



## NOTE

Wildlife Science

# Seasonal variation in the number of deaths in *Pteropus lylei* at Wat Pho Bang Khla temple, Thailand

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**ABSTRACT.** Flying foxes have been widely studied as they are well-known reservoirs of infectious agents. Understanding their population dynamics might help to explain seasonal patterns of disease prevalence, and contribute towards the conservation of flying fox populations. Therefore, this study explored the annual variation in the number of deaths in *P. lylei*. The study was conducted from 2015–2017, at a Buddhist temple in Thailand, which is the roosting site of *P. lylei*. The average total number of bat deaths in a month significantly varied between times of a year. A peak was observed during March and May, which ranged in the period of birthing and lactating. There were no significant differences in the average total number of bat deaths in a month between sexes or age classes across times of a years.

**KEY WORDS:** birthing period, lactation period, *Pteropus lylei*, population dynamic

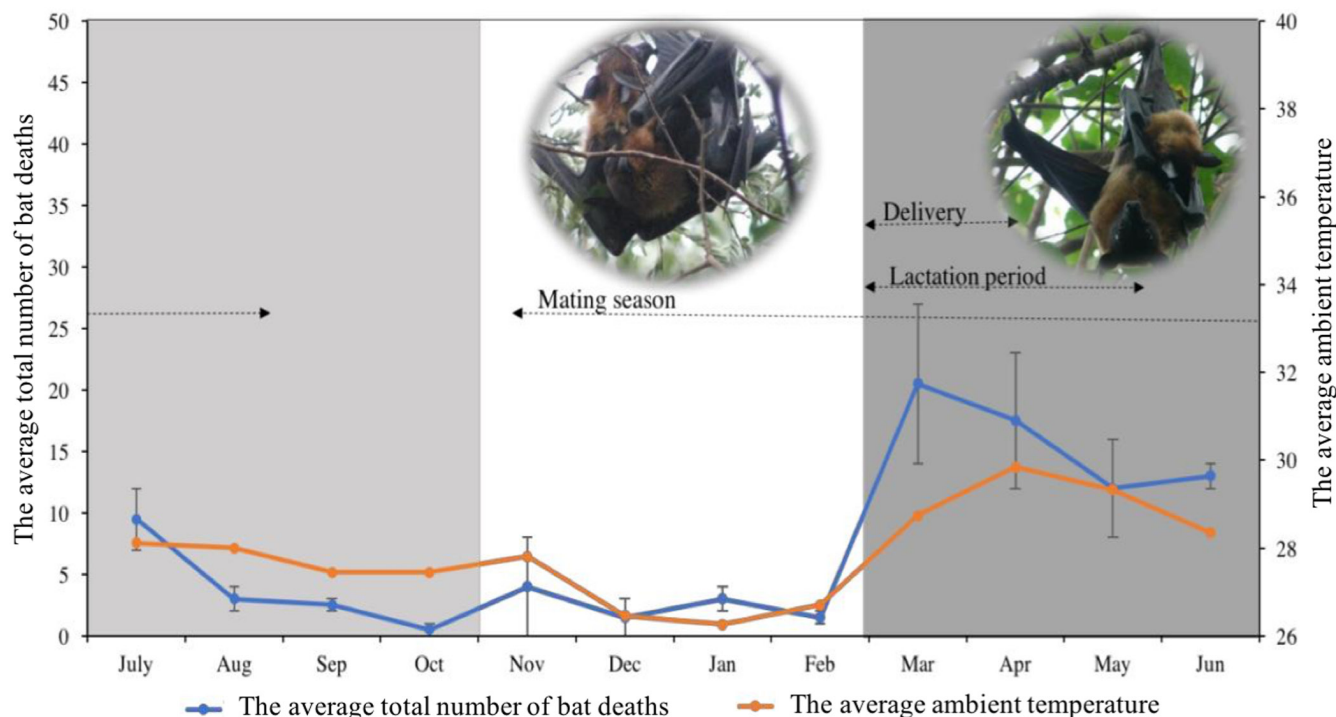
Thailand has four species of *Pteropus* bat (*P. hypomelanus*, *P. intermedius*, *P. lylei*, and *P. vampyrus*) [2]. *P. hypomelanus*, *P. intermedius*, and *P. vampyrus* have roosting sites on islands and in forests, while *P. lylei* live in human communities (e.g., temples) where contact between bats and humans occurs [3, 14]. To establish whether a higher contact with humans carries higher risk of disease, therefore, this study focused on *P. lylei* (Lyle's flying fox). Their home ranges include Cambodia, Thailand, Vietnam, and southern China, but their distribution in Thailand is restricted to the central and eastern parts [4, 6]. This bat is classified as "Vulnerable" by the IUCN Red List due to the reduction in their populations [5]. Surveillance of the Nipah virus confirmed that Lyle's flying foxes living in Thailand were infected with this virus, especially during the reproductive cycle, which lasts for 5 months [15, 16]. This suggested that there was seasonal variation in disease transmission, which might be related to their behavior and/or population dynamics. The annual variation in the number of bat deaths not only drives the population dynamics of flying foxes, but also it affects the number of susceptible hosts of viruses. Therefore, we examined the variation in the number of deaths in Lyle's flying foxes at their permanent roosting site in Thailand, from 2015–2017, to understand the population dynamics of this bat species.

