Phototactic response of climbing perch *Anabas testudineus* to different colors and light pattern of LED light traps

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Abstract. Phototaxis of climbing perch (*Anabas testudineus* Bloch 1792) in a pond was examined by subjecting them to light-emitting diode (LED) light traps and control. A total of 711 specimens (total weight of 8.123 g) consisted of 318 males (3.530 g) and 393 females (4.593 g) were collected from a recapture experiment and used in the present one. Total length (TL) of the catch ranged from 62-110 mm. Total yield per unit efforts (YPUEs) for males and females were 706 g (39±28.22 g) and 919 g (51±31.85 g) respectively. There was no significant difference in the number of catches between the light traps and control or between continuous and blinking light traps (P>0.05). It can be pointed out that *A. testudineus* is able to differentiate various tested colours. The Fulton condition factor (K) values of 1.53±0.22 for male and 1.64±023 for female indicates that fishes were in good condition. Positive group responses of fish were more pronounced in lower size classes than that of higher ones. The size distribution of 80-89 mm TL provides the highest number of catch for male (41.82%) and female (35.20%). *A. testudineus* showed negative allometric growth pattern, implies that the culture management system should be refined.

Key Words: Continuous light, blinking light, trap, LED, negative allometric.

Introduction. The use of Light Emitting Diode (LED) in fishing has been introduced in many countries to optimize fish catch considering that fish and other aquatic species have color receptions in their eyes that could recognize various intensities of light that lead to their aggregation in lighted areas (Arimoto et al 2010). The LED lamp is one of the most recent advance lamps being promoted in light fishing-based fisheries (Sato et al 2010; Yamashita et al 2012; Hua & Xing 2013; Mills et al 2014; Puspito et al 2015) instead of incandescent, halogen, and metal halide illuminations (Baskoro et al 2002; Misund et al 2003; Matsushita et al 2012) or chemical light sticks (Gehrke 1994; Kissick 1993; Marchetti et al 2000).

As for fishing gear auxiliary, the use of LED lamp is being promoted for sampling fish and shrimp from the inland waters (Ahmadi 2012; Ahmadi & Rizani 2013). It is quite reasonable because inland fishery in South Kalimantan has been not optimally utilized yet. Phototactic study on the commercially important endemic fish species (e.g. *A. testudineus, Channa striata, C. mircopeltus*, *Helostoma temmincki, Trichogaster trichopterus* and *T. pectoralis*) has wide dimensions and presents enough interest to be investigated; moreover, scientific literatures on the characteristic of specific species that behaves positively or negatively phototaxis are still rare and not well documented yet. By doing all these, it would become a significant work in our phototactic studies to support sustainable wetlands environment management in South Kalimantan in term of fisheries and aquaculture as well as academic enrichment program.

The climbing perch (*Anabas testudineus* Bloch 1792) is well-known as one of the commercially important freshwater species not only in Indonesia (Akbar et al 2016), but also in many countries especially in Thailand, Malaysia, Philippines (Chotipuntu & Avakul 2010), Bangladesh (Begum & Minar 2012) and India (Kumar et al 2013). They are an indigenous species that inhabit swampy area and other freshwater areas (Talwar & Jhingran 1992) and can be cultured in cages, tanks and ponds (Kumar et al 2013). This species is very adaptable to low dissolve oxygen (DO) and survive out of water for prolong period because of having labyrinth organ (Rahman et al 2015). They are usually served as delicious food with high quality meat (Van & Hoan 2009).

