Advances in Biology & Earth Sciences
Vol.3, No.2, 2018, pp.114-129

PHOTOTACTIC RESPONSES OF CLIMBING PERCH (*ANABAS TESTUDINEUS*) TO VARIOUS INTENSITIES AND COLORS OF LED UNDERWATER LAMPS: RECOMMENDATION FOR FUTURE RESEARCH

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Abstract. The present study aimed to investigate phototactic response of climbing perch (*Anabas testudineus*) to various intensities and colors of light emitting diode (LED) underwater lamps. Catches by traps equipped with lamps emitted six different light colors (red, green, yellow, blue, orange, and white) were compared with catches of control traps without any lamps. Each light color was estimated in three illumination levels. The trials consisted of 140-trap hauls per lamp type with a submersion time of 10 h. *A. testudineus* positively responded to all colors of the lamps regardless of its intensity. The light traps (except yellow and orange) were considerably higher in the number of catch as compared to the control ($P<0.05$). The daily averages of catch for male were 9 (2-24) fishes and 149 (28-399) g weights; while for female were 17 (1-43) fishes and 262 (22-785) g weight. The size of catch ranged of 60-170 mm total length and 4-84 g weight. The average catch per unit effort (CPUE) was from 0.04 to 2.36 fish trap^{-1} night^{-1}, while the average yield per unit effort (YPUE) was from 0.32 to 40.76 g trap^{-1} trial^{-1}. The mean condition factors of male and female were 1.41±0.18 and 1.52±0.25 respectively, indicating the fish are in better condition. The positive group responses of fish were more pronounced at the length sizes between 100 and 109 mm TL. Negative allometric growth pattern (b = 2.7255-2.8247) was observed in *A. testudineus*, implies that culture strategy should be developed. In addition, efforts to collect them from the wild for breeding and commercial purposes may benefit from this research.

Keywords: *Anabas testudineus, LED underwater lamp, negative allometric, growth type, CPUE, YPUE.*

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***Received**: 28 May 2018;* ***Accepted**: 9 July 2018;* ***Published**: 02 August 2018*

1. Introduction

The climbing perch (*Anabas testudineus* Bloch, 1792) plays a significant role in fisheries and aquaculture practices because of having a high market value as important food fish, not only in Indonesia (Akbar *et al*., 2016) but also in Lao PDR (Sokheng *et al*., 1999), Cambodia (Sverdrup, 2002), Vietnam (Van & Hoan, 2009), southern Thailand (Chotipuntu & Avakul, 2010), Malaysia (Zalina *et al*., 2012), the Philippines (Bernal *et al*., 2015), Bangladesh (Hossain *et al*., 2015a; Uddin *et al*., 2017), and India (Kumar *et al*., 2013). It is rich in iron and copper that support haemoglobin synthesis (Sarma *et al*., 2010) and has high quality poly-unsaturated fats and many essential amino acids (Kohinoor *et al*., 1991). It also provides 19.50% of protein and 2.27% of lipid (Ahmed *et al*., 2012). In nature, they can be found in all freshwater bodies such as rivers, streams, swamps, ponds, lakes, canals, reservoirs, and estuaries (Sarkar *et al*., 2005; Rahman & Marimuthu, 2010), and can also be cultured at cages, tanks and ponds (Long *et al*., 2006; Mondal *et al*., 2010; Kumar *et al*., 2013) with different culture strategies (Trieu *et al*., 2001; Phu *et al*., 2006; Chotipuntu & Avakul, 2010; Putra *et al*., 2016). Some of studies are dedicated to describe on breeding biology (Hafijunnahar *et al*., 2016), boldness (Binoy, 2015) or morphometric characteristic of this species (Hossain *et al*., 2015b).

Statistically, climbing perch contributes about 12% (8.31 tons) of total inland capture fisheries production (69.97 tons) in South Kalimantan Province. It is abundantly found in three different types of swamp areas, namely "monotonous swamp" located on Hulu Sungai Selatan District (452.704 ha), "rain reservoir swamp" in Banjar, Tanah Laut, and Pulau Laut Districts (169.094 ha), and "tidal swamp" in Barito Kuala, Tanah Laut, and Kota Baru Districts (372.637 ha). *A. testudineus* is locally called "papuyu" and is well-known as an indigenous air breathing freshwater species and is capable of spending days out of water provided the breathing organ remains moist (Storey *et al*., 2002) as function of labyrinth organ (Rahman *et al*., 2015). In Australia, Papua New Guinea and India, the presence of them is exactly expected to out-compete native freshwater and estuarine species such as birds, reptiles, animals and predatory fish by using their sharp dorsal and opercular spines (Storey *et al.*, 2002; Hitchcock, 2008; Paliwal & Bhandarkar, 2014). Indiscriminate harvesting of fry and fingerlings, habitat modification, reduced water flow, growing human interventions on wetlands are the main threats to this species (Rahman *et al*., 2012; Kalita & Deka, 2013; Hossain *et al*., 2015b).

