The Natural History Journal of Chulalongkorn University 9(2): 223-234, October 2009

Reproductive Seasonality of Myanmar Long-tailed Macaque (*Macaca fascicularis aurea*)

AYE MI SAN[1] AND YUZURU HAMADA[2*]

[1]Department of Zoology, Yangon University, University Avenue Road, Kamayut, Yangon, Union of Myanmar.
[2]Evolutionary Morphology Section, Primate Research Institute, Kyoto University, 41-2 Kanrin, Inuyama, Aichi, 484-8506, Japan.

Abstract.– The Myanmar long-tailed macaques (Macaca fascicularis aurea) are distributed to coastal regions in Myanmar, ranging from 10˚ to 21˚N. Reproductive pattern was studied on a troop of long-tailed macaque inhabiting the steep limestone-rock Bayin Nyi Naung Mountain (16˚ 58.2' N), in Southern part of Myanmar, where the climate is seasonal. Bayin Nyi Naung Mountain troop shows the reproductive seasonality which appears to be related with the seasonal food availability. Birth season occurs from March to July that coincides with the food abundance season and mating occurs during November to February that during the lean season. There are positive correlations between rainfall and fruit availability, mean temperature and frequency of birth, fruit availability and lactation. There is a highly significant correlation between rainfall and lactation. The rainfall is critical determining food abundance and the rainy season is the best period for females to lactate to grow up their infants.

KEY WORDS: *Macaca fascicularis aurea*, Myanmar, food availability, reproductive seasonality

INTRODUCTION

The long-tailed macaques (*Macaca fascicularis*) are widely distributed in the insular and peninsular Southeast Asia ranging from ca 10˚ S to 21˚ N (Fooden and Albrecht, 1999). Fooden (1995) classified long-tailed macaques into 10 subspecies, of these the Myanmar subspecies is *M. fascicularis aurea*. This subspecies is distributed to the area along coastal regions and is continuously from Southern end (Thanintaryi Division, 10˚ N) to the Northwestern end in Myanmar (Rakhine State, border with Bangladesh, 21˚ N; Aye Mi San, 2007 and Nwe et al., 2005) with some populations inhabiting the Andaman sea coastal localities in Thailand and the southeastern-most area of Bangladesh (Fooden 1995; Malaivijitnond et al., 2005). This subspecies has rarely been reported.

Every primate species is considered to adapt to its own habitat in general, and the

*Corresponding author:
Tel: (81) 0568-63-0521
Fax: (81) 0568-61-5775
Email: hamada@pri.kyotou.ac.jp

Myanmar subspecies (*M. f. aurea*) should have adapted to their specific habitat, particularly to the habitat in rather higher latitude for the species. The climate in higher latitude tends to be seasonal in rainfall and temperature, which is reflected by the phenology of food plants. Primates living in seasonal environment with respect to food availability, rainfall, and temperature, appear to respond to different environmental signals to determine the timing of reproductive events (Crockett and Rudran, 1987; Gevaerts, 1992; Lancaster and Lee, 1965).

Annual fluctuations in food abundance undoubtedly affect the time of female fecundity and reproduction. In Old World monkeys, birth season and birth peak (Butynski, 1988, Lindburg, 1987; Nakagawa, 2000), conception period (Koenig et al., 1997), or period of lactation (Lee, 1987) appear to be determined by the food abundance. van Schaik and van Noordwijk (1985) stated that in an environment with unpredictability in the height of the annual food peak, pregnancy rather than lactation coincides with the period of food abundance.

The long-tailed macaques (*M. f. fascicularis*) distributed to the lower latitude do not exhibit distinctive reproductive seasonality, as Furuya (1965), Chiang (1968), and Mah (1980) reported for the wild long-tailed macaques distributed in Peninsular Malaysia and Singapore. Fittinghoff (1978) and Wheatly (1978) mentioned that *M. f. fascicularis* in Borneo produce infants in 10 months of the year at least. However, *M. f. fascicularis* in Sumatra showed birth peaked in the second half of the calendar year (van Schaik and van Noordwijk, 1988). Although it is supposed that the reproduction becomes definitive in higher latitude, no study was made.