In natural habitats, local fishermen in South Kalimantan usually catch *A. testudineus* with *rengge* (gillnet), *lalangit* (horizontal set gillnet), *pancing* (hand-line), *lukah* (fish trap) and *tempirai* (stage trap) with or without bait (Irhamsyah et al 2017). Meanwhile, collecting them with other conventional gears e.g. "anco" (liftnet), "tangguk" (scoop net) and "lunta" (cast net) particularly from the densely vegetated habitats is found to be inefficient. In rainy season, fish become difficult to be caught because they spread out in wider areas. By learning from previous studies (Ahmadi 2012; Ahmadi & Rizani 2013; Aminah & Ahmadi 2018) and combining with the present study, we believe that trapping with lights shows the promising option to sample fish including *A. testudineus* and shrimp from the wetlands (e.g. rivers, swamps, ponds). It is therefore of high interest to improve the harvesting procedures. Within the present study, phototactic responses in *A. testudineus* were subjected to different colours and light pattern of LEDs through a series of trapping experiments in the pond. It is a great challenge for us to convince the local people that *A. testudineus* could be lured into the light traps. For this reason, we used continuous and blinking LED light traps as an alternative sampling tool for collecting this species.

Material and Method

Pond experiment. Trapping experiments were undertaken in a concrete pond (11.5×10×1.55 m, 0.50 m deep), which belonged to the Faculty of Marine and Fisheries, Lambung Mangkurat University using about 1000 adults of *A. testudineus*. The fishes were fed twice 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 Nephelometric Turbidity Unit (NTU). The water surface temperature ranged from 29.0-30.5°C through the trials. The research activity was done from July to November 2017.

Trap and lamp setup. A total of 13 circle-shaped traps were constructed with the same dimensions and materials (Figure 1). They were six continuous light traps, six blinking light traps and a control (trap without lamp), and simultaneously tested in the concrete ponds at the beginning of trials. The trap was made of black waring net (material usually used for cages), which fastened around two-wire (∅ = 2 mm) ring frames; 1,540 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. From the initial experiment, we caught more females with the eggs and therefore we decided to stop catching them during spawning time. For this reason we bought another 300 specimens from cultured ponds and put them into a plastic pond (3×2×1 m, 70 cm deep). We only used three circle-shaped traps as those used in the first experiment. The traps were comprised from continuous light trap, blinking light trap and control. By doing this, phototactic response in *A. Testudineus* for each group of particular lamp became easier to be observed.

Each of the light traps was assigned with 0.9 W LED Torpedo light (215×50 mm, Fishing Net Industry Co. Ltd. China) containing blue = 8.4±1.65 lx (460 nm), orange = 42.5±2.68 lx (620 nm), yellow = 332.0±37.14 lx (590 nm), red = 376.4±93.40 lx (625 nm), white = 1282.6±91.35 lx, and green = 3116±342.74 lx (530 nm), powered by 3 V dry-cell batteries each. In addition, white LED cannot be differentiated by wavelength; it appears "cool", "neutral" or "warm" white due to its colour temperature, measured in Kelvin (K). The intensity of each lamp was measured with a light-meter LX-100 (Lutron, Taiwan) at basic laboratory of the faculty of Mathematics and Natural Sciences from Lambung Mangkurat University. The objective of this experiment was to evaluate the effect of different colours and light pattern of LED light traps on the number of catch.

Figure 1. The traps and lamps used during the trapping experiments in a pond.

Trapping experiment. Fishing trials were carried out at night after setting the lamps under ambient light environment. The traps were lowered on the pond and retrieved 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 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 were used to record body wet weight. The size distribution of fish recaptured was set at 10-interval class for TL and 5-interval class for weight group.

Length-weight relationship and condition factor. The data points of length-weight relationship of *A. testudineus* were plotted in a curve. Such relationship was expressed with the parabolic equation: $W = {}_{a}L^{b}$ (Begum & Minar 2012), where W is the total weight in g and L the total length in mm, while *a* is the constant and *b* is the exponent. The proper fit of the growth model is given by the coefficient of determination (R^2). The coefficient of correlation (r) between variables is computed by the square regression. The analysis of covariance was performed to determine variation in *b* values for species. The statistical significance of the isometric exponent (*b*) was analyzed by a function: $t_s = (b-3)/S_b$ (Sokal & Rohlf 1978), where t_s is the *t* student statistics test value, *b* the slope and S_b the standard error of *b*. The obtained values of *t*-test and the respective critical values are compared to determine the *b* values statistically significant. When the *b* value is greater than 3, it indicates positive allometric, less than 3 shows a negative allometric, and equal to 3 demonstrates an isometric individual (Morey et al 2003). Positive allometric means that weight increases more than length. Negative allometric means that length increases more than weight. While isometric means that length and weight are growing at the same rate. The condition factor of male and female *A. testudineus* was calculated using Fulton's condition factor, $K = 100W/L^3$ (Wootton 1998), where L is total length in cm and W is weight in g. The yield per unit effort (YPUE) was calculated using the following equation (Godøy et al 2003), which was adapted for this study:

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

Statistical analysis. The Kruskal-Wallis test and the analysis of variance by ranks were employed to determine if there were significant differences in the total catches of each trap group. A post-hoc analysis test was performed using the Multiple Comparison to see which catch differed significantly among the traps. The t-test was used to determine whether or not significant differences in the number of catches between the tested light trap and the control or between continuous and blinking light trap were present. All statistical tests were evaluated at the 95% confidence level using SPSS 16.0 software.

Results. A total of 711 specimens of *A. testudineus* (8.123 g) consisted of 318 males (3.530 g) and 393 females (4.593 g) were collected from trapping experiment with the body sizes ranged of 62-110 mm TL (Table 1). There was no significant difference in total YPUE between males and females ($t = -1.18$, $df = 34$, $P>0.05$). Total YPUEs for males and females were 706 g (39±28.22 g) and 919 g (51±31.85 g) respectively. The K values of 1.53±0.22 for males and 1.64±023 for females indicated that fishes were in good condition. The overall, Kruskal-Wallis test showed that there were no statistically significant differences in the number of catches among the six continuous light traps and control ($\chi^2 = 6.80$, $df = 6$, $P>0.05$), as well as the six blinking-light traps and control ($\chi^2 = 8.59$, $df = 6$, $P>0.05$). In other words, the continuous light traps as effective as the blinking light traps typically used for harvesting *A. testudineus* from a pond ($t = -0.49$, $df = 38$, $P>0.05$). Paying attention to each of trap group trial, no significant difference was observed in the catch number of respective light trap (blue, green, yellow, red and white) compared to the control ($P>0.05$), except orange-light trap ($\chi^2 = 7.75$, $df = 2$, $P<0.05$). The detailed daily catch data for each trial are given in Table 2. It can be pointed out that *A. testudineus* is able to differentiate various colours tested.

Results of the test also showed no significant differences in terms of total average catch and sizes between males and females ($P>0.05$). Mean±standard deviation of total length, weight and ratio of body sizes of males and females are described in Table 3. The length-weight relationship analysis confirmed that males (N = 318) and females (N = 392) of *A. testudineus* have a negative allometric growth pattern, which means that length increases more than weight. The *b* values obtained were 2.7956 for males and 2.7143 for females as given in the following parabolic equations: $W = 4\times10^{-5}\ TL^{2.7956}$ and $W = 6\times10^{-5}\ TL^{2.7143}$. The R^2 values of 0.8338 for males and 0.8329 for females explained the proper fit of the model for growth (Figure 2). The index of regression (r) obtained shows that for every mm of length, weight increases by 0.9131 g in males, and by 0.9126 g in females. The trend lines of curves closed each other indicated identical growth pattern between males and females.

