NAT. HIST. BULL. SIAM SOC. 36: 135 – 141, 1988

FLY-OUT COUNT OF THE BAT, *TADARIDA PLICATA*, USING A VIDEO RECORDING

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ABSTRACT

The number of bats (*Tadarida plicata*, Buchanan 1800) flying out of a cave in Khao Yai National Park, Thailand, was estimated from video recordings. The recordings were made on 2 and 3 April 1988. The bats first appeared at 1817 h local time and continued flying out for about an hour as monitored using a bat detector. The number of bats crossing a line drawn on the screen of a video monitor were counted in 10 consecutive frames (400ms) each minute until 1848 h when the ambient light level was too low for video recording. The peak exit rate was ca. 60,000 bats per min occurring at 1831 h. The bats had a rather constant flight speed of from 4 to 5 m/s. The total number of bats flying out of the cave was estimated at 500,000 making this colony one of largest known colonies in Thailand.

INTRODUCTION

Estimating the number of bats leaving a cave containing a large population presents formidable problems. Periodic trapping methods are impractical owing to the sheer numbers of bats. Electronic counting (DEGN et al.) is difficult owing to the large exit area. Acoustical methods become impossible when the number of bats is large, since individual echolocation signals blend into nearly continuous ultrasonic "noise" Counting resting bats in the cave presents problems in estimating the area occupied by bats. The most widely used method to estimate the number of bats in a population is banding and recapture (HILL & SMITH, 1984). This method has been prohibited in many countries and was impractical for our study. Photographic methods can be used (WARDEN, 1980), the expense of which is proportional to the accuracy of the estimate. We opted to use a continuous video recording to estimate the number of bats (*Tadarida plicata*) leaving a cave in Khao Yai National Park, Thailand. Our video recorder was equipped with a CCD (charge coupled device) sensor and a fast electronic shutter, which increase light sensitivity and improve single frame resolution. We estimated the total number of bats leaving the cave on 3 April 1988 to be about 500,000 individuals. Factors influencing the count are discussed.

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METHODS

A guano cave in Khao Luk Ch'ang mountain near the northern end of Khao Yai National Park, Thailand (14° 32′ N, 101° 21′ E), is known to house a large colony of tadarid bats (*Tadarida plicata*). The bats leave the cave through an opening about 6 m high by 4 m wide. We do not know of other exits.

A Panasonic VHS movie camera (NV-M5) was strapped to a tree at a distance of about 15 m from the exiting bats. The camera was adjusted such that the exiting stream of bats was at a right angle to, and filled the field of view. The bats appeared as dark silhouettes against the light sky. Ultrasonic signals were digitized by a bat detector (Peterson D960), slowed down by a factor of 10, and recorded on the audio channel of the video tape twice each minute (0.75 s per sample).

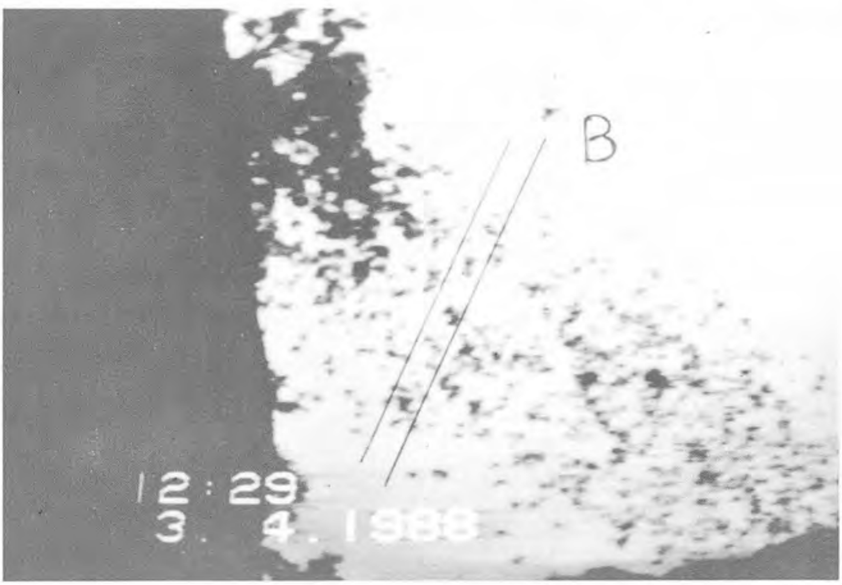
The fly-out was recorded continuously for 63 min starting at 1817 h when the first bat appeared. (Sunset was at ca. 1810 h). The electronic fast shutter mode (1 ms exposure per frame) could be used for the first 22 min of fly-out, until 1838 h. The fast shutter mode essentially freezes the subject for single frame viewing (Figure 1). The normal shutter mode, which gives a more blurred single-frame picture, could be used for counting bats during the next 10 min, from 1839 to 1849 h. For the remaining 31 min only visual observations and ultrasonic recordings were made since the ambient light level was too low for video recording. Consequently, we extrapolated the count to zero for the last 31 min.