The Myanmar subspecies (*M. f. aurea*), which ranges widely in latitude, from 10˚N to 21˚ N, is considered as the good model to elucidate the relationship between environment and reproductive seasonality. We evaluated fluctuations in the food availability, rainfall, and temperature across seasons and their effect on the pattern of reproduction of a troop in Bayin Nyi Naung Mountain (16˚ 58.2' N, BNNM), which locates the intermediate in the range of this subspecies. The climate in BNNM shows clear seasonality; hot, rainy and cool seasons with seasonal precipitation and temperature pattern. Our goal was to examine the role of food availability and environment factors that effect on the reproductive patterns of *M. f. aurea*.

MATERIALS AND METHODS

Study Area

A population of long-tailed macaques inhabiting Bayin Nyi Naung Mountain (BNNM), Kayin State, Southern part of Myanmar is the subject. The habitat locates at the right bank of the Thanlwin River, at 16˚ 58.2' N and 97˚ 29.6' E. The BNNM is a natural limestone steep mountain with wild vegetation of evergreen lowland forest. The area is surrounded by river, wetlands, agricultural fields, and human settlements. Thus, the population is isolated from neighboring conspecific populations. BNNM is low in altitude, and the highest peak of the mountain is 122 m above sea level (a.s.l), however, the slope is so steep that it is difficult to walk around the mountain. There are two major study sites; site No. 1 is situated near the entrance of the cave at 16˚ 58' 16.5" N, 97˚ 29' 37.4" E and 39 m a.s.l; site No.2 is situated at the south-western foot of the BNNM along the walking pass to the cave at 16˚ 58' 11.7" N, 97˚ 29' 36.4" E, and 3 m to 34 m a.s.l., with three ha of area. We

observed macaques from the stairways and paths connecting the two study sites. Long-tailed macaques spent most of their day time in these sites.

Climate and Vegetation

Based on climatology data recorded at the Meteorological Department, Tha-ton city situating 7.7 km from the BNNM, between January 2005 and May 2007. The climate is characterized by three defined seasons: a hot dry season from March to May, rainy season from June to October and a cool dry season from November to next February. July and August are the two wettest months, contributing 56% -58% of the total annual rainfall. The mean monthly rainfall and temperature during January 2004 to May 2007 were shown in Fig. 1.

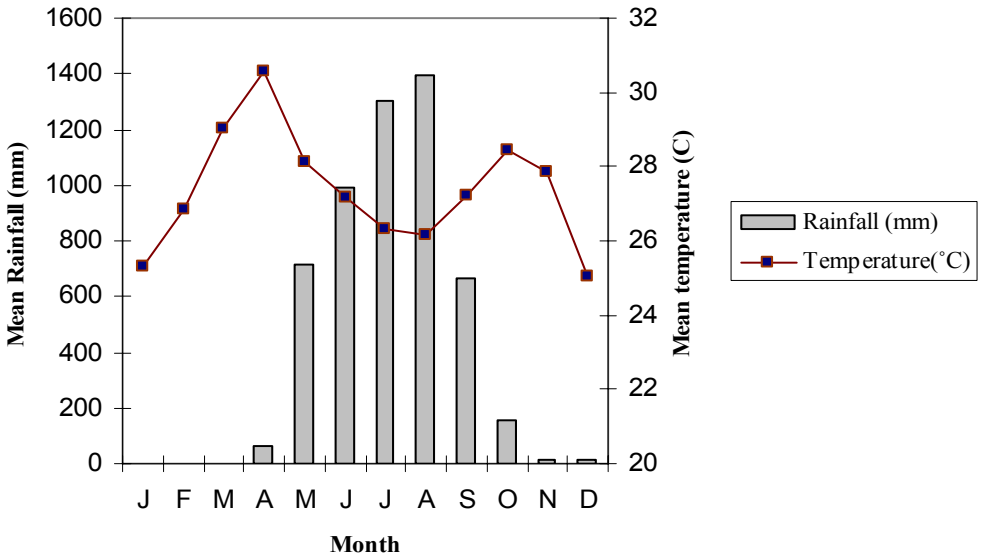

FIGURE 1. Monthly temperature and rainfall at the Meteorological Station of Tha-ton.

Although the wild vegetations cover the whole mountain, vegetation in the two study sites were changed by humans, which are dominated by *Ficus* sp., *Litsaea* sp., *Artocarpus* sp., *Mangifera indica, Xylia* sp., *Annona* sp., *Carica papaya* and *Stephania venosa.* The food plants were identified and phenological states, that is, presence or absence of young leaves, ripe or unripe fruits, and flowers, were determined. The percentage availability of fruits were monthly calculated.