A. testudineus encompasses a divergence feeding behaviour. They are a fierce predator, and will also eat other fish if they can master them. Some are omnivorous, feeding on invertebrates, fish and plants. Local fishermen usually utilize their feeding behaviour to attract them into the traps or the nets with or without baits (Iwata *et al*., 2003; Bernal *et al*., 2015; Hossain *et al*., 2015b; Kumary & Raj, 2016; Irhamsyah *et al*., 2017). At the same time, study on the light-induced behavioral response in *A. testudineus* is completely lacking in these publications. By learning from previous studies (Ahmadi & Rizani, 2013; Aminah & Ahmadi, 2018) and combining with the present study, we believe that trapping with lights shows the promising option to harvest them from both culture pond and wild sources. It is therefore improvement of the harvesting procedures is essential. For this reason, we carried out a series of trapping experiments to investigate phototactic responses of *A. testudineus* to various intensities and colors of light emitting diode (LED) underwater lamps in the pond, as well as to analysis the size distribution, length-weigh relationship and condition factor of this species.

2. Materials and methods

Trapping experiments were undertaken in a concrete pond (11.5×10×1.55 m, 0.50 m deep), belonged to the Faculty of Marine and Fisheries, Lambung Mangkurat University. The fish population in pond was estimated more than 1000 individuals of *A. testudineus*. Fish were fed three times a day with commercial pellet at feeding ratio of 5% body weight. 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 of 29.0-30.5 °C through the trials.

A total of four circle-shaped traps were constructed with the same dimensions and materials (Fig. 1), consisted of trap with one-lamp, trap with two-lamp, trap with three-lamp, and trap without lamp as a control. The trap was made of black waring net (material usually used for cages), which fastened around two-wire (∅ 2 mm) ring frames; 1540 mm perimeter was placed on the top and bottom with diameter of a circle 490 mm and 270 mm high. The trap had three entry funnels located around the trap with a 50 mm inside ring entrance. A sheet of Polyethylene (PE) nylon multifilament was placed on the top allowed for removal of the catch and another was placed on the bottom where the lamp was attached.

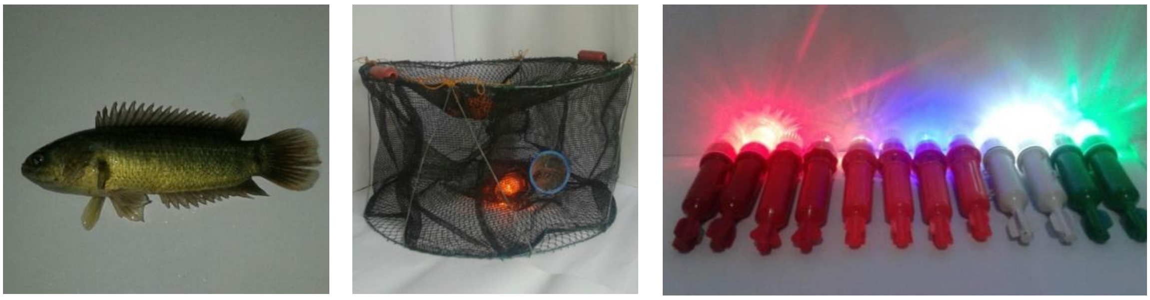

Figure 1. *A. testudineus*, trap and lamps used during the trapping experiments in a pond.

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

Light Trap	Treat-ment	Intensity (lx)	Number of catches			Total catch (g)			K Mean ± SD	
			Male	Female	Total	Male	Female	Total	Male	Female
Blue	1-lamp	8.4 ± 1.65	24	29	53	371	408	779	1.47±0.22	1.43±0.29
	2-lamp	13.9 ± 1.73	8	21	29	100	340	440	1.47±0.16	1.51±0.17
	3-lamp	20.4 ± 2.12	11	23	34	130	347	477	1.45±0.23	1.47±0.17
	Control	-	4	9	13	65	128	193	1.57±0.17	1.49±0.13
Green	1-lamp	3116 ± 342.74	6	12	18	78	166	244	1.61±0.16	1.66±0.23
	2-lamp	5277 ± 395.48	3	13	16	28	185	213	1.68±0.20	1.63±0.14
	3-lamp	6730 ± 533.33	2	18	20	22	196	218	1.51±0.16	1.63±0.12
	Control	-	-	-	-	-	-	-	-	-
Yellow	1-lamp	332 ± 37.14	10	42	52	211	694	905	1.60±0.16	1.67±0.22
	2-lamp	593.2 ± 38.85	4	15	19	65	253	318	1.65±0.22	1.55±0.37
	3-lamp	757.6 ± 33.88	12	43	55	234	785	1019	1.56±0.18	1.64±0.36
	Control	-	6	10	16	110	156	266	1.48±0.24	1.54±0.21
Orange	1-lamp	42.5 ± 2.68	21	12	33	318	168	486	1.47±0.18	1.47±0.19
	2-lamp	79.1 ± 3.25	7	11	18	89	147	236	1.38±0.19	1.56±0.11
	3-lamp	92.5 ± 3.92	11	10	21	163	154	317	1.41±0.21	1.54±0.17
	Control	-	6	7	13	108	78	186	1.48±0.16	1.47±0.31
Red	1-lamp	376.4 ± 93.40	24	35	59	399	547	946	1.53±0.23	1.67±0.45
	2-lamp	414.8 ± 49.43	14	28	42	231	453	684	1.54±0.14	1.64±0.41
	3-lamp	554.4 ± 38.02	12	22	34	178	321	499	1.58±0.36	1.59±0.16
	Control	-	7	8	15	107	121	228	1.41±0.14	1.41±0.23
White	1-lamp	554.4 ± 38.02	4	12	16	102	310	412	1.56±0.13	1.77±0.74
	2-lamp	1756.3 ± 78.71	8	9	17	240	150	390	1.66±0.19	1.96±0.72
	3-lamp	2220 ± 351.85	6	8	14	231	160	391	1.66±0.28	1.74±0.20
	Control	-	-	1	1	-	22	22	-	1.56±0.00
Daily average of catch			9	17	25	149	262	411	1.41 ± 0.18	1.52 ± 0.25