The video recordings were analysed as single frames using a video monitor and a Panasonic AG-6200 VHS Video Cassette Recorder. Each frame represents a 40-ms time slice. Since the flight speed of the bats was estimated and found to be rather constant, two lines were drawn on the screen of the video monitor the distance between which was equivalent to the distance flown by the bats in 40-ms (Figures 1, 2). The number of bats between the lines was counted in each frame for 10 consecutive frames (400 ms). The number of bats leaving the cave per minute was then calculated from the 400 ms sample for each of the first 32 min of the video recording (ending at 1848 h). Relatively few ultrasonic signals were heard after 63 min of recording, indicating a low activity of bats near the cave. (Some of the ultrasonic signals might represent bats returning to the cave.)

RESULTS AND DISCUSSION

A preliminary investigation on the night of 2 April 1988 indicated the possibility for estimating the number of bats leaving the cave by using a highly light-sensitive CCD video recorder. Such a recorder allows a frame by frame count of exiting bats. It was also possible to measure the average flight speed by measuring the number of body lengths moved between two frames (40 ms). A continuous, 63-min recording of the fly-out was made on the evening of 3 April 1988.

The species was positively identified by capturing an injured bat at the mouth



Figures 1. and 2. Two consecutive video frames in the fast shutter mode taken at 1829 h local time of *Tadarida plicata* leaving a cave in Khao Luk Chang on 3 April 1988. The time lapse between A and B is 40 ms. The two lines on the video screen represent the average distance flown in 40 ms (see text). Bats between the lines were counted in 10 consecutive frames for each minute, giving the counts up to minute 49 illustrated in Figures 3 and 4.

