Reproductive Condition of Lesser Dawn Fruit Bats *Eonycteris spelaea* (Dobson, 1871) in Nankathu Cave, Kwingauk Township, Hinthada District

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Abstract

Nankathu cave in Kwingauk Township was chosen as the study area. Bats were captured by mist nets near the entrance of the cave for a period of 12 months from June 2018 to April 2020. The reproductive status was determined based on the morphology of the bats. The reproductive pattern of *E. spelaea* appeared to be polyestrous and monotocus. The parous females were observed nearly throughout the year. Pregnant females were mainly captured before the period of maximum rainfall and end of the rainy season indicating two peaks of reproductive activity. The peak number of lactating females was found in October (end of the rainy season) and December (onset of the cold season). The results indicated that the peak of reproductive condition was not synchronized with rainfall. The reproductive condition of male was not likely to be correlated with the rainy season as the reproductive males were recorded throughout the year. The findings are important in understanding the reproductive biology of bats and in protecting this ecologically important and diverse group of mammals.

Key words: *Eonycteris spelaea*, fruit bat, reproduction, mist nets, mammals

INTRODUCTION

Most species of mammals live in the tropics and many breed seasonally, but little knows about the regulation and maintenance of their seasonal cycles. Mammals typically match peaks in food availability with lactation and / or late pregnancy because maternal energy and nutritional demands peak in lactation or late pregnancy (Heideman and Bronson, 1994).

Bats are mostly monotocous, i.e., they produce one young per pregnancy. Animals undergo either only one cycle or monoestrous or multiple cycles, called polyestrous. Some bat species are monoestrous but bimodal polyestry (two birth peaks per year) is more common in tropics. In tropical regions, patterns of parturition are highly variable (Wilson, 1979). Bats (order Chioptera) are distinguished among mammals by their capacity for true flight. They are the second largest mammals recognized 1,150 species of worldwide as reported by (IUCN, 2011). Megachiroptera are an average, larger in size than Microchiroptera. Microchiroptera are commonly known as 'fruit bat' because they eat fruit and nectar (Rainey and Pierson, 1992). The roosting and foraging behavior of nectar feeding bat can affect their interactions with plants and flowers in a variety of ways. Roosts provide sites for mating, hibernation and rearing young; they are social interaction and digestion of food; they offer protection the adverse weather and predators (Kunz, 1982). Evening emergence time of bat is subject to natural selection through effects of variation in food availability and predation risk, both of which are related to flight technique and foraging strategy (Erkert, 1982).

Birth usually takes place once (most insectivorous species) or twice (most fruit and nectar feeding bats) a year eventually year-round (in some vespertillionidae) (Hutson *et al*,

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2001). The reproductive strategies in chiropteran are quite complex and diverse; depending on the latitude and habitat type that bats in habit vary within the same family, genus and even within a species (Wilkinson and Barclay, 1997).

The cave nectar bat *E. spelaea* is found in primary forests and in distributed and agriculture area. It roots in caves. *E. spelaea* travels many kilometers each night in search of the nectar of flowering trees and shrubs. Because of that, this bat species is a very important pollinator of fruit trees, such as durians. It also feeds such as banana and jackfruit. *E. spelaea* is seen as an important species for pollination in distributed areas bordering on urban and agricultural farms.

Rising development in industries urbanization, animal husbandry and agriculture has been affecting bat's population. If these man-made disturbances prevail without any perturbation, it will lead to bat's population being threatened with extinction due to habitat loss, decreasing food resources, pollution, deliberate killing and loss of genetic diversity (Meffe *et al*., 1994). Therefore, a better knowledge on the reproductive biology is important in the management and conservation of this diverse group of mammals. This study was carried out to investigate the synchronization of the reproductive pattern between the male and female *E. spelaea* and to correlate it with the rainfall.

MATERIALS AND METHODS

Study Site

This study was carried out in Nankathu cave (17° 51' 42.9" N and 94° 56' 46.9" E) at Kwingauk Township, Hinthada District from June 2018 to April 2020(Plate 1 and 2).