Except the control trap, each of trap was assigned with 0.9-2.7 W LED (Light Emitting Diode) Torpedo lamp (215×50 mm, Fishing Net Industry Co. Ltd. China) containing blue (460 nm), green (530 nm), yellow (590 nm), orange (620 nm), red (625 nm) and white, powered by 3 V dry-cell batteries respectively. In addition, white LED cannot be differentiated by wavelength because it appears "cool", "neutral" or "warm" white due to its color temperature. The lamps are constructed with advance circuit design technology and latest high-brightness LED component, as well as safe to use, convenience and more durable. The light intensity was ranged from 8.4 ± 1.65 lx to 6730 ± 533.33 lx, and measured with a light-meter LX-100 (Lutron, Taiwan) at the Basic Laboratory of the Faculty of Mathematic and Natural Science, Lambung Mangkurat University as presented in Table 1.

Trapping experiments with the lamps were carried out at night under ambient light environment. The traps were spread out around the pond and retrieved the following morning. The traps were rotated each night with soaking time of 10 h. The trials consisted of 140-trap hauls per lamp type. After retrieval, the catches were counted, identified for sex, measured for total length and weight, and released back into the pond. Total length (TL) was measured to the nearest 0.1 mm using a 30 cm ruler as the distance from the tip of the anterior most 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 fish captured was set at 10-interval class for TL and 5-interval class for weight group.

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

$$W = {}_{a}L^{b}$$

or in the linear form:

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

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 grows increase isometrically, it is therefore *b*=3. When weight increases more than length (*b*>3), it shows positive allometric. When the length increases more than weight (*b*<3), it indicates negative allometric (Morey *et al*., 2003). The condition factor of male and female was calculated using formula (Wootton, 1998):

$$K = 100W/L^3$$

Where K is condition factor, L is total length (cm) and W is weight (g). The CPUE (catch per unit effort) was determined as average number of fish per net per night (Baker *et al*., 2008), which is adapted for this study. The YPUE (yield per unit effort) was calculated using the following equation (Godoy *et al*., 2003):

$$YPUE = \frac{\sum weight}{\sum number\ of\ nets\ *\ \sum fishing\ trials}$$

The Mann-Whitney test was used to determine whether or not significant difference in number of catches, weight, CPUE or YPUE between two light traps or between light trap and control. The Kruskal-Wallis test, the analysis of variance by ranks, was employed to determine if there were significantly differences in the total number of catches, weight, CPUE or YPUE of each trap group. All statistical tests were evaluated at the 95% confidence level using SPSS 16.0 software.

3. Results

The results of trapping experiments with various intensities and colors of LED underwater lamps were presented in Table 1. The daily averages of catch for male were 9 (2-24) fishes and 149 (28-399) g weights; while for female were 17 (1-43) fishes and 262 (22-785) g weight. Many more females caught than males ($P<0.01$) indicating that females were more attractive to color tested than males. Females were also heavier than males ($P<0.05$). The mean body size of male ranged from 82.00 ± 0.55 to 127.00 ± 34.93 mm TL and from 9.33 ± 2.31 to 38.50 ± 26.42 g weight; while for female ranged from 86.39 ± 9.49 to 104.17 ± 27.49 mm TL and from 10.89 ± 3.91 to 25.83 ± 25.33 g weight (Table 2). Except yellow and orange light traps, there were significantly differences in the number catch of blue, green, red and white light traps ($P<0.01$) as well as found in the total catch (Table 3). In other word, the use of light traps is more effective in catching climbing perch as compared to the trap without lamp ($P<0.001$). No significant difference was observed in condition factor between male and female ($P>0.05$). It can be pointed out that *A. testudineus* is able to differentiate various colors tested. The mean K values of 1.41 ± 0.18 for males and 1.52 ± 0.25 for females indicating the fish are in better condition (Table 1).

