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Cave-Roosting Bat Ecology in Malaysian Agroecosystems: The Gunung Keriang Study

Vithyadarrsinee Thanabalasingam[1], Nurul-Ain Elias[1,♥]

[1] School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia

ABSTRACT

Malaysia is home to remarkable biodiversity, with bats comprising nearly one-fifth of all mammal species globally. This study investigated the diversity and breeding patterns of bats at Gunung Keriang, which is surrounded by rice field areas. A total of 1,250 individuals representing 22 species were recorded between April 2021 and April 2022, primarily from the families Rhinolophidae, Hipposideridae, and Vespertilionidae. The most abundant species was *Rhinolophus pusillus* (n=857). Several species face extinction risks based on the IUCN Red List, including *Myotis ridleyi* (Near Threatened), *H. lekaguli* (Near Threatened), and *H. halophyllus* (Vulnerable). Regardless of family, the three studied bat species in Gunung Keriang exhibited a unimodal breeding pattern throughout the year. This indicates that cave-roosting bats reproduce only once annually, with active breeding stages (pregnancy and lactation) concentrated in April and May. Based on species-specific observations, pregnancy was recorded two months later in *Myotis ridleyi* (April, early dry season) than in *Rhinolophus pusillus* and *Hipposideros larvatus* (February, end of wet season). The percentage of non-reproductive *Hipposideros larvatus* began to increase in August, approximately three months after the first juvenile/pup was recorded. Lactating females of *Rhinolophus pusillus* were recorded in April, with peak lactation occurring in May. These findings emphasise Gunung Keriang's importance as a vital natural refuge for Malaysia's bat conservation. The breeding pattern of cave-roosting bats in Gunung Keriang showed synchronised maternity with the availability of insects (food resources) in agricultural areas.

Keywords: bats diversity, reproductive pattern, cave conservation, agricultural area

1. Introduction

Bats (Order Chiroptera), which represent nearly 20% of all mammalian species worldwide, with at least 143 species recorded in Malaysia alone [1], are vital to ecosystem health. Their roles in pollination, seed dispersal, and insect regulation are crucial in maintaining ecological balance. This is especially true for cave-roosting bats, whose large colonies are keystone components for sustaining local biodiversity and nutrient cycles.

However, agricultural expansion and habitat modification increasingly threaten bat populations. Gunung Keriang, a limestone hill in Kedah, provides a critical case study; despites being surrounded by vast paddy fields, it persists as a vital roosting and breeding habitat for several bat species [2]. This study aims to assess the overall diversity of bats roosting in Gunung Keriang and to investigate the breeding patterns of key cave-roosting species.

♥ *Corresponding author.*
E-mail address: nurulain.elias@usm.my

2. Methodology

Gunung Keriang (6°10'N, 100°18'E, 218 m a.s.l.) is a prominent limestone outcrop surrounded by rice fields, small villages, and secondary vegetation located near Alor Setar, Kedah. Fieldwork was conducted between April 2021 and April 2022. Bats were captured monthly using harp traps from 1800 to 2300 hours and identified based on [3,4]. Each adult female bat's reproductive condition was assessed through external examination based on [5].

3. Results & discussion

From the study, out of the 22 species and four families recorded, *Rhinolophus pusillus* (Rhinolophidae; n = 857) showed the highest number of captured individuals (Figure 1) in Gunung Keriang. It indicates that this small and isolated mountain provides a safe and suitable environment to supports the thriving bats population in Malaysia, especially in agricultural setting. The high abundance of Rhinolophus pusillus may also suggest that the microhabitat conditions in Gunung Keriang such as temperature, humidity, and resource (prey) availability are particularly favorable to this species. Meanwhile, *Hipposideros larvatus* (Family Hipposideridae) and *Myotis ridleyi* (Family Vespertilionidae) was the most abundance species under its own taxa level.

Based on IUCN Red List, most of the species listed as Lest Concern. However, several species are facing extinction risks, including *Hipposideros pomona* (Endangered, n=14), Myotis ridleyi (Near Threatened, n=350), *Hipposideros lekaguli* (Near Threatened, n=3), and *Hipposideros halophyllus* (Vulnerable, n=3). These findings emphasize Gunung Keriang's importance as a vital natural refuge for Malaysia's bat conservation.

The breeding patterns of three cave-roosting insectivorous bat species were monitored over 12 months, revealing a synchronised, unimodal reproduction cycle across all species. Figure 2 shows *Hipposideros larvatus* exhibited a distinct unimodal breeding pattern with peak pregnancy observed in February, followed by lactation in April, and the appearance of juveniles in May. The percentage of non-reproductive females increased in August, approximately three months after the first juveniles were recorded, followed by a post-lactation phase by September.

Rhinolophus pusillus also demonstrated a unimodal breeding pattern (Figure 3). Pregnancy was recorded from February through May (four months). Lactating females first observed in April, with lactation peaking in May. The percentages of non-reproductive and post-lactation females reached their highest levels in August, suggesting that the juveniles born in April had reached adult stage approximately four months post-birth.

