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Research Article

Postnatal growth and age estimation in preterm infant of long-fingered bat (*Myotis capaccinii*) reared in a flight cage

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Abstract

Three Capaccinii's bats (*Myotis capaccinii*) which were born and reared in a flight cage were subjected to a postnatal study. Length of forearm, body mass and length of the total gap at the fourth metacarpal- phalangeal joint of the neonats were measured in order to develop empirical growth curves and their derivatives. The pups at birth had a mean birth body mass of 2.6gr ± 0.1 and forearm length of 18mm±1.5. At 54 days, mean body mass was 82.71% of adult mass (6.7gr ± 0.2) and mean forearm length was 80.37% of adult length (34.56mm ± 0.4). The length of forearm and body mass increased linearly during first, three weeks, and thereafter maintained in an apparent stability. The epiphyseal gap of the fourth metacarpal- phalangeal joint increased until 12 days, then decreased linearly until 50 days and thereafter fused. The rate of body mass gain and forearm growth during the first 24 days was 0.09 g/d and 0.6 mm/d, respectively.

Keywords: Capaccinii's bats, postnatal, neonate, Iran.

Introduction

The size of animals at birth and the subsequent postnatal growth are important for understanding the influence of these factors on the life history of animals (Baptista *et al*. 2000). In many free-ranging mammals, neonates are not easily available for the study of postnatal growth. However, some colonial insectivorous bats provide excellent opportunity for such studies because pups are often accessible in maternity roosts from birth until weaning (Kunz and Robson 1995). Various investigations on different species of bats have shown that measurement of body size, length of forearm and length of the gap of the fourth metacarpal-phalangeal joint (Burnett and Kunz 1982, Fanis and Jones 1995, Isaac and Marimuthu 1996, Hoying and Kunz 1998, Stern and Kunz 1998, Elangovan *et al*. 2002, Sharifi and Akmali 2006, Sharifi *et al*. 2012, Sharifi, and Vaissi 2013) can be used to estimate the age of bats during the early postnatal period. Moreover, studies on postnatal development would facilitate investigation on various aspects of early development such as foraging, echolocation, feeding and breeding behavior (Rajan and Marimuthu 1999), energy and mineral accretion (Studier and Kunz 1995, Chen *et al*. 2016), milk composition (Kunz *et al*. 1995) and ontogeny of flight (Kunz and Anthony 1996). These studies on postnatal growth carried out both under captive (Jones 1967, Kleiman 1969, Taft and Handley 1991, Chaverri and Kunz 2006, Sharifi *et al*. 2012, Sharifi and Vaissi 2013) and natural conditions (Case 1978, Buchler 1980, Kunz and Stern 1995, Elangovan *et al*. 2002, Sharifi 2004a).

Patterns of growth and development vary among species and families of bats (Tuttle and Stevenson 1982, Kunz and Hood 2000). Developmental studies conducted on microchiropteran bats show that various environmental factors such as availability of food as well as biological factors such as size at birth, sex, metabolic rate and foraging success influence the pattern of the postnatal growth in bats (Tuttle and Stevenson 1982, Kunz and Stern 1995, Kunz *et al*. 2009). These studies also indicated that bats with larger litter size have slower growth rates compared with those with smaller litter size (Kunz and Stern 1995). Available information on postnatal growth indicates that no previous investigation has been carried out on Capaccinii's bat. In this paper we describe postnatal growth and derive quantitative estimates of age in young of this species under captive condition.

Material and methods

Myotis capaccinii is a medium weight (approximately 8 g) bat with a wide distribution in the Mediterranean region of Europe, Turkey, Iraq and in Israel (Corbet 1978, Benda *et al*. 2006). *M. capaccinii* is one of eight species belonging to the genus Myotis reported from Iran (Karami *et al*. 2008). M. capaccinii has been reported from five localities in southern Iran (DeBlase 1980). These areas include Pol-i-Abgineh (Etemad 1963), Perspolis, Shapur cave, Canae Gabru cave in north Jahrom in Fars Province (DeBlase 1971) and two specimens from south east Kazeron (DeBlase 1971). Recent reports of presence of this species in Mahidasht cave (33°, 23'N and 47°, 30'E) and Qasre-e Shirin (34°, 31'N and 45°, 35'E) in Kermanshah Province by Sharifi *et al*. (2006) indicate that this species has a much greater distribution. Based on IUCN estimate of the conservation status of microchiropteran bats (Hutson *et al*. 2001) the Capaccinii's bat in its Iranian range is ranked as a vulnerable species. On the basis of another evaluation of conservation status of the Iranian bats (Sharifi *et al*. 2000) consisted of four classes (common, rare, very rare and extremely rare) this species is ranked as a rare species.

