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Original article

The Habitat Use and Feeding Activity of *Tadarida plicata* in Thailand

Kessarin Utthammachai[1] **Sara Bumrungsri**[2]
Vijak Chimchome[1] **Jon Russ**[3]
Iain Mackie[3]

[1] Faculty of Forestry, Kasetsart University, Bangkok 1900
Tel. 086-6218-958 E-mail: g4863006@ku.ac.th, k_utthammachai@hotmail.com, fforvjc@ku.ac.th, vchimchome@hotmail.com
[2] Faculty of Science, Prince of Sonkla University, Hat Yai, Songkla 90110
E-mail: sara.b@psu.ac.th
[3] School of Biological Science, University of Aberdeen, United Kingdom
E-mail: j.russ@abdn.ac.uk, i.mackie@abdn.ac.uk

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ABSTRACT

The study quantified feeding rate and habitat use of *Tadarida plicata* demonstrated the important role they play in the natural and cultivated ecosystems. This study determined habitat use and feeding activity of *T. plicata* in an agricultural landscape including seasonal variation in habitat use and foraging activity. The proportion of signal-receiving time over the total recording time was measured to obtain an estimate of the relative activity of bats within each habitat. It was found that bats selected villages and dry rice fields. This is probably because these habitats supported higher insect densities. In addition, it was used the number of feeding buzzes per unit of activity time to calculate an index of attack rate by bats. Bat activities at each site were estimated by calculating the average number of bat passes per minute. Analysis of Variance was conducted to examine differences in mean attack attempt (numbers of feeding buzzes per unit of activity time) between recording sessions, among habitats and seasons.

Keywords: *Tadarida plicata*, Habitat use, Feeding activity, Seasonal variation

INTRODUCTION

The wrinkle-lipped Free-tailed bat (*Tadarida plicata*) is an insectivorous cave dwelling species, sometimes found roosting in very large colonies of several millions, and is distributed throughout Southeast Asia. They inhabit often become economically important to the local community as the bat droppings (guano) are collected and used as agricultural fertilizer. A recent study demonstrated that *T. plicata* is a major predator of nocturnal insects and has the potential to act as a biological pest control agent in farmlands (Leelapaibul *et al*., 2005). Biological pest control involves suppressing pest population densities to levels lower than they would otherwise be (Van Driesche and Bellows, 1996). Thus large

colonies of *T. plicata* may result in the large-scale depletion of pest insects in areas surrounding the cave roosts such as rice fields. Quantifying the feeding rate and habitat use of *T. plicata* in relation to insect availability, particularly pest species, will demonstrate the important role they play in natural and cultivated ecosystems.

Knowledge about foraging behavior and habitat use of the bats is of primary importance to establish conservation practices for endangered species (Stebbings, 1988). Using this knowledge, one can manage nature reserves to increase the extent of these habitat types, and protect them (Carmel and Safriel, 1997). Thus, conserving of the population of natural biological control agents should be a priority. Most of the previous work on the ecology of bats has been conducted in caves or human-made structures and very little is known about foraging behaviour. For example, bats may be important in controlling insect populations (Machmer and Steeger, 1995). Grindal (1996) explained that roosting and foraging habitat are two basic requirements of bats. Roosting habitat provides areas for reproduction and daytime shelter, whereas foraging habitat fulfills obvious energy and nutrient requirements. In Thailand, the bats are threatened by pressures such as caving, tourism, mining and harvesting. Direct economic benefits from guano collection at caves are available to a few individuals but more widespread interest in bat conservation will result from evidence of agricultural benefits. This study focused on the habitat use and feeding activity of *T. plicata* in an agricultural landscape and assessed to the seasonal variations.

MATERIALS AND METHODS

Data Collection

The habitats around the cave are identified within a radius of 30 km from the karst area. Habitat types can be classified into five main groups (1) rice fields, (2) forest patches, (3) urban areas, (4) sugarcane fields and (5) others. Almost all sample sites are located in Ratchaburi province and few are in Kanchanaburi province within the estimate foraging range of this bats.

