

understanding the results obtained by Hayasaka and Takeuchi, though it is clear that it is difficult to explain their result in a simple model².

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Relationship between infant size and carrying of infants by hipposiderid mother bats

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The newborn individuals of a cave-dwelling insectivorous bat *Hipposideros speoris* are hairless, sightless and flightless. A study was undertaken on the details of how these are nursed under natural conditions. The mothers carry their infants of early stages along with them while leaving the cave for foraging after sunset. A few young ones are left behind while their mothers leave for foraging. More and more infants are left behind when they become larger in size and volant (able to fly). Interestingly a few volant young ones are still carried to the foraging area at the cost of increasing the wing loading of mothers. This process may be beneficial to the volant young in learning the topography at the foraging areas, prey detection and capture by using their echolocating system.

ONE of the fascinating areas in the behavioural repertoire of bats is the relationship between mother and infant. There are several reports on this component describing the lavishness of meticulous care showered by mothers on their infants¹. In the earlier stages of life young ones attach themselves tenaciously to the body of the mothers and are even carried on foraging flights. At the later (volant) stages most of the females prefer to leave their young in the day roosts (caves, temples, etc.) while foraging². However a few mothers continue to carry their volant young for foraging even though it

causes an increase in wing loading (body wt/wing area) and needs more energy³. The present study deals with the mother-young relations in a cave-dwelling insectivorous bat *Hipposideros speoris* and explains how the mother bats carry even their volant young to the foraging areas in order to acquaint them with the topography and foraging strategies.

The study site is a natural cave situated on the Samanar Hill complex near the village Keela Kuyil Kudi about 8 km south-east of the Madurai Kamaraj University. A colony of about 500 individuals of *H. speoris* of both sexes inhabit this cave. Observations were made from August to December 1989.

At intervals of 3-4 days, we entered the cave past-midnight hours and counted the number of young bats of mixed ages and sex left behind by their mothers in the several pockets of the cave. Their right-hand forearm length, which is a good measure of size, was measured by using vernier calipers. The home-flying bats were trapped at the entrance of the cave during the pre-dawn hours (03.00-06.00 h) using a mosquito nylon net. The young bats clinging to the body of the returning mothers were also measured. A test was done to find out the relationship between the size of the young ones and their being carried or left inside the cave by the mothers.

During the early part of August the majority of the females were in an advanced stage of pregnancy. Parturition occurred till the end of December and the maximum number of infant bats was recorded during September and October. The newborn babies were altricial-naked body with eyes and ears closed. Figure 1 depicts the pattern of mothers i) carrying their young and ii) leaving them behind as a function of the size of the young ones. The two distributions differ significantly (Kolmogorov Smirnov test, $P=0.05$) and thus more young ones are left inside the cave as they become

