GROWTH RESPONSE IN HATCHLINGS OF BURMESE ROOFED TURTLE, *BATAGUR TRIVITTATA* (DUMERIL AND BIBRON, 1835) AT YADANABON ZOOLOGICAL GARDENS, MANDALAY

Moe Thandar Khaing[1]

Abstract

This study investigated the growth performance of 30 Burmese Roofed Turtle (*Batagur trivittata*) hatchlings housed in three groups (n=10 per tank) at Yadanabon Zoological Gardens, Mandalay, from December 2019 to August 2020. Hatchlings were fed three different kinds of protein sources, such as the shrimp, *Macrobachium* sp. (Tank 1), dog food (Tank 2) and fish, *Oreochromis* sp. (Tank 3) biweekly combining with *Ipomoea* sp. (water spinach or "kazun-ywet") at the designated day. The results revealed that the negative allometric growth pattern in relationship of body weight and carapace length $b < 3$ with strong correlation $r > 0.95$ at the level of significant at $p < 0.05$ observed in all trials. Similarly, the monthly increments of body weight $b < 3$ with determination of coefficient $R^2 > 0.6655$ and carapace length $b < 0.05$ with determination of coefficient $R^2 > 0.7416$ were investigated. Pearson's correlation (r) generated the perfect association in various parameters of Burmese roofed turtles at the level of significance $p < 0.05$. In addition, t-test revealed that the significant difference in all trials at $p < 0.01$. The best absolute growth (AG), absolute growth rate (AGR) and relative growth rate (RGR) revealed in Tank 1, however, the moderate relative growth rate (RGR) disclosed in Tank 3 followed by Tank 2. Thus, providing the protein richness of various diets and fresh food has a great impact on the growth assessments of Burmese roofed turtles in captivity.

Keywords: turtles, feed, body weight, carapace length, Pearson correlation, t-values

Introduction

Turtles have long been associated with human either in myths, as food sources, as ornaments or as traditional medical ingredient (Rashid & Khan, 2000). The Burmese roofed turtle (*Batagur trivittata*) is one of six species of turtle in the genus *Batagur* of the family Geoemydidae.

The Burmese Roofed Turtle (*Batagur trivittata*) is endemic to the larger rivers of Myanmar. The females of *Batagur trivittata* are larger than males. The hatchlings are somewhat spherical, greenish yellow in color. The Burmese Roofed Turtle is one of the rarest turtle species on earth, and its biological conservation has been successively ongoing for more than 10 years (Cilingir, 2017).

In captivity, aquatic turtles should be fed a variety of foods. A few of the herbivores feed predominantly on plant matter and fruit in nature. Most herbivores will eagerly consume commercial turtle food which is high in protein and fat (Gurley, 2003). Diet containing a mix of protein, carbohydrates, vitamins and essential nutrient promoted faster turtle growth than a single food type. The high amount of animal protein in the diet should facilitate the rapid growth of animals.

[1] Department of Zoology, University of Mandalay

Recently, feeding of nutritional benefits on different diets in Burmese roofed turtles in captive breeding at Yadanabon Zoological Gardens is limited information concerning with their size structure of the turtle population. Therefore, the present study was carried out to investigate the growth performance of Burmese roofed turtle in captivity and to evaluate the efficacy of substituting a diet in these turtles.

Materials and Methods

Study area and period

The research was conducted at the captive breeding facility within the Yadanabon Zoological Gardens is located north of the Mandalay Royal Palace and at the foot of Mandalay Hill, Aungmyaythazan, Mandalay Region. It is situated at North Latitude 21° 58′ 30″ N and East Longitude 96° 5′ 0″ E, and sea level has above 80 meters (22 feet) (Fig. 1.). The study period spanned nine months, from December 2019 to August 2020.

Figure.1. Map of study area (Yadanabon Zoological Gardens). Source: Geography Department, University of Mandalay

Experimental design

Thirty *B. trivittata* hatchlings were randomly divided into three experimental groups (n=10 individuals per tank). Each group was housed in a separate concrete tank (5′×5′×4′), maintained with approximately 0.10 m of water, which was changed bimonthly (Plate 1.A). Individual identification was ensured by serially marking the carapace with enamel paint.