Subject Population

The subject macaques were classified as the *Macaca fascicularis aurea* by their morphological traits, that is, infrazygomatic pattern of cheek hairs and no hair-crest at the vertex of the head (Fooden, 1995; Aye Mi San, 2007). Individuals were classified into six sex-age classes based on their morphological characteristics:

Adult Male (Ad-M): secondary sexual traits completely developed, such as muscular

body, distinct cheek hair and fully erupted canines

Adult Female (Ad-F): parous with nipples elongated by suckling

Sub-adult Male (Sub-M): fully grown linear body size with suspension of testicle

Sub-adult Female (Sub-F): reproductively mature but nulliparous indicated by the shorter nipples

Juvenile (Juv): weaned and reproductively immature

Infant (Inf): blackish pelage and carried by the mother. The color gradually changed during development. Neonates (age less than 1 month) were determined by size, blackish pelage, pinkish skin, forehead hair pattern, and uncontrolled behavior.

Individual Identification and observation

Seven adult males and eleven adult females were selected as focal animals. All these individuals were identified by their natural marks on the body (scars, lack of finger, wart, and so on), physiognomic differences, pelage color pattern, body size and habit.

Observation of Behavior

Behavioral observation was made bi-monthly in four consecutive days on 18 focal animals. We visited the BNNM two times per season, and totally 15 times of observations were made during January, 2005 to May, 2007. Instantaneous focal animal sampling (Martin and Bateson, 2000) was used to record the activity (rest, feed, travel and social) of each focal animal in 3-min intervals. Focal samples lasted for 15 min, were conducted between 07:30 and 17:30 hr daily. During the study period we completed 2,160 (15 min) focal samples totaling 540 hr of focal observations.

Swelling states were recorded for focal animals as follows (Engelhardt, et al. 2004);

r red coloration (without swelling) around the genitalia

\+ slight swelling under the tail root

++ medium-sized swelling under the tail root

+++ large swelling under and sides of the tail root continuous to the genitalia

All socio-sexual behaviors, including sexual solicitation, copulation, interference in copulation, and rejection of copulation were recorded. In addition to the recording of sexual interactions, mating partners were identified and consortships were recorded with the focal animal sampling method**.**

The pregnant females and neonates and/or small infants were counted. Although the exact dates of births could not be determined, we assigned a birth month to each infant based on monthly census data (From January, 2005 to May, 2007) and the developmental states (body size, pelage color, and positional behavior).

Data Analysis

Feeding activity data were summarized by diet category and percentage of food availability was calculated for each month. Fruit availability (%) was calculated by the division of number of fruit species with the total number of plant species and multiplication of 100. The Simpson's Diversity Index (Levins, 1968) was used to evaluate seasonal variation in dietary diversity. The index was calculated as follow: $D=1/\sum P_i^2$, where P_i was the observed feeding frequency of i-th plant species. According to Eisenberg et al. (1981), annual birth rate [b] was obtained by $b= I_t/F_t$, where I_t is the number of births observed in a year (t) and F_t is the number of adult females observed during the same period. All analyses were performed using SPSS statistical software version 13.5.

RESULTS

Population Structure

The population size of the long-tailed macaque in BNNM was found to range from 29 to 49 animals (mean 39.7±4.9). Fig. 2 shows the mean numbers for age and sex classes. The sex ratio was 1: 1.2 (male: female), and the mean number of adult male was significantly smaller than that of adult female (t= -3.595, P= 0.003).

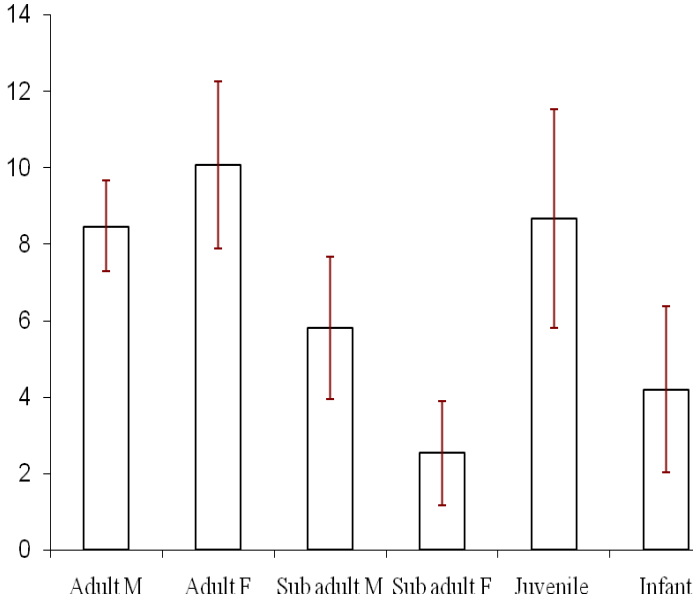

FIGURE 2. Population structure of Bayn Nyi Naung Mountain troop: Mean number and standard deviation in each age and sex class.

