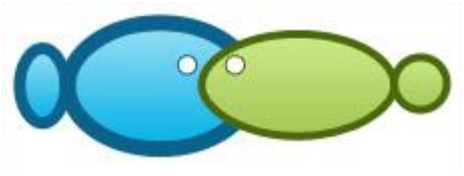

Length-weight relationships and condition factor of *Anabas testudineus* in the Semayang Lake, East Kalimantan, Indonesia

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Abstract. The environment of the Semayang Lake is a floodplain lake area that has unique habitat characteristics in the East Kalimantan province, Indonesian. *Anabas testudineus* is one of the fish found in Semayang Lake. The length-weight relationship research have been conducted in Semayang Lake, for one full year (dry and rainy season) in providing basic data in resources management of *A. testudineus* so that this fish species can be harvested optimally and sustainably. Growth pattern analysis of the allometric linear model (LAM) was used to calculate intercept (a) and slope (b). The relative weight (Wr) was determined by the equation Wr = (W / Ws) x 100. The condition factor was determined from the Fulton coefficient (K). The results of the present research suggest that *A. testudineus* has negative allometric growth pattern. The coefficient determination value (R^2) of male individuals at swamp habitat is at range of 76-94% (r value: 0.87-0.97), females ranges 78-98% (r value: 0.889-0.99) and coefficient determination value (R^2) on male in lake habitat ranges 77-93% (r value: 0.877-0.96); female ranges 75-92% (r value: 0.866-0.959). Relative weight (Wr) value obtained from the standard weight and total weight in swamp habitats in males ranged from 100.04±0.72 to 100.93±2.41, the females ranged from 100.25±1.39 to 101.13±2.60. In lake habitat the relative weight value in male fish was 100.29±1.57 - 101.06±2.65, and for females 100.40±2.98 - 101.60±3.07. The observed weight in swamp habitat was 34.2205±0.397 higher than the average standard weight of 34.012±0.386. Condition factor of *A. testudineus* in swamp habitat on male fish was 3.102±0.0058, in female fish 3.141±0.007, whereas in the lake habitat (Station 2, 3 and 5) condition factor was 3.114±0.007 and 3.143±0.009 for females respectively.
Key Words: growth pattern, relative weight, climbing perch, *A. testudineus*.

Introduction. The Semayang Lake is a floodplain lake area that has unique habitat characteristics in the East Kalimantan province, Indonesia, because on the water bodies there are swamps and lakes habitats. Swamp habitats are characterized by a large coverage of aquatic plants and shallow water (Archibold 1995; Lopez & Kursar 2007; Corlett & Primack 2011). The lake habitat is characterized by relatively broad water surface, high quantity of aquatic plants at the littoral area and has deeper water than the swamp habitat (Pokorný & Björk 2010; Romanowski 2013).

Inundation is the main characteristic of floodplain lake caused by simultaneous hydrodynamics and can be distinguished by the duration and frequency of puddles which are the main cause of ecological differences between swamp and lake habitats. This hydrodynamic occurrence is valid for a one-year cycle, but at the same location even though the flow of water and the height of the inundation from month to month even from year to year shows different traits and characters (Furukawa 1994; Mitsch & Gosselink 1993). This hydrodynamic condition occurs in the Semayang Lake (Noor 2007) reported that puddles length in the surroundings of Semayang Lake have a duration that is almost throughout the year. The main different in this case is the change in the water level, where during the rainy season, that have swamp habitats characteristics is

uniform, otherwise during the dry season the both habitat is separated and connected only by a channel of river.

The connection changes in habitat have implications to the dynamics of fish biology, and similarly, in the case of fish biology (growth patterns and condition factors). *Anabas testudineus* is a resident fish species (Welcomme 1985) and is naturally found in many countries from India to the Wallace line (Kohinoor et al 1991; Tay et al 2006; Mustakim et al 2009), predominantly of lentic habitats (swamps and lakes) and lotic habitats (rivers and canals). *A. testudineus* can thrive in low dissolved oxygen water bodies (Pethiyagoda 1991; Kumary & Raj 2016). This species has a high selling price due to its taste and soft meat texture (Helmizuryani & Muslimin 2016). *A. testudineus* is one of the fish species inhabiting Semayang Lake.