We conducted this study in a flight cage (6×2×2 m) at the department of biology, Razi University, in western Iran. Two pregnant females were collected from Mahidasht cave in approximately 10 km west of Kermanshah. Captured bats were marked individually with numbered aluminum alloy ring (Porzana Ltd, London) and then released in the flight cage. The cage was covered from outside by sheets of cardboards in order to isolate the bats from excess of light and noise in the laboratory and maintained under natural light regime. The bats had unlimited access to fresh water in shallow dishes and to mealworm in plates placed at the floor of the cage and also on a desk at the heights of 1m. Initially, all bats were fed by hand, but from 2-5 days after capture they fed themselves. Pups were marked with similar aluminum alloy four days after birth. Males were banded on the right forearm and females on the left. Young bats were gently removed from their mothers and body mass was measured to the nearest 0.1 gram using an electronic balance. The forearm was measured with a Vernier caliper. The length of the total epiphyseal gap in the fourth metacarpal- phalangeal joint was measured to the nearest 0.1 mm using a binocular microscope equipped with an ocular micrometer and sub-stage illumination to view the transilluminated wing (Kunz and Anthony 1982). All measurements carried out at four days interval from the second day of birth until day fifty-four.

The first parturition occurred on the 9st of May, 3 days after the bats were released into the flight cage. The second and third parturition occurred on 10th of May. At birth, young *Myotis capaccinii* were altricial-naked and pink, with closed eyes and folded pinnate. The young bats were attached to their mother's nipples at any time they were examined during their first 2-3 days. By the first week of age, the ears became erected and few spare hairs were present on their bodies. The eyes opened during the first week and the pups began to move. The short and soft hair of the pups was distinguishable between 6 and 10 days. The color of hair changed to a dark grey, which was similar to that of the adults. The mothers carry the young bats with their plagiopatagium for the first 3 weeks. Physical contacts between the mothers and pups decreased as the pups increased in age. At the age of 34 days, they began to roost separately, but close to their mothers. The young bats ability to flight improved when they were about 40 days old. At this time, they began independently to bite and lick the mealworms. Young bats flew well and began to feed on mealworm when they were 40 to 45 days old (Table 1). Upon the completion of the study, all bats (three newborn and two females) were released after sunset at the site of capture at the vicinity of their roost.

Linear regression equations were derived to predict age on the basis of values of length of forearm and phalangeal joint. Using age as the dependent variable; age-estimating equations were derived using linear regression analysis.

Table1. Life-history characteristics of three *M. capaccinii* borne and bred in the flight cage

Life history characteristics and growth parameters	X ± SE
Parturition dates	9-10 May
Number of pups born	3
Mean + SE mass at birth	1.7gr+0.1
Mean + SE forearm length at birth	18mm+1.5
Growth rate of forearm (mm/day)	0.6
Growth rate of body mass (g/day)	0.09

Results

Empirical growth curves were drawn for three captive *M. capaccinii* based on body mass, lengths of the forearm, and epiphyseal gap of the fourth metacarpal-phalangeal joint (Figure 1, 2 and 3). Figure 1 demonstrates the growth pattern in body mass in three infant bats. At birth, mean body mass was 2.6gr±0.1. Growth of body weight was rapid and linear during first 3 week of age but decreased until weaning. A slight decrease in the juvenile body mass was observed before the growth curve reaches to the steady state. On the days 54, when the young bats started independent foraging in the flight cage the average body mass of juveniles was 6.5g±0.2. This corresponded to 80.24% of the adult weights. The rate of body mass gain during first 20 day was 0.09 g/d.

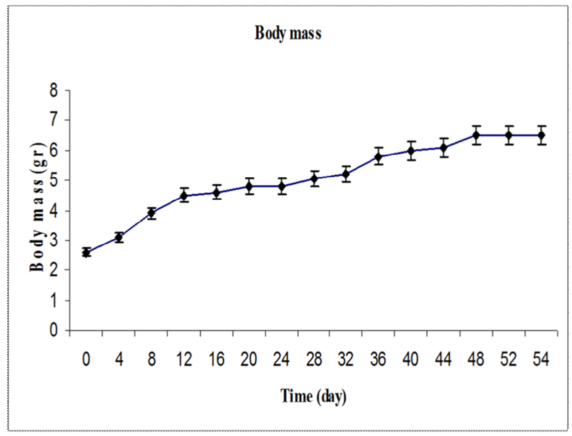

Figure 1. Growth of the body mass of three young *M. capaccinii* from day 1 to 54 in a flight cage.