Food Availability and Diet

Based on the individual activity records of feeding, the long-tailed macaque used at least 23 plant species from 15 families in two study sites of BNNM (Table 1). The number of natural food plant species fluctuated seasonally from 9 to 17. Availability of fruits (number of species) in the BNNM peaked from June to July, that is, during the rainy season; and reached the nadir during the cool season (Fig. 3).

TABLE 1. List of Plant Species Utilized as Food in BNNM

Scientific Name	Myanmar Name	Family	Status*	Fruit	Leaf	Flower	Stem
Ficus glomerata	Thapan	Moraceae	T	√	√	√	
Ficus sp.	Nyaung	Moraceae	T	√	√	√	
Artocarpus heterophyllus	Peinne	Moraceae	T	√	√		
Mangifera indica	Thayet	Anacardiaceae	T	√	√	√	
Zizyphus jujuba	Zi, Zi-daw	Rhamnaceae	T	√			
Moringa oleifera	Dant-tha-lon	Moringaceae	T	√	√	√	
Carica papaya	Thinbaw	Annonaceae	T	√	√	√	
Annona sp.	Awza	Annonaceae	T	√	√	√	
Eugenia	Taung-thabye	Myrtaceae	T	√	√		
Averrhoa carambola	Zaung-ya	Averrhoaceae	T	√	√		
Shorea cinerea	Kadut	Dipterocarpaceae	T	√	√		
Cedrela serrata	Taung-tama	Meliaceae	T	√	√	√	
Tamarindus indica	Magyi	Caesalpiniaceae	T	√	√		
Phyllanthus urinaria	Taung-zi-phyu	Euphorbiaceae	T	√			
Litsaea sp.	Ondon	Lauraceae	T		√		
Cynodon dactylon	Myesa-myet	Graminae	G				√
Paspalum distichum	Sinngo-myet	Graminae	G				√
Convolvulus arvensis	Kyauk-yo-nwe	Convolvulaceae	C		√		√
Ipomoea sp.	Kazun	Convolvulaceae	C		√		√
Amarantus spinosus	Hinnu-nwe-subauk	Amarantaceae	H		√		
Citrus sp.	Than-ba-ya	Rutaceae	Sh	√			
Citrus decumana	Kywe-gaw	Rutaceae	Sh	√			
Dendrocalamus sp.	Hmyin-wa	Graminae	B		√		

*: Status of plant, T for Tree, G for Grass, C for Climber or Creeper, H for Herb, Sh for Shrub, and B for Bamboo.

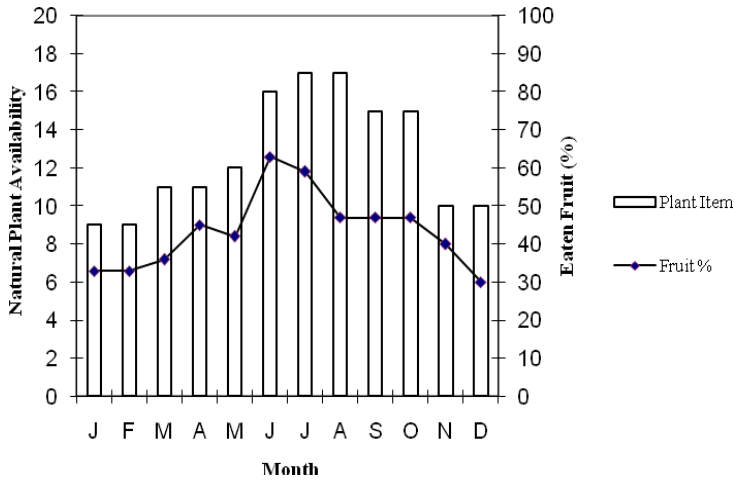

FIGURE 3. Availability of natural plant foods and percentage of fruit species eaten.