The spot sample sites are chosen according to 7 road transects using the cave as the center, one transect contained 8-10 spot samples. The closest transects to the cave is 12-15 km away and the farest transects is about 27-30 km away. The start and the end point of spot samples are alternated to reduce bias from spatial distribution of bats over time.

The main study site is the area around the Khao Chong Pharn cave in Ratchaburi province, Central Thailand. Khao Chong Pharn Cave is the 11.5 hectare limestone outcrop and was designated as a non-hunting area to protect the bats. This cave is surrounded by rice fileds, plantations and sprase local settlement. The cave contains one of the largest colonies of *T. plicata* in Thailand and the population estimated up to 2.6 million individuals (Hillman, 1998).

An ultrasonic bat detector (Pettersson D240x) was used to determine the species, the relative activity of bats and the insect capture rate and to monitor high frequency sounds (echolocation that bats produce in order to navigate and forage in complete darkness). On a single night, five-minute spot samples of bat activity were recorded for 120 minutes beginning after sunset (20:00 to 22:00). A vehicle was used to travel between sampling sites to ensure that there is a large distance between adjacent sample sites and thus samples were independent. It was estimated that 8-10 spot samples per transect were collected, five per habitat type with sampling taking place for 7 nights per month (one transect per one night). Two types of bat activities (commuting i.e. traveling or searching for prey and foraging i.e. feeding attempt) were differentiated based on the structure of sequential echolocation calls. Bat activities were assessed by two methods used simultaneously.

Time Expansion: For each five-minute spot sample the bat detector was set under automatically triggered time expansion (TE) mode (x10) which recorded 'snapshots' of ultrasound and then stretched it out to audible levels so that the sound could be recorded to a recording device. The duration of the 'snapshot' was 1.7 seconds. The time expanded sound was stored by a recorder. Then recorded sound was transferred to a PC, converted to the WAV format and analyzed by BatSound (Pettersson Elektronic, Sweden) to identify the species, number of calls, and foraging activities.

Heterodyne: The investigator listened the sound in heterodyne mode (HD). The bat sounds was tuned within the range 23 - 30 kHz by bat detector. The investigator counted the number of feeding buzzes and bat passes heard in order to obtain a measure of insect capture rate. A bat pass is defined as a sequence of 1 or more echolocation pulses with < 1s between sequential pulses (Fenton, 1970; Korine and Pinshow, 2004). Feeding buzzes were easily identified on a heterodyne detector as they consisted of a series of calls with an increasing repetition rate as a bat approaches and attacks an insect. The feeding buzzes were distinguished from search-phase calls and counted the number of bat passes and feeding buzzes heard. The grid reference and altitude was recorded at each spot sample using a GPS system to identify important areas of bat activity.

This data may also be useful for future monitoring of *T. plicata* activity with respect to landscape changed. Full time fieldwork and analysis was carried out from July 2006 to May 2007 (no observations made for 4 months in August, September, October 2006 and March 2007) with supplementary data collection till July 2007 if necessary. This allowed us to make comparisons of the bat activities between bat reproductive periods (e.g. lactation, mating) and also harvesting-crop cycles (e.g. before and after harvesting) which was assessed on a monthly basis.

Data Analysis

The proportion of signal-receiving time was measured over the total recording time to obtain an estimate of the relative activity of bats within each habitat using Russ *et al*. (2003) protocol. It was used the number of feeding buzzes per unit of activity time to calculate an index of attack rate by bats similar to Lee and McCracken (2002). Bat activities were estimated at each site by calculating the average number of bat passes per minute. However, these numbers are not be able to distinguish multiple passes of a single bat from single passes of many bats, thus, activity frequency rather than abundance of bats will be used.

The sonograms were analyze used to identify the bat and count feeding buzzes and compare this with the data in heterodyne. The data were presented as means. Significant differences were determined at a significance level of 0.05. It was conducted MANOVAs to examine within-year variation and the effect of recording sessions and habitat types to the length of the activity time and the mean number of feeding buzzes emitted by bats. ANOVA was further used to examine differences in mean attack attempt (numbers of feeding buzzes per unit of activity time) between recording sessions, among habitats and seasons (Lee and McCracken, 2002).

