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EFFECT OF LACTATION ON FOOD CHOICE AND ENERGY BALANCE IN THE SHORT-NOSED FRUIT BAT, *CYNOPTERUS SPHINX*

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ABSTRACT
Reproductive status is one of the potential intrinsic factors that influence the fruit consumption and feeding behaviour of frugivorous bats. In order to study the effect of lactation in the short-nosed fruit bat (*Cynopterus sphinx*), the rate of food intake of lactating females was compared with males and non-lactating females. Ripe fruits of guava, papaya, grape, custard apple and banana were offered to the males, non-lactating females and lactating females, maintained in captivity. The three categories of experimental bats showed differential quantities of food intake. However, all the three categories of bats consumed higher amount of guava and papaya than other varieties of fruits. The quantity of fruit consumption ranged from 52.8 % to 166.6 % mean body mass of males, 55.0 % to 178.5 % mean body mass of non-lactating females and 73.0 % to 216.9 % mean body mass of lactating females. Invariably, the lactating females consumed significantly higher quantity of fruits compared to males and non-lactating females ($F_{2, 4}$ = 15.2, $P < 0.001$). The males and the non-lactating females consumed nearly equal quantity and there was no significant difference on their food consumption ($t = 0.24$, $P > 0.05$). The greater amount of fruit intake during lactation is apparently essential to fulfill the energy requirement. In general all the three groups of bats over ingested the energy poor fruits such as guava, papaya and grape than energy rich fruits like custard apple and banana. It infers that the fruit bats could able to meet their energy requirements by adjusting their food intake.

KEYWORDS: *Cynopterus sphinx*; Energy balance; Frugivorous bat; Fruit intake; Lactation

INTRODUCTION

Bats are the largest group among the mammalian frugivores. The Old World fruit bats purely rely on fruits, in a mere extend they feed upon leaf, nectar and flowers/pollen to fulfill their nutritional requirements (Elangovan, 2000). The foraging behaviour of obligate frugivores constrained by many extrinsic factors such as nutritional quality, abundance and temporal availability of fruits (Elangovan et al., 1999, 2001). Similarly, the food choice and foraging behaviour of fruit bats constrained by a variety of intrinsic factors includes body size, sex and reproductive status (Fleming, 1982, 1988). The foremost goal of animals is to obtain sufficient energy and nutrients for maintenance, growth and reproduction (Rasweiler, 1977). The fruit intake and preference have been studied on phyllostomid bats by observing the amount of food consumption in captivity (Stashko, 1982; Bonaccoroso and Gush, 1987). Frugivorous species of the paleotropical family Pteropodidae rely on nutrition poor fruits but apparently they don't supplement insects as diet (Thomas, 1984). Studies on pteropodid bats suggest that they could balance protein requirements on fruit diet, but they were forced to over-ingest energy to do so (Thomas, 1982; Wheelwright and Orians, 1982).

This study documents the influence of lactation on food choice and positive energy balance in the short-nosed fruit bat *Cynopterus sphinx*. *Cynopterus sphinx* is a tent roosting frugivorous bat widely distributed in India and Southeast Asia. It feeds upon 23 species of fruits, 8 species of leaves (Bhat, 1994), flowers of *Coccinia indica* (Elangovan et al., 2001), and nectar from *Musa paradisiaca*, *Bassia latifolia* (Elangovan et al., 2000) and *Ceiba pentandra* (Singaravelan and Marimuthu, 2004; Nathan et al., 2005).

MATERIALS AND METHODS

Bats of both sexes were captured at the botanical garden of Madurai Kamaraj University (lat 9° 58' N, long 78° 10' E), using mist net (AVINET). Advance stage pregnant bats were maintained in captivity till parturition, thereafter the lactating females were used for the experiments. A total of five males, five non-lactating females and seven lactating females were used in this study. Bats were individually maintained under captivity in nylon mesh cage (1.0 X 0.5 X 0.5 m) under 12:12 h light and dark cycles. A plastic sheet was spread at the bottom of each cage to collect the stools and discarded materials.