Table 1

The number of catches, weight, YPUE and condition factor (K) of *Anabas testudineus* collected from trapping experiments in a pond

Light trap	*Treatment*	*Number of catches*			*Weight (g)*			*YPUE*			*Kmean±SD*	
		Males	*Females*	*Total*	*Males*	*Females*	*Total*	*Males*	*Females*	*Total*	*Males*	*Females*
Blue	Continuous	43	38	81	479	457	936	95.80	91.40	187.20	1.67±0.38	1.64±0.25
	Blinking	32	36	68	350	374	724	70.00	74.80	144.80	1.62±0.26	1.67±0.25
	Control	30	49	79	307	573	880	61.40	114.60	176.00	1.61±0.19	1.79±0.29
Green	Continuous	18	41	59	208	490	698	41.60	98.00	139.60	1.50±0.14	1.65±0.17
	Blinking	16	26	42	148	300	448	29.60	60.00	89.60	1.49±0.37	1.67±0.19
	Control	21	30	51	232	398	630	46.40	79.60	126.00	1.51±0.23	1.70±0.20
Yellow	Continuous	8	12	20	112	133	245	22.40	26.60	49.00	1.51±0.22	1.58±0.26
	Blinking	10	11	21	135	119	254	27.00	23.80	50.80	1.53±0.33	1.61±0.28
	Control	5	8	13	52	79	131	10.40	15.80	26.20	1.32±0.15	1.75±0.26
Orange	Continuous	7	14	21	80	151	231	16.00	30.20	46.20	1.53±0.15	1.64±0.26
	Blinking	7	13	20	78	152	230	15.60	30.40	46.00	1.49±0.28	1.60±0.25
	Control	1	4	5	3	36	39	0.60	7.20	7.80	1.26±0.00	1.35±0.15
Red	Continuous	31	26	57	334	301	635	66.80	60.20	127.00	1.77±0.31	1.68±0.30
	Blinking	22	17	39	212	162	374	42.40	32.40	74.80	1.65±0.22	1.75±0.27
	Control	38	9	47	440	132	572	88.00	26.40	114.40	1.69±0.22	1.65±0.15
White	Continuous	17	28	45	252	394	646	50.40	78.80	129.20	1.46±0.25	1.53±0.19
	Blinking	6	20	26	58	217	275	11.60	43.40	55.00	1.57±0.26	1.61±0.15
	Control	6	11	17	50	125	175	10.00	25.00	35.00	1.38±0.06	1.58±0.28
Total		318	393	711	3530	4593	8123	706	919	1624.6	-	-
Mean±SD		18±12.64	22±13.01	40±23.05	196±141.08	225±159.24	451±269.76	39±28.22	51±31.85	90±53.95	1.53±0.22	1.64±0.23

Table 2

Daily catches and weight of *Anabas testudineus* collected from trapping experiments in the pond

Light trap	Trials	Number of catches						Weight (g)					
		Blue	*Green*	*Yellow*	*Orange*	*Red*	*White*	*Blue*	*Green*	*Yellow*	*Orange*	*Red*	*White*
Continuous	1	0	32	5	7	1	5	0	372	61	68	10	48
	2	30	6	5	3	15	5	368	106	62	37	177	66
	3	34	12	1	3	3	16	378	139	12	29	26	248
	4	6	4	6	5	18	12	73	43	64	66	199	120
	5	11	5	3	3	20	7	117	38	46	31	223	110
Blinking	1	0	8	7	1	0	10	0	63	176	11	0	118
	2	20	9	1	5	11	10	238	104	10	61	91	103
	3	12	10	3	4	4	2	111	109	24	45	36	21
	4	26	7	5	7	19	1	254	76	51	69	209	7
	5	10	8	5	3	5	3	121	96	55	44	38	26
Control	1	1	33	6	1	3	1	9	410	67	11	35	13
	2	37	5	4	1	22	2	411	48	26	11	263	27
	3	11	8	1	1	4	6	123	94	14	3	38	55
	4	20	1	2	1	15	9	228	12	24	10	200	93
	5	10	4	0	1	3	1	109	66	0	4	36	21
Total		228	152	54	46	143	90	2540	1776	692	500	1581	1076
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)		0.05	1.29	1.40	7.75	0.13	3.39	0.07	0.54	1.24	8.72	0.32	4.42

Table 3
Mean±standard deviation, total length (TL), weight (W) and ratio (TL/W) of body sizes of males and females of *Anabas testudineus*