Feeding procedure

The shrimp, *Macrobachium* sp. (24 g) were fed on Burmese roofed turtles on Monday (Tank 1), dog food (24 g) on Tuesday (Tank 2) and fish, *Oreochromis* sp. on Saturday (Tank 3). These supplementary feeds were provided once per week. The *Ipomoea* sp. (Kazun-ywet) (24 g) was supplied every day in all tanks (Plate 1.A) and (Plate 3).

A. Turtle hatchlings tanks B. Measuring the weight C. Measuring the carapace length

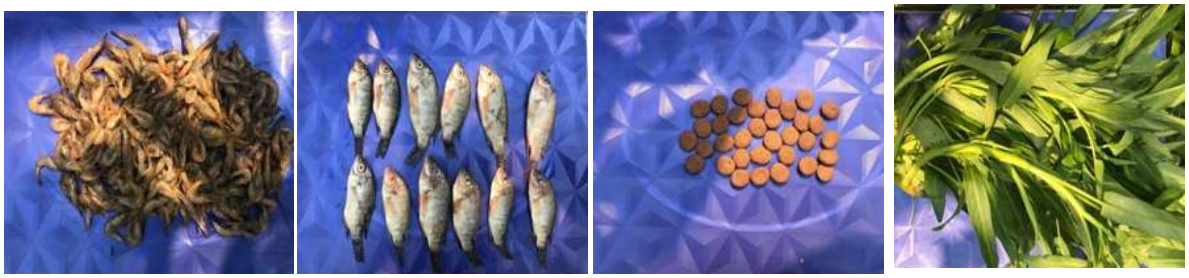
Plate 1 Materials for requirements of Burmese roofed turtles

Morphometric measurements

The body weight of Burmese roofed turtles was recorded with Digital kitchen scales in the nearest 0.01g (Plate 1.B). The carapace length for each turtle was measured with caliper in the nearest 0.01cm (Plate1.C).

(A) Carapace (B) Plastron

Plate 2 Dorsal (Left) and ventral (Right) view of juveniles *Batagur trivittata*



(A) Shrimp (B) Fish (C) Dog food (D) Kazun-ywet

Plate 3 Different types of diet for Burmese roofed turtles

Identification of the studied specimen

Identification and classification of specimen were carried out according to Shi *et al*. (2013) (Plate 2.).

Calculation of growth

The absolute growth (AG), absolute growth rate (AGR) and relative growth rate (RGR) were calculated by following Ricker (1979):

$$\text{Absolute growth rate (AGR)} = \frac{(W_t - W_i)}{t}$$

$$\text{Relative growth rate (RGR)} = \frac{(W_t - W_i)}{t} \times 100$$

Where, W_i is the initial weight or length, W_t is the weight at time, t is the length of the culture period

Regression analysis

The estimation of relationships between the carapace length and body weight of Burmese roofed turtles was investigated followed by LeCren (1951) using the linear equation: Y = a + b X. Where Y is the length (mm), and parameters a is the intercept, b is the slope, and X is the body weight (g). The logarithmic regression equation was used as followed Log Y=Log a + Log b X.

Data analysis

All data for growth performance of Burmese roofed turtles were analysed with t-tests and Pearson's correlation (r) at the level of significance $p < 0.01$ by using Microsoft Excel 2020.

Results

Thirty hatchlings Burmese roofed turtles *B. trivittata* were investigated by feeding on different diets (shrimps *Macrobachium* sp. in Tank 1, dog food in Tank 2 and fish *Oreochromis* sp. in Tank 3) combining with kanzun-ywet at Yadanabon Zoological Gardens, during December 2019 to August 2020.

The various parameters on growth performances of *B. trivittata* in each trial were shown in Table 1, Fig. 2, 3 and 4. The mean carapace length was presented in Table 2. The effect of different diets on their growth performance in each tank was presented in Table 3 and Fig. 4. And the relationships of their growth development in captivity breeding were shown in Table 4. The relationship of growth coefficient on these turtles was shown in Fig.5.