The biological aspect of fish that is one of the instruments in the management of fish resources is the length-weight relationship (Khristenko & Kotovska 2017; Tsoumani, et al 2006), focus the length-weight relationship of fish can be used to determine the pattern of fish growth (Mousavi-Sabet et al 2013; Vilizzi et al 2013; Lorenzoni et al 2015), further condition factor that are important derivatives in fish growth (Everhart & Youngs 1981; Tsoumani et al 2006; Froese 2006). Research of length-weight relationship and condition factors of *A. testudineus* have generally been previously conducted in other biotopes (Alam et al 2007; Mustakim et al 2009; Begum & Minar 2012; Kumar et al 2013; Rahman et al 2015; Kumary & Raj 2016). However, length-weight relationship research has not been conducted in Semayang Lake, for a whole year (dry and rainy season), this matter, signify why this research is important, as the preliminary data in resources management of *A. testudineus* so that can be harvested optimally and sustainably.

Material and Method. The research location is located in Semayang Lake, with the selection of research stations based on the characteristics of swamp habitats (stations 1, 4 and 6) and lake habitats (stations 2, 3 and 5) (Figure 1).

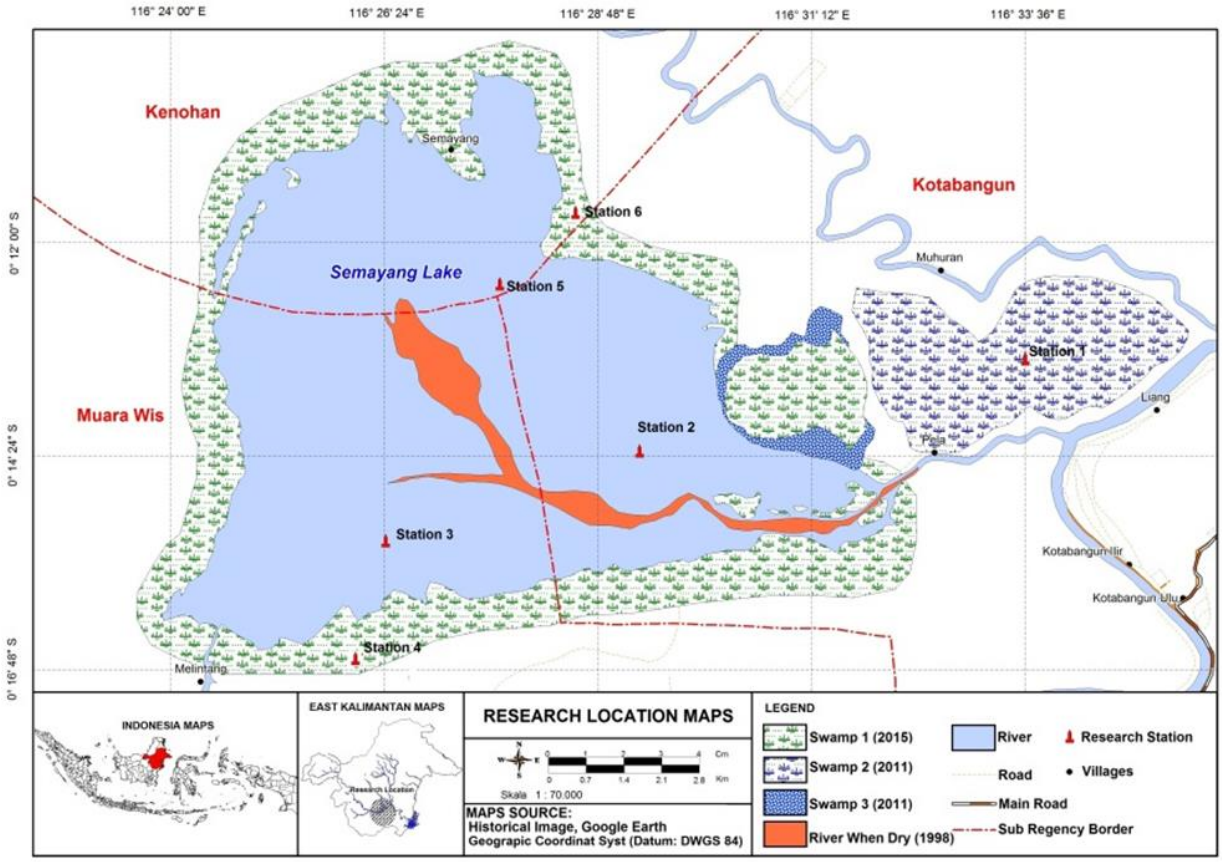

Figure 1. Research Location Map (Semayang Lake East Kalimantan Province, Indonesia).

