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Chick Growth Patterns of Three Sympatric Tern Species on Nakhilu Island, the Persian Gulf

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Abstract
This study compares the chick growth patterns of the Bridled Tern (*Sterna anaethetus)*, Greater Crested Tern (*S. bergii*) and Lesser Crested Tern (*S. bengalensis)* on Nakhilu Island, Persian Gulf, Iran in 2010 and 2011. Chicks at different ages and adults were captured and their growth parameters were measured at one-week intervals. Body weight, wing, tail, bill, tarsus and head to bill lengths of chicks measured on weekly basis were significantly different for all these three species (P<0.01). The average ratio of the fledging weight to the adult weight was 1.01 for Bridled Tern, 0.85 for Lesser Crested Tern and 0.96 for Greater Crested Tern. Regarding the complex effect of growth parameters, the growth rate of the Bridled Tern has discriminately been increased from the third week while for the Greater and Lesser Crested terns it increased from the fourth week. However, adults and the last week chicks had not showed significant difference of growth parameters (P>0.05). The study result supports the hypothesis that the growth rate represents an optimum balance between the low energy requirements and short development period of terns.

1. Introduction

Patterns of growth in avian chicks have been studied primarily because of their relationships with ecology and evolutionary history of different species (Ricklefs 1968, 1979, Ricklefs & White 1981, Visser 2002). Variation in growth patterns of different species reflects adaptation to energetic constraints or to other ecological factors. In contrast, among individuals of a species, variation in growth rates reflects variation in individual performance or variability in environmental factors (Ricklefs 1979, Langham 1983). Monitoring of chick growth rates over consecutive breeding seasons provides an indication of food availability and environmental factors between and within breeding seasons (Langham 1972, Visser 2002). Intraspecific growth patterns can be variable and also flexible because of environmental variability and selective pressures (Cooch *et al.* 1991).

Growth patterns of seabird chicks have been studied for many species (Langham 1983, Hulsman & Langham 1985, Langham & Hulsman 1986, Nisbet *et al.* 1995, Villard & Bretagnolle 2010), but few studies have comparatively addressed variation among sympatric species in a particular region (Hulsman 1977, Ricklefs & White 1981,

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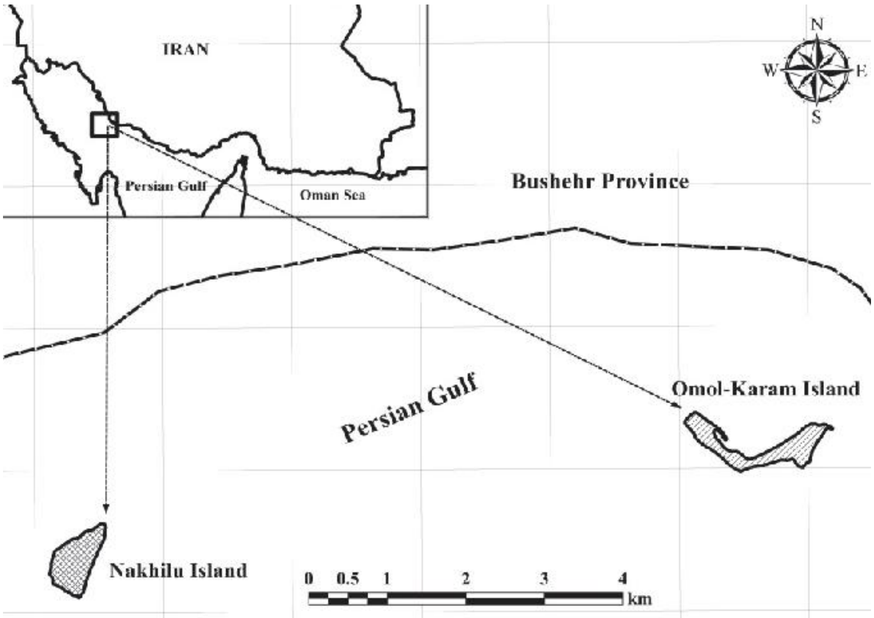

Fig. 1. Map of the northern Persian Gulf showing Nakhilu Island, Iran, where the growth patterns of the Bridled, Greater and Lesser Crested terns were studied.

Nicholson 2002). In seabirds, whose chicks are fed by parents, variation in the growth rate of chicks results primarily from variation in the quality and characteristics of parents (Furness 1983, Nisbet *et al.* 1995). Also, differences in chick growth reflect variations in the use of available resources within an area. It is accepted that the growth rate matches the rate at which parents are able to provide food for their growing chicks (Ricklefs *et al.* 1987).

Investigation on growth patterns of the Bridled Tern *Sternaana ethetus* (hereafter BT) chicks have been studied by Hulsman & Langham (1985) on One Tree Island in Queensland, Australia. Although the first investigation on the breeding biology of the Greater Crested Tern *Sterna bergii* (hereafter GCT) was published by Langham & Hulsman (1986), patterns of growth in Lesser Crested Tern *Sterna bengalensis* (hereafter LCT) and GCT was studied by Nicholson (2002).

