Asian Journal of Conservation Biology, July 2023. Vol. 12 No. 1, pp. 73–81 AJCB: FP0212/77832
ISSN 2278-7666 ©TCRP Foundation 2023 https://doi.org/10.53562/ajcb.77832

Research Article

Distribution, diversity and roost preference of microchiropteran bats in southern districts of Tamil Nadu, India

S. Balasingh, Ezhilmathi Sophia* and S. Suthakar Isaac

Postgraduate and Research Department of Zoology, St. John's College, Palayamkottai, Tirunelveli - 627 002, India (Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli-627 012, Tamilnadu, India)

(Received: October 27, 2022; Revised: December 12, 2022; Accepted: June 10, 2023)

ABSTRACT

Availability habitat and microhabitats for roosting are crucial for any species for its survival. Bats prefer and use cave, crevices, tree cavities, foliage and many anthropogenic structures as their roosting sites. In the present study, an investigation was made on the distribution, diversity, and roost preference of microchiropteran bats in Tirunelveli and Tenkasi districts of Tamilnadu, Southern India. A total of ten species of microchiropterans bats namely *Hipposideros speoris, Hipposideros ater, Hipposideros fulvus, Taphozous melanopogon, Taphozous nudiventris, Pipistrellus tenuis, Pipistrellus coromandra*, *Megaderma lyra, Rhinopoma hardwickii,* and *Tadarida brasiliensis* were observed between January to December 2021. These bat species mainly preferred temples (59.15%), buildings (38.02%), and hillocks (2.83%) as their roosting sites. It is also found that 79.70% of the roosts were found in the vicinity of agriculture fields and water bodies. The species abundance was calculated by Margalef's Index for *H. speoris* (2.5), *P. tenuis* (2.3), *M. lyra* (1.7), *H. ater* (1.2), *T. melanopogon* (0.7)*, R. hardwickii* (0.5), *T. nudiventris* (0.3), and *T. brasiliensis* (0.2).The present study reveals that the bats mostly prefer temples and anthropogenic structures which provide suitable microhabitats, which are located in the vicinity of agricultural landscape.

Key words: Microchiropteran bats, Distribution, Roost preference, Margalef's Index, Agricultural landscape.

INTRODUCTION

Bats are distributed all over the world except in the Arctic, Antarctic and a few isolated oceanic islands. They are the second-largest order of mammals with more than 1,400 species worldwide (Ali, 2022). As per the Chiroptera Conservation and Information Network of South Asia (CCINSA) and Management Plan Workshop Report, India has 114 species of bats (Molur *et al*., 2002).Two Indian bat species i.e Salim Ali's fruit bat, *Latidens salimalli* and Wroughton's free-tailed bat *Otomops wroughtonii* in listed as Schedule I under Wildlife (Protection) Act of India (1972) (BCI, 2003). These two species mainly found in areas adjacent to the Western Ghats in Southern India (Ali, 2022).

Chiropterans are important groups of mammals found almost in all parts of India. They play important roles in all types of ecosystems such as forest, wetland, etc (Rahman and Choudhury, 2017). The bat species present around Western Ghats belongs to 2 sub-orders, 8 families and 25 genera. Microchiroptera is the largest suborder contributing to 88% of bat species with seven families, of which Vespertilionidae is the most abundant family contributing 40% of the bat fauna of the Western Ghats. Family Hipposideridae is the second dominant family with 14% of total species. Of the 52 species 84% are insectivorous, 12% are frugivorous and 2% are carnivorous (Vishakha *et al*., 2007).

Bats are functionally diverse mammalian order playing important roles in insect control, pollination and seed dispersal (Altringham, 2011; Boyles *et al*., 2011; Kunz *et al*., 2011). In addition, they have been recognized as a valuable bio-indicator group (Jones *et al*., 2009). Despite of this, bats are poorly studied taxon in the palaeotropics whose conservation is generally not prioritized, (Meyer *et al*., 2016). Little is known about the vulnerability of most bat species to disturbance and habitat modification. In conserving bats, as with other taxa, it is important to protect both taxonomic and functional diversity (Tilman, 2001; Villéger *et al*., 2008; Mouillot *et al*., 2011). Functional diversity is the variability in morphological and ecological traits among species, and is thought to be more important than taxonomic diversity for ecosystem resistance, resilience and functioning (Petchey and Gaston, 2006).