This research has been conducted for one year (February 2017 - January 2018). Samples were collected from the fishermen using non-selective trapping gear category (traditional name is Pengilar and Sawaran). The sample number is 10% of the catch, the sample were then preserved in 10% formalin solution then analyzed in the laboratory for total length and total weight measurements. The total length was measured using a ruler of 1 mm accuracy and the total weight was measured with a digital scale of 0.1 g accuracy (Anderson & Neumann 1996). The total length (TL) was expressed in mm units and total weight (TW) in gram units. Sexes were determined by dissection and observation of the color and gonad shape.

Growth pattern analysis. The Allometric Linear Model (LAM) was applied to calculate a and b parameters through measurement of weight and length changes. The bias correction on the mean weight change of the logarithmic unit was used to predict the weight of length parameters of allometric equations, according to De Robertis & Williams (2008). $W = a\ TL^b$, where W is the weight of the fish (g), TL is the total length of the fish (mm), a (intercept) and b (slope). The value of a (intercept) obtained from the relationship of total length (mm) and weight (g) was converted by the formula $a' = a10^b$ (Froese 2006). The t_{test} was performed on the value of b to find out whether b = 3 (isometric) or b ≠ 3 (allometric) to examine the value of b, it is necessary to compute the t test with the following hypotheses and formulas. Hypothesis: H0: b = 3 H1: b ≠ 3; $Ts = \frac{\beta_o - \beta_1}{S\beta_1}$ Decision making on the hypothesis is done by comparing t_{test} with t_{table} at 95% confidence interval. If $t_{test} > t_{table}$, then the decision is to reject Ho. If $t_{test} < t_{tabel}$, then the decision is to accept the Ho (Steel & Torrie 1993).

Condition factor. Relative weight (Wr) and coefficient (K) condition factors were used to evaluate the condition factor of each individual. The relative weight (Wr) was determined by the equation proposed by Anderson & Neumann (1996) as follows: Wr = (W / Ws) x 100, Wr is the relative weight, W weight of each fish, and Ws is the predicted standard weight of the sample which is the same because it is calculated from a combination of length-weight regression over distances between species: $Ws = aL^b$. The coefficient of the Fulton (K) condition Factor was determined by the following formula: $K = WL^{-3}$ x 100 Okgerman (2005), where K is the condition factor, W is the weight (g), L is the total length (mm) and -3 is the coefficient.

Result and Discussion

Length-weight relationship. The total number of *A. testudineus* caught during the study consisted of 1,592 individuals, which of 566 males and 409 females collected in swamp habitats, and 335 males and 282 females collected from lake habitats (Table 1). The average total length and total weight in swamp habitat (Station 1, 4 and 6) of male individuals was 119.8±0.55 mm, 31.72±0.46 g, and 126.6±0.75 mm, 37.69±0.67 g of female specimens. In lake habitat (Station 2, 3 and 5) the average total length and total weight of males was 121.99±0.66 mm and 32.91±0.55, and 125.81±0.90 and 37.47±0.86 of females. The results of the analysis of the length and total weight relationship $month^{-1}$ showed different b (slope) values between males and females, in both habitats, swamp (stations 1, 4 and 6) and lake (2, 3 and 5) the value of b (slope) during the study is b ≠ 3 (b<3; 3<b), so that the growth pattern of *A. testudineus* is negative allometric and positive allometric. *A. testudineus* growth patterns in Semayang Lake changed dynamically; this result is consistent with previous studies that the value of b (slope) was depending on physiological and environmental conditions such as temperature, pH, salinity, geographical location and sampling techniques (Jennings et al 2001; Turkmen et al 2002) and also on biological condition development of gonads and food availability including growth phase, season, abdominal fullness, gonadal maturity, gender, range of measures, and disease (Le Cren 1951; Tesch 1971; Neff & Cargnelli 2004; Ecoutin et al 2005; Froese 2006).

Table 1

Length and weight of *Anabas testudineus* (males and females) harvested form Lake Semayang in February 2017 - January 2018