These three tern species were selected for our study of chick growth rate because they have good population on the Persian Gulf islands. Several thousand pairs of these three species were recorded on the Mond Islands (Scott 2007). In 2010 and 2011, the population of these species was estimated 21,000–23,000 pairs LCT, followed by 17,000–19,000 pairs BT, while the GCT had the smallest breeding population of 2,400–2,500 pairs (Tayefeh *et al*. 2011, 2013).

The objective of this research was to study chick growth patterns of BT, GCT and LCT on Nakhilu Island, the northern Persian Gulf, Iran. The objectives were: 1) to describe the chick growth patterns in tern species breeding in colonies syntopically, 2) to compare the chick growth rate of tern species with each other, and 3) to investigate factors affecting the chick growth of these species during the 2010 and 2011 breeding seasons.

2. Materials and Methods

2.1. Study area

Nakhilu Island (27° 49' N, 51° 28' E) is located at a distance of 133 km from the city of Bushehr, south of Iran (Fig. 1). The island is basically originated from clashes of the sea bed ruggedness and sediments of the Mond River. The island area covers about 35 ha, which reaches to 34.2 and 36.2 ha during the low and high tides, respectively. The highest point of this island is about 3 m higher than the sea level. The main vegetation of Nakhilu Island includes *Atriplex* which often grows in sparse to dense masses. Three types of vegetation, however, occur on Nakhilu Island: 1) *Atriplex leucoclada*, 2) *Cyperus conglomeratus-Halopyrum mucronatum* that occur in the sandy hills together with *Scrophularia* sp., *Cicer* sp. and *Heliotropium* sp., and 3) *Arthrocnemum macrostachyum* that occurs seasonally in the east of this island. The fauna of Nakhilu Island includes mammals, in particular Black Rat (*Rattus rattus*), reptiles such as *Chalcides occellatus* and *Cyrtopodion scabrum* and sea turtles *Eretmochelys imbricata*. Nakhilu Island is uninhabited and is only used as resting area for the local fishermen and as shelter during seasonal storms.

2.2. Chick growth

The selected species of the present study were the semi-precocial BT and the precocial GCT and LCT as these species were three most abundant sympatric seabird species on Nakhilu Island, northern Persian Gulf, Iran. Measurements of BT chicks was started from 12–14 June in 2010 and from 20–22 June in 2011. Regarding GCT and LCT, it was similarly started from 16–17 June in 2010 and the same as BT (20–22 June) in 2011.

Nests of BTs were checked and newly hatched chicks were selected in our marked nests. Chicks of BTs were marked using numbered plastic colored legbands in the first catch. From the third week onwards, chicks were bounded with numbered metal rings which allow the recognition of individual chicks. Also, up to 100 newly chicks of GCT and LCT were banded using numbered plastic colored legbands. Banding of chicks continued during the data collection using metal rings. Weighing and measuring growth parameters took place on a weekly basis.

Chicks were grouped in several age categories (classified as newborn, 1, 2, 3, 4, 5, 6, 7, 8 weeks with ±3 days and adults) (Keitt *et al.* 2003). Chicks of GCT and LCT were corralled and captured in the crèche. When each chick was measured, it was assigned to a chick category based on its feather development and similarity with the known age (of marked chicks). To obtain the required number of chicks, marked chicks were weighed and measured along with some other chicks that were assumed to be at the same age of marked ones based on their similarities to the known chick features.

Foraging of BT is mostly diurnal, with occasional feedings taking place shortly after the sunset (Hulsman & Langham 1985, Garavanta & Wooller 2000, Nicholson 2002). In order to prevent the regurgitation of food by chicks, measurements of BT took place in the early morning immediately after the dawn when parents left their nests for foraging areas while there was enough light to find chicks under the vegetation. Measurements of GCT and LCT took place at midnight (24.00 hr) to minimize effects of overheating on chicks and the prevention of food regurgitation. Adults of all the three species were captured at their nest and colony during the night hours. The capture device was consisted of a set of two nylon mistnet suspended between three poles next to each other at 45 degrees. Net dimension was approximately 2 m in height and 20 m in length, while the bottom of the net placed on the ground.

Data on BT were collected from the breeding sites with 5%–50% vegetation cover during the hatching and chick rearing periods (June–July) in 2010 and 2011. In the vegetated areas, chicks rarely leave their nests until they can fly. The study was done only in the afore-mentioned type of habitats because: it was observed that in areas less than 5% cover, chicks left nests earlier than other sites, in order to find safe places to hide from predators, and to find shelter for protection from the sunlight (similar to the findings of Villard & Bretagnolle 2010). Also, marked chicks were hard to find in the areas with more than 50% vegetation cover as chicks moved into tunnels under the vegetation (Hulsman & Langham 1985).

To estimate the growth rate of GCT and LCT chicks, data were collected simultaneously, as they nested together within the same colony. GCT and LCT chicks hatched synchronously. Moreover, morphological characters and the weight of adults were measured during the early incubation period due to the loss of body mass by breeding birds, observed especially during the nestling period (Chastel *et al.* 1995).