Figure 2 demonstrates average changes in the forearm length of three *M. capaccinii* neonates. On the day of birth, mean forearm length for the three new born was 18 mm±.1.5. Similar to body mass, growth was rapid and linear during the 3 week of the experiment. The size of forearm at birth was 41.86% of the adult length. At the time of release (54 days), the average length for forearm was 34.56 ± 0.4 mm. This was 80.37% of the mean length for adults. The average rate of forearm growth for the early period of growth was 0.6mm/d. The length of the total epiphyseal gap of the fourth metacarpal-phalangeal joint showed a linear increase until 12 days and then decreased with increasing age until 50 days, when it fused (Figure 3). The rate of decrease in the total gap during day 12 until days 48 was -0.14 mm/d.

In order to derive age-predictive growth equations from pooled data on the length of forearm (1-24 days), body mass (1-24 days) and total epiphyseal gap (12-50 days) a least-squares linear regression model was used. To derive an age-predictive equation for the length of forearm, body mass and epiphyseal gap the axes on the growth curves for the identified period are reversed and age for the specific periods are considered as the dependent variable (Kunz and Anthony 1982). Based on the coefficient of determination for the relationships between length of forearm and age, and length of total epiphyseal gap and age, these equations can be used to estimate the age of *M. capaccinii* pups. Results of these linear regressions are shown in Figure 4, 5 and 6 respectively.

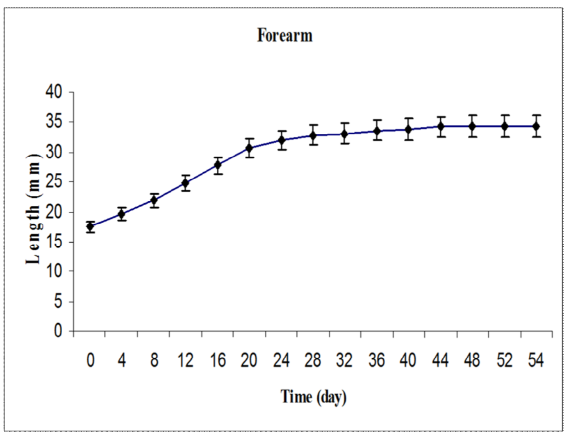

Figure 2. Growth of the length of the forearm of three young *M. capaccinii* from day 1 to 54 in a flight cage

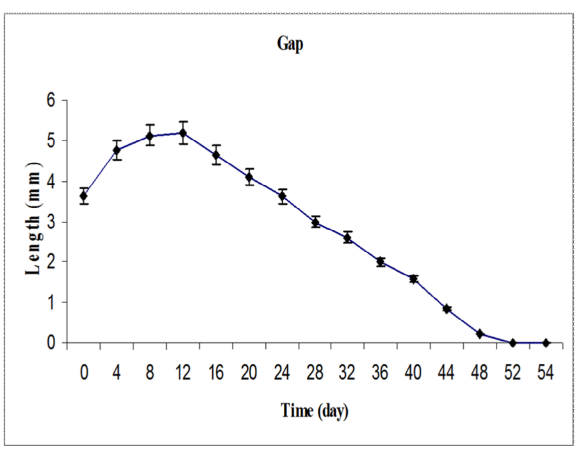

Figure 3. Growth of the fourth metacarpal-phalangeal joint of three young *M. capaccinii* from day 1 to 52 in a flight cage

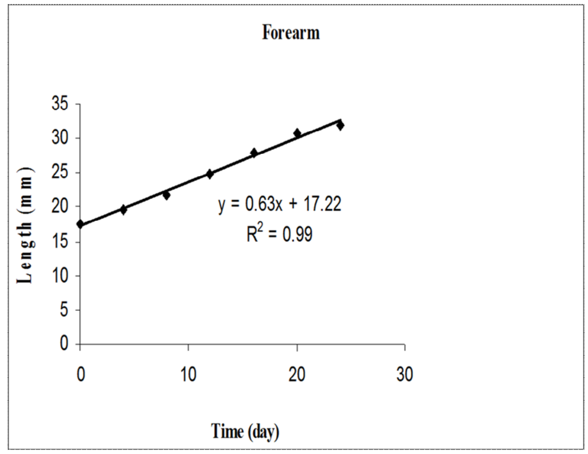

Figure 4. Regression line estimating the age of *M. capaccinii* from the values of the length of forearm for 24 days after birth.

