mm TL. Uočen je uzorak negativnog alometrijskog rasta (b) (1.7271-1.8828), što moguće ukazuje na nedostatke uzgojnog sustava. *A. testudineus* je pokazao pozitivnu fototaksiju izložen “obojanoj svjetlosti”.

Ključne riječi: *Anabas testudineus,* kontinuirano svjetlo, treperavo svjetlo, LED, negativna alometrija, svjetlosna zamka

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