Table 2 Carapace length of Burmese roofed turtles

Month	Carapace length (cm)		
	Tank 1	Tank 2	Tank 3
December	10.20	10.21	10.60
January	10.38	10.40	10.77
February	10.57	10.40	10.93
March	11.36	10.89	11.76
April	12.10	11.47	12.44
May	13.20	12.58	13.21
June	14.70	13.78	14.24
July	15.70	14.76	15.30
August	16.00	13.30	16.00
Mean	12.10	11.47	12.44

Table 1 Growth performance of Burmese roofed turtles *Batagur trivittata* during December 2019 to August 2020

Months	Tank 1				Tank 2				Tank 3			
	BW (g)	AG (g)	AGR (g/day)	RGR (%)	BW (g)	AG (g)	AGR (g/day)	RGR (%)	BW (g)	AG (g)	AGR (g/day)	RGR (%)
December	188	-	-		191	-	-	-	204	-	-	-
January	194	6	0.2	3.19	191	0	0	0.00	213	17	0.3	4.41
February	216	28	0.47	14.89	203	12	0.2	6.28	239	35	0.58	17.16
March	254	66	0.73	35.11	227	36	0.4	18.85	281	77	0.86	37.75
April	309	121	1.01	64.36	261	70	0.58	3.65	318	114	0.95	55.88
May	388	200	1.33	106.38	339	148	0.99	77.49	389	185	1.23	90.69
June	501	313	1.74	166.50	423	232	1.29	121.47	475	271	1.51	132.84
July	581	393	1.87	209.04	499	308	1.47	161.26	551	347	1.65	170.10
August	598	410	1.71	218.09	523	332	1.38	173.82	598	394	1.64	193.14
Mean	309	160.5	1.17	85.37	261	109	0.785	48.17	318	149.5	1.09	73.285

BW = body weight, AG = absolute growth, AGR = absolute growth rate, and
RGR = relative growth rate

Table 3 Descriptive statistics on growth parameter of Burmese roofed turtles ($p < 0.01$)

Trials	Body weight (g)	Carapace length (cm)	Pearson correlation (r)	Degree of freedom	t-Critical	t-Statistics	p-value
Tank 1	358.778	12.690	0.999	8	2.306	6.381	0.00021
Tank 2	317.444	11.977	0.950	8	2.306	6.931	0.00012
Tank 3	363.111	12.806	0.998	8	2.306	7.189	0.00009

Table 4 Pearson correlation on various growth parameters in Burmese roofed turtles during December 2019 to August 2020

Parameters		Body weight (g)			Absolute growth (AG)			Absolute growth rate (AGR, g/day)			Relative growth rate (RGR, %)		
		Tank 1	Tank 2	Tank 3	Tank 1	Tank 2	Tank 3	Tank 1	Tank 2	Tank 3	Tank 1	Tank 2	Tank 3
Body weight (g)	Tank 1	1											
	Tank 2	0.9978	1										
	Tank 3	0.9968	0.9971	1									
Absolute growth (AG)	Tank 1	1	0.9978	0.9968	1								
	Tank 2	0.9978	1	0.9971	0.9978	1							
	Tank 3	0.9969	0.9978	0.9998	0.9969	0.9978	1						
Absolute growth rate (AGR, g/day)	Tank 1	0.9646	0.9471	0.9521	0.9646	0.9471	0.9490	1					
	Tank 2	0.9803	0.9688	0.9707	0.9803	0.9688	0.9685	0.9954	1				
	Tank 3	0.9682	0.9539	0.9644	0.9682	0.9539	0.9607	0.9927	0.9921	1			
Relative growth rate (RGR, %)	Tank 1	1	0.9978	0.9968	1	0.9978	0.9969	0.9646	0.9803	0.9682	1		
	Tank 2	0.9793	0.9879	0.9792	0.9793	0.9879	0.9806	0.9154	0.9471	0.9272	0.9793	1	
	Tank 3	0.9968	0.9971	1	0.9968	0.9971	0.9998	0.9521	0.9707	0.9644	0.9968	0.9792	1