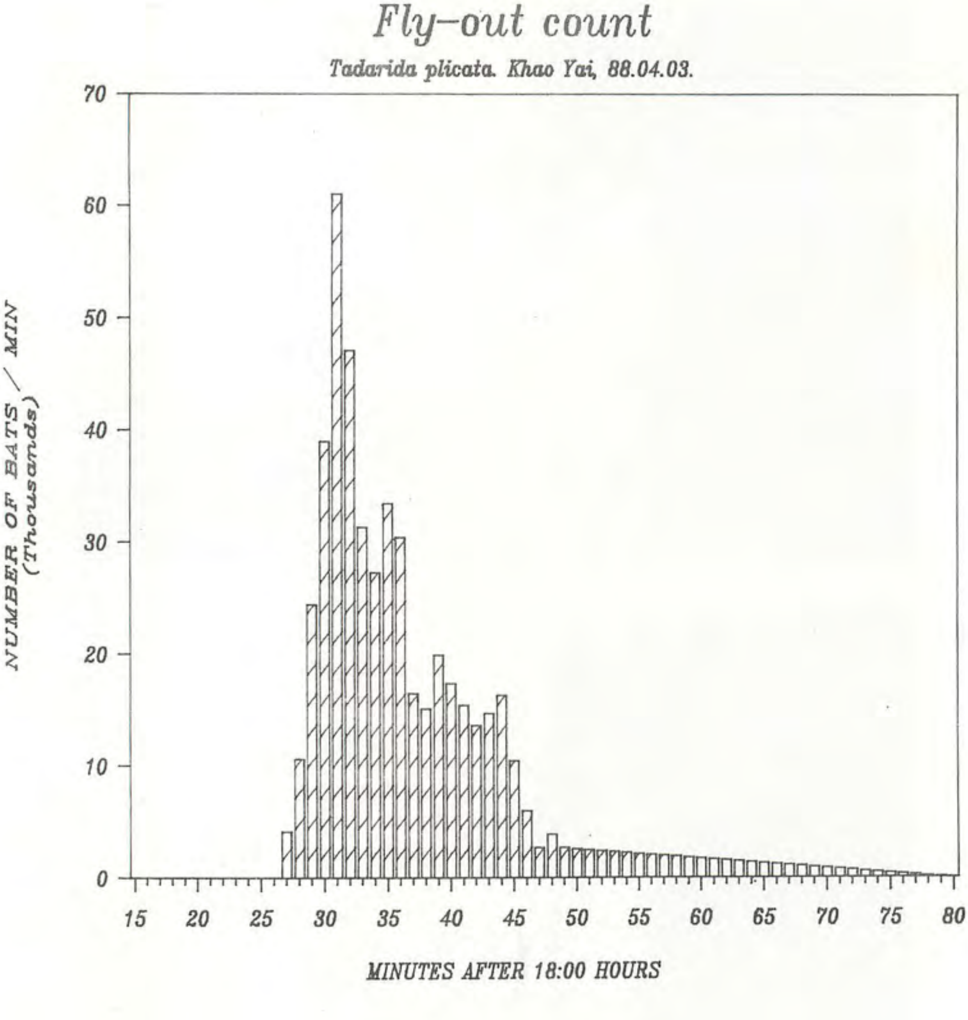


Figure 3. Number of bats emerging from the cave opening each minute based-on counts from 10 consecutive video frames per minute until 1848 h. Counts from 1849 to 1920 h are based on a linear extrapolation to zero.

of the cave. The body length of the species is from 65 to 75 mm (LEKAGUL & MCNEELY, 1977). The bats flew out in a stream the major portion of which could readily be recorded. The velocity of the stream was fairly constant suggesting a rather uniform flight speed. We measured the flight speed of 18 individual bats and found it to be about 4 to 5 m/s (mean $\pm$ SD = 0.07 $\pm$ 0.009 body lengths per ms). The bats began to appear at 1817 h at a rate of one bat per min. The exiting rate increased to 71 bats per min at 1825 h, but 3 min later (1828 h) the rate had suddenly increased to 10,000 bats per min (Figure 3.). The maximum rate was 61,000 bats per min at 1831 h corresponding to an average of 40.7 bats between the counting lines per frame. The ambient light level was still sufficiently high at 1831 h to allow for video recording in the fast shutter mode facilitating counting.

Figure 4 shows the cumulative counts of bats having left the cave. Our estimate indicates that nearly 500,000 bats left the cave during the 63 min of recording. The estimate is likely to be low since errors will tend to reduce our tally.

Bats nearer the camera will have an apparently higher flight speed than distant bats. Consequently close bats may move across the two counting lines between frames and not be counted, while distant bats might be counted twice. These two errors will tend to balance each other.

Since the flow of bats seemed fairly steady, we counted bats in only 10 of the 1500 frames per min. For an uneven flow, this method introduces sampling errors. When the density of exiting bats is high, the closer bats could shadow more distant bats introducing a counting error that will reduce the tally. A re-count of 4 randomly chosen minutes (between 1833 and 1842 h) gave a variation of about 15%. This variation represents the sum of sampling and counting errors. The sampling and counting errors can be reduced by counting bats in each and every frame. Technically, this is possible using computerized video image analysis, but such methods were not available to us.

It was possible to cover the major fly-out area, but a few bats flew above or below our recorded field.

Some bats began returning about 20 min after the beginning of the fly-out. However, the returning bats did not use the same flight corridor as the exiting bats, and were probably not counted.

Errors due to apparent flight speed and sampling errors are relatively unbiased. The remaining factors will depress the count. The accumulated count (Figure 4) should thus be regarded as an estimate erring towards the low side. The major uncertainty is related to the events after 1848 h. Our linear extrapolation from 1849 h to the end of the recording is a guess. If the extrapolation is reasonable then over 90% of the bats could be counted using the video recording technique.

Seasonal fluctuations in the population undoubtedly occur. One would expect a noticeable increase in the number of bats exiting the cave when the young become volant. In this species females have one birth per season, which occurs at the beginning of the rainy season (around June). The weaning period is about 30 days and we could expect the young to take wing during July (LEKAGUL & MCNEELY, 1977;