Table 2. Mean ± standard deviation of total length (TL) and weight of male and female of *A. testudineus*

Light Trap	Treatment	Intensity (lx)	Mean ± SD of TL (mm)		Mean ± SD of weight (g)	
			Male	Female	Male	Female
Blue	1-lamp	8.4 ± 1.65	100.54 ± 12.20	98.31 ± 12.76	15.46 ± 5.52	14.07 ± 5.24
	2-lamp	13.9 ± 1.73	94.25 ± 11.60	102.05 ± 9.66	12.50 ± 3.63	16.19 ± 1.89
	3-lamp	20.4 ± 2.12	92.45 ± 12.60	99.78 ± 12.34	11.82 ± 4.35	15.09 ± 4.97
	Control	-	100.75 ± 12.69	97.56 ± 14.28	16.25 ± 4.57	14.22 ± 5.40
Green	1-lamp	3116 ± 342.74	92.83 ± 10.24	94.33 ± 0.13	13.00 ± 3.42	13.83 ± 2.27
	2-lamp	5277 ± 395.48	82.00 ± 0.55	94.69 ± 8.99	9.33 ± 2.31	14.23 ± 3.90
	3-lamp	6730 ± 533.33	90.00 ± 7.07	86.39 ± 9.49	11.00 ± 1.41	10.89 ± 3.91
	Control	-	-	-	-	-
Yellow	1-lamp	332 ± 37.14	109.20 ± 8.42	98.98 ± 11.80	21.10 ± 5.07	16.52 ± 5.02
	2-lamp	593.2 ± 38.85	99.50 ± 12.69	103.80 ± 22.43	16.25 ± 4.11	16.87 ± 5.87
	3-lamp	757.6 ± 33.88	106.58 ± 11.32	103.35 ± 11.20	19.50 ± 6.33	18.26 ± 4.94
	Control	-	107.50 ± 5.24	99.70 ± 13.31	18.33 ± 3.14	15.60 ± 5.17
Orange	1-lamp	42.5 ± 2.68	100.62 ± 11.36	96.42 ± 13.96	15.14 ± 3.81	14.00 ± 6.32
	2-lamp	79.1 ± 3.25	95.00 ± 16.33	93.82 ± 12.03	12.71 ± 6.40	13.36 ± 4.74
	3-lamp	92.5 ± 3.92	100.91 ± 14.07	99.40 ± 10.77	14.82 ± 4.81	15.40 ± 4.27
	Control	-	106.17 ± 9.39	89.43 ± 10.95	18.00 ± 4.60	11.14 ± 5.24
Red	1-lamp	376.4 ± 93.40	99.13 ±19.93	97.17 ± 13.26	16.63 ± 5.02	15.63 ± 5.49
	2-lamp	414.8 ± 49.43	101.43 ± 12.29	98.79 ± 13.72	16.50 ± 5.14	16.18 ± 5.47
	3-lamp	554.4 ± 38.02	97.75 ± 12.73	95.68 ± 13.01	14.83 ± 4.43	14.59 ± 5.76
	Control	-	101.86 ± 10.12	100.75 ± 15.12	15.29 ± 4.64	15.13 ± 5.28
White	1-lamp	554.4 ± 38.02	110.50 ± 30.07	104.17 ± 27.49	25.50 ± 23.84	25.83 ± 25.33
	2-lamp	1756.3 ± 78.71	111.38 ± 33.34	89.33 ± 16.43	30.00 ± 31.00	16.67 ± 16.44
	3-lamp	2220 ± 351.85	127.00 ± 34.93	95.63 ± 27.44	38.50 ± 26.42	20.00 ± 24.86
	Control	-	-	80.00 ± 0.00	-	8.00 ± 0.00

Table 3. Total number of catches, total catch and significance test of *A. testudineus* taken from the pond experiments

Light Traps	No. Trials	Total number of catches and Values of the test						Total catch (g) and Values of the test					
		Blue	Green	Yellow	Orange	Red	White	Blue	Green	Yellow	Orange	Red	White
1-lamp	5	53	18	52	33	59	16	779	244	905	486	946	412
2-lamp	5	29	16	19	18	42	17	440	213	318	236	684	390
3-lamp	5	34	20	55	21	34	14	477	218	1019	317	499	391
Control	5	13	0	16	13	15	1	193	0	266	186	228	22
Significance test		P<0.01	P<0.05	P>0.05	P>0.05	P<0.01	P<0.05	P<0.01	P<0.05	P>0.05	P>0.05	P<0.01	P<0.05
Chi-square (χ^2)		12.496	9.894	2.901	7.502	12.573	9.875	12.496	9.894	2.901	7.502	12.573	9.875

Morphometric analysis showed that the mean ratio of body width to total length (W_d/TL) of female was significantly higher than male across the trials (P<0.0001). The W_d/TL ratios obtained for male were ranged from 0.188 to 0.299 (0.230 ± 0.02) and for female were from 0.176 to 0.417 (0.252 ± 0.03) (Fig. 2A). No significant difference was observed in the mean ratio of body weight to total length (W/TL) between male and female (P<0.05). The W/TL ratios obtained for male and female were 0.160 ± 0.06 (0.067 -0.509) and 0.155 ± 0.05 (0.052 - 0.583) respectively (Fig. 2B). The size classes of *A. testudineus* collected from trapping experiments are described in Table 4. The positive group responses of fish were more pronounced at the length sizes between 100 and 109 mm, where more than 30% individual (72 males and 127 females) were caught. Over 119 mm TL, only a few of fish was captured or less than 3% of total catch. The heaviest catch for male (62.38%) and female (59.30 %) was exactly found in the lower class of 11-20 g weight.