Simpson's diversity index ($D=1/\sum Pi^2$) ranged from 7.17 in cool season to 8.08 in rainy season, and the overall average was 7.61. In all seasons four species of plants were most frequently used by macaques, that is *Ficus* sp., *Ficus glomerata*, *Mangifera indica* and *Artocarpus* sp. or *heterophyllus*.

Fluctuation of mating and birth

Although the occurrence of estrous cycle is spread rather evenly over the year, the highly frequency of the mating occurred in November to February (cool season), which is the period of low plant food availability (Fig. 4).

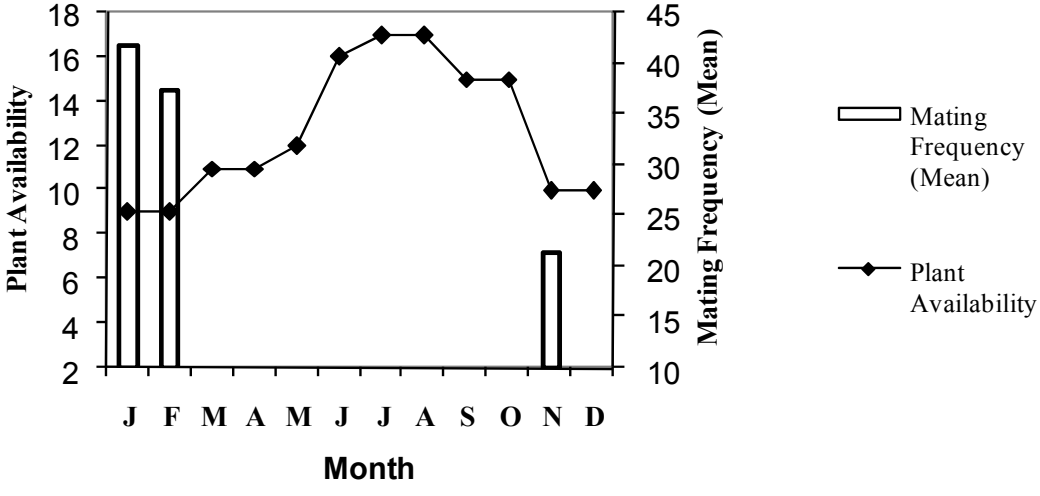

FIGURE 4. Relationship between the ratio of females (%) showing mating behavior and availability of food plants.

Seasonality of Birth

Early pregnancy could not be discerned visually, however, mid or late pregnancy could be noticed by the body profile of females. At least four females were pregnant in the year 2005 and seven in 2006 and six in the year 2007 (observation was made until May). A total of 15 births and two pregnant females (in May 2007) occurred in study group. Live births were found for these females showed pregnancy. The birth rate (b) from year to year ranged from 0.36 infants/female/year in 2005, 0.54 in 2006, and 0.31 – 0.46 in 2007 (according to the result of the two pregnant females).

Birth dates, which were determined from the focal observation of pregnant females and the developmental states of neonates and infants, were confined to the period from March to July. The greatest number of births per month, four, was recorded in March out of seven births in the year 2006. Neonates carried by their mothers were not found in September to February during the study three years (Fig. 5).

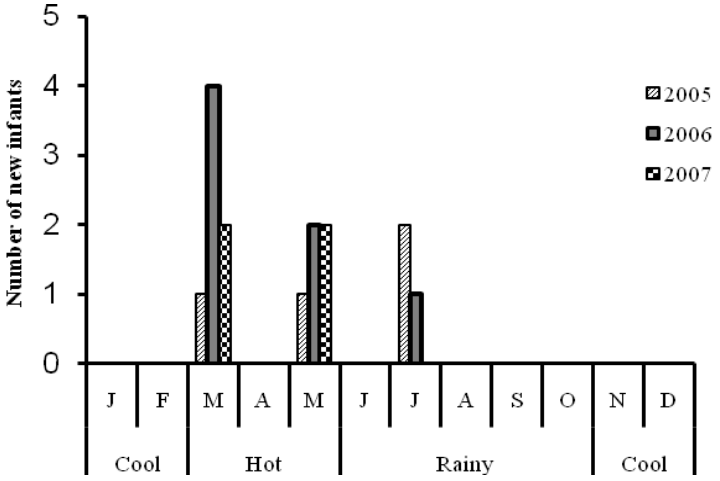

FIGURE 5. Number of neonates in the study period from 2005 January to 2007 May.