Plate1.Nankathu Cave

Plate2. Map of Study Site

Bat Trapping

Bats were captured by mist nets near the entrance of the cave when they emerged to forage in the evenings and by using hand net when they rested in their roots. Data were collected to record the reproductive study of bats. 20 individuals were bimonthly captured at the cave. The bat's body mass (g), length of forearm (mm), sex and their reproductive status were classified as non- reproductive (abdominal testis) or reproductive (scrotal testis); and female as non-reproductive or nulliparous; reproductive or parous; pregnant; lactating and post lactating.

Monthly climatic data were obtained from Meteorology and Hydrology Department, Hinthada.

Statistical Analysis

The analysis of all recorded data was shown in graphic preforming Microsoft Excel Programme. Statistical analysis was made by Statistical Package for the Social Science (SPSS) version 16. Chi – square test was used to analyze the sex ratio. Significant level was defined at 0.01 and 0.05 levels.

RESULTS

Systematic position and Descriptive account of studied bat species.

Phylum - Chordata
Class - Mammalia
Order - Chiroptera
Suborder - Megachiroptera
Family - Pteropodidae
Genus - *Eonycteris* Dobson, 1873
Species - *Eonycteris spelaea* (Dobson, 1871)
Common name – Dawn bat

Diagnosis

It is a medium sized fruit bat with an average forearm length of 73.4mm. Upper parts Grey-brown to dark brown; under parts paler with neck and shoulders yellow in some individuals are found. There are short external tails and no claws on the second digit of the wing. Male has a well-marked ruff on the chin and ventral aspect of the neck; in female, this area is sparse.

Reproductive characters of male and female *E. spelaea*

Male

During the study period, mature males possessed enlarged scrotal testes. In breeding period, the colour of surrounding reproductive organ of male was known than normal condition. Reproductive behavior of male as sexual activity was forearm attaches directed towards other males. After mating, the hairs surrounding the reproductive organ of male were lesser than the normal condition (Plate 3B).

(A) Non-reproductive Male

(B) Reproductive Male

Plate 3. Reproductive Condition of Male

Female

Reproductive female of *E. spelaea* was classified as four statuses. In parous female, the nipples were clearly found to be enlarged, more or less hairless surrounding area. A pregnant female showed palpation of the abdomen and swollen mammary gland. In lactating female, the nipples were larger than normal situation and presence of milk. During lactating period, females attached with a single pup were occasionally observed. In post lactating individual, lack of milk production and gradually involution of nipple covering with more or less hair were clearly observed. (Plate 4B, C, D, E).

(A) Nulliparous (B) Parous (C) Pregnant

(D) Lactating (E) Post lactating

Plate4. Reproductive condition of female *E. spelaea*

Non-reproductive Character of Male and Female *E. spelaea*

Possession of abdominal testes indicated non-reproductive condition of male *E. spelaea*. In non-reproductive females, it could be recorded to have absence of visible nipples or nipples with hair grown over them known to be as nulliparous (Plate 3A and Plate 4A).

Sex ratio

A total of 120 bats were captured, being 41 males and 75 females during June 2018 to April 2019. According to Chi- square test of monthly data, the sex ratio of male to female (1:3) was significantly high ($P<0.05$) in February 2019 although the lowest sex ratio (1:1.2) was not significant in October 2018. The overall sex ratio 1: 1.9 of male to female was significantly different from the expected 1:1 ratio ($P<0.01$) (Table 1).

During June 2019 to April 2020, a total of 120 bats were captured, being 41 males and 79 females. The highest sex ratio of male to female (1:2.3) was observed in August 2019, February and April 2020 while the lowest value (1:1.5) was observed in June and October,

2019. The overall sex ratio (1: 1.9) of male to female was significantly different from the excepted (1:1) ratio ($P < 0.01$). (Table 2)

Reproductive Condition of Male and Female *E. spelaea*

The mean forearm length and body weight of adult male were 69.8 ± 3.57 mm (n = 82) and 68.15 ± 6.40 g (n = 82), while 67.02 ± 1.80 mm (n = 158) and 66.77 ± 3.66 g (n = 158) in adult female respectively. The body weight of females started to increase at the stage of pregnancy. The average body weight of pregnant females was 67.21 ± 7.21 g (Table 3 and 4).