The wing length (distance from the carpal joint to the tip of the longest primary on the closed wing) and the tail length (defined as the distance from the base to the tip of the longest tail feathers) were measured (±1mm) using a set of stopped stainless steel (Rising & Somers 1989, Gosler 2004, Goodenough *et al.* 2010). The bill length (bill tip to the feathered base of bill), head to bill (the distance between the back of the skull and the tip of the bill) and the length of inner tarsus (the length of the tarsometatarsal bone, measured from the angle of the foot bent to 90 degrees to the notch of the intertarsal joint) of chicks of all the three species were measured (±0.01mm) with digital calipers.

Chicks and adults of these three species were weighed (±0.1g) with a digital electronic balance. Birds were placed in cloth bags for weighing. The weight of the bag was measured after each use and subtracted from the gross weight. The balance was placed in a box in order to reduce the influence of wind (Ricklefs 1979).

2.3. Data analysis

Due to the similarity of sexes (Cramp *et al.* 1985), we pooled data for the sexes. For the growth rate of chicks, the normality of data was tested by Skewness-Kurtosis, Kolmogorov-Smirnov and Shapiro-Wilk tests. Outliers were searched and removed by checking box plots and Mahalanobis distances (Tabachnick & Fidell 2007). Following ANOVA, the *post hoc* multiple comparison by Tukey (HSD) was used to compare values between the chick categories. Morphological characters, the length measurements and the body weight of chicks were also compared with those of adults. Discriminant Function Analysis was used to compare effects of parameters on different chick ages. Statistical analyses were performed using SPSS statistical software (SPSS Inc., 2001) with the α-level set at 0.05 or 0.01. All values are reported as the mean±SE.

3. Results

3.1. Growth parameters

The mean (± SE) body weight and measurements of growth parameters of BT, GCT and LCT chicks in age categories that were measured on Nakhilu Island (combined data of 2010 and 2011) are shown in Table 1 and Figures 2–4. The body weight reached one-half adult body weight at the second week for BT while for GCT and LCT it occurred at three weeks. The *post hoc* multiple comparisons by Tukey (HSD) indicated that the body weight of chicks increased by the fifth week for all the three species (P<0.01). The length of wings of BT and GCT increased significantly from the second week up to the fledging while for LCT it increased significantly through all the chick categories and adults. One-half adult wing length was attained between the weeks five and six for all these three species.

The tail length of BT and LCT began to grow rapidly from the third week and continued until the fledging while for GCT it increased from the fourth week. The bill length of all the three species increased significantly in all chick categories and also in comparison to that of adults (Table 1). The bill length of LCT increased significantly from hatching to six weeks old chicks. One-half adult bill length for BT attained after three weeks, for LCT between the second and third weeks and for GCT after 4 weeks.

The head to bill length of chicks of all the three species increased significantly in all chick categories and also in comparison to adults. The longest chick head to bill length was at the age of eight weeks for BT while for GCT and LCT it was six weeks. All the three species exceeded one-half length of adults head to bill at third week.

The inner tarsus length of BT and GCT increased significantly from the newborn to the fourth week of the development while for LCT it significantly increased from the newborn to the third week of the development. All the three species exceeded one-half adults tarsus length at the first week.

Chicks reached to the half size of the adults tarsus length at the first week, the body weight after two weeks for BT and three weeks for GCT and LCT, the head to bill length at the third week, the bill length between two and four weeks, the wing length between five and sex weeks, the tail length after six or seven weeks.

3.2. Complex effect of growth parameters

Discriminant Function Analysis showed significant difference of the chick growth parameters in different weeks for all the three species (P<0.001, Table 2). There was significant difference of the growth parameters between weeks for all these three species (Box's M for BT= 350.16, for GCT= 160.01, for LCT= 139.86) (P<0.001 for all the three species).

Comparison of parameters between chicks of the last week and adults showed that the tarsus length and body weight were not significantly different for BT, also not for the body weight of GCT and the tarsus length of LCT (P>0.01, Table 3). Other factors were significantly different between adults and chicks of the last week (P<0.01, Table 3). Considering growth parameters altogether, adults and chicks of the last week could be discriminated from each other for none of the three species (Wilk's for BT= 0.047, for GCT= 0.035, for LCT= 0.020).

Discriminant Analysis showed that considering all parameters altogether, the growth of BT chicks increased significantly from the third week whereas for GCT and LCT it increased from the fourth week (Table 4).

Table 1. Measurements of weekly intervals for the body weight (g) and wing, tail, tarsus, bill and head to bill lengths (mm) of chicks of three tern species on Nakhilu Island. Data for 2010 and 2011 are combined. Data of adults were caught at night during the study period in their colony during the incubation phase. Statistics are reported for comparisons between each chick categories using the *post hoc* multiple comparisons by Tukey (HSD) of ANOVA. Values are given as mean±SE. **Note:** Means in the same column followed by the same letter are not significantly different at the *P*<0.05 as determined by Tukey (HSD).