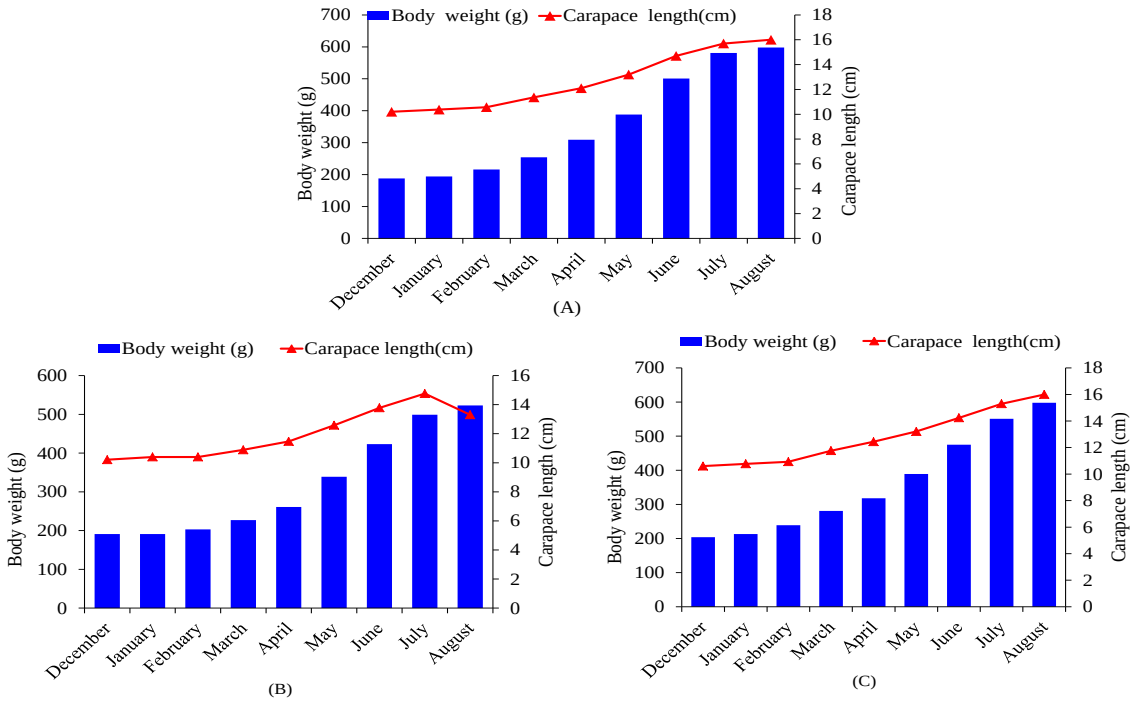


Figure.2. Relationship of body weight and carapace length of Burmese roofed turtle in Tank 1 (A), Tank 2 (B) and Tank 3 (C)