RESULTS AND DISCUSSION

Sound Analysis

BATSOUND is the software used to analyse bat calls i.e., the total number of individual calls per spot sample (Figure 1a) and the total number of feeding buzzes per spot sample (Figure 1b). Figure 1 showed the spectrogram of *T. plicata* calls and feeding buzze indicating the frequency within the range of 25-30 kHz.

Bats primarily selected areas in villages and dry rice fields (Figure 2). This is probably

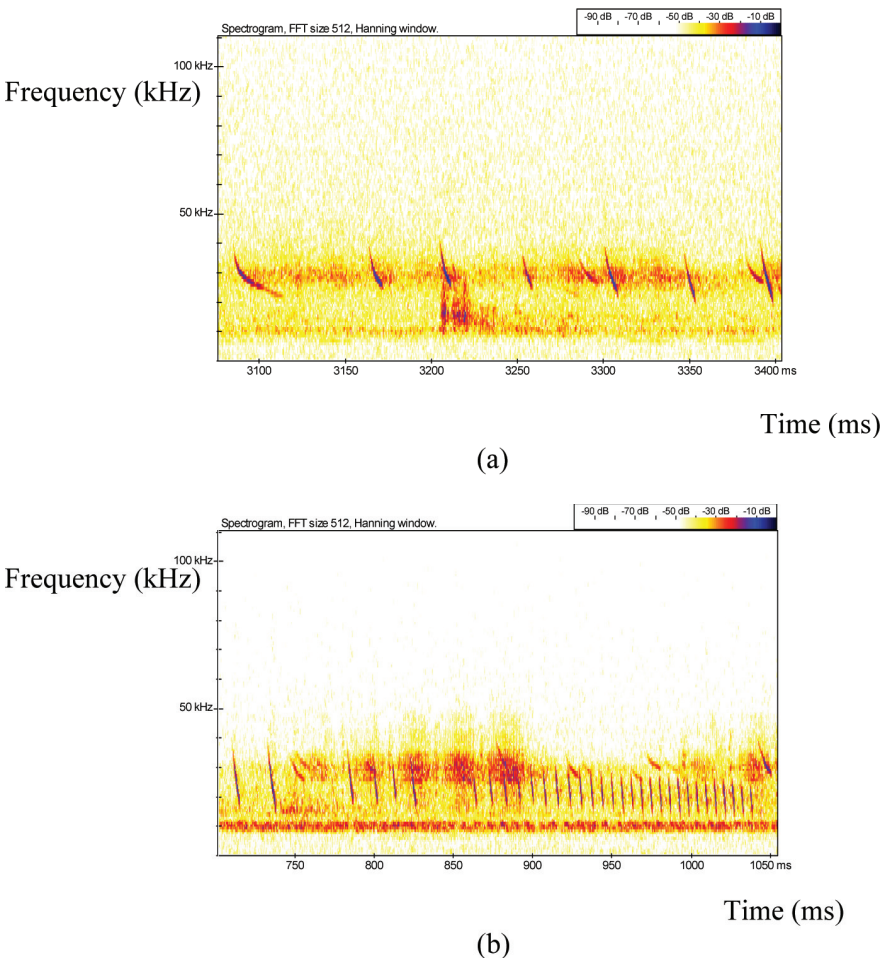

Figure 1. The Spectrogram of *Tadarida plicata* calls (a) individual calls and (b) feedin.