Species	**Age (weeks)**	***N***	**Body weight (g)**	**Wing length (mm)**	**Tail length (mm)**	**Tarsus length (mm)**	**Bill Length (mm)**	**Head to Bill length (mm)**
Bridled Tern	**Newborn**	28	14.22±0.26$_{a}$	17.93±0.24$_{a}$	0.00±0.00$_{a}$	13.83±0.15$_{a}$	12.20±0.16$_{a}$	33.48±0.21$_{a}$
	1	27	27.02±0.66$_{b}$	20.81±0.50$_{a}$	0.00±0.00$_{a}$	17.80±0.11$_{b}$	14.43±0.22$_{b}$	39.35±0.65$_{b}$
	2	24	54.21±1.12$_{c}$	31.17±0.80$_{b}$	1.42±0.52$_{a}$	19.29±0.18$_{c}$	19.68±0.21$_{c}$	49.04±0.35$_{c}$
	3	28	69.23±1.58$_{d}$	41.07±2.77$_{c}$	14.93±0.68$_{b}$	20.24±0.20$_{d}$	21.28±0.19$_{d}$	51.41±0.64$_{d}$
	4	25	89.65±1.69$_{e}$	84.44±2.42$_{d}$	26.36±1.51$_{c}$	21.51±0.11$_{e}$	24.07±0.17$_{e}$	56.86±0.39$_{e}$
	5	31	99.67±1.98$_{f}$	118.58±1.93$_{e}$	44.52±1.03$_{d}$	21.60±0.10$_{e}$	26.19±0.20$_{f}$	61.33±0.23$_{f}$
	6	29	102.23±1.64$_{f}$	154.62±2.88$_{f}$	66.76±1.81$_{e}$	21.67±0.12$_{e}$	29.26±0.22$_{g}$	63.74±0.36$_{g}$
	7	24	101.14±1.22$_{f}$	185.62±3.23$_{g}$	85.42±1.85$_{f}$	21.86±0.18$_{e}$	31.30±0.24$_{h}$	66.43±0.60$_{h}$
	8	30	105.88±1.41$_{f}$	218.30±2.30$_{h}$	106.40±1.15$_{g}$	21.92±0.16$_{e}$	33.54±0.26$_{i}$	70.41±0.30$_{i}$
	Adult	**51**	**104.83±1.36$_{f}$**	**255.69±0.91$_{i}$**	**164.57±1.52$_{h}$**	**22.10±0.10$_{e}$**	**42.09±0.23$_{j}$**	**82.41±0.61$_{j}$**
Greater Crested Tern	**Newborn**	22	39.43±0.49$_{a}$	25.18±0.35$_{a}$	0.00±0.00$_{a}$	18.71±0.18$_{a}$	16.24±0.19$_{a}$	45.04±0.37$_{a}$
	1	29	71.86±2.14$_{b}$	30.69±0.49$_{a,b}$	0.00±0.00$_{a}$	25.31±0.33$_{b}$	20.16±0.26$_{b}$	56.34±0.51$_{b}$
	2	14	116.14±4.54$_{c}$	41.57±0.60$_{b}$	0.00±0.00$_{a}$	29.05±0.36$_{c}$	24.65±0.42$_{c}$	63.81±0.54$_{c}$
	3	18	171.49±8.12$_{d}$	64.83±3.11$_{c}$	5.39±1.23$_{a}$	31.67±0.29$_{d}$	29.15±0.44$_{d}$	73.70±0.69$_{d}$
	4	18	243.56±4.83$_{e}$	107.50±4.18$_{d}$	21.89±1.61$_{b}$	33.57±0.24$_{e}$	34.80±0.53$_{e}$	79.26±1.41$_{e}$
	5	20	306.44±6.60$_{f}$	171.85±2.94$_{e}$	48.20±1.68$_{c}$	33.82±0.23$_{e}$	40.53±0.42$_{f}$	91.70±0.85$_{f}$
	6	20	327.87±6.40$_{f,g}$	239.85±5.22$_{f}$	87.95±3.00$_{d}$	34.14±0.33$_{e}$	46.34±0.55$_{g}$	98.14±1.52$_{g}$
	Adult	**9**	**342.59±8.42$_{g}$**	**385.00±6.84$_{g}$**	**184.67±3.17$_{e}$**	**38.25±0.55$_{f}$**	**69.92±0.53$_{h}$**	**127.62±1.58$_{h}$**
Lesser Crested Tern	**Newborn**	43	24.00±0.37$_{a}$	18.09±0.39$_{a}$	0.00±0.00$_{a}$	14.65±0.34$_{a}$	13.02±0.12$_{a}$	37.50±0.19$_{a}$
	1	29	44.88±1.45$_{b}$	26.07±0.63$_{b}$	0.00±0.00$_{a}$	20.61±0.30$_{b}$	17.65±0.25$_{b}$	48.64±0.70$_{b}$
	2	24	62.97±2.48$_{c}$	35.21±1.48$_{c}$	0.00±0.00$_{a}$	23.23±0.23$_{c}$	20.94±0.35$_{c}$	55.95±0.71$_{c}$
	3	19	84.98±2.70$_{d}$	60.68±2.19$_{d}$	8.74±0.68$_{b}$	24.76±0.25$_{d}$	23.87±0.39$_{d}$	62.34±0.76$_{d}$
	4	21	120.88±3.51$_{e}$	98.86±4.28$_{e}$	24.19±1.65$_{c}$	26.07±0.18$_{e}$	27.40±0.46$_{e}$	67.93±0.94$_{e}$
	5	26	151.96±1.84$_{f}$	135.88±2.04$_{f}$	42.85±1.24$_{d}$	26.36±0.12$_{e}$	31.27±0.34$_{f}$	73.58±0.29$_{f}$
	6	48	159.83±1.88$_{f}$	189.33±1.75$_{g}$	72.06±1.15$_{e}$	26.32±0.12$_{e}$	36.22±0.20$_{g}$	79.86±0.26$_{g}$
	Adult	**32**	**188.51±3.92$_{g}$**	**300.94±1.4$_{h}$**	**141.19±1.24$_{f}$**	**26.23±0.10$_{e}$**	**52.89±0.35$_{h}$**	**98.45±0.44$_{h}$**