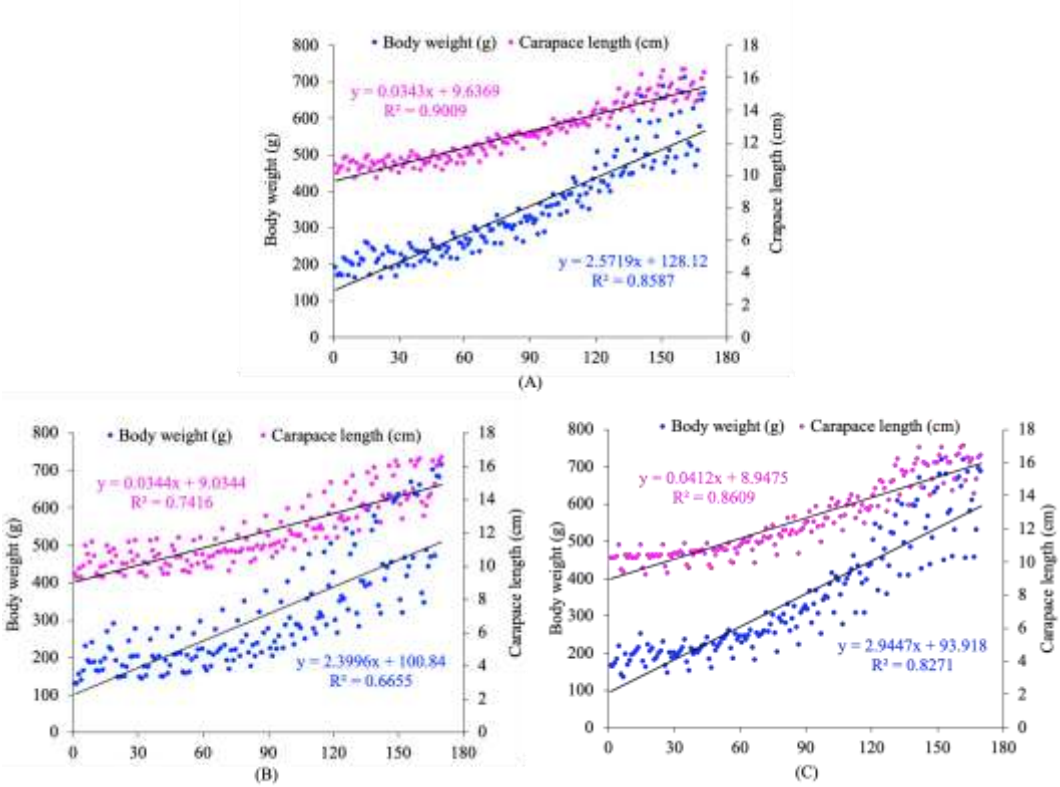


Figure 3. Relationship of body weight and carapace length of Burmese roofed turtle in Tank 1 (A), Tank 2 (B) and Tank 3 (C)

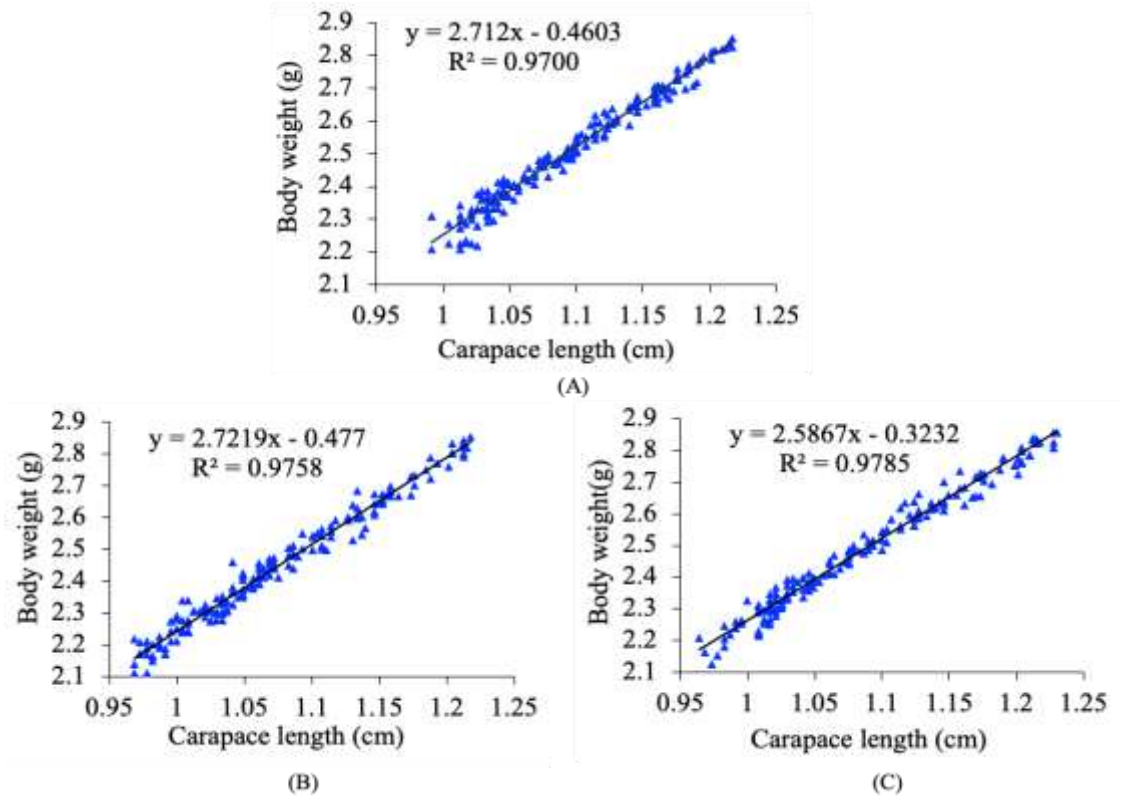


Figure.4. Relationship of body weight and carapace length of Burmese roofed turtle in Tank 1 (A), Tank 2 (B) and Tank 3 (C)