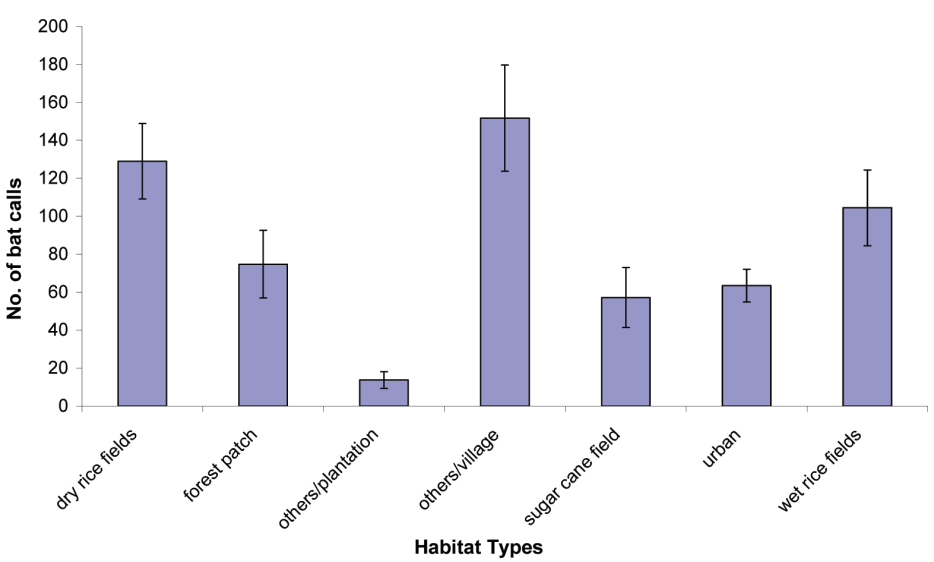

Figure 2. The Mean ± SE of *Tadarida plicata* calls and habitat used.

because the habitats support higher insect densities. The suggestion is that villages are selected because bats are feeding on the insects attracted by streetlights. There were significant differences number of bat calls among habitats ($P < 0.05$). However, there was no differences in feeding activity ($P < 0.05$). The results are similar to those of some previous studies on difference species (Geggie and Fenton, 1985) and suggested that streetlights are also important foraging habitats for free-tailed bats (Lee and McCracken, 2002). Seemingly, this results did not agree with the prediction that *T. plicata* should selected areas with in an agricultural landscape, because the number of bat calls over villages was higher than other habitats.

In Figure 3, six categories were identified based on mean distance from the cave. There was significant differences in bat activity among distance categories ($P = 0.001$). The number of bat calls were highest at 0-5 km from the cave. This is probably because there was a lot of activities near the caves as bats are continually flying out and returning to the cave througout the night. There was no significant differences in feeding activity among categlories.

Analysis of Variance of numbers on bat activities showed that seasonal variation in number of bat calls depended on breeding periods. In February, the number of bat encounters were highest due to the female bats were pregnant so they needed more nutrition and energy. Bat activities were highest within a 0-5 km radius of Khao Chong Phran Cave (Figure 3). Thus, could aspected that distance near the cave also still had some bats continuing flied out and returned to the cave along the night. However, there were no relationship between feeding activity and distance from the cave ($P = 0.223$). One explanation for the localization of feeding activity with any distance maybe these bats simultaneously fly and feed on, thus, no matter how distance near or far from cave they were captured and eaten their foods.

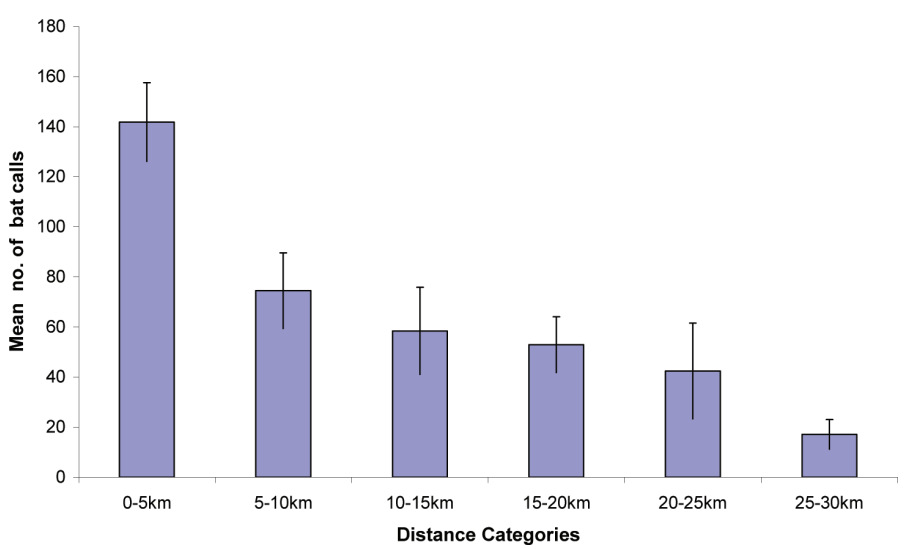

Figure 3. Bat activity (mean ± SE) and distance from cave of *Tadarida plicata*.