Bats were fed with five varieties of ripe fruits, such as guava *Psidium guajava*, papaya *Carica papaya*, grape *Vitis vinifera*, custard apple *Annona squamosa* and banana *Musa paradisiaca*. Each bat was fed with 200 g of any one variety of the above mentioned fruits for nine days randomly to avoid habituation for certain varieties of fruits. The discarded materials and stools were removed at 0600 h of the following days and weighed to the nearest 1.0 g using a spring balance (AVINET). The quantity of food intake of individual bat was calculated after correcting the desiccation loss from control samples (Thomas, 1984). The energetic values of different fruit varieties were obtained from Gopalan et al. (1980) and furthermore the values were used to calculate the energy content in the consumed fruits. One Way Repeated Measures ANOVA was performed to find out the statistical difference in the quantity of fruit consumption and thus energy uptake by the three categories of bats. In addition, Bonferroni t-test was performed for pair-wise multiple comparisons among male, non-lactating females and lactating females. Throughout the text the values are given as mean ± SD.

RESULTS

All the three categories of bats started visiting the fruits about 20 min after placing the latter inside the cages during dark hours. Always they collected pieces of fruits in their mouth, reached their roosting sites and started consuming them leisurely. The bats chewed the fruit pieces, swallowed the juice and dropped the bolus. The lactating females deposited their pups in their roosting places before leaving to collect the fruit pieces. All the three categories of bats (body mass: male 48.3 ± 1.1 g, non-lactating female 45.4 ± 0.97 g and lactating female 48.6 ± 1.2 g) consumed greater amount of guava and papaya than other three varieties of fruits (Fig. 1). All the three categories of bats actively ingested the energy rich fruits such as *A. squamosa* and *M. paradisiaca* during early hours of the night with short inter-bout interval (10 – 15 min), whereas they fed the energy poor fruits throughout the night with long inter-bout interval (15 – 25 min). The mean quantity of fruit consumption ranged from 52.8 % to 166.6 % mean body mass of males, 55.0 % to 178.5 % mean body mass of non-lactating females and 73.0 % to 216.9 % mean body mass of lactating females. The quantity of food consumption across three groups of bats differed significantly ($F_{2,\ 4} = 15.2$, $P < 0.001$). However, Bonferroni t-test suggests that the amount of fruit consumption not differed significantly ($t = 0.240$, $P > 0.05$) among males and non-lactating females. Interestingly, the lactating females consumed all the varieties of fruits significantly more compared to that of males ($t = 4.893$, $P < 0.01$) and non-lactating females ($t = 4.654$, $P < 0.01$).

Energy intake from the consumed fruits showed significant difference across three groups of bats ($F_{2,\ 4} = 158.2$, $P < 0.001$). As similar to food intake, the energy intake did not differ between male and non-lactating females ($t = 0.481$, $P > 0.05$). However, there was no significant difference in the energy uptake from different varieties of fruits by male ($F_{4,\ 102} = 2.1$, $P > 0.05$) non-lactating female ($F_{4,\ 75} = 1.7$, $P > 0.05$) and lactating female ($F_{4,\ 85} = 2.4$, $P > 0.05$). The quantity of energy intake from the consumed fruits was decreased linearly until 61-day of lactation and thereafter the energy intake was stabilized (Fig. 2). However, there was no such decrement in the quantity of energy intake in males and non-lactating females during the course of experimentation (Fig. 3a and 3b).

DISCUSSION

Efficient acquisition of a nutritionally balanced diet is a major adaptive concern in the lives of all animals. It is important for frugivores, particularly the pteropodid bats that mainly rely on low protein diet (Fleming, 1988). By careful mastication of the fruits, they extract and ingest only fluids, leaving the fiber as bolus. This permits food transit times as low as 20 min (Fleming, 1988; Wolton et al., 1982) and enabling the fruit bats including *C. sphinx* to process up to 216.9 % of their body mass of low-protein diet like papaya (Gopalan et al., 1980). Such over consumption of low-protein fruits is reported in Old World megachiropterans (Delorme and Thomas, 1996; Thomas, 1984; Stellar, 1986). The fruit eating phyllostomid bats supplement their food with insects, which facilitates obtaining adequate protein (Gardner, 1977). Since pteropodid bats do not supplement their food with insects (Thomas, 1982), daily food consumption exceeding their body mass appears to be the rule for them (Thomas, 1984; Morrison, 1980; Herbst, 1986).