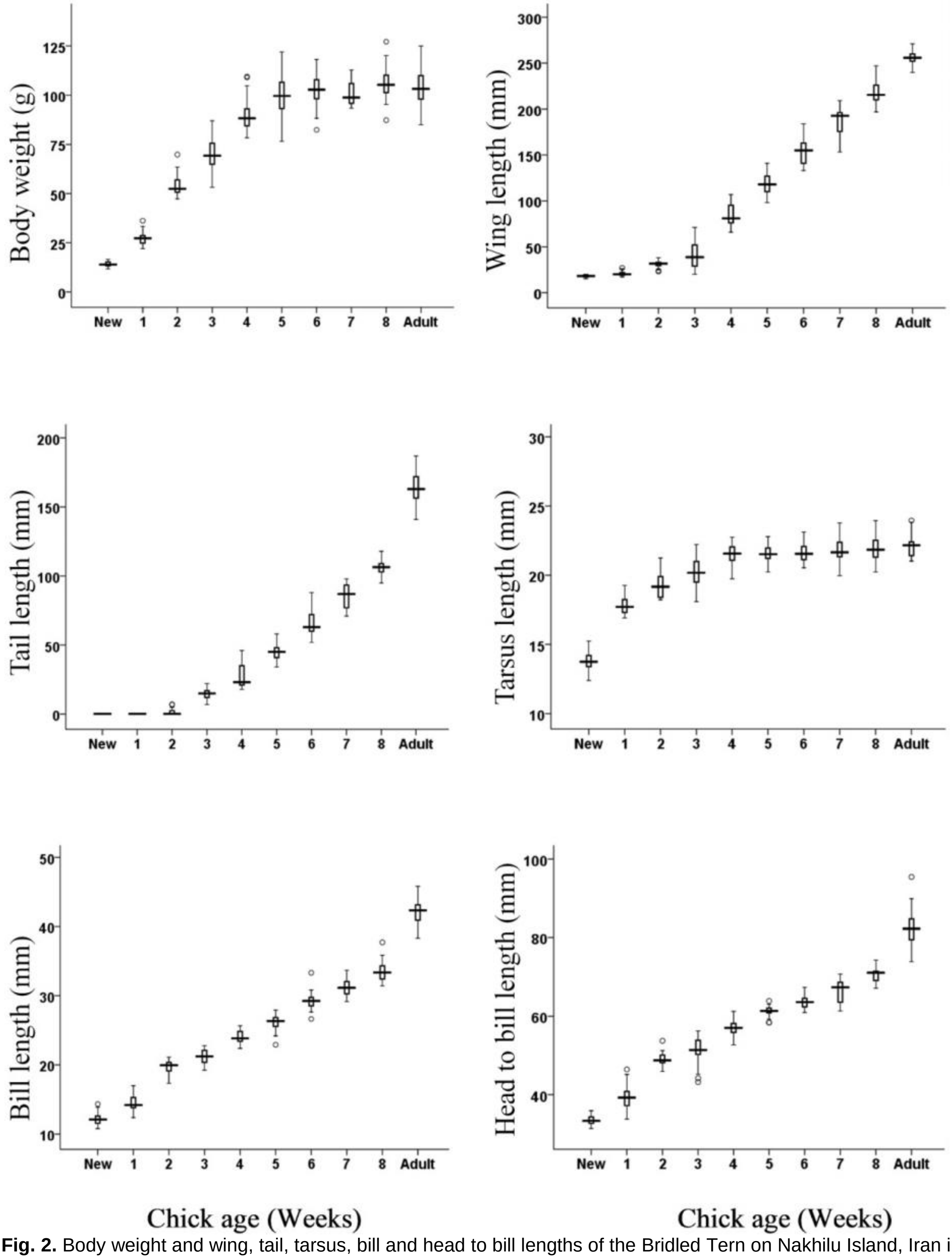

Fig. 2. Body weight and wing, tail, tarsus, bill and head to bill lengths of the Bridled Tern on Nakhilu Island, Iran in 2010 and 2011 combined. A box represents the interquartile range; a line across the box indicates the median; bars extend from the box to the highest and lowest values; outliers are illustrated by circles.

