

Bat-Mediated Seed Dispersal and Germination: Ecological Contributions of *Rousettus leschenaulti* and *Cynopterus sphinx* to Plant Regeneration in Southern Tamil Nadu

M. Stephen

Assistant Professor, PG & Research Department of Zoology, St. John's College, Palayamkottai-627 002, Tirunelveli. Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli, 627012, Tamil Nadu, India.

Abstract

Fruit bats are important components of tropical ecosystems because their feeding movements can transport seeds away from parent plants and contribute to plant recruitment. The ecological importance of bat-mediated dispersal depends not only on the distance travelled by seeds but also on the characteristics of the deposition sites and subsequent germination performance. The present study investigated seed dispersal and germination associated with two fruit bats, *Rousettus leschenaulti* and *Cynopterus sphinx*, in southern Tamil Nadu. Field observations were used to document feeding activity, seed deposition, and dispersal distance, while germination trials were conducted under different habitat conditions. The mean seed-dispersal distance recorded for *R. leschenaulti* was 21.3 ± 5.2 m, whereas *C. sphinx* showed a mean dispersal distance of 18.5 ± 4.6 m. Germination success differed among deposition habitats, with the highest value recorded in forest gaps ($91.7 \pm 4.41\%$), followed by feeding roosts ($86.7 \pm 1.67\%$) and parent-tree sites ($78.3 \pm 1.67\%$). Seeds associated with bat-derived material showed $92.0 \pm 6.11\%$ germination and a mean germination time of 10 ± 1.2 days, compared with $88.0 \pm 2.31\%$ and 15 ± 1.6 days for untreated seeds. Statistical analysis indicated significant differences in feeding behaviour, seed-dispersal distance and germination performance. The findings demonstrate that fruit bats can contribute to plant regeneration through seed movement and deposition in different microsites. Conservation of fruit bats and protection of their feeding and roosting habitats are therefore relevant to maintaining ecological interactions associated with tropical plant regeneration.

Keywords: Fruit bats; seed dispersal; germination; *Rousettus leschenaulti*; *Cynopterus sphinx*; forest regeneration; feeding roosts; southern Tamil Nadu

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1. Introduction

Seed dispersal is a fundamental ecological process that determines the spatial distribution, recruitment and regeneration of plant populations. The movement of seeds away from parent plants can reduce density-dependent mortality and allow plants to colonize suitable microsites. Animals constitute important seed-dispersal agents in tropical ecosystems, and the ecological outcome of dispersal depends on both dispersal distance and the characteristics of the sites in which seeds are deposited (Howe & Smallwood, 1982).

Among vertebrate frugivores, bats are particularly important because of their mobility, nocturnal activity and ability to transport fruits and seeds between feeding and roosting locations. Frugivorous bats can contribute to plant recruitment by removing fruits, transporting seeds and depositing propagules in locations that may differ substantially from the parent plant environment (Muscarella & Fleming, 2007). Their contribution is particularly relevant in fragmented and disturbed tropical landscapes where natural regeneration may depend on the movement of seeds between remnant vegetation patches.

Bats provide several ecosystem services, including seed dispersal and pollination, and these services can influence both natural and agricultural ecosystems (Kunz et al., 2011). The importance of a frugivore cannot, however, be determined simply from fruit consumption. Seed-dispersal effectiveness depends on the interaction between animal movement, fruit selection, seed characteristics, deposition location and subsequent seed fate (Jordano et al., 2007).

In India, *Rousettus leschenaulti* and *Cynopterus sphinx* are widely distributed fruit bats associated with different roosting and feeding habitats. *R. leschenaulti* is commonly associated with caves, temples and other dark structures, whereas *C. sphinx* frequently uses vegetation and foliage as roosting sites. Both species consume a range of fruits and have been recognized as important components of tropical plant-animal interactions.

Previous studies have demonstrated that these two species can act as seed dispersers. For example, research on *Syzygium oblatum* in southwest China demonstrated that *R. leschenaulti* and *C. sphinx* transported seeds away from parent trees and deposited them at feeding sites and forest gaps.

However, the ecological consequences of seed deposition depend on local habitat conditions and the subsequent fate of dispersed seeds.