Light trap	*Treatment*	*Mean±SD of TL (mm)*		*Mean±SD of W (g)*		*TL/W*	
		Males	*Females*	*Males*	*Females*	*Males*	*Females*
Blue	Continuous	86.84±10.67	88.82±11.41	11.14±4.02	12.03±4.62	8.49±2.47	8.35±3.08
	Blinking	87.16±9.84	84.58±9.65	10.94±3.49	10.39±3.73	8.57±2.28	8.80±2.06
	Control	84.87±9.56	85.98±10.47	10.23±3.95	11.69±3.94	9.08±2.43	8.04±2.31
Green	Continuous	88.33±16.45	89.05±9.99	11.56±7.85	11.95±3.54	9.42±3.49	8.00±2.02
	Blinking	84.50±9.34	87.69±8.88	9.25±3.61	11.54±3.47	10.58±4.46	8.07±1.72
	Control	89.14±10.75	91.60±8.84	11.05±4.16	13.27±3.38	8.85±2.58	7.25±1.50
Yellow	Continuous	97.25±11.11	86.83±10.92	14.00±3.70	11.08±5.04	7.30±1.59	9.20±3.53
	Blinking	98.00±33.12	86.64±10.14	19.70±23.20	10.82±4.19	9.07±5.74	8.84±2.60
	Control	89.80±15.77	82.38±7.80	10.40±5.46	9.88±2.59	10.39±4.48	8.69±1.57
Orange	Continuous	89.57±12.16	86.86±8.48	11.43±4.58	10.79±2.69	8.54±2.15	8.42±1.64
	Blinking	88.29±16.39	89.46±10.60	11.14±5.64	11.69±4.01	9.96±5.42	8.24±1.90
	Control	62.00±0.00	86.00±12.83	3.00±0.00	9.00±3.37	20.67±0.00	10.70±4.08
Red	Continuous	83.74±12.12	87.73±8.35	10.77±4.12	11.58±3.87	8.79±3.27	8.14±1.93
	Blinking	83.05±9.80	81.59±7.48	9.64±3.14	9.53±2.18	9.22±2.11	8.85±1.43
	Control	87.45±8.47	95.22±11.42	11.58±3.72	14.67±4.87	8.02±1.65	6.96±1.65
White	Continuous	99.76±11.14	89.25±13.50	14.82±4.77	10.25±4.35	7.27±2.03	9.61±2.85
	Blinking	85.00±11.19	87.10±7.50	9.67±3.20	10.85±2.66	9.19±1.64	8.41±1.76
	Control	84.33±5.68	89.36±8.27	8.33±1.51	11.36±3.38	10.28±1.08	8.28±1.69

The size classes of *A. testudineus* caught by the continuous and blinking light traps are displayed in Figure 3. It is clearly demonstrated that the light traps collected more specimens of *A. testudineus* at the size distribution between 70-79 mm and 100-109 mm TL as well as between 1-5 g and 16-20 g weight of the interval classes used. On the other hand, positive group responses of *A. testudineus* were more pronounced in lower size classes than that of higher ones. The highest number of catch for both males (41.82%) and females (35.20%) was found in the size class of 80-89 mm TL. For dealing with the heaviest catch, it was recorded at the interval class of 6-10 g (49.06% for males) and of 11-15 g (50.94% for females).