Table 4. The size classes of total length and weight of *A. testudineus* obtained from trapping experiments

Class interval	Number of catches				Class interval	Number of catches			
of Total length	Male	%	Female	%	of Weight	Male	%	Female	%
60-69	2	0.95	7	1.76	1-10	38	18.10	96	24.12
70-79	7	3.33	22	5.53	11-20	131	62.38	236	59.30
80-89	26	12.38	72	18.09	21-30	35	16.67	61	15.33
90-99	38	18.10	79	19.85	31-40	-	-	-	-
100-109	72	34.29	127	31.91	41-50	1	0.48	-	-
110-119	53	25.24	78	19.60	51-60	1	0.48	2	0.50
120-129	6	2.86	9	2.26	61-70	1	0.48	1	0.25
130-139	-	-	-	-	71-80	2	0.95	1	0.25
140-149	1	0.48	-	-	81-90	1	0.48	1	0.25
150-159	1	0.48	1	0.25					
160-169	3	1.43	2	0.50					
170-179	1	0.48	1	0.25					

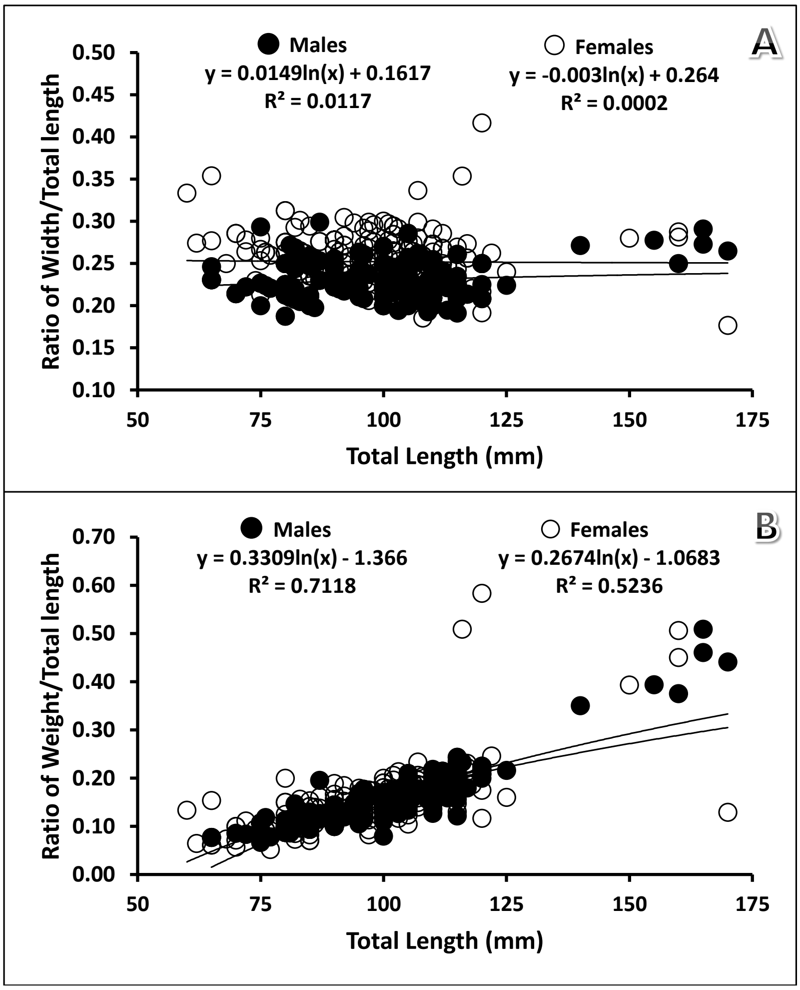

Figure 2. Female of *A. testudineus* had the mean ratio of body width to total length significantly higher than male (**A**), but no significant difference in the mean ratios of body weight to total length between them was observed (**B**).

Comparative fishing showed that the daily averages of CPUE for blue, green, red and white light traps were considerably higher than the control (P<0.05), but not for yellow and orange light traps (P>0.05). The values obtained ranged between 0.04 and 2.36 fish trap^{-1} night^{-1}. Dealing with the daily average of the estimated YPUE, each light trap was found to be higher than the control (P<0.05), except yellow light trap (P>0.05). The values obtained ranged between 0.32 and 40.76 g trap^{-1} trial^{-1} (Table 5). Table 6 shows comparative variables tested to show significances of the daily averages of CPUE for each group of light traps used. Blue trap with 1-lamp or 2-lamp was significantly higher than control (P<0.05); meanwhile, trap with 1-lamp was greater than 2-lamp (P<0.05). For the green trap, all lamps tested were considerably higher than control (P<0.05), but no significant differences among them was observed (P>0.05). There were no statistically significant differences in the yellow traps across the trials (P>0.05). The only orange trap with 1-lamp or 3-lamp was found to be higher than control (P<0.05). For the red and white traps, all lamps tested were considerably higher than control (P<0.05), but no significant difference was observed between trap with 1-lamp and 2-lamp, as well as trap with 2-lamp and 3-lamp (P>0.05).