The study was conducted at Wat Pho Bang Khla temple (13° 43' 16.37" N, 101° 12' 06.00" E), Chachoengsao Province, Thailand, which is home to 6,128 Lyle's flying foxes [6]. The study site is a tourist attraction that covers a large area (17,300 m<sup>2</sup>). Therefore, it is a potential hotspot for bat-borne disease in Thailand. To evaluate annual variation in the number of deaths, the number, sex, and age class of dead bats were recorded from the beginning of July 2015 to the end of July 2017. We performed spatial census method, in which a count is made of all dead bats in roosting areas, covering 5,700 m<sup>2</sup> (1 out of 3 temple area). All dead bats were removed after observation, to avoid counting the same individual twice. The total number of bat deaths in each month was calculated as cumulative number of dead bats over one-month period. The average total number of bat deaths in each month and the average total number of bat deaths in each sex/age class was calculated and shown in Figs. 1 and 2, respectively. The variation and sex/age class difference in the average total number of bat deaths among months was examined using the Kruskal-Wallis test. To examine whether ambient temperature is associated with the average total number of bat deaths in a month, the data of ambient temperature at 2 m height aboveground around the temple during observation period was collected by the Japanese 55-year Reanalysis (JRA-55) [8]. The relationship between the average total number of bat deaths in a month and

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**Fig. 1.** The relationship between the average total number of bat deaths in a months and ambient temperature. Light-gray, white, and dark-gray areas represent the rainy, cold, and hot seasons, respectively. The mating season last from November to August, while the maternity season last from March to May.

ambient temperature was analyzed using Spearman’s rank correlation. Significance of all tests was determined at  $P < 0.05$  (IBM SPSS 18, IBM Corp., New York, NY, U.S.A.).

A significant difference in the average total number of bat deaths between months was found (Kruskal-Wallis test:  $\chi^2=44.6$ ,  $df=11$ ,  $P < 0.001$ ). The highest average total number of bat deaths was recorded during March and April, which was the birthing period. Birthing or parturition period is the specific period of a year that many bats were observed to perform the process of delivering baby. The lowest was observed from August to February, which was a part of the mating season (Fig. 1). Mating season is the specific period of a year that many bats perform mating and courtship behaviors. In this season, we found that males approach females and lick genital area of females, followed by holding the females from behind and inserts the penis into the vagina. During March and April, the average number of newborn deaths was higher than adults of both sexes. From May to July, the average number of adult female deaths was higher than adult males and juveniles. In November and January (mating season), the average number of adult male deaths was higher than females and juveniles (Fig. 2). However, these sex/age class differences were not significant (Kruskal-Wallis test:  $P > 0.05$ ). This might be the effect of a small sample size of only 2 years data ( $n=2$ ). A larger sample size might have higher power to detect a statistical significance. We found a strong correlation between the average total number of bat deaths in a month and average ambient temperature (Spearman’s rank correlation:  $r=0.73$ ,  $P < 0.001$ ) (Fig. 1).