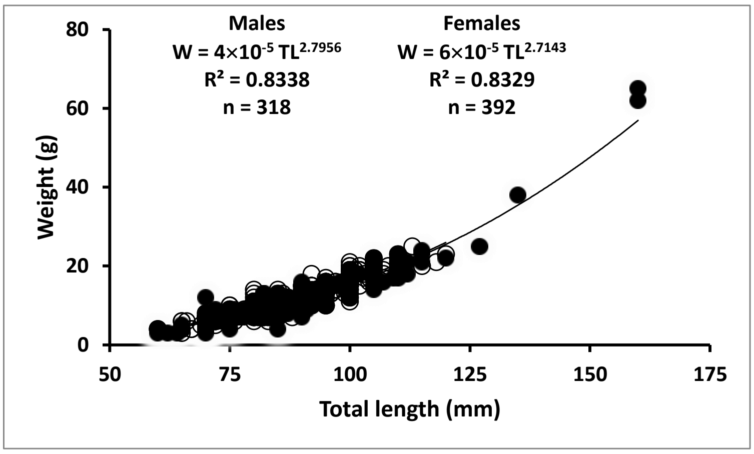

Figure 2. The length and weight relationship of *Anabas testudineus* obtained from recapture experiment using continuous-light traps and blinking-light traps in a pond. ● = males, ○ = females.

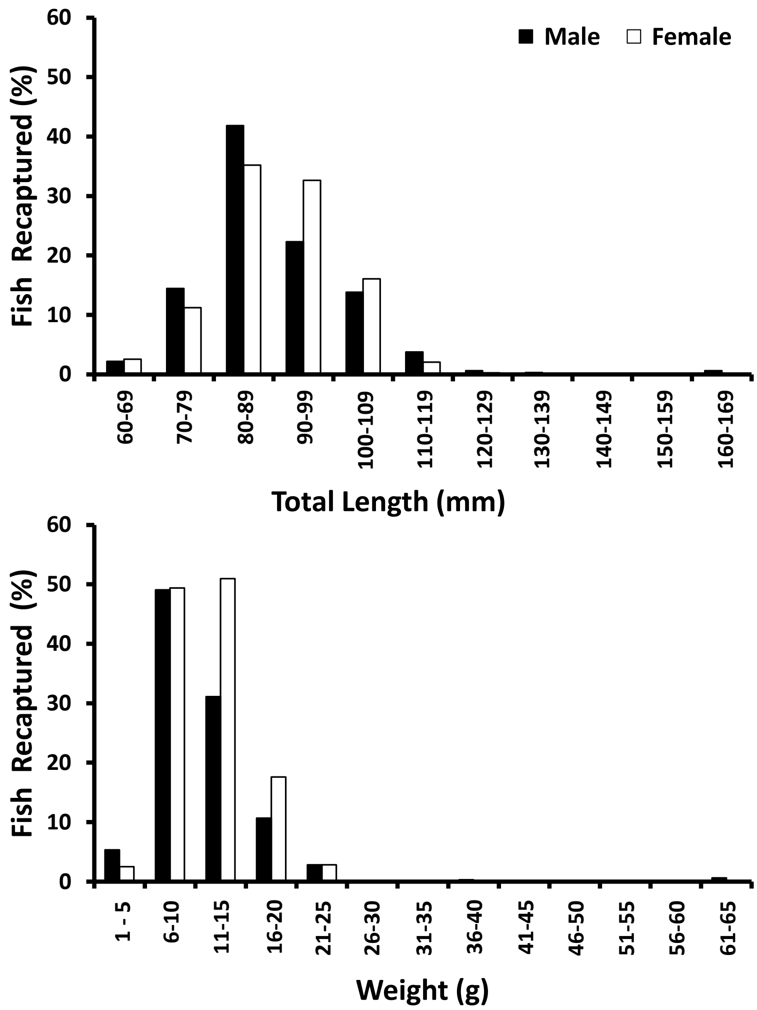

Figure 3. The size classes of total length (top) and weight (bottom) of *Anabas testudineus* caught by the light traps from the pond.