Table 5. Daily averages of CPUE, YPUE and significance test of *A. testudineus* taken from the trapping experiments

Light Traps	No. Trials	Daily averages of CPUE (fish trap^{-1} night^{-1})						Daily averages of YPUE (g trap^{-1} night^{-1})					
		Blue	Green	Yellow	Orange	Red	White	Blue	Green	Yellow	Orange	Red	White
1-lamp	5	2.12	0.72	2.08	1.32	2.36	0.64	31.16	9.76	36.2	19.44	37.84	16.48
2-lamp	5	1.16	0.64	0.76	0.72	1.68	0.68	17.6	8.52	12.72	9.44	27.36	15.6
3-lamp	5	1.36	0.8	2.2	0.84	1.36	0.56	19.08	8.72	40.76	12.68	19.96	15.64
Control	5	0.52	-	0.64	0.52	0.56	0.04	7.72	-	10.64	7.44	9.12	0.32
Significance test		P<0.01	P<0.05	P>0.05	P>0.05	P<0.01	P<0.05	P<0.01	P<0.05	P>0.05	P<0.05	P<0.01	P<0.05
Chi-square (χ^2)		12.496	9.894	2.901	7.502	12.573	9.875	11.623	9.729	2.636	10.177	12.527	9.268

Figure 3 clearly demonstrates that male and female of *A. testudineus* had negative allometric growth pattern, which means that length increases more than weight. The *b* values obtained for males and females were 2.8247 and 2.7255 respectively. No significant difference in the slope was observed between male and female captured (P>0.05). Such relationships of length and weight were expressed as: $W = 3\times10^{-5}\ TL^{2.8247}$ and $W = 6\times10^{-5}\ TL^{2.7255}$. The coefficient of determination (R^2) values for males and females were 0.9000 and 0.8274 respectively. The index of regression (r) obtained showing that for every mm of length, weight increases by 0.9487 g in males, and by 0.9096 g in females. The trend lines of curves closed each other indicating identical growth pattern between males and females.

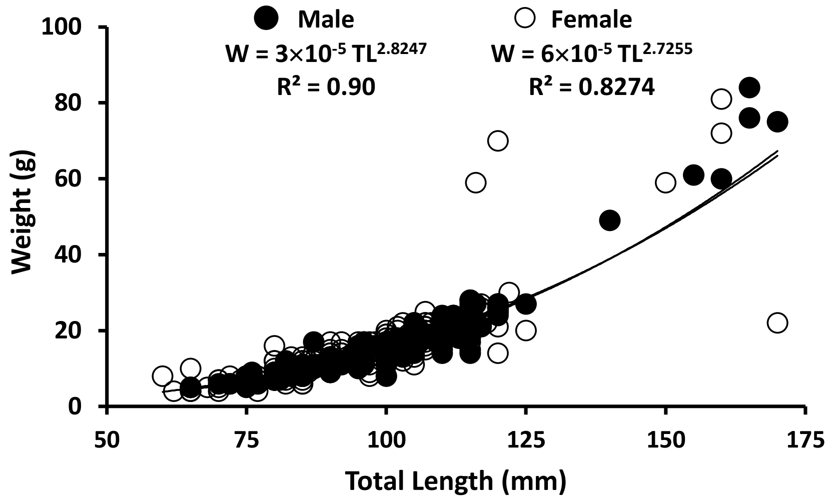

Figure 3. The regression curve of length-weight relationship of *A. testudineus*. Both male and female showed negative allometric growth pattern.

4. Discussion

The most important result of this study was that climbing perch positively responded to various intensities and colors tested. The results also clearly confirmed that the six different light traps differed significantly in CPUE, with the red trap having the highest performance of all traps used. Furthermore, the differences in specific CPUEs appeared to depend not only on the probability of fish to enter the different light traps, but also on differences in the spectral colors. At short-wavelengths (blue-orange), the traps with 1-lamp yielded the catches as effectively as traps with 3-lamp. Otherwise, at longer wavelength, the use of red or white traps with 1-lamp found to be more effective as compared to traps with 3-lamps (see Table 6). In the following way, the implications of these findings are useful for energy saving and improving the harvesting procedures for climbing perch light trap fishery.

It is acknowledged that research on LED light fishing rapidly developed (Li, 2010; Hua & Xing, 2013) instead of chemical light sticks (Kissick, 1993; Marchetti *et al*., 2004), incandescent, halogen, or metal halide illuminations (Baskoro *et al*., 2002; Matsushita *et al*., 2012). The light intensities of LED underwater lamps used in our trapping experiment was much lower as compared to those used for squid jigging boats (Yamashita *et al*., 2012; Matsushita *et al*., 2012), artisanal fishing net (Mills *et al*., 2014) or lift net fishery (Puspito *et al*., 2015; Susanto *et al*., 2017) that using high electricity power. The light intensities (8.4 ± 1.65 lx to 6730 ± 533.33 lx) of LED lamps used in the present study were adaptable for climbing perch in the pond without incurring visual damage, and potentially used for catching them from wild source. It is also a great challenge for us to test this experiment results to other commercially important fish species (e.g. snakehead, giant snakehead, snake-skin gourami, and giant freshwater shrimp) since inland fishery in South Kalimantan is not optimally utilized yet; meanwhile the characteristics of endemic fish species that behave positively or negatively phototaxis are poorly studied. The use of LED underwater fishing light appeared to be a promising option. By doing all these, it would become a significant work in our historical phototactic studies (Ahmadi *et al*., 2008; Ahmadi, 2012; Ahmadi & Rizani, 2013; Aminah & Ahmadi, 2018).