Month	Sexes	N	Swamp				N	Lake			
			TL (mm)		TW (g)			TL (mm)		TW (g)	
			(Mean±SE)	Range	(Mean±SE)	Range		(Mean±SE)	Range	(Mean±SE)	Range
Feb-17	M	82	115.2±1.66	87-171	29.23±1.41	11.2-79.4	43	120.19±2.46	94-173	32.279±1.96	12.9-87.4
	F	45	126.3±2.82	85-193	38.89±2.280	11.2-88.2	32	122.72±3.33	100-193	35.42±2.63	16.0-83.5
Mar-17	M	77	117.9±1.38	95-148	30.59±1.28	16.11-58.6	49	122.16±1.69	100-150	33.02±1.39	16.0-54.4
	F	45	120.3±1.95	97-149	34.22±1.89	13.4-60.6	34	121.41±2.12	100-145	33.54±1.69	16.-53.21
Apr-17	M	30	118.2±2.29	94-152	31.00±2.29	13.6-72.4	32	120.19±1.63	99-140	30.37±1.66	15.6-52.8
	F	25	128.9±4.80	83-172	42.51±4.56	10.5-81.4	24	118.04±3.83	93-154	32.27±4.08	11.2-81.8
May-17	M	53	117.2±2.12	84-151	30.31±1.80	11.7-68.0	21	118.05±2.07	101-141	32.13±2.22	18.1-55.6
	F	22	116.0±3.84	78-155	30.36±2.45	7.9-81.5	11	122.00±5.78	97-160	36.35±6.41	16.5-85.4
Jun-17	M	26	116.5±2.39	94-144	29.43±1.76	16.3-52.3	22	119.68±2.35	103-145	30.53±2.09	16.6-60.4
	F	29	125.3±2.22	102-148	36.27±1.92	20.8-57.2	23	122.70±2.29	102-144	33.91±2.08	21.8-55.4
Jul-17	M	29	118.0±2.07	92-142	31.96±1.56	16.0-49.3	27	117.93±1.68	100-142	30.65±1.30	15.8-51.5
	F	34	130.1±2.36	105-158	40.41±2.05	22.5-66.0	19	125.58±4.25	95-170	37.71±4.09	16.6-92.9
Aug-17	M	54	116.9±1.45	97-144	28.28±1.04	11.7-48.4	19	119.11±3.41	99-142	30.63±2.15	18.2-49.4
	F	21	123.2±2.18	104-140	31.98±1.89	18.2-47.2	10	128.00±3.13	116-142	37.25±2.73	28.3-49.2
Sep-17	M	35	128.3±1.70	115-164	39.82±1.74	25.2-78.0	21	123.71±2.30	102-143	35.04±1.76	23.2-56.5
	F	34	132.0±1.95	105-165	42.90±1.87	21.5-76.4	20	126.10±2.37	112-152	38.87±2.46	24.6-71.6
Oct-17	M	48	129.8±1.77	104-154	38.66±1.41	20.9-63.1	24	128.92±2.46	104-150	38.58±1.80	21.6-55.2
	F	39	135.1±1.90	111-161	42.52±1.65	24.9-67.1	29	132.41±2.49	109-161	41.14±2.64	23.5-81.0
Nov-17	M	56	118.6±1.41	94-145	30.91±0.96	15.2-45.9	37	124.73±1.78	102-160	34.91±1.46	23.3-69.9
	F	48	124.4±1.97	100-160	35.49±1.71	15.5-67.7	37	129.22±2.32	102-161	41.91±2.39	16.6-75.1
Dec-17	M	33	122.1±1.72	102-140	30.99±1.47	15.3-47.3	26	123.35±2.49	101-150	30.77±2.49	16.6-62.6
	F	32	122.6±2.05	100-155	32.65±2.18	13.9-67.6	25	133.77±2.25	115-154	41.86±2.72	18.4-71.7
Jan-18	M	43	124.8±1.63	101-143	33.50±1.43	17.8-57.7	14	128.14±3.00	108-145	38.48±2.63	22.4-58.1
	F	35	132.0±1.66	110-152	40.87±1.92	25.0-64.5	18	126.44±3.08	101-146	37.89±3.07	16.9-63.1
Total	M	566	119.8±0.55	84-171	31.72±0.46	11.2-79.4	335	121.99±0.66	94-173	32.91±0.55	12.9-87.4
	F	409	126.6±0.75	78-193	37.69±0.67	7.9-88.2	282	125.81±0.90	93-193	37.47±0.86	11.2-92.9
	A	975	122.6±0.46	78-193	34.22±0.40	7.9-88.2	617	123.74±0.55	93-193	34.99±0.50	11.2-92.9

Source: Primary Data, 2017-2018

M - Male; F - Female; TL - Total length; TW - Total weight.

Based on the value of b (slope) (Table 2 & Figure 2) in general the growth pattern of *A. testudineus* during the study had a negative allometric growth pattern, where length growth is faster than weight growth. Actually in field, if *A. testudineus* body shape was a combination between rover-predator and bottom rover, that has a slightly elongated body (Moyle & Cech 2004). Reinforced with result of t_{test} analysis concluding that $t_{test} > t_{table}$ (0.05), it means Ho is rejected (B ≠ 3). *A. testudineus* growth patterns that had negative allometric patterns were also reported by several studies (Satrawaha & Pilasamorn 2009; Mustakim et al 2009; Kumar et al 2013).