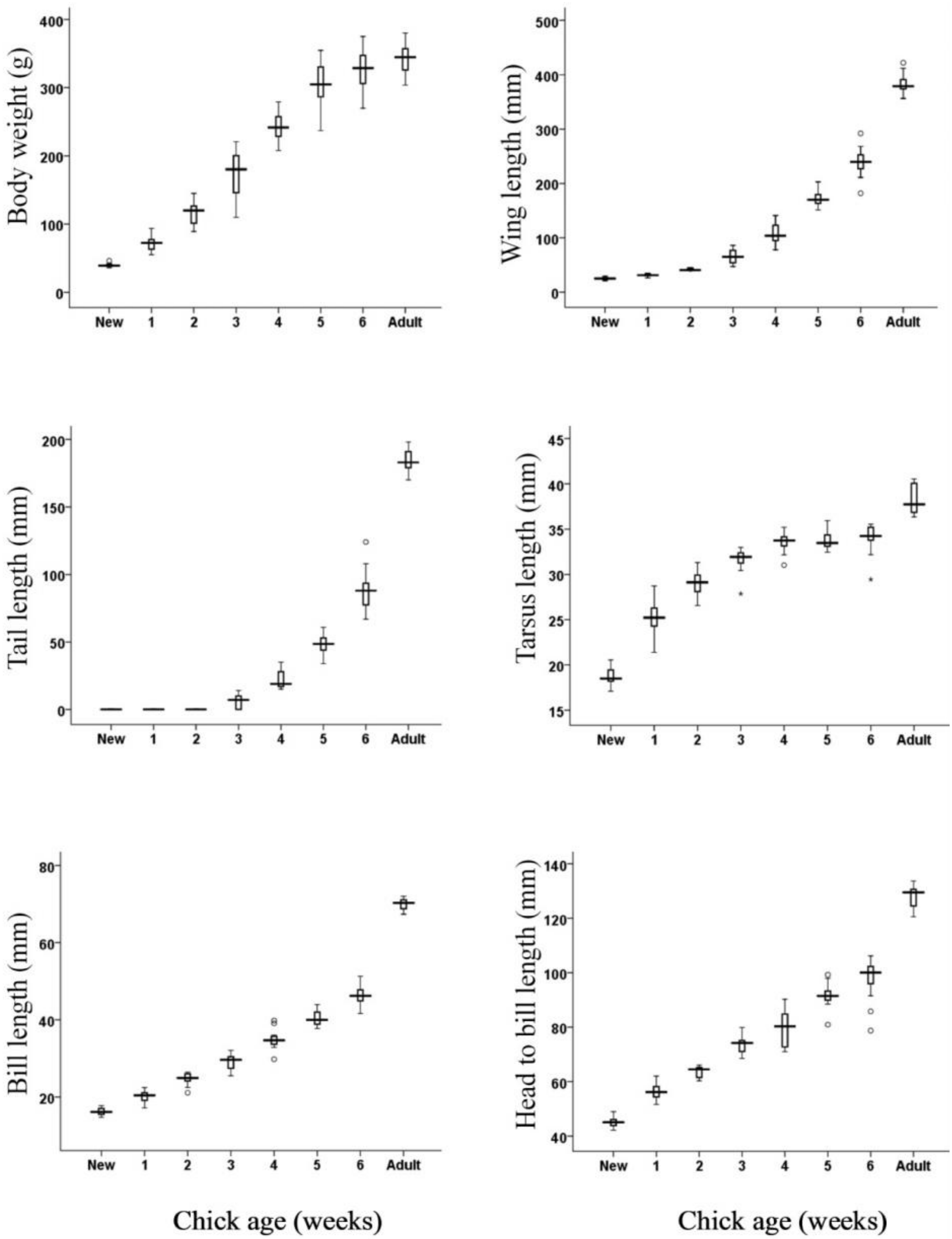

Fig. 3. Body weight and wing, tail, tarsus, bill and head to bill lengths of the Greater Crested Tern on Nakhilu Island, Iran in 2010 and 2011 combined. A box represents the interquartile range; a line across the box indicates the median; bars extend from the box to the highest and lowest values; outliers are illustrated by circles.