Relationship among Climate, Food Availability and Reproduction

We calculated Spearman's coefficients of correlation among climate (monthly means of rainfall and temperature), food availability (leaves and fruits) and reproduction (births and lactation). We found significant correlations between rainfall and availability of fruits (Rs = 0.509, P = 0.005) and a negative correlation between mean temperature and availability of fruits (Rs = -0.566, P = 0.001). There is a positive correlation between rainfall and young leaves (Rs = 0.417, P= 0.029) and a highly significant one between mean temperature and availability of leaves (Rs = -0.630, P = 0.000). There is a positive correlation between mean temperature and birth (Rs = 0.471, P = 0.010) in the BNNM group. However, there is no relationship between rainfall and birth (Rs = -0.021, P= 0.921). There is also a highly significant correlation between rainfall and number of lactating females (Rs = 0.812, P= 0.000) and no relationship between mean temperature and number of lactating females (Rs = 0.181, P= 0.347).

A negative correlation was found between birth and availability of leaves (Rs = -0.405, P= 0.029) and no relationship was found between birth and fruit availability (Rs = -0.198, P = 0.303). The positive correlation was found between availability of fruits and number of lactating females (Rs = 0.472, P = 0.010) and there is no relationship between number of lactating females and availability of young leaves (Rs = 0.0204, P= 0.289).

DISCUSSION

Reproductive Seasonality

The primates distributed to the higher latitude tend to be seasonal breeders. Long-tailed macaques (*Macaca fascicularis*), which are distributed to the lower latitude, have been studied to show the spectrum from non-seasonal to partially seasonal breeders (Fooden, 1995). The long-tailed macaques in Myanmar (*Macaca fascicularis aurea*) are distributed to the higher latitude for the species, and therefore, are good subject for elucidating the relationship between environment and the reproduction. In Myanmar, there are three different seasons in general, hot (March to May), rainy (late-May to October) and cool season (November to next February), and accordingly food availability is highly seasonal. The weather in BNNM also exhibits seasonal variation in temperature and rainfall (Fig. 1), with the majority of rain occurring in June through mid-October. Although we controlled neither availability of plant species nor quantity of food items, the results indicate that the BNNM forest is characterized by greater temporal variability in the availability of fruits and leaves. Fruit abundance shows seasonal fluctuation which is shown by Simpson's diversity index, the highest in rainy season (8.08) and the lowest in cool season (7.17). The peak in flowers and young leaves at BNNM begins just prior to or at the early stage of the rainy (wet) season. There is a positive correlation between rainfall and fruit availability and negative correlation between mean temperature and fruit availability.

Correlation between birth and food availability has also been confirmed in many species of primates, including Cercopithecines in Asia (Andelman, 1986). BNNM population follows the ordinary reproductive seasonality. Field studies have shown that the yearly pattern of reproduction is related to rainfall and food availability in squirrel monkey (*Saimiri,* Boinski and Fowler, 1989), so that the birth season occurs during the time of the year when fruit production is the greatest (Boinski, 1987).

The seasonality of foods is the determinant of reproductive seasonality. Most colobine monkeys in Africa, which are mainly folivores, breed throughout the year with a variable pattern of birth peaks (Struhsaker and Leland, 1987), and baboons, which are omnivores (graminivores), are also non-seasonal breeders. On the other hand, long-tailed macaques at BNNM are primarily folio-frugivores and utilize at least 23 species of trees and shrubs. Among them, they frequently used four species of tree plants. The *Ficus glomerata*, that is the major food fruits, offers not only fruits but also leaves and buds which are exceptionally available throughout year. Yeager (1989) stated that dietary necessity is the most highly satisfied during the period of high fruit availability and the least during periods of fruit scarcity.

The BNNM long-tailed macaques had definite season of birth restricted to five months in a year, from March to July (hot and rainy season), just before the peak of fruits and leaves (June and July) (Fig. 6). Mating and conception occurred during cool season (November to February) when

animals are in good nutritional condition after feeding on abundant fruits and young leaves (June to October) (Fig. 4). Pregnancy lasted the whole cool season when the troop only relied on poor food resources. Births occur in hot and early rainy season (March to July), when fruits and young leaves are flourishing, which fulfilled the nutritional requirements of lactating females.