The coefficient determination value (R^2) in males of swamp habitat had a range of 76-94% (r value: 0.87-0.97), and females of 78-98% (r value: 0.889-0.99), and coefficient determination value (R^2) in lake habitat for males was 77-93% (r value: 0.877-0.96), and 75-92% (r value: 0.866-0.959) for females. In terms of the value of r that is near to 1, it can be stated that the relationship of length and weight of *A. testudineus* has a positive correlation, in which each length increase will be followed by weight. The coefficient determination value (R^2) and correlation value (r) of *A. testudineus* near to 1 was are also found in several studies (Alam et al 2007; Mustakim et al 2009; Satrawaha & Pilasamorn 2009; Begum & Minar 2012; Kumar et al 2013; Rahman et al 2015; Kumary & Raj 2016). The value of the coefficient of determination in general was near to 100%, this signifies that the diversity influenced by other factors (sex, disease, and food of availability) is small and the relationship between the total length and total weight of *A. testudineus* is very tight.

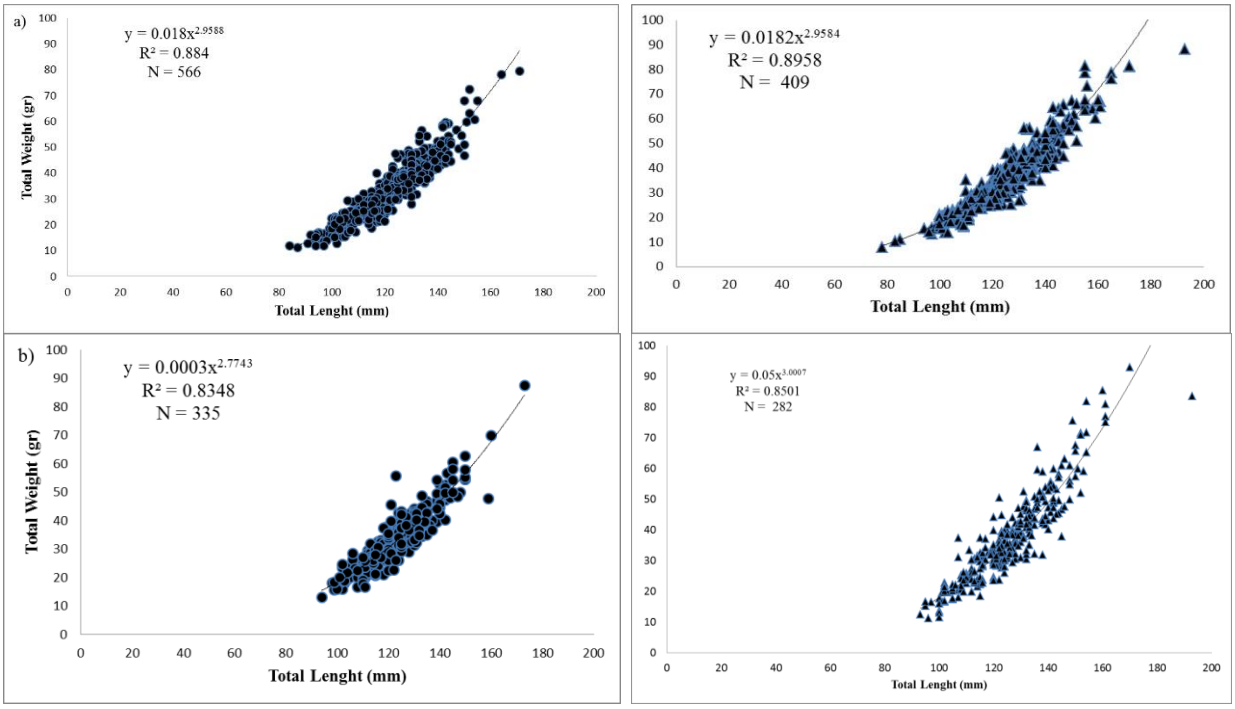

Figure 2. Black circle (male) and back triangle (female). a) The combined length-weight relationship of *A. testudineus* at Swamp habitat. b) The combined length-weight relationship of *A. testudineus* in lake habitat for one year in Semayang Lake East Kalimantan Province, Indonesia.