In a study of bat activity and breeding status of *T.plicata*, this species breeds twice a year. Female bats are pregnant in February and March and again in September and October. Lactation occurs in November and again in April to May. Young foraging was found in July and again in December to January (Hillman, 1998). Bat activity was highest when bats were

lactating (P< 0.001) (Figure 4). With respect to feeding activity and status, It was found that feeding activity highest during pregnancy and lowest when the young foraging (P < 0.001). During pregnancy, the body mass of females increases, thus, the decreased maneuverability of pregnant females may be responsible for its lower diet diversity compared to lactating females (Leelapaibul, 2003). It seems to be difference with this results that pregnant females should fed on their food lower than lactating females maybe also depend on the variation of insect availability at that time. Bat activity was significantly correlated with temperature (Spearman correlation coefficient = 0.466, P< = 0.01). Bat activity and feeding activity varied significantly with breeding status.

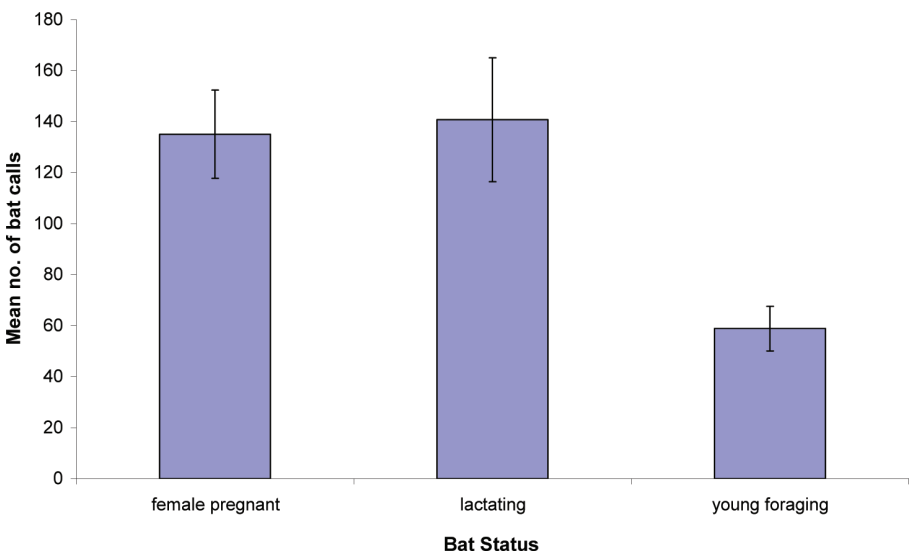

Figure 4. Bat activity (mean ± SE) and breeding status of *Tadarida plicata*.

CONCLUSION AND RECOMMENDATION

1. Bats selected areas most in villages and dry rice fields. There were significant differences number of bat calls among habitats (P <0.05). Villages were most selected because streetlights provided many insects. It have been collecting data on streetlights to see of bats select them. However, there was no differences in feeding activity (P <0.05).

2. Bat activity was highest within a 0-5 km radius of Khao Chong Phran Cave. However feeding activity was not related to distance from the cave.

3. Bat activity and feeding activity varied significantly with breeding status.

4. Bat activity was significantly correlated with temperature.

5. The study such as this was the one presented here, can be used directly for habitat use managing, for restoring bat habitat and protecting habitats that require conservation. Previous study indicated that homopterans as white-backed planthoppers which were the most common component of the diet for *T. plicata* in Ratchaburi province (Leelapaibul, 2005). This species is very common in an agricultural landscape such as rice fields. In the present study, villages and dry rice fields which the most habitats selection of *T. plicata*. This would be useful in combination with other studies and for monitoring these bats.

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