Eighty two males (34%) and 158 females (66%) were captured. It included two statuses of males as non-reproductive (45%, n = 37) and reproductive (55%, n = 45) and five statuses of females as non-reproductive or nulliparous (17%, n = 27) and post lactating (8%, n = 12). During the study period, higher population of female was recorded than compared to male (Fig 1, 2).

A total of non-reproductive male (n = 37) was observed throughout the study period except December (2018 and 2019) and February (2020). The highest number of non-reproductive male was observed in April (2019 and 2020) (100%, n = 6), followed by June 2019 (62%, n = 5) and October 2018 (56%, n = 5). The reproductive male (n= 45) occurred through the study period except April. The highest number of reproductive male was observed in December (2018, 2019) (100%, n = 6) and (100%, n =6), August 2018 (71%, n = 5) and October 2019 (63%, n = 5) (Fig.3.A, 4.A).

Among the captured females (n = 158), nulliparous females (n = 27) were found throughout the study period except December 2018, October 2019 and December 2019. A total of parous of females (n = 50) were observed throughout the study period. The highest number of parous females was observed in February 2019 (67%, n = 10), 2020 (64%, n = 9) and followed by December 2018 (43% n = 6). Pregnant females (n = 32) occurred throughout the study period except August (2018, and 2019) and December 2019. The highest number of pregnant females were observed in April 2019 (43%, n = 6), April 2020 (36%, n = 5) and followed by June 2019 (33%, n = 4), and October 2018(36%, n = 4). Except February (2019, 2020) lactating females (n = 37) also occurred throughout the study period. The highest number of lactating females occurred in October 2019 (58%, n = 7) and December 2018 (43%, n = 6) and followed by June 2018(42%, n = 5). Post lactating females (n = 12) were observed in August (2018, 2019) and December 2019 (Fig.3.B, 4.B).

Reproductive Condition of Female *E. spelaea* on association with rainfall

Parous females were observed almost throughout the year. Lactating female was also recorded all year round except February. The peak of lactating female was observed in end of rainy season (October) and onset of cold season (December). It was also noted that the breeding condition of female *E. spelaea* was not related to the rainy season.