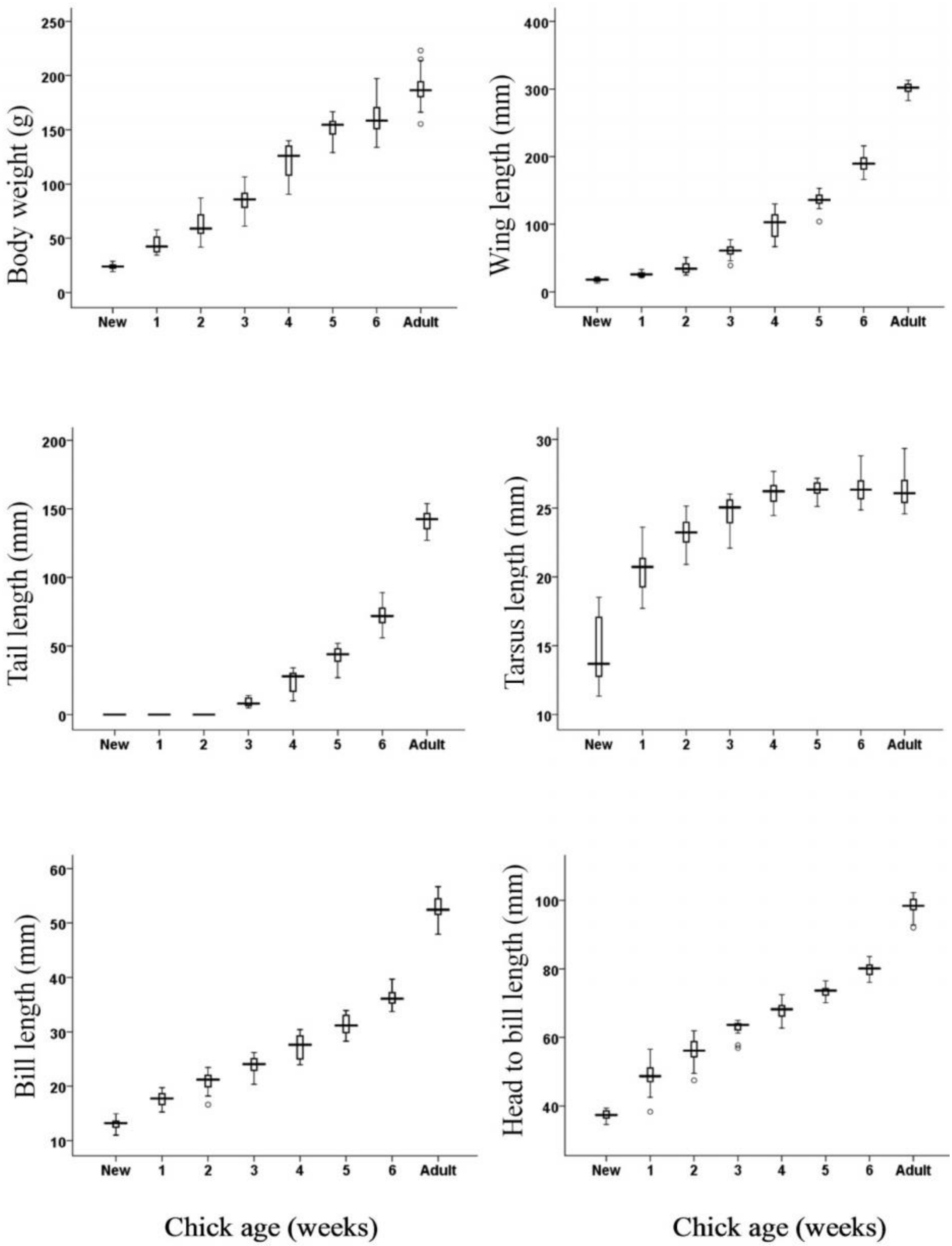

Fig. 4. Body weight and wing, tail, tarsus, bill and head to bill lengths of the Lesser Crested Tern on Nakhilu Island, Iran in 2010 and 2011 combined. A box represents the interquartile range; a line across the box indicates the median; bars extend from the box to the highest and lowest values; outliers are illustrated by circles.

Table 2. Statistics of discriminant function analysis of chick growth parameters in different weeks.

Factors	Bridled Tern			Greater Crested Tern			Lesser Crested Tern		
	Wilks' Lambda	F	Sig.	Wilks' Lambda	F	Sig.	Wilks' Lambda	F	Sig.
Body weight	.047	606.74	.000	.039	552.74	.000	.036	899.56	.000
Wing length	.023	1233.47	.000	.026	826.53	.000	.021	1562.14	.000
Tail length	.024	1207.17	.000	.040	531.75	.000	.028	1154.32	.000
Tarsus length	.083	325.45	.000	.051	414.03	.000	.083	371.37	.000
Bill length	.024	1214.06	.000	.027	796.16	.000	.028	1168.25	.000
Head to bill	.034	832.70	.000	.046	466.21	.000	.029	1141.21	.000

Table 3. Statistics of discriminant function analysis of chick growth parameters between adults and chicks at the last week.

Factors	Bridled Tern			Greater Crested Tern			Lesser Crested Tern		
	Wilks' Lambda	F	Sig.	Wilks' Lambda	F	Sig.	Wilks' Lambda	F	Sig.
Body weight	.997	0.25	.617	.939	1.75	.196	.467	89.01	.000
Wing length	.203	310.87	.000	.095	257.49	.000	.036	2111.41	.000
Tail length	.100	710.16	.000	.067	377.65	.000	.047	1568.70	.000
Tarsus length	.987	1.06	.307	.372	45.58	.000	.998	0.18	.675
Bill length	.122	570.56	.000	.038	684.86	.000	.037	2035.51	.000
Head to bill	.268	215.85	.000	.164	137.85	.000	.049	1499.02	.000

Table 4. Log of determinant of different chick ages for chick growth.