The color of light is one of important variables for light trap use. Of the colors tested in this study, red (25%) appeared to be the strongest attractor for *A. testudineus*, followed by yellow (23%), blue (21%), orange (13%), green (10%) and white (9%), indicating that magnitude response of fish tend to shift from long- to short-wavelength of the spectrum. Since *A. testudineus* are able to alter independently their behavioral responses to different colors, it is therefore they are considered to have true color vision. Kong & Goldsmith (1977) stated that the 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 case, *A. testudineus* has multichromatic visual system between blue and red, suggesting that result of this study is valid. In addition, Marchetti *et al*. (2004) reported that cyprinid larvae in the Sacramento River, USA were more attractive to green than red of chemical light sticks. Meanwhile golden perch *Macquaria ambigua* and silver perch *Bidyanus bidyanus* in floodplain habitat preferred to yellow/orange (Gehrke, 1994). Dealing with the spectral emissions, most teleost (marine finfish) responds to red (600 nm), green (530 nm), blue (460 nm), and ultraviolet (380 nm) because of having four types of cone cells in their retinas (Helfman *et al*., 1997; Moyle & Cech, 2000). The behavioral 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; Marchetti *et al*., 2004).

The present study confirms that female-biased attraction to the light traps with the sex ratio of male to female was 1 : 1.9, indicating that female (n = 363) were more responsive to colors as compared to male (n = 187) across the trials. Many females with the eggs captured in this study.

Table 6. Comparative variables tested to show significances of the daily averages of CPUE for each group of light traps used.

Type of trap	Variable tested[1]	Daily averages of CPUE[1]	Variable tested[2]	Daily averages of CPUE[2]	Mann-Whitney test	z	P
Blue	1-lamp	10.60	2-lamp	5.80	1.00	-2.417	P<0.05
	1-lamp	10.60	3-lamp	6.80	3.50	-1.892	P>0.05
	1-lamp	10.60	control	2.60	0.00	-2.652	P<0.001
	2-lamp	5.80	3-lamp	6.80	10.00	-0.527	P>0.05
	2-lamp	5.80	control	2.60	1.50	-2.341	P<0.05
	3-lamp	6.80	control	2.60	3.50	-1.940	P>0.05
Green	1-lamp	3.60	2-lamp	3.20	11.50	-0.211	P>0.05
	1-lamp	3.60	3-lamp	4.00	12.00	-0.106	P>0.05
	1-lamp	3.60	control	0.00	2.50	-2.362	P<0.05
	2-lamp	3.20	3-lamp	4.00	9.00	-0.738	P>0.05
	2-lamp	3.20	control	0.00	0.00	-2.795	P<0.001
	3-lamp	4.00	control	0.00	0.00	-2.785	P<0.001
Yellow	1-lamp	10.40	2-lamp	3.80	7.50	-1.061	P>0.05
	1-lamp	10.40	3-lamp	11.00	12.00	-0.105	P>0.05
	1-lamp	10.40	control	3.20	6.50	-1.257	P>0.05
	2-lamp	3.80	3-lamp	11.00	7.500	-1.061	P>0.05
	2-lamp	3.80	control	3.20	11.00	-0.319	P>0.05
	3-lamp	11.00	control	3.20	6.50	-1.265	P>0.05
Orange	1-lamp	6.60	2-lamp	3.60	5.50	-1.494	P>0.05
	1-lamp	6.60	3-lamp	4.20	6.50	-1.281	P>0.05
	1-lamp	6.60	control	2.60	1.50	-2.348	P<0.05
	2-lamp	3.60	3-lamp	4.20	9.00	-0.747	P>0.05
	2-lamp	3.60	control	2.60	8.50	-0.894	P>0.05
	3-lamp	4.20	control	2.60	3.00	-2.081	P<0.05
Red	1-lamp	11.8	2-lamp	8.4	6.50	-1.261	P>0.05
	1-lamp	11.8	3-lamp	6.8	3.00	-1.997	P<0.05
	1-lamp	11.8	control	3	0.00	-2.635	P<0.001
	2-lamp	8.4	3-lamp	6.8	10.50	-0.424	P>0.05
	2-lamp	8.4	control	3	0.50	-2.530	P<0.05
	3-lamp	6.8	control	3	0.50	-2.538	P<0.05
White	1-lamp	3.2	2-lamp	3.4	11.50	-0.224	P>0.05
	1-lamp	3.2	3-lamp	2.8	11.00	-0.230	P<0.05
	1-lamp	3.2	control	0.2	0.00	-2.712	P<0.001
	2-lamp	3.4	3-lamp	2.8	9.00	-0.752	P>0.05
	2-lamp	3.4	control	0.2	0.00	-2.730	P<0.001
	3-lamp	2.8	control	0.2	3.00	-2.132	P<0.05