Relative weight and condition factor. The relative weight (Wr) value obtained from the standard weight and total weight in swamp habitats in males ranged from 100.04±0.72 to 100.93±2.41, and in females from 100.25±1.39 to 101.13±2.60. In lake habitat the relative weight value in male individuals was 100.29±1.57 - 101.06±2.65, and in females 100.40±2.98 - 101.60±3.07. The average value of relative weight was constantly > 100, this indicates that the environmental conditions of *A. testudineus* in Semayang Lake which have the character of swamp and lake habitat provide good environment in terms of food availability and predation (Blackwell et al 2000). According to Anderson & Neumann (1996), if the value of weight is below 100, it indicates issue

such as lack of prey or high predation density, and vice versa if it is above 100 it indicates high prey availability or low predator density.

The average value of relative weight >100 is obtained from the comparison between observation weight with standard weight, so that it can be stated that the higher observation weight compared to standard weight can be used as an indicator of the aquatic environment that is good for life, survive and thrive. Based on this understanding, the standard weight data on male and female fish in both swamp and lake habitat measured for 1 year (February 2017 - January 2018) (Table 2, Figure 3 & 4) with relative dynamic value changes. The observed weight in swamp habitat was 34.2205±0.397 g, higher than the average standard weight of 34.012±0.386 g. As well as observed weight in lake habitat was 34.995±0.501 g, higher than the average standard weight of 34.735±0.473 g. The result shows that the observed weight is higher than the predicted weight (standard weight), this indicates that the water condition is healthy enough to support growth.

Table 2

Standard weight, condition factor (Fulton) and relative weight of *Anabas testudineus* (male-female) (in swamp habitat and lake habitat) in Semayang Lake, East Kalimantan Province, Indonesia

Month	*Sexes*	*N*	*Swamp*			*N*	*Lake*		
			Standard weight (Mean±SE)	*Condition factor (Mean±SE)*	*Relative weight (Mean±SE)*		*Standard weight (Mean±SE)*	*Condition factor (Mean±SE)*	*Relative weight (Mean±SE)*
Feb-17	M	82	29.19±1.48	3.07±0.01	100.04±0.72	43	32.88±1.94	3.12±0.02	100.49±1.54
	F	45	39.29±2.67	3.17±0.09	100.25±1.39	32	35.30±3.05	3.14±0.03	101.46±3.09
Mar-17	M	77	30.35±1.17	3.09±0.01	100.53±1.22	49	32.91±1.40	3.11±0.02	100.60±1.57
	F	45	34.06±1.87	3.15±0.02	100.66±1.74	34	33.34±1.64	3.14±0.02	100.73±2.09
Apr-17	M	30	30.89±2.24	3.09±0.03	100.50±1.83	32	30.00±1.38	2.06±0.03	101.06±2.65
	F	25	42.47±4.75	3.13±0.04	100.66±2.44	24	31.85±3.82	3.03±0.06	101.43±3.61
May-17	M	53	30.15±1.76	3.07±0.02	100.70±1.72	21	31.85±1.95	3.15±0.03	100.90±2.76
	F	22	30.12±3.17	3.05±0.04	100.41±2.02	11	35.72±5.06	3.13±0.05	101.03±4.56
Jun-17	M	26	29.34±1.67	3.10±0.01	100.26±1.53	22	30.29±1.88	3.08±0.03	100.76±2.81
	F	29	36.08±1.76	3.15±0.02	100.29±1.66	23	33.61±1.76	3.14±0.03	100.73±2.61
Jul-17	M	29	31.82±1.49	3.16±0.02	100.54±1.89	27	30.54±1.20	3.13±0.01	100.38±1.74
	F	34	40.05±1.79	3.17±0.02	100.89±2.37	19	37.23±3.63	3.14±0.03	101.11±3.54
Aug-17	M	54	28.07±0.93	3.06±0.02	100.86±1.86	19	30.43±1.99	3.10±0.03	100.67±2.72
	F	21	31.77±1.66	3.08±0.03	100.62±2.48	10	37.11±2.45	3.15±0.03	100.40±2.98
Sep-17	M	35	39.66±2.63	3.20±0.01	100.38±1.55	21	34.92±1.56	3.16±0.02	100.30±1.68
	F	34	42.78±1.82	3.20±0.01	100.33±1.45	20	38.62±2.17	3.21±0.02	100.55±2.56
Oct-17	M	48	38.46±1.28	3.15±0.01	100.52±1.50	24	38.48±1.73	3.16±0.01	100.29±1.57
	F	39	41.30±1.48	3.16±0.01	100.49±1.70	29	40.84±2.35	3.15±0.02	100.47±2.03
Nov-17	M	56	30.74±0.89	3.12±0.02	100.69±1.59	37	34.72±1.29	3.14±0.02	100.55±1.71
	F	48	35.30±1.70	3.13±0.02	100.89±2.02	37	41.27±2.07	3.20±0.03	101.60±3.07
Dec-17	M	33	30.71±1.31	3.06±0.03	100.93±2.41	26	30.49±2.00	3.02±0.03	100.68±2.43
	F	32	32.24±1.91	3.08±0.03	101.13±2.60	25	41.62±2.66	3.14±0.03	100.80±2.62
Jan-18	M	43	33.21±1.20	3.09±0.02	100.83±1.99	14	38.28±2.30	3.217±0.02	100.43±2.60
	F	35	40.58±1.69	3.16±0.02	100.70±2.09	18	37.70±2.88	3.15±0.04	100.54±2.54