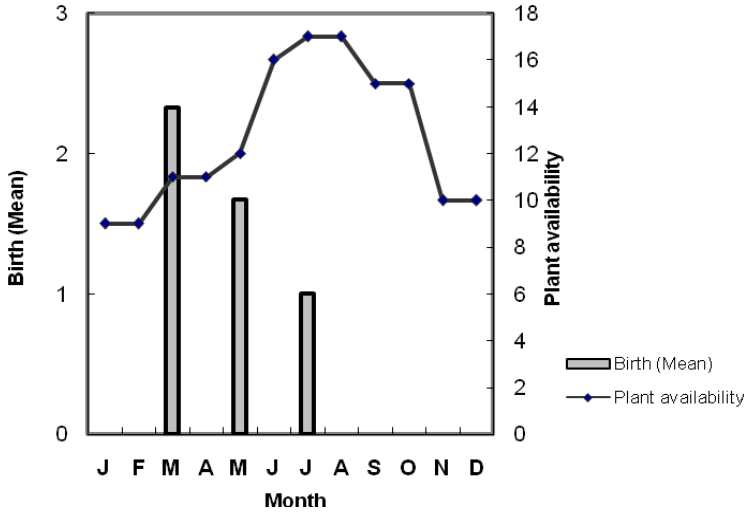

FIGURE 6. Relationship between the number of birth and availability of natural plant.

The lactation may be the major determinant of the reproductive seasonality. In BNNM, the birth season starts from the March (hot season) and the mid or late-lactation which necessitates mother to greatly invest coincides with the timing of higher rainfall and higher fruit availability, in June to October (rainy season). There is a positive correlation between the fruit availability and number of lactating females. The period from mating (conception) to the birth coincided with that of the low availability of fruits and young leaves in BNNM.

Van Schaik and van Noordwijk (1985) suggested that there are two different strategies in which monkeys tune their reproductive cycle to the food availability; one is that the conception coincides with the lean season and lactation with the period of rising and high food availability, and another is that the period of pregnancy is during a rise in the availability of food to store reserves. Myanmar long-tailed macaques followed the first strategy.

What environmental cue starts mating is not known for the long-tailed macaques (*M. f. aurea*). Temperature (and daytime) seemed to have the greatest impact on the initiation of mating season. As temperature decreased, number of mating per month increased. Births (parturitions) occurred when it was hotter. This is the pattern that was expected and also is in agreement with Dumond's (1968) observation of mating during winter and births during summer. Thus, BNNM troop follow the ordinary reproductive seasonality.

ACKNOWLEDGEMENTS

We extend our sincere thanks to Reverend and all monks at the Bayin Nyi Naung Mountain, who permitted to conduct research. All research reported in this manuscript are in compliance with animal care regulations and adhered to the legal requirements of Myanmar. The manuscript was improved thanks to the comments provided by two anonymous reviewers. We express our special thanks to Wildlife Conservation Society (WCS) Myanmar for financial support.

LITERATURE CITED

Andelman, S. J. 1986. Ecological and social determinants of Cercopithecine mating systems. Ecological aspects of social evolution. Princeton; Princeton University Press. pp. 201-216.

Boinski, S. 1987. Birth synchrony in squirrel monkeys (*Saimiri oerstedi*). Behavioral Ecology and Sociobiology, 21: 393-400.

Boinski, S. and Fowler, N. L. 1989. Seasonal patterns in a tropical lowland forest. Biotropica, 21: 223-233.

Butynski, T. M. 1988. Guenon birth seasons and correlates with rainfall and food. In: Gautier-Hion A, Bourlière F, Gautier J-P, Kingdon J, editors. A primate radiation: evolutionary biology of the African guenons. Cambridge: Cambridge University Press. pp. 284-322.

Chiang, M. 1968. The Annual Reproductive Cycle of a Free-living Population of Long-tailed Macaques in Singapore, Master Thesis, University of Singapore, Singapore.

Crockette, C. M. and Rudran, R. 1987. Red howler monkey birth data. I: seasonal variation. Am J Primatol 13: 347-368.

DuMond, F. V. 1968. The squirrel monkey in a seminatural environment. The squirrel monkey. New York: Academic Press. pp. 87-145.

Eisenberg, J. F., Dittus, W. P. J., Fleming, T. H., Green, K., Struhsaker, T., and Thorington, R. W. 1981. Techniques for the study of primate population ecology. Washington, DC: National Academy Press, pp. 135-155.

Engelhardt, A., Pfeifer, J. B., Heistermann, M., Niemitz, C., van Hooff, J. A. R. A. M., and Hodges, J. K. 2004. Assessment of female reproductive status by male longtailed macaques, *Macaca fascicularis*, under natural conditions. Animal Behaviour, 67: 915-924.