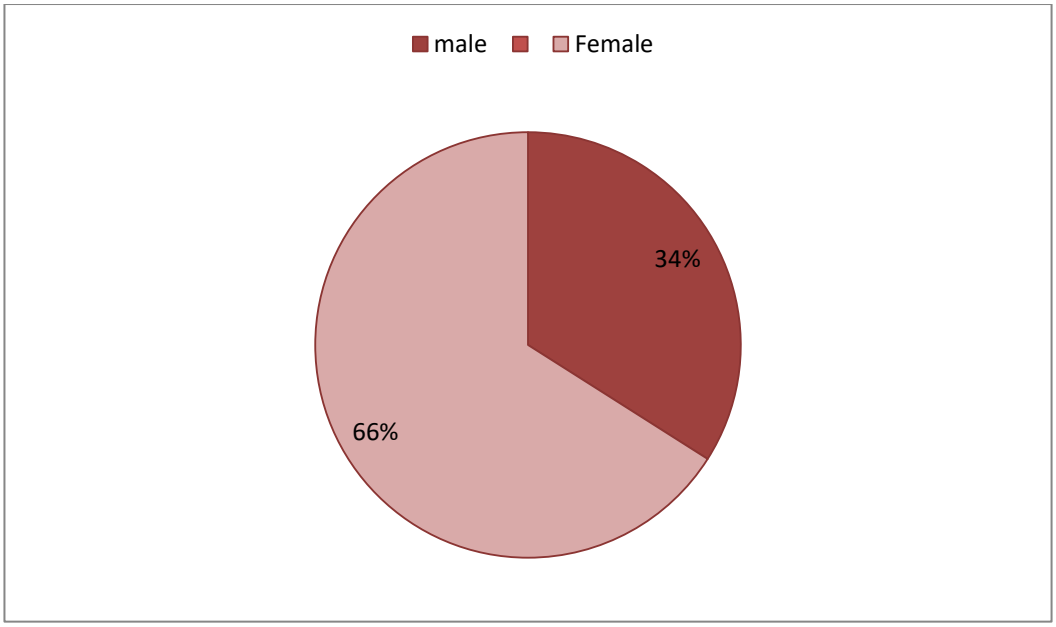


Fig 1. Proportion of Captured Male and Female

Table 1. Variation in Sex Ratio of *E. spelaea* in 2018-2019

Month	♂		♀		Chi-square	P value	Sex ratio
	No.	%	No.	%			(Male:Female)
June	8	40	12	60	0.800	0.371	1:1.5
August	7	35	13	65	1.800	0.18	1:1.9
October	9	45	11	55	0.200	0.655	1:1.2
December	6	30	14	70	3.200	0.74	1:23
February	5	25	15	75	5.000	0.025	1:3
April	6	30	14	70	3.200	0.074	1:2.3
Total	41	34.17	79	65.83	12.033	0.001**	1:1.9

X^2 test ** significant at p ‹.01 level

Table 2. Variation in Sex Ratio of *E. spelaea* in 2019-2020

Month	♂		♀		Chi-square	P value	Sex ratio
	No.	%	No.	%			(Male:Female)
June	8	45	12	55	0.800	0.371	1:1.5
August	6	30	14	70	3.200	0.074	1:2.3
October	8	40	12	60	0.800	0.371	1:1.5
December	7	35	13	65	1.800	0.18	1:1.9
February	6	30	14	70	3.200	0.074	1:2.3
April	6	30	14	70	3.200	0.074	1:2.3
Total	41	35	79	65	12.033	0.001**	1:1.9

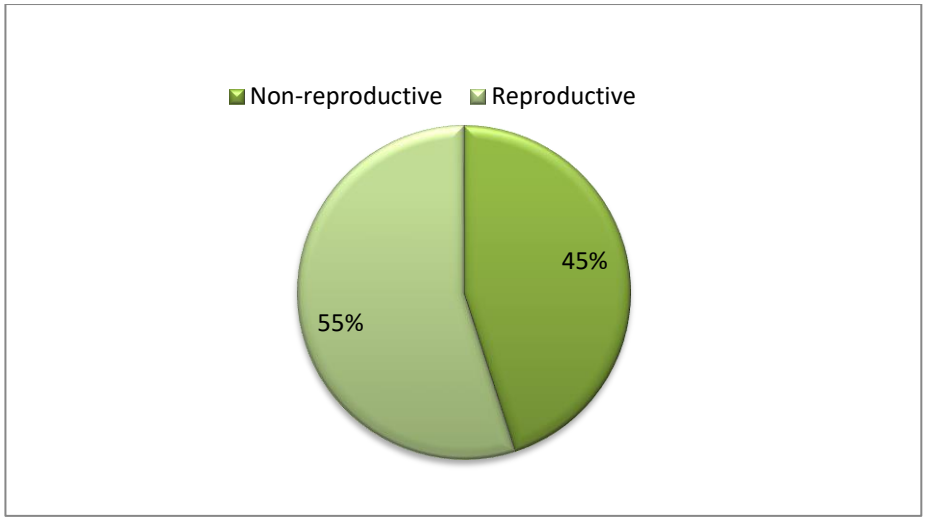
X^2 test ** significant at p ‹.01 level

Table 3. Forearm Length and Body Weight in Different Stages of Male *E. spelaea* in 2018- 2020