Source: Primary Data, 2017-2018.

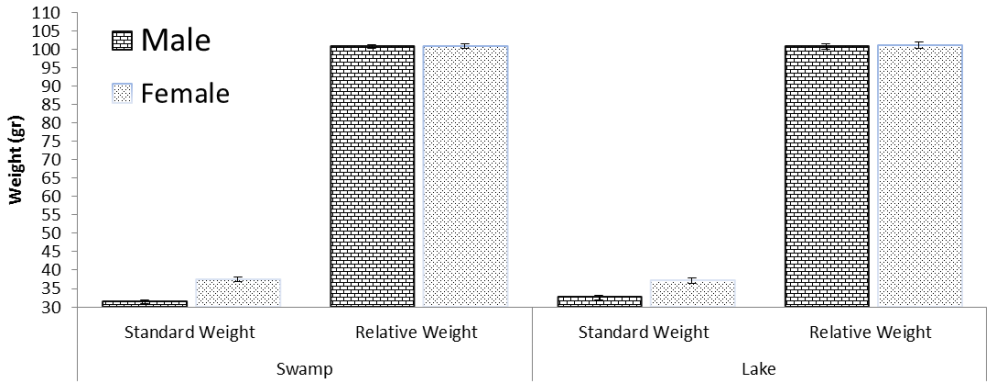

Figure 3. Standard weight and relative weight of *Anabas testudineus* (males and females) (in swamp and lake habitat respectively) for one year in Semayang Lake East Kalimantan Province, Indonesia.