Fittinghoff, N. A. 1978. *Macaca fascicularis* of Eastern Borneo: Ecology: Demography, Social Behavior and Social Organization in Relation to a Refuging Habitus, Doctoral thesis, University of California, Davis.

Fooden, J. 1995. Systematic review of Southeast Asian longtail macaques, *Macaca fascicularis* (Raffles, [1821]). Fieldiana: Zoology (new series), 81: 1-206.

Fooden, J. and Albrecht, G. H. 1999. Tail-length variation in *fascicularis* –Group macaques (Cercopithecidae: *Macaca)*. International Journal of Primatology, 20: 431- 440.

Furuya, Y. 1965. Social organization of the crab-eating monkey. Primates, 6: 285 - 336.

Gevaerts, H. 1992. Birth seasons of *Cercopithecus*, *Cercocebus* and *Colobus* in Zaire. Folia Primatologica, 59: 105-113.

Koenig, A., Borries, C., Chalise, M. K., and Winkler P. 1997. Ecology, nutrition, and the timing of reproductive events in an Asian primate, the Hanuman langur (*Presbytis entellus*). Journal of Zoology (London), 243: 215-235.

Lancaster, J. B., and Lee, R. B. 1965. The annual reproductive cycle in monkeys and apes. In DeVore, I. (ed), Primate Behavior: Field studies of monkeys and Apes, Holt, Rinehort and Winst, New York, pp. 486-513.

Lee, P. C. 1987. Nutrition, fertility and maternal investment in primates. Journal of Zoology (London), 213: 409-422.

Levins, R. 1968. Evolution in changing environments. Princeton: Princeton University Press.

Lindburg, D. G. 1987. Seasonality of reproduction in primates. In: Mitchell G, Erwin J, editors. Comparative primate biology. IIB. Behavior, cognition, and motivation. New York, Alan R. Liss. pp. 167-218.

Mah, Y. L. 1980. The Ecology and Behavior of *Macaca fascicularis*, Doctoral thesis, University of Malaya, Kuala Lumpur.

Malaivijitnond, S., Hamada, Y., Varavudhi, P., Takenaka, O. 2005. The current distribution and status of macaques in Thailand. Natural History Journal of Chulalongkorn University, Supplement 1: 35-45.

Martin, P. and Bateson, P. 2000. Measuring behaviour. An introductory guide, second Edition, Cambrige University Press, Cambridge. pp. 222.

Nakagawa, N. 2000. Foraging energetics in patas monkeys (*Erythrocebus patas*) and tantalus monkeys (*Cercopithecus aethiops tantalus*): implications for reproductive seasonality. American Journal of Primatology, 52: 169 -185.

Nwe, D. T., Aye Mi San, Nang Wah Wah Min, Min Kyaw Thu, Oi, T., and Hamada, Y. 2005. Species Diversity and Distribution of Primates in Myanmar. Natural History Journal of Chulalongkorn University. Supplement 1: 47-53.

San, A. M. 2007. Distribution Status of Long-tailed Macaques (*Macaca fascicularis aurea*) in Some Areas of Myanmar and Its Behavioral Study in Bayin Nyi Naung Mountain, Kayin State. Ph. D dissertation, University of Yangon.

Struhsaker, T. T. and Leland, L. 1987. Colobines: infanticide by adult males. Primates societies. Chicago: University of Chicago Press. pp. 83-97.

van Schaik C. P. and van Noordwijk, M. A. 1985. Interannual variability in fruit abundance and the reproductive seasonality in Sumatran long-tailed macaques (*Macaca fascicularis*). Journal of Zoology (London), 206: 533-549.

van Schaik C. P. and van Noordwijk, M. A. 1988. Scramble and contest in feeding competition among female long-tailed macaques (*Macaca fascicularis*). Behavior, 105: 77-98.

Wheatley, B. P. 1978. The Behavior and Ecology of the Crab-eating Macaque (*Macaca fascicularis*) in the Kutai Nature Reserve, East Kalimantan, Indonesia, Ph.D. dissertation, University of California- Davis, Davis.

Yeager, C. P. 1989. Feeding behavior and ecology of the proboscis monkey (*Nasalis larvatus*). International Journal of Primatology, 10: 497-530.

Received:6 July 2009
Accepted: 24 August 2009