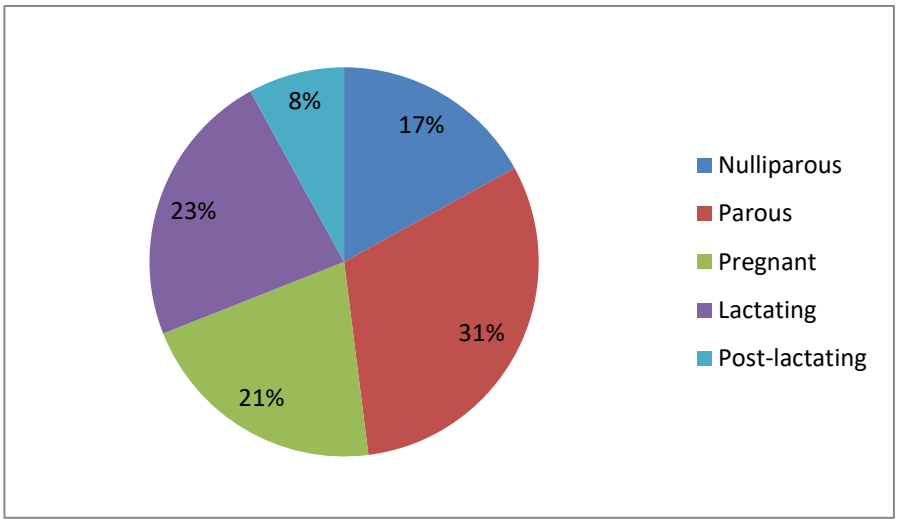
Sex	No. of bat	Forearm length(mm)	Body weight (g)	%
Non-reproductive	37	57.64 ± 3.775	40.48 ± 6.48	45
Reproductive	45	69.80 ± 3.57	68.15 ± 6.40	55

Table 4. Forearm Length and Body Weight in Different Stages of Female *E. spelaea* in 2018-2020

Sex	No. of bat	Forearm length(mm)	Body weight (g)
		mean ± SD	mean ± SD
Nulliparous	27	60.09 ± 4.88	54.87 ± 5.48
Parous	50	67.02 ± 2.98	61.87 ± 6.01
Pregnant	32	68.39 ± 3.82	67.21 ± 7.21
Lactating	37	68.74 ± 2.12	64.59 ± 5.96
Post-lactating	12	67.02 ± 1.80	66.77 ± 3.66