In the present study, the significance of the vicinity of bat roosts to agricultural fields, river and irrigation channel was focused (Ganesh *et al*., 2022).Diversity and distribution of bats in human settlement such as undisturbed and abandoned houses, ancient temples, hillocks and under the bridges are studied.

MATERIAL AND METHODS

Study area

Tirunelveli District: Tirunelveli district (area 3876. 06 Sq.Kms) is the southernmost district of Tamil Nadu, having lofty mountains, low plains and adjacent to the Western Ghats, from which all the perennial rivers follow and drain towards the east. The surface water of the district is drained into the major river basin of Thamirabarani. The river is the major source of irrigation and fed by the northeast and southwest monsoons.

Tenkasi District: The Tenkasi district (area 2882. 43 Sq.Kms**)** has two major rivers, namely the Chittar and the Anumanadhi, through which agricultural lands get irrigated. Water sources such as Gundar, Adavinayinar,

**Corresponding Author's E-mail:* sophiedanie@gmail.com

Karupanadhi, and Ramanadhi dams, along with more than 800 tanks for succor irrigation. The district also has diverse geographical and physical features such as lofty mountains and low plains, and thorny scrub jungles.

Survey of Microchiropteran bats

A survey on the distribution of microchiropteran bats was conducted in the plains of Tirunelveli and Tenkasi districts of Tamilnadu, Southern India from January to December 2021. Based on the local enquiries from the people, bat roosts were located and periodic visits were made in the day to roosting sites. Roosts were identified either by visually searching by presence of droppings, insect remains, urine, smell, marks/staining (Kalko *et al*., 1999) that had previously been used as roosts. Diurnal retreats in rock crevices were inspected by reflecting sunlight into their openings with a mirror (O'Shea and Vaughan, 1977). On each field trip, an effort was made to estimate the number of bats found in various roosting sites. By using GCS Software, the bat roosting areas were marked and analyzed for Density Cluster Analysis (Spatial Reference GCS: GCS WBS 1984 Datum: 1984 Map units: Degree). The diversity index indicating the degree of species abundance (Margalef's Index) was calculated for the 10 bat species found in the study area. During the roost visit and capture the bats were released in the same roosts in around 5 - 10 minutes, guidelines for the use of Wildlife Mammal Species in research (Sikes *et al*., 2011; Robert *et al*., 2016) was strictly in which followed. The geographical coordinates of each bat roost were obtained using a Garmin GPS MAP 78S receiver (Garmin, Olathe, Kansas, USA).

RESULTS

During the study period bat roosts were located in 71 places in 16 taluks of Tirunelveli and Tenkasi District. Ten bat species were identified, such as *Hipposideros speoris, Hipposideros ater, Hipposideros fulvus*, *Taphozous melanopogon, Taphozous nudiventris, Rhinopoma hardwickii, Tadarida brasiliensis*, *Pipistrellus coromandra*, *Pipistrellus tenuis* and *Megaderma lyra*. These bats prefer to roost in temples (59.15%), buildings (38.02%), and hillocks (2.83%) (Table 1).

The roosts occupied by *H. speoris* (26.76%). *H. ater* (16.90%), *H. fulvus* (1.40%), *M. Lyra* (16.90%), *T. melanopogon* (8.45%), *T. nudiventris* (2.81%), *P. tenuis* (16.90%), *P. coromandra* (1.40%), *R. Hardwickii* (5.63%), and *T. brasiliensis* (2.81%) are recorded.The colony size of *H. speoris* (n = 19) ranged from 8 to 551 individuals. *H. speoris* preferred to roost in temples, old buildings, and deserted houses. The roosting position of bats was always linear, and the bats maintained good inter-individual distance (ranged from 5 to 20 cm) *H. speoris* colonies were found to co-exist with *T. melanopogon* and *Rousettus leschenaulti*. The colony size of *H. ater* (n=12) varied from 22 to 632 individuals. It was also noticed that, *H. ater* preferred to roost in temples, deserted buildings, and unused motor rooms. The roosting position of bats was always linear, and the bats maintained good inter-individual distance (5 to 11 cm). The survey found only one roost for *H. fulvus* (n=1) with just 3 individuals in area around a temple 7 to 10 feet height. *H. fulvus* colonies were found to co-exist with *M. lyra*. *M. lyra* was with the colony size of (n = 12) ranged from 2 to 113 individuals. Preferred to roost in temples, deserted buildings, stone buildings, and chariots. The inter-individual distance roughly 7 to 12 cm. *M. lyra* colonies were found to co-exist with *H. fulvus*.