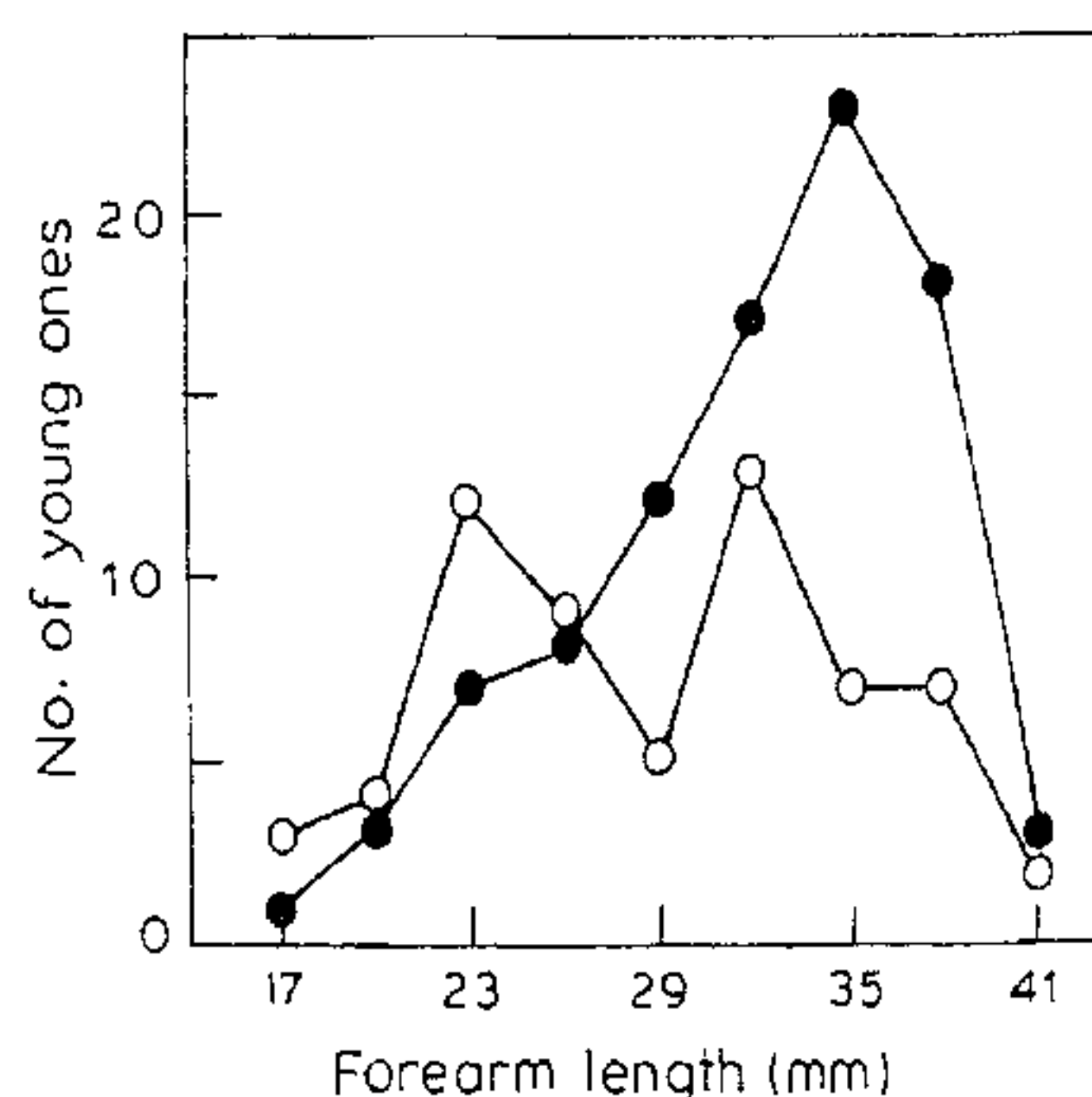


Figure 1. The pattern of mother bats carrying their young (hollow circles) or leaving them behind at the cave (solid circles) as a function of the size of the young ones.

larger. However it is interesting to observe that a few volant young are still carried by their mothers.

At the time of breeding in several species of bats there is a high energy demand especially during the periods of advanced pregnancy and lactation. In addition to the cost of lactation the mother bats spend large additional amounts of energy soon after parturition in which mothers carry their infants continuously. The majority of bat species breed annually at energetically favourable periods when availability of insects for the nurture of the young and to meet their own demands of energy is maximum⁴.

Since the newborn bats are hairless, sightless and flightless the mothers take care of their infants. The young never leave the nipple or pubic teats of the mothers during their early stage of life and may cling to the body of the mothers even while the latter forage¹. Since the cave is a well-protected area, a few mothers of *H. speoris* leave their infants even at the newborn stage inside the cave to forage⁵. The mother-young relations progressively decline and thus more young bats are left behind in the cave as they become older (Figure 1). However it is of great interest to note that a few volant young (forearm length is about 40 mm) were still carried to the foraging areas. Even though this process increases the wing loading of mothers³ the volant young must be highly benefitted by it. They practice the inborn and ingenious method of echolocation by following their mothers at foraging areas⁶. The volant young are able to emit the adult's type of CF-FM echolocation sounds of 135 kHz⁷. Brigham and Brigham⁸ and Vaughan and Vaughan⁹ have reported for temperate species of insectivorous bats evidence for association between mother bat and its young during and after foraging. In the case of the African yellow-winged bat *Lavia frons*⁹ each young shared its parents foraging territory, synchronized its grooming and foraging periods with those of its parents and periodically huddled against its mother while roosting until at least 50 days after its first flight. Thus the relationship between mother and infant includes not only lactation but also training and practice the mother imparts to infants to navigate in the foraging areas dexterously using the echolocatory machinery. However we have no information as yet that the same infants get carried by the same mother bats on a daily basis. If that is not the case then one can account for volant subadults which are left behind. We can also then believe that being taken for the 'acquaintance flights' is a feature that applies to all subadults and is thus a part of their training and growing up.

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Studies on interrelationship between different anaerobic bacteria in biogas digester

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Studies on interrelationship between methanogenic sulphate-reducing and denitrifying bacteria were carried out in a anaerobic biogas digester. Most probable number of these bacteria, concentration of sulphate and nitrate in fermenting slurry, gas production and redox potential were compared for 52 days. It was observed that sulphate-reducing bacteria reduce initial sulphate content of the fermenting slurry to bring it to low level and denitrifying bacteria help to establish the anaerobiosis by reducing the redox potential through utilization of nitrate.

A large variety of microorganisms are involved in production of methane by anaerobic digestion of organic matter. Although only three types of microorganisms, viz. cellulolytic, acid-producing and methanogenic bacteria are directly involved in production of methane, there are some other species of bacteria also present in anaerobic ecosystem which affect methanogenesis.

Sulphate-reducing and denitrifying bacteria are of particular importance since they have been reported to inhibit methanogenesis when sulphate and nitrate respectively is available in the ecosystem. These bacteria have been reported to compete with methanogenic bacteria for their common substrates and thus inhibit methanogenesis¹⁻³. It has also been reported^{4,5} that when sulphate is depleted from the ecosystem sulphate-reducing bacteria help methanogenesis by interspecies hydrogen transfer.

All these studies have been carried out on marine sediment

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