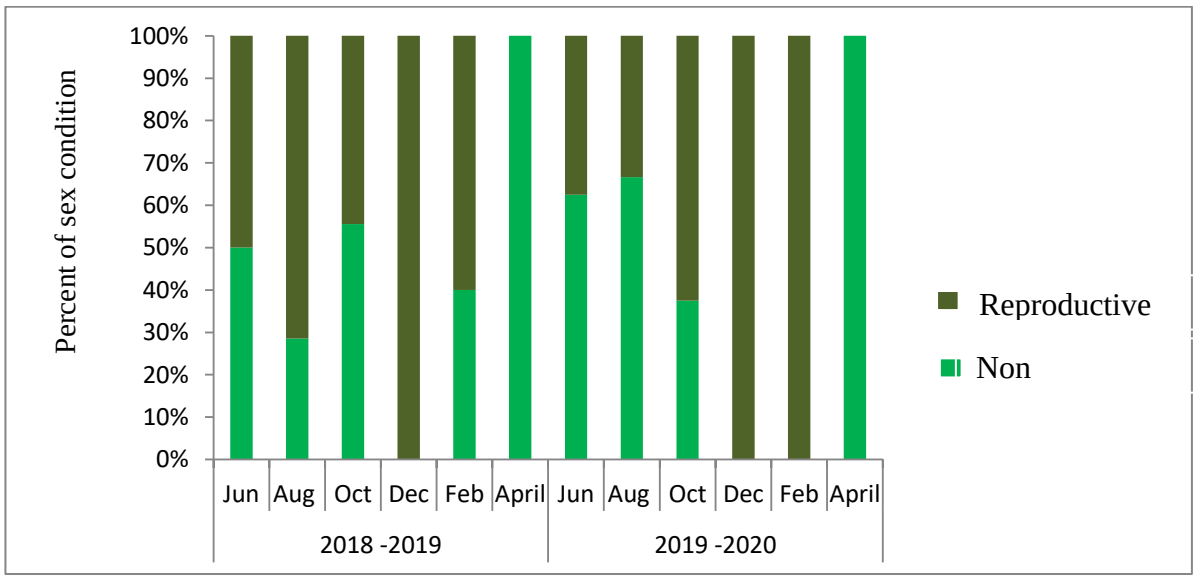


(A) Male *E. spelaea*

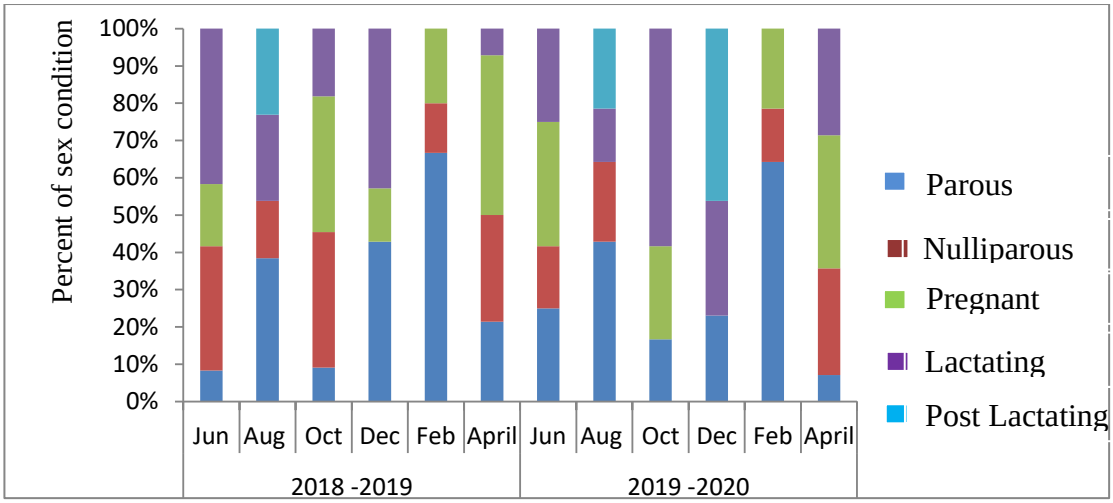


(B) Female *E. spelaea*

Fig 2. Proportion of Reproductive Condition by Captured Bats

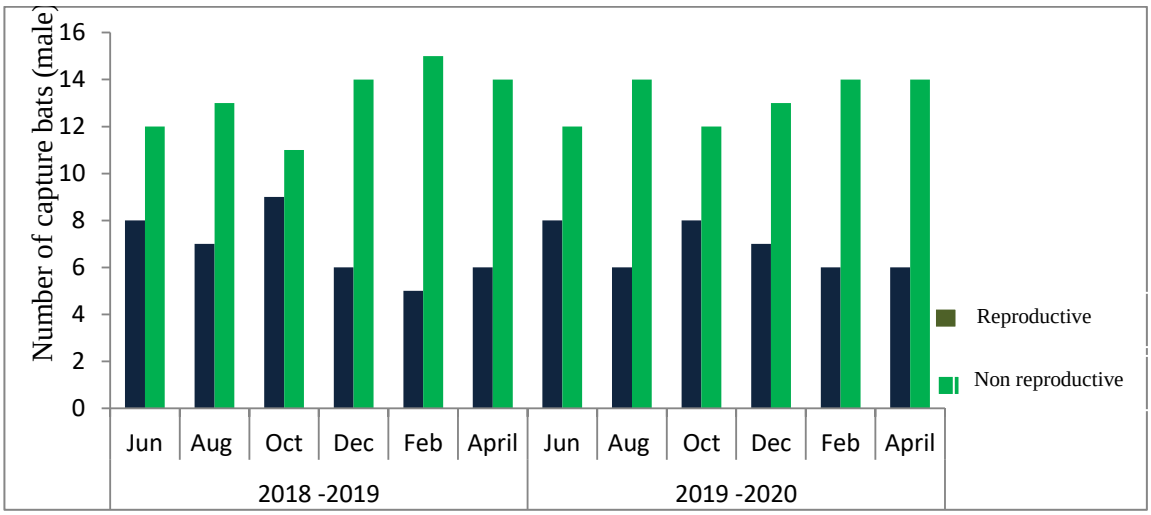


(A) Male *E. spelaea*

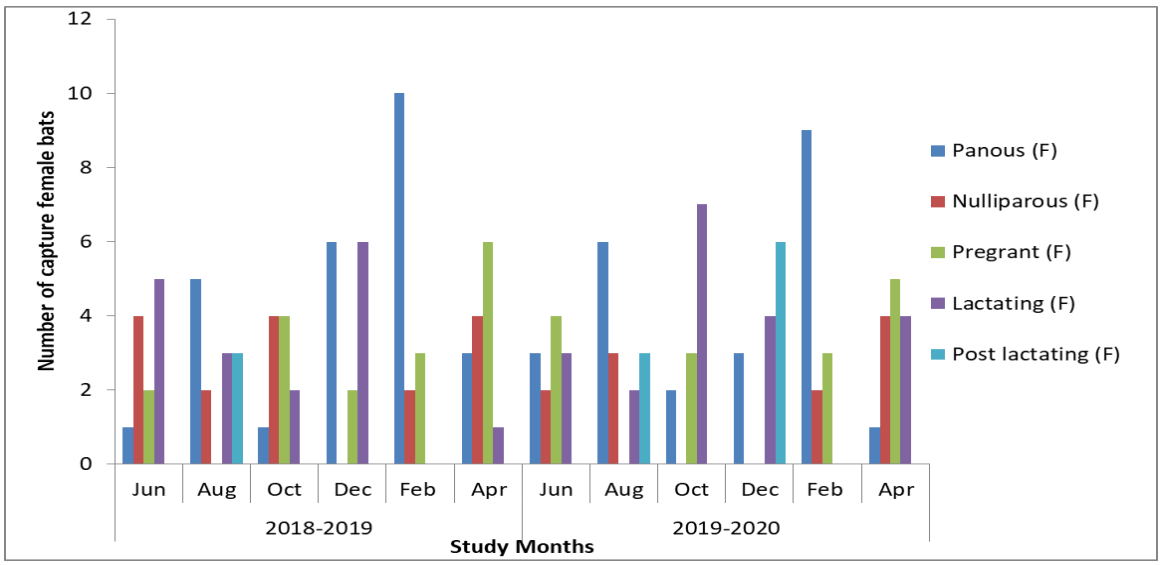


(B) Female

Fig 3. Percentage of Sex Condition by Captured Bats



(A) Male



(B) Female

Fig 4. Number of Captured Bats According to Sex Condition

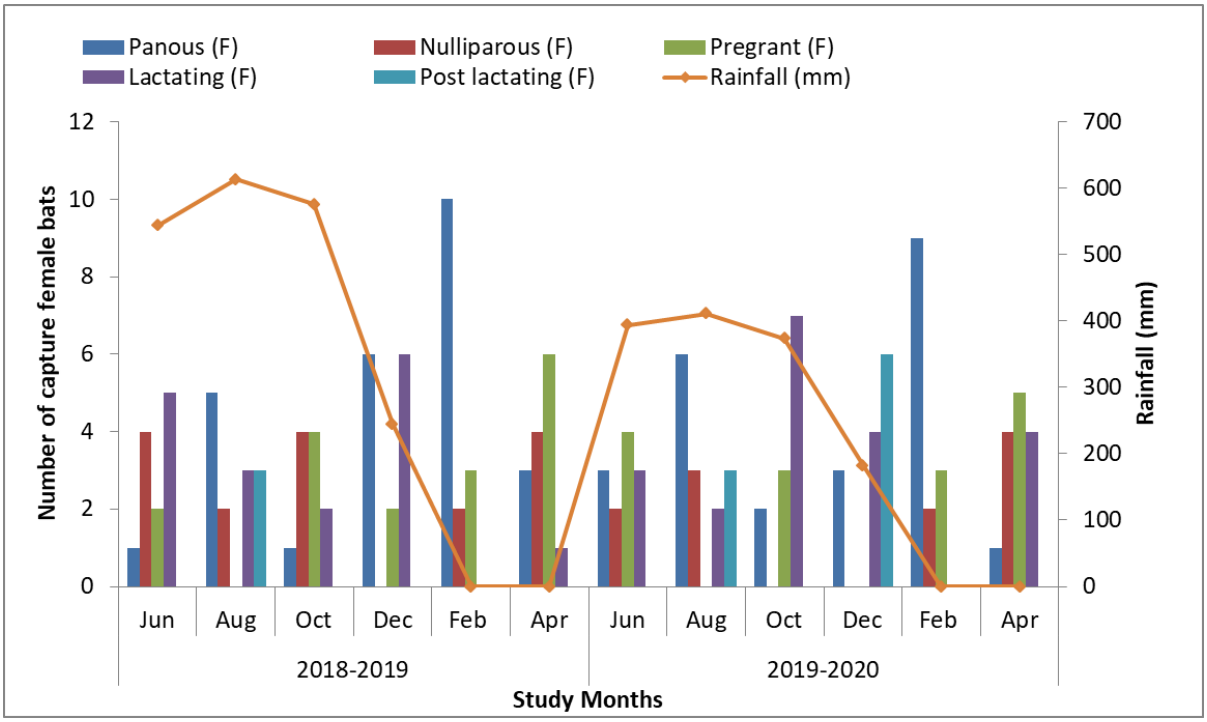


Fig 5. Reproductive Condition of Female *E. spelaea* Based on Captured Number in Relation to Rainfall

DISCUSSION

The adult males of *E. spelaea* were larger than the females with forearm length, and the parous females also occurred throughout the year. Generally, the female *E. spelaea* dominated the male (1:1.9) and were significantly different from expected ratio (1:1). According to Reinke (2010), the sizes of male sexual dimorphism are larger than female, moreover these fruit bats are polyestrus and births occur in two seasonal peaks, which is consistent with females coming into estrus twice a year, which is similar to the present study.

Payne and Francis (1985) also discussed that adult females were reproductively active year around. Lactating females occurred in April, June, Augusts, October and December. Paul and Ruth (2003) stated that *E. spelaea* had a seasonal pattern, with two birth periods in each year, centered on March or April and