It in some cases, female with the eggs are usually less active during the breeding season and are not responded to the baited trap (Holdich, 2002). They become more active after releasing the young and preparing for matting (Faller *et al*., 2006). On other words, the use of light traps for sampling the egg-bearing females may benefit from this study. In South Kalimantan, the climbing perch production mostly depends on natural harvest (Azizi & Noveny, 2001; Yunita, 2010), meanwhile the fish farming measures are still deficient due to high mortality at fingerling stage and slow growth. In other word, the wild seed demand for culture pond is still high. Therefore, understanding the food habits, habitat and reproduction biology of fish at different stages is necessary (Ansyari *et al*., 2008; Rupawan, 2009). According to Bernal *et al*. (2015), female climbing perch showed a marked increase in their food intake early in the wet season. In addition, climbing perch appears to be visual feeders, feeding primarily during the day (Patra, 1993) and also active at night to search for food. For this reason, the use of lights seems feasible for trapping juvenile (fingerling) and adults to fill the gap (Ahmadi & Rizani, 2013), particularly during rainy season/flood when using conventional gears (e.g. lift net, cast net or scoop net) are considered not useful.

This study presents useful reference on the weight-length relationships of *A. testudineus* in the culture system. Figure 3 clearly demonstrates that the growth slope of fish was negatively allometric, where the *b* values (2.7255 for female and 2.8247 for male) were significantly lower than the critical isometric value ($b<3$), indicating that the species becomes leaner as the length increases. Negative allometric growth pattern was also reported in *A. testudineus* collected from cages, tank, ponds and river in India (Kumar *et al*., 2013; Kumary & Raj, 2016) and Bangladesh (Begum & Minar, 2012; Hossain *et al*., 2015b). It is contrary to *A. testudineus* caught from Deepar Beel (wetlands) of Assam, India that exhibited positive allometric growth pattern (Rahman *et al*., 2015). Dealing with variation of these growth types, some of other studies may provide much lower *b* values than these findings (Froese & Pauly, 2018). The weight-length relationships are not constant over the entire year and vary according to factors such as food availability, feeding rate, gonad development and spawning period (Amin *et al*., 2010; Wong *et al*., 2015), temperature (Lopez-Martinez *et al*., 2003), inherited body shape (Yousuf & Khurshid, 2008), salinity (Chotipuntu & Avakul, 2010) and fecundity (Lawson, 2011).

Morphometric analysis showed that female of *A. testudineus* had the W_d/TL ratios greater than male (see Fig. 2A), indicating that female develop wider abdomens when they become reproductively mature (Lowery, 1988). Regardless the sex, the value of W_d/TL ratio (0.216) in the present study was lower compared to the ratio values (0.363 and 0.390) described by Kumary & Raj (2016) and Kumar *et al*. (2013), but it was higher than the ratio values (0.069 and 0.162) stated by Begum & Minar (2012) and Rahman *et al*. (2015). With regard to condition factor of fish, the K value (2.115) obtained from this study was the highest rate of the K values reported by the above studies (Table 7). The K value greater than 1 indicates the fish is in better condition (Le Cren, 1951), suggesting that result of this study is valid. Variation in the value of the mean *K* may be attributed to biological interaction involving intraspecific competition for food and space (Arimoro & Meye, 2007) between species including sex, stages of maturity, state of stomach contents and availability of food (Gayanilo & Pauly, 1997; Abowei *et al*., 2009; Gupta *et al*., 2011). Information on condition factor of fish is considerably needed for culture system management and control particularly to understand specific condition and healthy of fish being cultured. When the fish becomes leaner as the length increases, the manager or fish farmer should take management strategies, for example, by improving the quality of feed contents and its feeding ratio, and rearranging fish density to reduce competition for food and space.

Table 7. Comparative parameters of length-weight relationships of *A. testudineus* from different geographical areas.
a = constant, b = exponent, R^2 = determination coefficient, r = regression coefficient, A = allometric, K = condition factor

Locations	Country	n	W/TL	a	b	R^2	r	Allometric pattern	Mean K	References
Banjarbaru, South Kalimantan	Indonesia	608	0.216	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	0.8500	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
Tetulia River	Bangladesh	176	0.083	0.0220	2.90	0.9740	0.9869	A-	-	Hossain *et al*., 2015b

5. Conclusion

Light traps collected more climbing perch compared to control trap. The use of trap with 1-lamp seemed to be as effective as trap with 2-lamp or 3-lamp in term of battery energy saving. The climbing perch has multichromatic visual system between blue and red, and the magnitude responses of fish tend to shift from long- to short-wavelength of the spectrum. The current culture system needs to be improved since the fish in the pond showed negatively allometric growth type.

Acknowledgments

This work was funded by the Lambung Mangkurat University under the Ministry of Research Technology and High Education the Republic of Indonesia. Our gratitude goes to the Head of Wet Laboratory and undergraduate students of Faculty of Marine and Fisheries, and also Mrs. Siti Ubaidah for their kind helps during fieldworks and resultant measurements. The author also thanks reviewers for significantly improving the contents of manuscript.

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