The present study therefore focuses on three related aspects of bat-mediated plant regeneration: (i) feeding behaviour and fruit selection, (ii) seed-dispersal distance, and (iii) germination performance under different deposition conditions. The study specifically examines *R. leschenaulti* and *C. sphinx* and evaluates their potential contribution to plant regeneration in southern Tamil Nadu.

2. Materials and Methods

2.1 Study Area

The study was conducted at selected fruit-bat roosting and feeding locations in southern Tamil Nadu. The study area included sites associated with caves, temples, abandoned dark structures, palm foliage and dense vegetation. *R. leschenaulti* was predominantly associated with caves, temples and abandoned dark rooms, whereas *C. sphinx* was observed mainly in palm foliage and dense vegetation. The thesis records multiple roosting locations for both species in the study region. 4 results

2.2 Study Species

Two fruit bat species were considered:

- *Rousettus leschenaulti* (Desmarest, 1820)
- *Cynopterus sphinx* (Vahl, 1797)

The species were selected because of their fruit-feeding behaviour and their potential importance in seed dispersal.

2.3 Observation of Feeding Behaviour

Feeding behaviour was documented through field observations at fruiting plants and feeding locations. Fruit selection, frequency of visits and feeding activity were recorded for the two bat species. The observations indicated that *R. leschenaulti* frequently utilized soft, fleshy fruits including *Mangifera indica*, *Anacardium occidentale* and *Syzygium cumini*, whereas *C. sphinx* also utilized harder fruits including *Phoenix pusilla* and *Areca catechu*. 4 results

2.4 Measurement of Seed-Dispersal Distance

Seed-dispersal distance was estimated by measuring the distance between the relevant fruiting/parent plant or feeding source and the location where dispersed seeds were detected. Feeding roosts were examined for deposited seeds, and the distance travelled by seeds was compared between the two bat species.

The mean dispersal distance recorded for *R. leschenaulti* was 21.3 ± 5.2 m, while the corresponding value for *C. sphinx* was 18.5 ± 4.6 m. 4 results

2.5 Germination Experiment

Seed germination was assessed under three deposition conditions:

1. Parent-tree site
2. Forest gap
3. Feeding-roost site

Germination success was recorded as the percentage of seeds that successfully germinated.

A separate comparison was also made between bat-associated seeds and untreated control seeds. The thesis describes the bat-associated treatment as seeds exposed to bat-derived material, including fecal matter. 4 results

2.6 Statistical Analysis

The data were analysed using SPSS version 16.0 and Microsoft Excel. Analysis of variance (ANOVA) was used to evaluate differences in feeding behaviour and germination success among habitats. Independent comparisons of dispersal distance and germination performance between groups were evaluated using t-tests.

Statistical significance was considered at $p < 0.05$, consistent with the statistical analysis reported in the source thesis.

3. Results

3.1 Feeding Behaviour and Fruit Selection

The two bat species showed differences in their feeding associations with plant species. *R. leschenaulti* showed relatively greater association with soft, fleshy fruits, particularly *Mangifera indica*, *Anacardium occidentale* and *Syzygium cumini*. *C. sphinx* showed greater association with fruits including *Phoenix pusilla* and *Areca catechu*. Both species were also observed feeding on *Anacardium occidentale*.

ANOVA indicated a significant difference in feeding behaviour between the two bat species across the plant species examined ($F = 4.68$, $p = 0.03$). 4 results

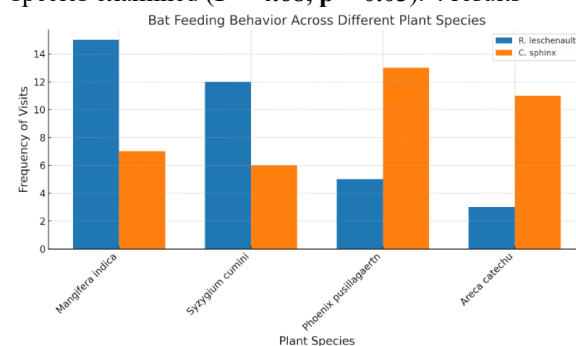


Figure 1. Feeding behaviour and fruit-selection patterns of *Rousettus leschenaulti* and *Cynopterus sphinx* across major fruiting plant species.