August or September. In the present study, parous females were observed throughout the year and lactating females occurred in August and April. The present result was in agreement with this finding. Concerning the seasonal reproductive cycle, Kofron (2007) also stated that birth patterns of pteropodids have been widely studied and usually occur during the wet periods both in the northern latitudes (February to April) and southern latitudes (August to November). Species that are polyesterous will give birth during the rainy season of both study years. It was predicted that birth during these seasons yields high survival rates because location occurs when fruit availability was at maximum. In the present study, the two peaks of lactating females were observed in October (end of the rainy season) and April (onset of the cold season). Thus the present finding is in line with this statement.

Although lactating females were found throughout the year, except February, the peak numbers of lactating females were only observed in October (end of the rainy season) and December (onset of the rainy season). It could thus be suggested that peak of reproductive

condition was not synchronized with rainfall. The two seasonal peaks of this species might be coincided with food availability of fruit abundance.

Based on two criteria of conservation, value of bat species as stated by Arita and Ortega (1998) and Fujita and Tuttle (1991), (1) direct economic value; either by consumption or by the sale of animals, its parts or it products (2) indirect economic value as in the case of nectarivores, important pollinators and economically important plants, conservation value of *E. spelaea* can be generally defined as both direct and indirect economic values.

Medium sized *E. spelaea* was suitable as meal for some native people who like to eat bats as delicacy and medicinal purpose especially to cure asthma. During August 2018, it was observed that several hundreds of bats from Nankathu cave were caught by lumberjacks. Lumberjacks reported that they caught large quantity of approximately 150 to 200 individuals of these bats as protein source for several time. Pierson (1998) reported that decline in bat abundance and diversity could have serious consequence for ecosystem.

CONCLUISION

The primary significance of lesser dawn bat *E. spelaea* is the pollination of commercially important plant species, especially during fruiting season. Guano of *E. spelaea* was also traditionally used in some paddy fields and other cultivated plants as biofertilization in Kwingauk environs since many years back. It could be thus assumed that perspective strategies of *E. spelaea* could be partly involved as valuable economic species in ecosystem. In depth information of the reproductive pattern of the species will help promote its protection in the forest.

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