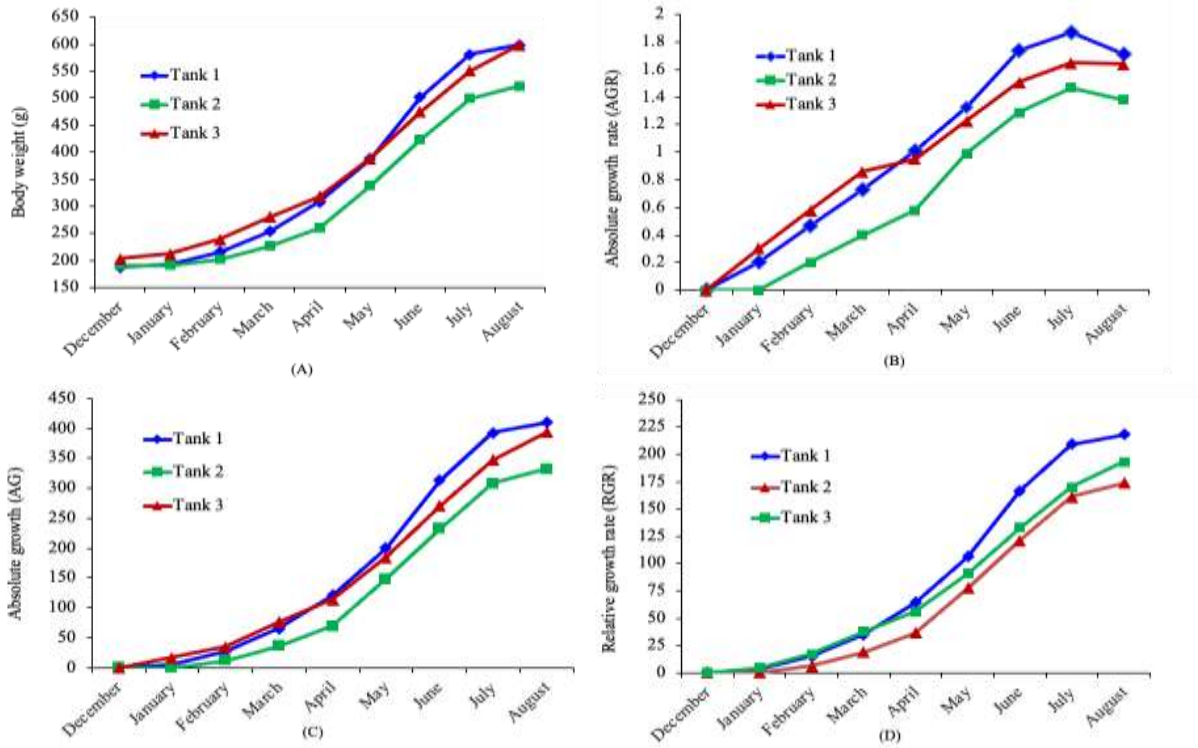


Figure.5. Comparison of different diets on growth performance of Burmese roofed turtle in each trial during December 2019 to August 2020. (A) Body weight (BW), (B) Absolute growth rate (AGR), (C) Absolute growth (AG) and (D) Relative growth rate (RGR)

Discussion

The Burmese roofed turtle *Batagur trivittata* is an endemic species and inhabited into the large rivers of Myanmar. These species are valuable in ecological approach serves as scavengers in the tanks, rivers and stagnant water and thus keep the aquatic ecosystems free from pollution.

In the experiment, the hatchlings are altered to juvenile stage in the months of May to August observed during the study period. All of 30 *Batagur trivittata* hatchlings are healthy and survived throughout the study period.

The nutrient composition of turtle diets are different depend on feeding of the animal and plant materials in which proteins are the major nitrogen source. According to the reference of the value of protein content was 76.44% in shrimp, 71.88 % in fish, 20% in dog food and 2.6 % in kazun-ywet (USDA Nutrient Database, 2019). Thus, the efficacy of different diets on growth performance of Burmese roofed turtles were investigated by feeding on different diets rearing in captivity, each group contains ten individuals per tank and the experimental duration for nine months.