3.2 Seed-Dispersal Distance

Both bat species transported seeds away from feeding and parent-plant locations. The mean seed-dispersal distance was higher for *R. leschenaulti* than for *C. sphinx*.

R. leschenaulti recorded a mean dispersal distance of 21.3 ± 5.2 m, whereas *C. sphinx* recorded 18.5 ± 4.6 m. The reported t-test showed a significant difference between the two species ($t = 2.13$, $p = 0.04$). 4 results

The highest concentration of deposited seeds was reported within approximately 20–25 m of feeding

locations. Seeds deposited in forest gaps showed greater germination success than those associated with parent-tree sites. 4 results

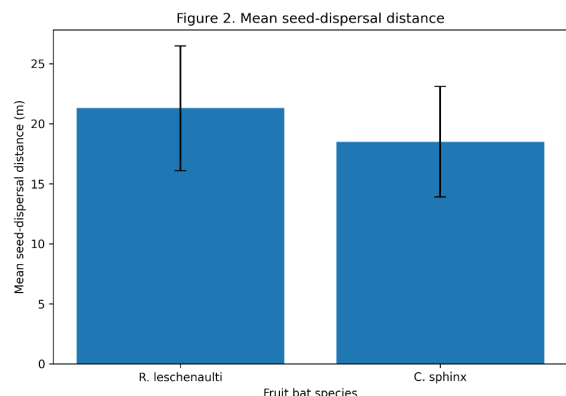


Figure 2. Mean seed-dispersal distance of *Rousettus leschenaulti* and *Cynopterus sphinx*.

3.3 Germination Success under Different Habitat Conditions

Germination success differed among the three habitat conditions. The highest germination percentage was recorded in forest gaps ($91.7 \pm 4.41\%$), followed by feeding-roost sites ($86.7 \pm 1.67\%$) and parent-tree sites ($78.3 \pm 1.67\%$).

The reported ANOVA indicated a significant difference among habitats ($F = 5.44$, $p = 0.03$). 4 results

Table 1. Germination success of seeds under different habitat conditions

Habitat condition	Germination (%)	Standard error (%)
Parent tree	78.3 ± 1.67	2.1
Forest gap	91.7 ± 4.41	2.6
Feeding roost	86.7 ± 1.67	3.2

The relatively greater germination percentage in forest gaps suggests that the microsite receiving dispersed seeds can influence subsequent recruitment. The result is consistent with the broader ecological concept that seed-dispersal effectiveness depends not only on movement away from the parent plant but also on the quality of the deposition environment.

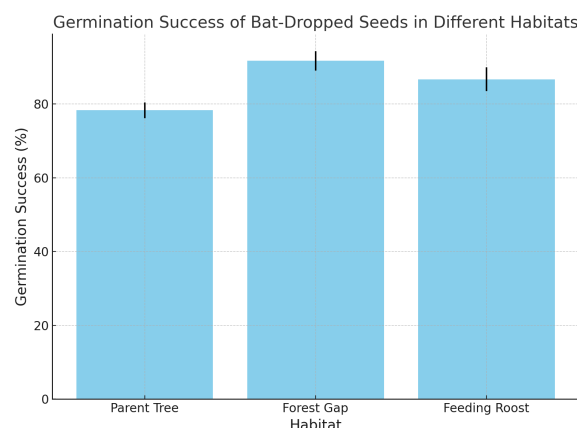


Figure 3. Germination success of bat-dispersed seeds under parent-tree, forest-gap and feeding-roost conditions.

3.4 Germination of Bat-Associated and Control Seeds

A comparison between bat-associated and untreated seeds showed differences in both germination percentage and germination time. Bat-associated seeds showed $92.0 \pm 6.11\%$ germination, whereas untreated control seeds showed $88.0 \pm 2.31\%$ germination.