Chick ages (weeks)	Bridled Tern	Greater Crested Tern	Lesser Crested Tern
1	.[a]	.[a]	.[a]
2	.[a]	.[a]	.[a]
3	7.677	.[a]	.[a]
4	13.053	15.102	14.041
5	11.192	15.750	13.484
6	11.160	16.794	12.063
7	11.681	-	-
8	13.620	-	-
Pooled within-group	12.037	21.674	13.884
Last week chicks	12.037	21.674	13.884
Adults	15.182	17.976	15.118
Pooled within-group	15.269	21.565	14.869

4. Discussion

This study compared chick growth patterns between three breeding tern species and found a prolonged growth period of BTs. In the present study, the age at which chicks attained the peak weight was 35 days (approximately 100 g) while on Lowendal Island, western Australia it was 42 days (117 g) in 1998 and 43 days (112 g) in 1999 (Nicholson 2002), on Penguin Island, south-western Australia 53 days (120 g) (Garavanta & Wooller 2000), on the Great Barrier Reef, north-eastern Australia 40 days (128 g, Hulsman & Langham 1985) and in New Caledonia, eastern Australia 37 days (132 g, Villard & Bretagnolle 2010). This study showed that chicks reached their half peak weight when they were two weeks old, similar to results of the Great Barrier Reef and Penguin Island (Hulsman & Langham 1985, Garavanta & Wooller 2000) and 3–5 days later than that of Lowendal Island (Nicholson 2002) and New Caledonia (Villard & Bretagnolle 2010). This variation may be related to the findings of Garavanta & Wooller (2000) who suggested the growth rates of BT chicks are negatively correlated with the distance to their feeding sites.

The present study also showed a rapid growth period for GCT and LCT, in accordance with the previous studies (Langham 1983, Nicholson 2002), the time taken to reach the half of the adult weight for GCT and LCT was 21 days, which is 21–28 days prior to the fledging. Their chicks had most rapid period of gaining weight in their first and second weeks of the development. The average ratio of the body weight of fledglings to adults (Tables 1–3) was similar to the range of 0.60–1.84 measured in 94 species of birds (Ricklefs 1968). The ratio of GCT and LCT was lower compared to BT, and was expected when the life history has evolved under selective pressures to minimize the age at which a chick fledges. This can happen in cases of heavy predation, high parasite load, or starvation during the chick phase (Miller 2010). The most likely explanation for the low weight at the fledging is severe food limitation during the later part of the breeding season due to colonial life, which forces chicks to allocate limited food for the growth of body parts (wings and tail) which is most vital for leaving the colony as soon as possible.

The growth of the wing and tail lengths was initially slow among these three tern species. When fledging, the wing and tail lengths of BT chicks reached up to 70% and 64% compared to that of adults, respectively. The wing length of GCT and LCT was about 62−63% while the tail length of these two species was around 50% at the fledging time in the sixth week (Tables 2−3, Nicholson 2002). In all the studied species, the growth of the tarsus length was more rapid, with chicks reaching to the length of the fledgling in the early stage of their development. Among the three studied species, BT had the lowest growth of the tarsus length in our study. The development of feet in LCT and GCT compared with BT chicks would facilitate the avoidance against predators, as well as being able to move quickly towards the parents when called for feeding (Nicholson 2002).

The bill and head to bill lengths are highly correlated with each other (De Marchi *et al.* 2012). Close to the fledging time, BT young had a bill length of up to 80% of the adult size while GCT and LCT had shorter bill length compared with that of adults. Indeed, the fact that the bill length did not reach a peak suggests that the growth of the bill continues after the fledging. This might not be a problem because chicks are singletons and do not have to compete with siblings, a situation that favors larger bills (Gil *et al*. 2008). Moreover, unlike most seabird chicks (Colwell 2010), they are not forced to feed by themselves while they are fed by their parents and probably do not require a fully developed bill until well after they fledge. Even when the chicks fledge, parents continue to feed them for several months (Powell *et al.* 2007).

There are some features in the breeding biology of BT that could affect the vulnerability of eggs and chicks to predation. Most of BT nests were under cover that prevents aerial predators from taking eggs or chicks (Hulsman & Langham 1985, Villard & Bretagnolle 2010). There are active behavioral features such as evasive tactics by chicks, nest defense by parents and defecating away from nests (Hulsman & Langham 1985).

Our results showed that it takes about eight weeks from the hatching to the fledging period for BT while it was recorded six weeks for LCT and GCT. The growth patterns of BT chicks could be a function of longer period between the hatching and the fledging than that of GCT and LCT. Compared to BT which requires more sheltered environment, GCT and LCT which breed in open areas have shortened their fledging period. Finally, this result accords the hypothesis that the growth rate represents an optimum balance between the selection for low rates of energy requirements and short development period.

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