After the experimental trials, the highest mean body weight of Burmese roofed turtles was 309 g (188g-598g) observed in Tank 1 followed by 318g (204g-598g) in Tank 3 and 261g (191g-523g) in Tank 2 in this study. Therefore, the diet of shrimp, *Macrobachium* sp. generated the highest mean body weight (g) of Burmese roofed turtles compared with other trials feeding on dog food in Tank 2 and fish *Oreochromis* sp. in Tank 3, in which turtle from Tank 2 showed the lowest growth performance. However, the growth increment of carapace length in Tank 3 was 12.44 cm (10.60 cm – 16.00 cm) followed by Tank 1 with 12.10 cm (10.20 cm – 16.00 cm) and Tank 2 with 11.47 cm (10.21cm – 13.30 cm) observed. Thus, the different diets of these turtles were not simultaneously provided the growth performance of Burmese roofed turtles in captivity.

The initial growth performance of turtles in Tank 1 and Tank 2 were found similar growth patterns in December and January, however the same growth development revealed in Tank 1 and Tank 3 during the April and May, furthermore, the similar growth increment was also observed in August at the end of the experiment. The significance difference of growth performance in all tanks was investigated at $p < 0.01$ with the Pearson correlation showed the perfect positive relationship $r > 0.9154$.

Concerning with the strength of the relationship between the carapace length and body weight of Burmese roofed turtles were investigated by using regression analysis indicated that the value of growth increment in carapace length was very low association $b = 0.0343$ with $R^2 = 0.9009$ in Tank 1; $b = 0.0344$ with $R^2 = 0.7416$ in Tank 2 and $b = 0.0412$ with $R^2 = 0.8609$ in Tank 3. In addition, the best growth performance of body weight in these turtles was observed in Tank 2 having the value of $b = 2.7219$ with $R^2 = 0.9758$ followed by $b = 2.712$ with $R^2 = 0.9700$ in Tank 1 and $b = 2.5867$ with $R^2 = 0.9785$ in Tank 3, respectively. Therefore, the efficacy of different diets generated the negative allometric growth patterns of Burmese roofed turtles in captivity.

Many researchers have been conducted the growth developmental pattern of turtles by feeding on various diets in situ and ex situ. Because growth can be quantitatively expressed as

the absolute growth (AG) on the basis of changes in length and / or weight in a determined duration. Absolute growth rate (AGR) was expressed in term of some intervals of time, e.g. day, week, month or year. The relative growth rate is given as percentage (Ricker, 1979).

In this study, the absolute growth (AG), absolute growth rate (AGR) and relative growth rate (RGR) of Burmese roofed turtles started at April indicated that the turtles from Tank 1 showed higher growth development than Tank 2 and Tank 3. The accelerated growth pattern of absolute growth rate (AGR) was also found in Tank 1, and the April is the unit development of their growth performance, and halts in July and then decreased in August. Thus, the growth developmental patterns were not influenced by feeding on different diets observed in this study.

Although the remarkable stunted relative growth rate (RGR) was found in April (Tank 2) after the July, their growth pattern was increased at the end of the trial. Therefore, feeding on the kazun-ywet and dog food generated the delay growth pattern in Burmese roofed turtles because they preferred more fresh meals and vegetables than dog food. Thus, among the different diets, the shrimp is more suitable for Burmese roofed turtles than fish and dog food in captivity.

Conclusion

The growth performances of Burmese roofed turtles were greatly influenced by providing the various diets, however, their growth pattern revealed the negative allometric growth pattern with determination of coefficient $R^2 > 0.90$ observed in all trials. Among the diets, the shrimp *Macrobachium* sp. was the better food for growth development of these turtles than fish *Oreochromis* sp. and dog. The good shape of body conformation revealed in Tank 1 than Tank 3 and Tank 2. The significant difference on various diets observed in all trials at the significant level $p < 0.01$. Therefore, the nutrients values of different diets are supplemental foods for growth development of these turtles in captivity.

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