This is the first report of annual variation in the number of deaths of *P. lylei* in Thailand. This data suggests that the number of bat deaths varied among times of a year. The higher number of bat deaths, especially in adult females and juveniles, was observed during the reproductive cycle, specifically the birthing and lactating periods. This can be explained by nutritional stress, high energetic requirements, and immunosuppression associated with pregnancy and lactation. Korine *et al.* (2004) [9] showed that lactating females increase their metabolic energy intake by up to 80%, compared to non-reproductive females. This demonstrates the high energetic demands of lactation. However, fruit bats consume low-carbohydrate/protein food, so that lactating females might also be deficient in nutrients. To compensate for the increase in such requirements, reproductive bats reduce their energy expenditure for self-maintenance [14]. Furthermore, immunosuppression during pregnancy and lactation has been demonstrated in bats [13]. This may partly explain why the number of female deaths was higher than those of males from March to July. The high number of juvenile deaths could have resulted from their weak immunity against infection and anthropogenic impacts. Muhldorfer, *et al.* (2011) [12] suggested that juvenile bats were significantly more susceptible to infection than adults, and this was a major cause of juvenile deaths in the maternity season. Furthermore, one study showed pesticide residues in the milk of bats after they consumed contaminated foods [11]. Therefore, consuming pesticide-contaminated milk could also influence the number of juvenile deaths. The higher number of adult male deaths during the mating season was also observed in this study. This can be explained by the male-specific behavior in breeding season. Adult males usually perform aggressive behavior (fighting) to protect their mating territories. This may cause injury and even death of males [7]. In addition, the number of bat deaths was positively related with

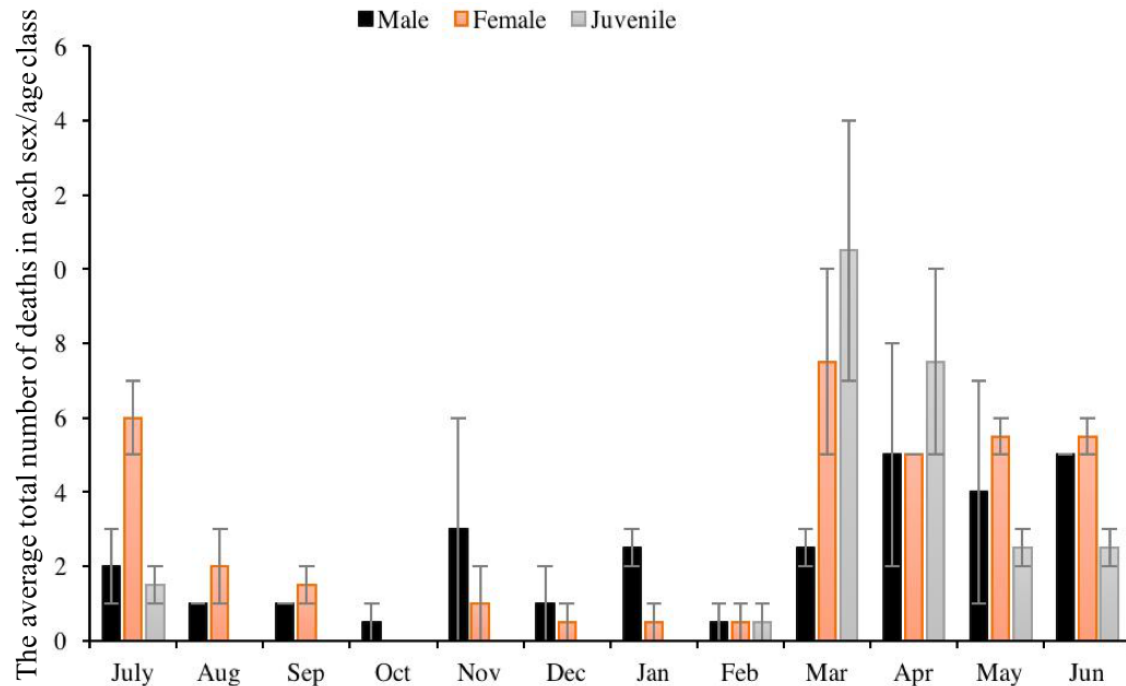


Fig. 2. The average total number of deaths in adult male, adult female, and juvenile bats in each month.

ambient temperature. Previous studies reported that climate change with extreme high temperature affects the survival and deaths of fruit bats, because they have low tolerance to high temperature [1]. According to the observation, 85% of dead bats dropped to the ground. Humans and dogs were occasionally observed to have direct contacts with dead bats on the ground. This might cause the disease transmission through the contacts with bodily secretions of bats, which contain the virus [10]. If the number of dead bats is increasing, the chance of direct contacts between bats, humans and domestic animals would be higher, resulting in the higher risk of infection. Based on the study of population size in *P. lylei* [4], there was an annual variation in population size of the flying foxes. The highest population size was found during April to May (lactation period), while the lowest was found in August. If the host population increases, the number of susceptible host would be increased. And this may cause the disease expansion in the future.

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