Our study reveals that compared to males and non-lactating females, the lactating females "over-ingested" all the varieties of fruits presumably to meet their energy demand related with nursing their young (Kunz, 1987; Barclay, 1989). During early lactation the lactating females met their energy requirement to suckle their babies by over ingesting all the five varieties of fruits. The energy requirement of lactating females decreased linearly with progress of lactation. As like early lactation, there was no over ingestion during post-lactational period which deduce that there was no much energy demand during post-lactation period. Similarly the lactating females of phyllostomid bat *Carollia perspicillata* (Delorme and Thomas, 1996) and other microchiropterans such as *Lasiurus cinereus* (Barclay, 1989), *Eptesicus nilssoni* (Rydell, 1991), *M. velifer* (Kunz, 1974) and *Tadarida brasiliensis* (Kunz and Diaz, 1995) consume relatively higher amount than males and non-lactating females. Neuweiler (2000) reported that the pregnant females of *M. lucifugus* (10 g) consume about 5.5 g of insects per night while the lactating females consume about 6.7 g. Previous studies on *C. sphinx* suggest that males commute short distance for foraging (Marimuthu et al., 1998; Nair et al., 1999) and also they spend most of their night hours in protecting and constructing their 'tent' (Balasingh et al., 1995) which make them to consume relatively least quantity of food compared to females. Many authors reported that the daily energy demand is typically highest during lactation and lactating bats often forage for longer than do pregnant ones (e.g. Kunz, 1974; Racey and Swift, 1985; Barclay, 1989; Rydell, 1993; Wilkinson and Barclay, 1997). Chruszcz and Barclay (2003) observed that the females of *M. evotis* spent about 90% of night time in the foraging ground and involved in active foraging. Racey and Speakman (1985) suggested that lactating bats maintain their energy demand by increasing food consumption. However, there is no wide range of difference on the food consumption between males and non-lactating females.

The result strikingly shows that the pteropodid bats could able to rely on low-energy fruits. The feeding response of *C. sphinx* clearly shows that the fruit intake influenced by positive energy balance. The poor energy diet (*C. papaya*, *P. guajava* and also *V. vinifera*) of *C. sphinx* expressed a compensatory increase in fruit intake, thereby maintaining the energy requirement. Such a compensatory intake occurred only in energy poor diets but they did not exploit the high-energy fruits such as *M. paradisiaca* and *A. squamosa*. The energy requirement of *C. sphinx* particularly lactating females was compensated by rapid food intake and food transit times.

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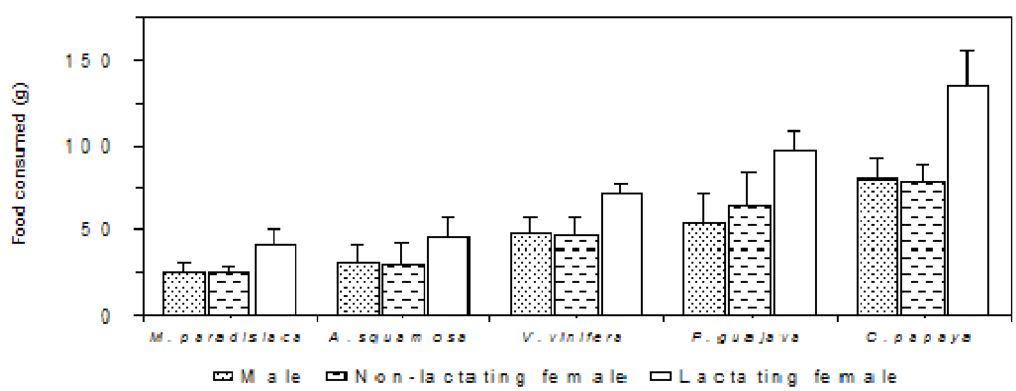

Figure 1. Quantity of mean food consumption by males, non-lactating females and lactating females. Values are given as mean ± SD.