Consistent with the other species, *Myotis ridleyi* displayed a unimodal reproductive pattern with a single distinct peak (Figure 4). Pregnant females were captured in April and May. Although no lactating females were recorded, the subsequent increase in non-reproductive females toward year-end suggests that parturition and juvenile emergence likely occurred between May and September, with these offspring reaching adulthood before the next breeding cycle.

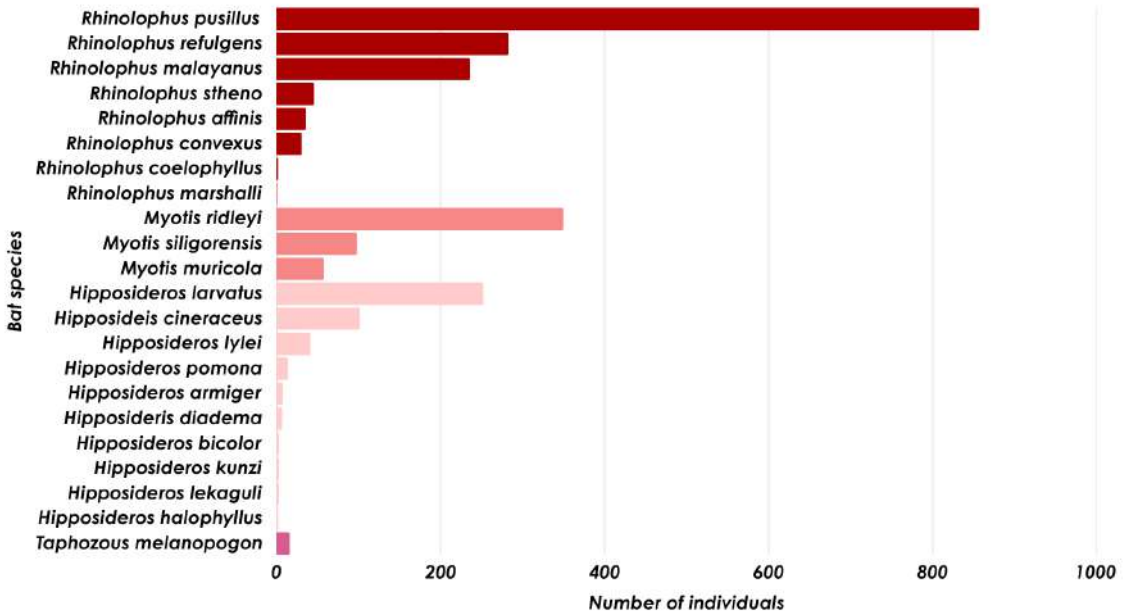

Fig. 1. Bat species that captured in Gunung Keriang grouped based on its Family. Note: Vivid red = Rhinolophidae, Pastel red = Vespertilionidae, Light red = Hipposideridae, and Pink = Emballonuridae

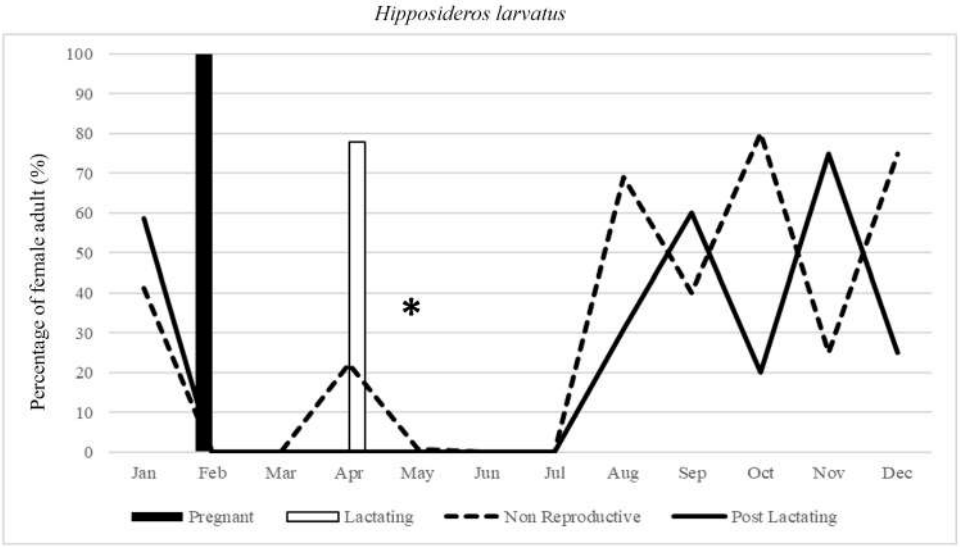

Fig. 2. Reproductive pattern of *Hipposideros larvatus* in Gunung Keriang. Note: * = the occurrence of juvenile