The mean time to germination was 10 ± 1.2 days for bat-associated seeds and 15 ± 1.6 days for untreated seeds. Thus, the bat-associated group showed a five-day difference in mean germination time. The reported t-test indicated a significant difference ($t = 3.34$, $p = 0.01$). 4 results

Table 2. Comparison of germination performance between bat-associated and untreated seeds

Seed treatment	Germination (%)	Time to germination (days)
Bat-associated material	92.0 ± 6.11	10 ± 1.2
Untreated control	88.0 ± 2.31	15 ± 1.6

These results indicate an association between bat-derived material and improved germination performance in the experimental conditions. However, the present dataset does not establish which chemical, microbial or physiological mechanism was responsible for the observed difference.

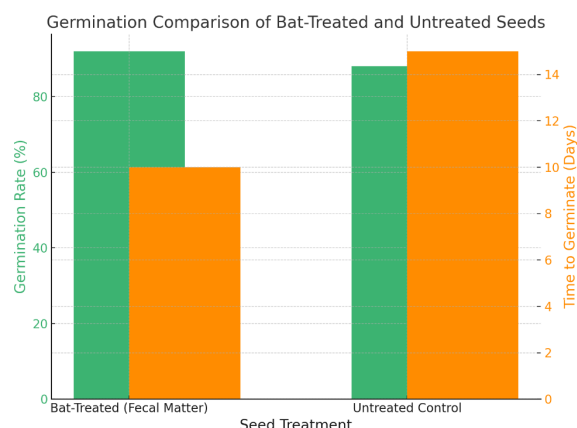


Figure 4. Comparison of germination percentage and mean germination time between bat-associated and untreated seeds.

3.5 Seed Characteristics and Dispersal

The thesis observations also documented variation in seed characteristics. Larger seeds, approximately 1.9–2.2 cm in size, were reported among the dispersed plant material, with fleshy fruit structures providing food resources for fruit bats. 4 results

The interaction between fruit characteristics and bat feeding behaviour may influence which seeds are removed from parent plants and subsequently transported to feeding locations.

4. Discussion

Seed dispersal by vertebrates is a major component of tropical plant regeneration. The present study demonstrates that *R. leschenaulti* and *C. sphinx* interact with multiple fruiting plant species and transport seeds away from their original locations. Such movement can potentially reduce the spatial concentration of seeds beneath parent plants and increase the probability that some seeds reach suitable microsites.

The observed difference in dispersal distance between the two species is ecologically relevant. *R. leschenaulti* showed a mean dispersal distance of 21.3 m, compared with 18.5 m for *C. sphinx*. Differences in movement patterns, feeding behaviour, fruit handling and roosting ecology may contribute to variation in the spatial distribution of dispersed seeds. Seed dispersal is increasingly understood as a process determined by interactions between animal movement and the spatial distribution of plant resources rather than by distance alone (Jordano et al., 2007).

The feeding ecology observed in the present study is also consistent with previous research on *C. sphinx* in southern India. Earlier work documented fruit-carrying behaviour in which bats frequently transport fruit away from fruiting trees to feeding locations. Research on *C. sphinx* in southern India has additionally demonstrated the importance of foliage-based roosting behaviour.

The germination results provide an additional perspective on dispersal effectiveness. Seeds associated with forest gaps showed the highest germination percentage, followed by feeding-roost and parent-tree locations. This suggests that the destination of a dispersed seed can be as important as the distance travelled. Open microsites may provide environmental conditions that differ from those beneath dense parent-tree canopies, potentially affecting germination and early establishment.

The importance of deposition microsites has been demonstrated in seed-dispersal research more generally. Frugivore species can differ not only in the distance over which they transport seeds but also in the types of microsites in which those seeds are deposited (Jordano et al., 2007). Therefore, evaluating seed-dispersal effectiveness requires consideration of both movement and post-dispersal seed fate.

The present study also found faster germination in the bat-associated treatment. However, the interpretation requires caution. Although the bat-associated group germinated approximately five days earlier than the untreated control, the available data do not identify the mechanism responsible for this difference. Previous research has shown that bat ingestion or handling does not universally increase germination percentage, and effects can differ among plant species and seed-handling mechanisms. Consequently, the present finding should be interpreted as an **observed association between bat-derived material and germination performance**, rather than evidence of a demonstrated growth-promoting chemical effect.