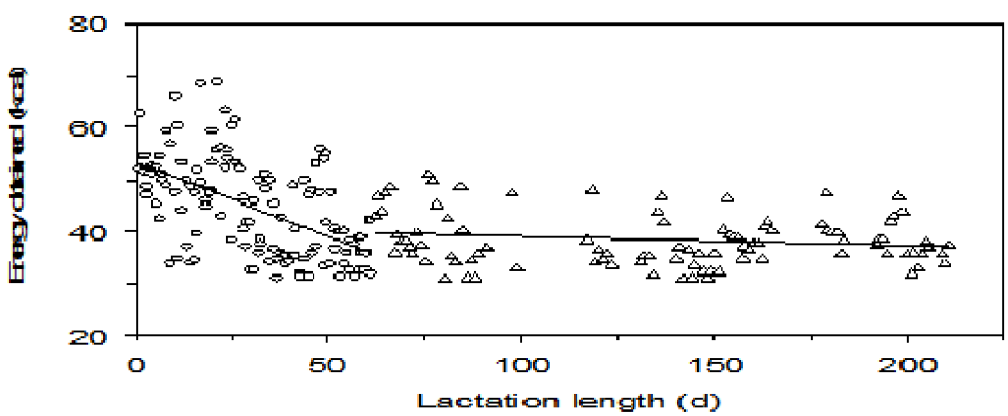

Figure 2. Quantity of energy intake during suckling period (until 61-day of lactation), r^2 = 0.299, y = – 0.2865 x + 53.345 (n = 147) and post-lactation (62 to 211-day of observation), r^2 = 0.0255, y = – 0.0169 x + 40.738 (n = 95).

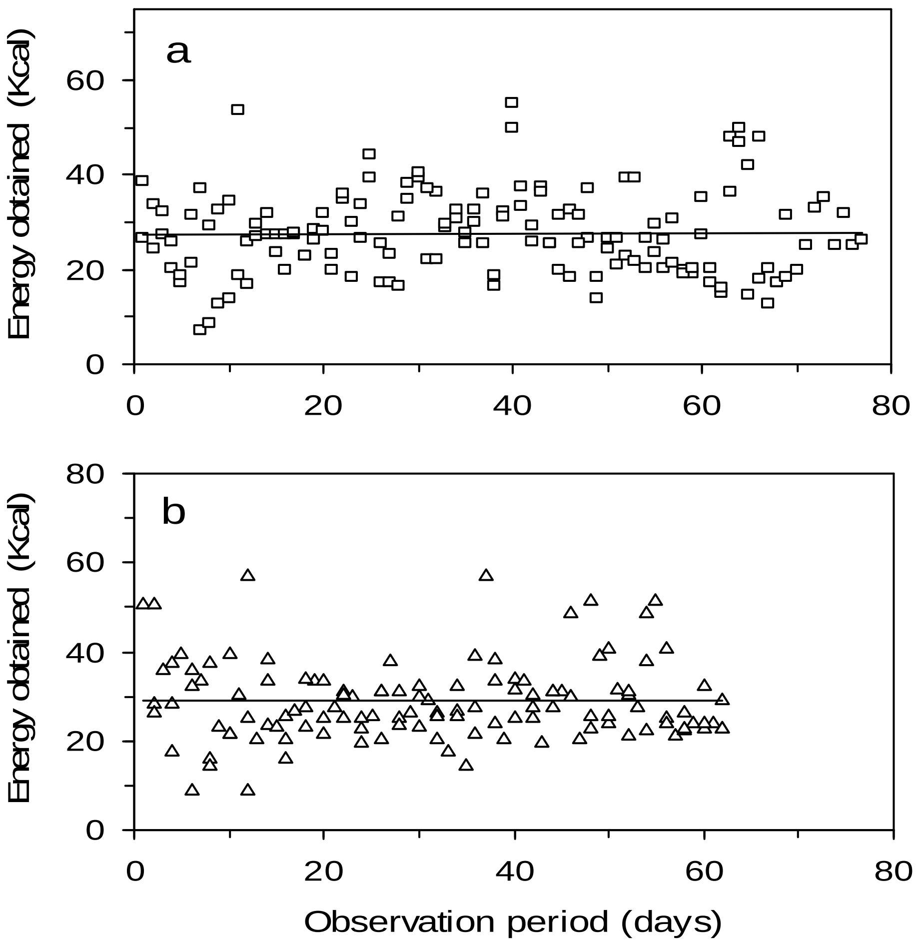

Figure 3. Quantity of energy intake during observation period by male (a), r^2 = 0.0001, y = 0.0045 x + 27.4 (n = 146) and non-lactating female (b), r^2 = 0.0017, y = 0.0204 x + 28.4 (n = 124).