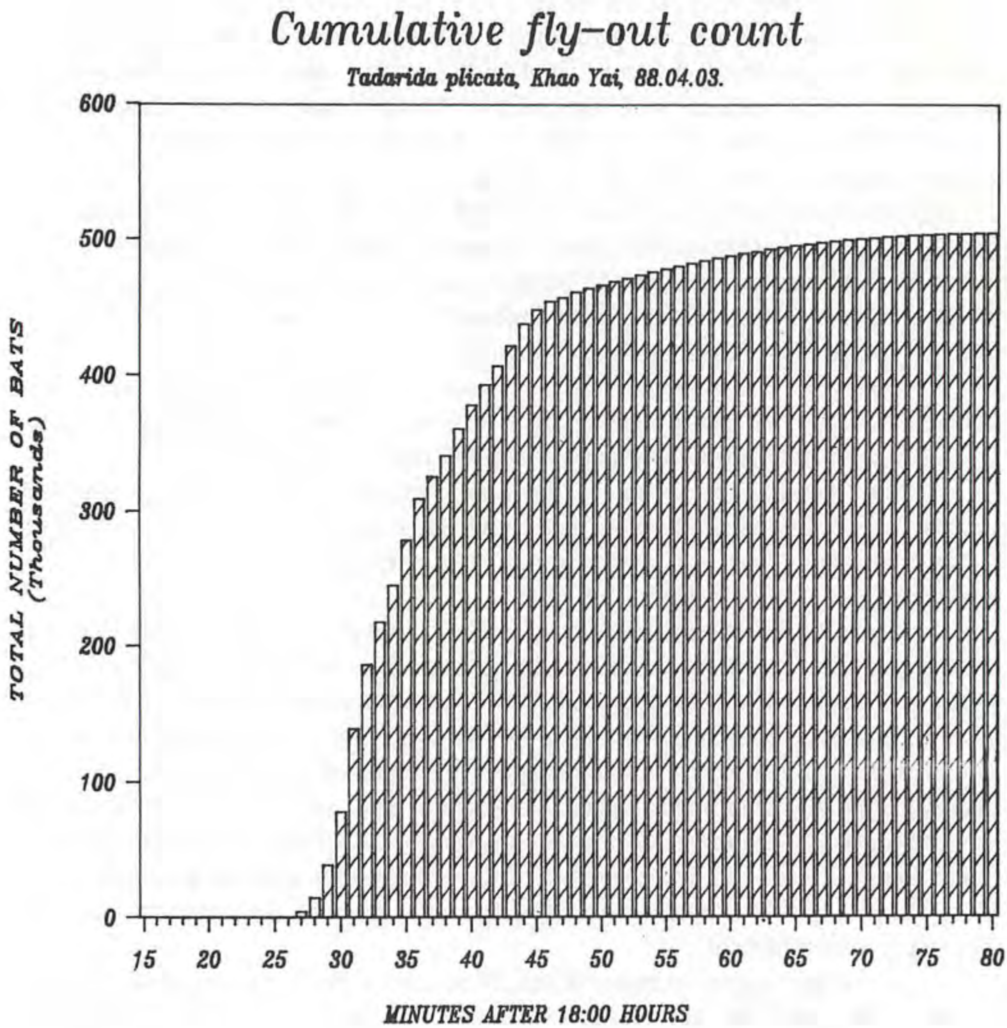


Figure 4. Accumulated count of bats having left the cave based on the data shown in Figure 3.

FENTON, 1983). Our technique should be sensitive enough to register a reproductive increase.

Consequently, the colony in the cave we studied contains at least 500,000 individuals making it one of the largest known colonies of this species in Thailand. *T. plicata* has an average body weight of 24 g (17 to 31 g) (LEKAGUL & MCNEELY, 1977). Since insectivorous bats consume about 20% to 30% of their body weight during a night's feeding (GRIFFIN, 1974; FENTON, 1983; HILL & SMITH, 1984) we would expect this colony to eat about 3500 kg of insects each night. This amount of biomass must be harvested from a fairly large area, possibly on the order of from 1000 to 3000 square km. About 12 tons of these tadarid bats, which occupy a high trophic level, pass through a restricted area each night and their population dyamics can be rather easily monitored. Also, monitoring the effect of large scale changes in the ecosystem caused by changes in agriculture, land reclamation, and reforestation should be feasible by using such methods to monitor the bat population.

ACKNOWLEDGEMENTS

We wish to thank the Carlsberg Foundation and the Danish Natural Science Research Council for financial support. We also thank Khao Yai Park officials for their helpfulness.

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[illegible] 1988). Our technique should be sensitive enough to detect a reproductive decrease.

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A C K N O W L E D G E M E N T S

We wish to thank the Carlsberg Foundation and the Danish Natural Science [illegible] for financial support. We also thank Khao Yai Park officials for [illegible] help.

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