6 colonies of *T. melanopogon* varied from 22 to 292 individuals and was found in towers of temples and the roosting position was mostly linear rarely aggregated together to form a cluster. *T. melanopogon* colonies were found to co-exist with *H. speoris. T. nudiventris* (n = 2) colony consists of 89 to 231 individuals, found to roosts only in porch, interior chamber, tower and sanctum of temples. Only 4 to 23 numbers of *P. tenuis* (n = 13) preferred to roosts in electric metre wooden boxes, crevices of houses, and churches. The survey found only one roost of *P. coromandra* (n = 1) with 3 individuals in a wooden box crevices.

R. hardwickii (4 colonies) with a population size of 6 to 33 preferred to roost in crevices of temples and hillocks. The survey found two roosts of *T. brasiliensis* with 17 - 23 individuals in dark area of temple crevices in7 to 20 feet height co-exist with *R. leschenaulti.* The species richness was measured by a software Diversity Indices revealed that the ranking of species richness of *H. speoris* (2.54), *P. tenuis* (2.31), *M. lyra* (1.79), *H. ater* (1.20), *T. melanopogon* (0.77), *R. hardwickii* (0.51), *T. nudiventris* (0.34), *T. brasiliensis* (0.22), (Table 2). Density cluster analysis of microchiropteran bats in Tirunelveli and Tenkasi districts has been shown in Figure 1.

79.7 % of roost preference is in the midst of agriculture fields surrounded by pond, river, and irrigation channel. Building offer roosting site for 17.3% bats and only 2.8% of preferred hillock. On studying the habitat preferences of ten bat species it is evident that they choose to roosts in agricultural areas and nearby irrigated lands with topography of canal banks, rivers and nearby ponds.

DISCUSSION

Several studies on the survey of microchiropteran bats provide their habitat preference and roost selection (Ali, 2022; Muthuselvam *et al*., 2021; Swamidoss *et al*., 2012). Generally, the habitat preference by bats depends on the foraging and roosting resources, they acquire from the habitats. Bats prefer their roosting habitat, where their foraging resources are in the close vicinity. It is also reported that bat roosting sites are nearer to the human settlements, water sources and or agriculture fields (Swamidoss *et al*., 2012). It is hypothesized that farmland heterogeneity increase bat abundance and richness in agricultural landscapes (Liv Monck *et al*., 2017).

Muthuselvam *et al*., (2021) reported that insectivorous bats of Southern districts of India prefer to roost in agriculture field with their foraging resource around the roosting environment. Besides, bats take advantage of roosting and foraging opportunities offered by urban areas (Kunz 2003).It is reported that in Tirunelveli, *H. ater* forages on the pests of stored grains (*Tribolium* spp) which constitute 55.83% of coleopteran and the rest includes lepidopteran pest. During winter, it feeds on dipteran insects especially mosquitoes that constitute 98.33% of the total intake. This species is selective but opportunistic in feeding their prey insects (Sophia, 2012).

Data on bat activity and richness collected using acoustic surveys in rural Eastern Ontario, Canada, to test the predictions that there should be greater bat activity and