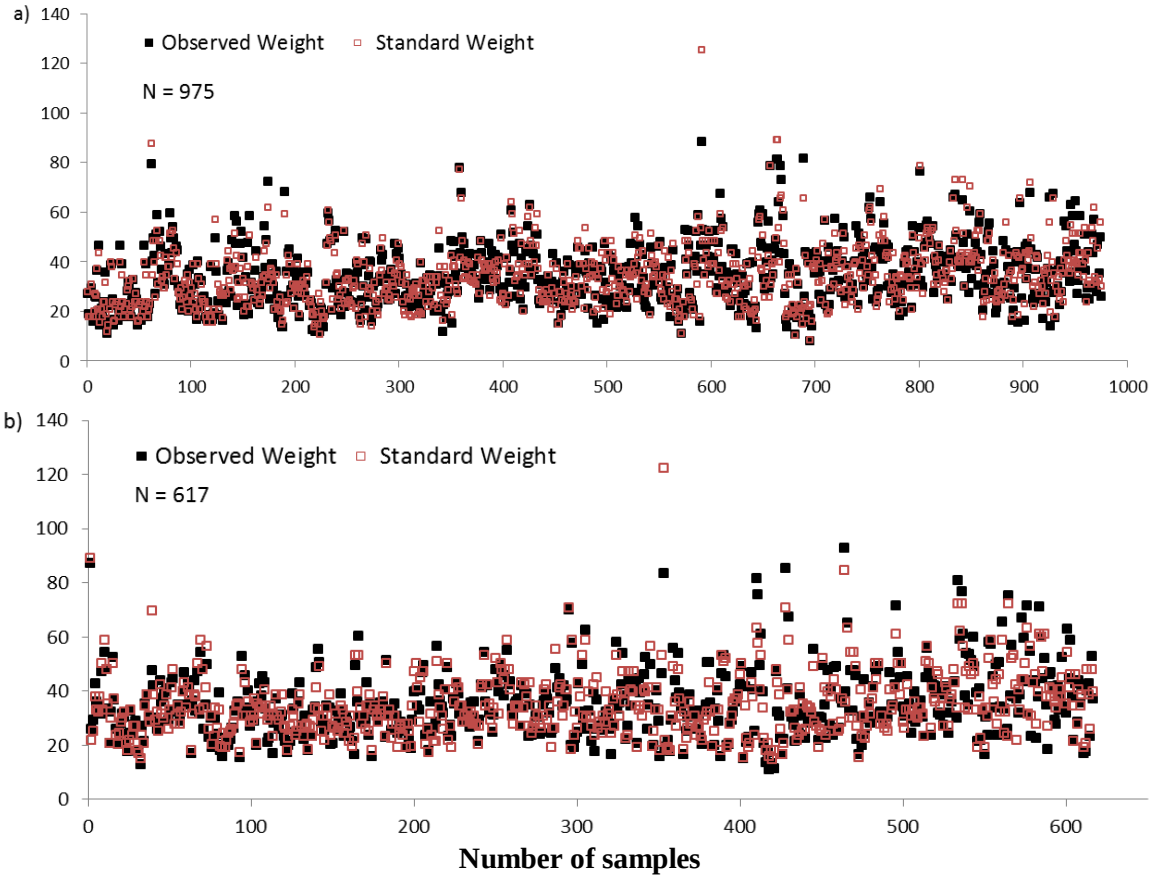

Figure 4. a) The combined observation weight and standard weight pattern of *Anabas testudineus* in swamp habitat. b) Observed and standard weight pattern of *Anabas testudineus* in lake habitat for one year in Semayang Lake East Kalimantan Province, Indonesia.

Condition factors were calculated to assess general fish health, productivity and physiological conditions of fish populations (Blackwell et al 2000; Richter 2007). This condition factor reflects the characteristics of the body's morphology, lipid content and growth rate (Bister et al 2000; Froese 2006; Stevenson & Woods 2006). The result of the condition factor analysis of *A. testudineus* in swamp habitat in males was 3.102±0.0058, and in female 3.141±0.007, whereas in lake habitat (Station 2, 3 and 5) condition factor was 3.114±0.007 for males and 3.143±0.009 for females. Descriptively it can be stated that the condition factor in female individuals is relatively greater than in male individuals

(Figure 5). The difference in the value of this condition factor is due to sexes (Lorenzoni et al 2015). Several other factors that are suspected to be the cause of fluctuation and variation of fish condition factor value are the difference of fish size and age (Enchina & Granado-Lorencio 1997); during the spawning season the fish do not engage in food activities, but uses the fat reserves of the body for energy supply (Tzikas et al 2007); and parasitic pressure (Neff & Cargnelli 2004).

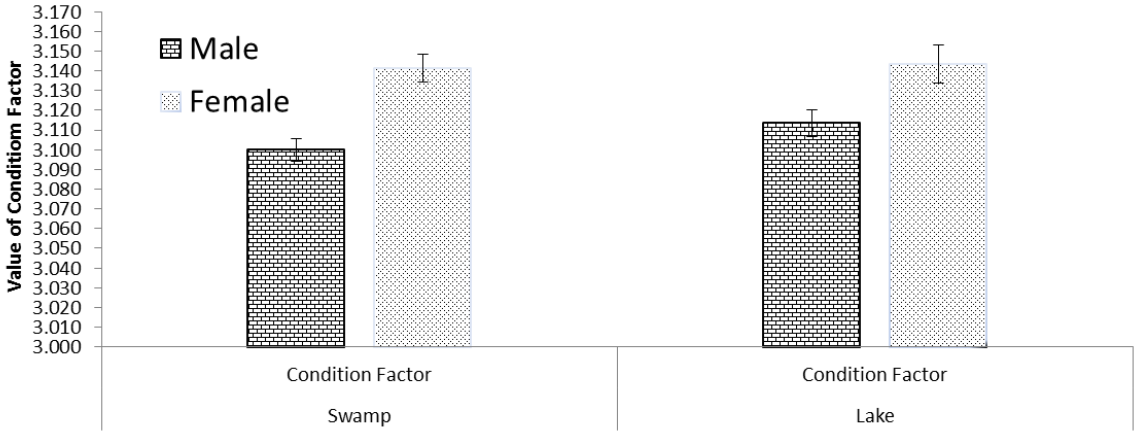

Figure 5. Combined condition factor of *Anabas testudineus* (males and females) (in swamp and lake habitat respectively) for one year in Semayang Lake East Kalimantan Province, Indonesia.

Conclusions. The general growth pattern of *A. testudineus* is negative allometric. Based on the relative weight value, the observed weight is higher than the standard weight value and factor condition value. Therefore it can be concluded that the Semayang Lake is still providing healthy aquatic habitat for the survival and thrive of *A. testudineus*.

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