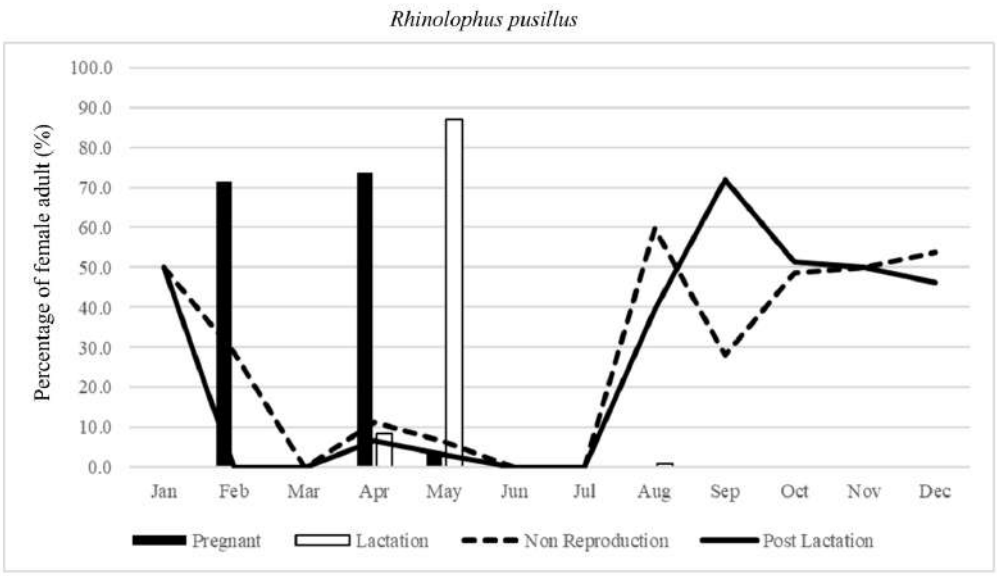

Fig. 3. Reproductive pattern of *Rhinolophus pusillus* in Gunung Keriang.

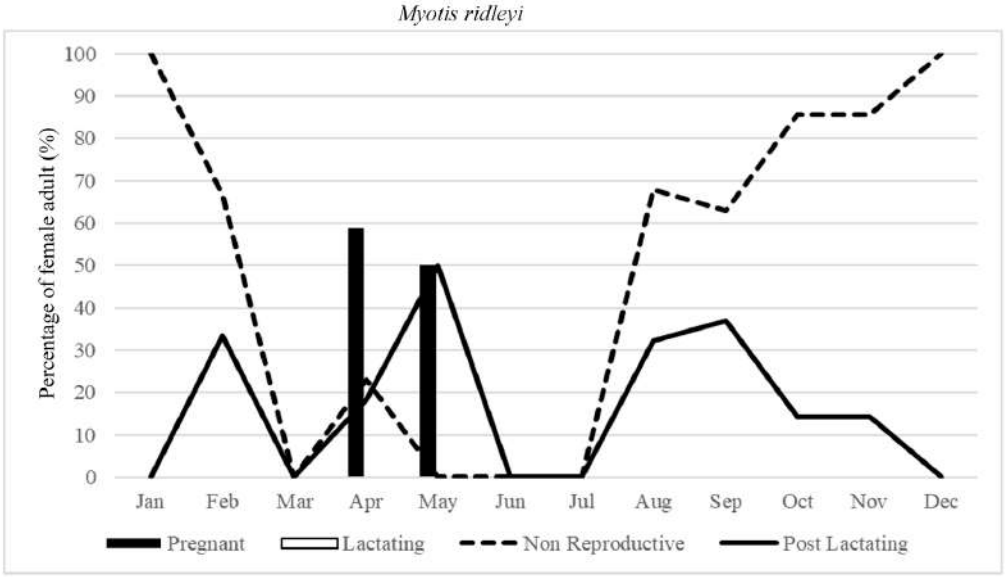

Fig. 4. Reproductive pattern of *Myotis ridleyi* in Gunung Keriang

The unimodal breeding pattern observed in the studied cave-roosting bats is consistent with patterns reported in other Southeast Asian cave bat populations. For example, in Cambodia, insectivorous cave bats of the genera *Hipposideros* and *Taphozous* show a single annual breeding peak timed with the onset of the wet season when insect biomass is high [6]. *Hipposideros* and *Rhinolophus* in Southeast Asia exhibit restricted seasonal breeding, likely aligned with increased food availability during the wet season [4, 5]. This suggests that climatic seasonality and food abundance are key ecological drivers shaping the reproductive timing of cave-roosting bats across the region.

4. Conclusions

This study highlights bats diversity and a unimodal and synchronised breeding pattern among selected bat species in Gunung Keriang. Despite agricultural surroundings, the site remains ecologically significant for both common and threatened species. Understanding these reproductive dynamics is essential for effective bat conservation and for sustaining ecosystem services in agricultural.

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