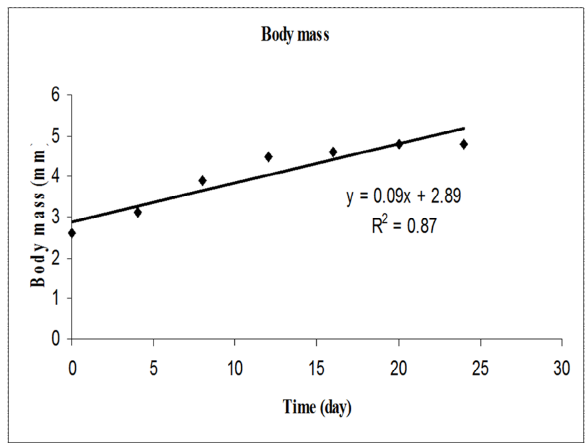

Figure 5. Regression line estimating the age of *M. capaccinii* from the values of body mass for 24 days after birth

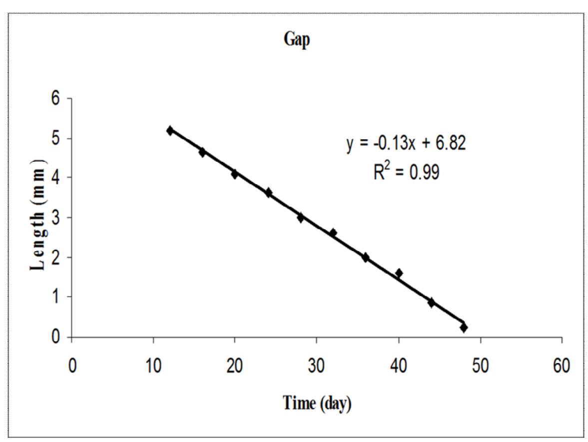

Figure 6. Regression line estimating the age of *M. capaccinii* from the values of epiphyseal gap from 12-50 days after birth

Data on postnatal growth for *M. capaccinii* is not available to the authors. Therefore, the present study may provide the first documented data on postnatal growth for this bat. However, it should be noted that the pattern of growth obtained in this experiment may differ from that under the natural situation. Such differences may be due to the effect of maternal nutrition on the growth of juveniles and also their inability to fly freely under captivity. It has been reported that the growth patterns in bats reared in captivity demonstrate less variation and may exceed to that observed under natural condition (Kleiman 1969, Kunz and Stern 1995).

The pattern of postnatal growth and development obtained for *M. capaccinii* is similar to many other species of bats showing linear increase in the length of forearm and growth of body mass during the preflight period (Kunz 1987, Kunz 2009). Similarly, the epiphyseal gap increased during first 12 days after birth and decreased until the closure of the gap at about 50 days of age. Forearm length and body mass of *R. mehelyi* increased linearly during the early postnatal period, and then decreased until approached to the steady state condition. The length of the total gap of the 4th metacarpal-phalangeal joint showed an increase, and then linearly declined in the later period (Sharifi 2004b, Sharifi and Vaissi 2013). All pups of *M. capaccinii* experienced a loss of body mass on the 4 week near the onset of flight (Figure1). Several other studies have also shown a similar recession in body weight (e.g. Kleiman 1969, Kratky 1970, Maeda 1972, Sharifi 2004b). It has been suggested (Kunz 1987) that recession of body mass in pups may reflect depletion of fat reserves following the onset of flight or a shift by young animals from a diet of milk to one of insects. However, this recession in body mass has also been reported in captive bats (Hoying and Kunz 1998). Therefore, the energy demands associated with early flight cannot fully explain this decrease. The pattern of growth in body mass during the postnatal period in *M. capaccinii* was more variable when compared to growth of the forearm. This has also been reported in other studies (Sharifi 2004b, Sharifi and Vaissi 2013), and is believed to be the result of higher responsiveness of body mass to environmental conditions than forearm length (Kunz and Robson 1995).

In studying postnatal growth in free-ranging mammals, neonates are not easily available. Although some colonial insectivorous bats provide good opportunity for such studies because pups are often accessible in maternity roosts for at least first few weeks after parturition (Kunz and Robson 1995, Kunz 2009) but the process of capturing, banding and subsequent recapturing of the pups during the course of the postnatal growth may cause harm to the newborn animals. Alternatively, investigation on the postnatal growth may be carried out under captive condition in which access to the neonates is much easier.

Among other three species of bat reproducing in the Mahidasht cave (*Myotis blythii*, *R. mehelyi* and *Miniopterus schreibersii*), The degree of synchrony at birth and the subsequent variation in size during the course of the neonatal growth in *M. capaccinii* is similar to that of *R. mehelyi and Miniopterus schreibersii*. This synchrony in parturition and growth rate may reflect their similarities in their body mass. However, *M. blythi*, which is a bigger species in the same cave, has more unsynchronized birth timing. Observations on fledging and foraging of young of the three bat species indicate that, although the bigger bat species (*M. blythii*) gives birth earlier, higher growth rate in smaller species causes an overall synchronization in foraging and other activities of the bat community in late summer and early autumn (Sharifi *et al*. 2004a, b). Further research is needed to determine whether the present variation in parturition in these species is a part of the species reproductive strategy or a reflection to the environmental variation.

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