Frugivorous bats have been recognized as important contributors to tropical forest regeneration because they can transport seeds between spatially separated locations and influence plant recruitment. Their ecological role becomes particularly relevant in fragmented landscapes where movement of propagules between forest patches may contribute to vegetation recovery.

The results therefore support the interpretation that *R. leschenaulti* and *C. sphinx* participate in plant–animal interactions that may contribute to natural regeneration. Nevertheless, seed dispersal should not be equated directly with successful forest establishment. A dispersed seed must survive germination, seedling establishment, herbivory, drought and other environmental pressures before contributing to the plant population.

5. Ecological Implications

The results have several ecological implications.

First, the two fruit bats function as seed-moving agents capable of transporting seeds beyond the immediate vicinity of parent plants. Second, the occurrence of dispersed seeds in feeding-roost locations and forest gaps demonstrates that bat activity can create spatially

distinct seed-deposition patterns. Third, the comparatively high germination percentage observed in forest gaps indicates that some deposition locations may provide favourable conditions for subsequent plant recruitment.

These processes are consistent with the broader ecological role of frugivorous bats in tropical ecosystems. Reviews have identified seed dispersal and pollination as important ecosystem services associated with bats, while emphasizing the need for site-specific evidence to quantify their actual contribution to ecosystem functioning (Kunz et al., 2011).

Fruit bats can therefore be considered components of plant regeneration networks rather than merely fruit consumers. Their conservation may have indirect consequences for the maintenance of plant diversity and ecological connectivity in tropical landscapes.

6. Conservation Implications

The results highlight the importance of maintaining both feeding resources and roosting habitats for fruit bats. The thesis documented *R. leschenaulti* in caves, temples and abandoned dark structures and *C. sphinx* in vegetation-associated roosts. 4 results

Loss of roosting sites, reduction of fruit-bearing vegetation and disturbance of feeding areas may alter bat movement patterns and consequently affect seed-dispersal interactions. In southern India, the ecological importance of fruit bats has previously been recognized in relation to pollination and seed dispersal.

Conservation strategies should therefore consider fruit bats as components of broader plant–animal interaction networks. Protection of natural roosting sites, retention of fruit-bearing trees and maintenance of vegetation corridors may help sustain these ecological interactions.

7. Limitations of the Study

Several limitations should be considered when interpreting the findings.

First, the available dataset does not provide complete sample sizes and degrees of freedom for all statistical tests. Second, the study evaluates germination performance but does not provide long-term seedling survival or recruitment data. Third, the bat-associated germination experiment does not identify the specific biological mechanism responsible for the observed difference in germination time.

Therefore, the results should be interpreted as evidence of differences in seed dispersal and germination performance rather than definitive evidence that bat activity alone determines successful forest regeneration.

8. Future Research

Future studies should incorporate larger sample sizes and repeated observations across multiple seasons.

Radio-tracking or GPS-based movement studies could provide more accurate estimates of bat movement and seed-dispersal kernels. Molecular identification of dispersed seeds could also establish plant–bat interaction networks with greater precision.

Long-term experiments following dispersed seeds from germination through seedling establishment would provide stronger evidence of the contribution of bats to plant recruitment. Controlled germination experiments comparing intact, pulp-removed, mechanically cleaned and bat-associated seeds would also help determine whether the observed germination differences arise from pulp removal, gut passage, fecal material or other mechanisms.

9. Conclusion

The present study demonstrates that *Rousettus leschenaulti* and *Cynopterus sphinx* are associated with seed-dispersal processes involving multiple fruiting plant species in southern Tamil Nadu. *R. leschenaulti* showed a mean seed-dispersal distance of 21.3 ± 5.2 m, while *C. sphinx* showed 18.5 ± 4.6 m. Germination differed among deposition habitats, with forest gaps showing the highest reported germination percentage.

The comparison between bat-associated and untreated seeds additionally indicated differences in germination percentage and germination time. Although the mechanism underlying this difference requires further investigation, the results demonstrate that the fate of dispersed seeds depends on both dispersal and post-dispersal conditions.

The findings emphasize the ecological relevance of fruit bats as components of plant–animal interaction networks. Maintaining suitable roosting habitats, feeding resources and vegetation connectivity may therefore support the ecological processes associated with seed dispersal and natural plant regeneration.

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