Discussion. The color of light used as an attractant is an important variable for light trap use. From the colors utilized in this study, orange appeared to be the strongest attractor for *A. testudineus*. Such phototactic response is also well-documented 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 (625 nm), green (530 nm), blue (460 nm), and ultraviolet (380 nm) (Helfman et al 1997; Moyle & Cech 2000). Quantitatively the present study results showed that *A. testudineus* females (N = 392) were more responsive to the tested colours than males (N = 318) over trapping experiment periods. This implies that light traps could be potentially used for broodstock purposes, especially to collect them from the wild or pond. The continuous light trap contributed 40%, the blinking light trap 30% and the control trap 30% of total recorded catches. In our data, it appears that blue, green and red were relatively preferred by *A. testudineus* compared to the remaining colors. Based on scientific data collected, it can be said that *A. testudineus* has true color vision and is able to alter independently their behavioural responses to different colours. Considering that true colour discrimination (Kong & Goldsmith 1977), it is only possible when the fish has at least two receptor types with distinct but overlapping spectral ranges. Colour discrimination requires inputs of different photoreceptor cells that are sensitive to different wavelengths of light. In this case, *A. testudineus* has a multichromatic visual system between blue and red.

Although total weight of females caught (4.593 g) was 1.3 times higher than that of males (3.530 g), statistical evidence showed no significant differences between females and males. Figure 2 illustrates that the growth slope of *A. testudineus* was negatively allometric, where the *b* values (2.7143-2.7956) were significantly lower than the critical isometric value ($b<3$), indicating that the species becomes leaner as the length increases. The *b* values may range from 2.5 to 3.5 (Pauly & Gayanilo 1997), suggesting that results of this study are valid. Such growth pattern was also found in *A. testudineus* from cages, tank and ponds in Bangladesh (Begum & Minar 2012) and in India (Kumar et al 2013). Conversely *A. testudineus* caught from Deepar Beel (wetlands) of Assam, India exhibited 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).

The *K* values of 1.53±0.22 for males and 1.64±023 for females of *A. testudineus* in the present study are also commonly found in the same fish species from other regions (Van & Hoan 2009; Chotipuntu & Avakul 2010; Begum & Minar 2012; Kumar et al 2013). The *K* value greater than 1 indicates better condition of fish (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 aquaculture system management 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 to be adopted during culture of this species, for example, by improving the quality of feed and the feeding ratio, and re-dimension the fish density to reduce competition for food and space.

One of crucial problem being faced in phototaxis research was the high rate of death of the fish (<10%) whether in the preparation and the trial steps. In the preparation steps of research, the fish from laboratory cages were transferred into the pond trial using plastic bags. It was beyond our expectation; we found many dead fish floating on the water surface in the morning before the research was conducted at the next evening. It was possible effect of water changes, stress and condition of fish health itself. The death of the fish continued to the early stage of trial (for five days) in which there were some fish died because of being trapped or maintained quite long in the trap, and all of them showed the same symptoms. It was interesting to observe the life habit of *A. testudineus* since they can survive on low level of oxygen because of having labyrinth organ (Rahman et al 2015) and even are able to walk on the land for some time. That would be different when *A. testudineus* is trapped. The survival ability of *A. testudineus* inside the trap depends on the health condition, how long the fish is trapped inside, and how often physical contact with net occurred when the fish tried to reach out of the trap. The healthy fish can survive inside the trap for more than 10 h and this fish species can be released back to the pond for the next trial after measurement process. Meanwhile, the dead fish can be buried on the ground. On the other hand, the unhealthy fish cannot survive for long time moreover in trapped condition. The more the fish tried to escape, the more energy the fish released and finally died. When *A. testudineus* is being trapped, it means that not only restricts them to the space, but also interrupts their habit to appear on the water surface even for only breathing oxygen. In order to solve the dead fish problems, the researchers need to conduct several steps such as by making sure about the fish sample is in healthy condition before releasing them into the pond, shortening the soaking time of trap, and reconstructing the trap including the instalment technique in the pond.

Conclusions. In a nutshell, there were no significant differences either in the number of catches among the traps or in the total YPUE between males and females. When continuous light, blinking light and empty traps were applied, some *A. testudineus* prefer lights and the others seek for empty trap as a shelter. Positive group responses of *A. testudineus* were more pronounced in lower size classes than that of higher ones. By determining the appropriate colour of lamps, the capture process for *A. testudineus* both in the pond and the wild would be easily handled by fishermen. Since *A. testudineus* showed negative allometric growth pattern, the current culture management system should be refined.

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