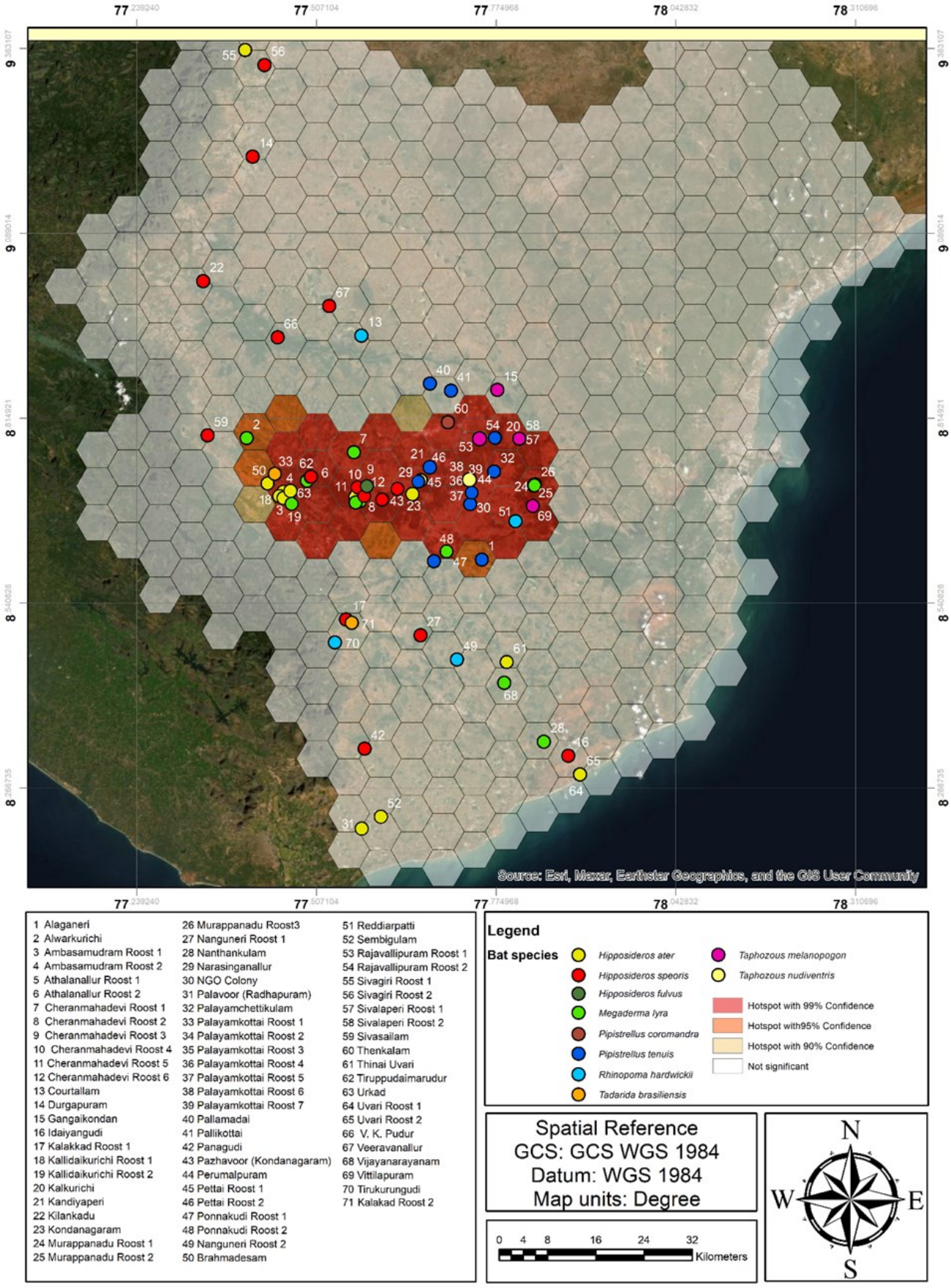

Figure 1. Distribution and density cluster analysis of Microchiropteran bats in Tirunelveli and Tenkasi districts of Tamil Nadu.

Table 1. Details of Roost sites, Population Size and Topography of microchiropteran bats in Tirunelveli and Tenkasi Districts

S.No	Bat Species	Population Size	Roost Site	Location	Lat/Long	Topography
1	*Pipistrellus tenuis*	5	House Crevices	Alaganeri	N 08°36.300' E 077°45.226'	NP/AF/RA
2	*Megaderma lyra*	42	Temple	Alwarkurichi	N 08º47.117' E 077º24.191'	AF/NP/RA
3	*Hipposideros ater*	195	Temple	Ambasamudram Roost 1	N 08º41.945' E 077º27.122'	RB/RA/AF/UA/CB
4	*Hipposideros ater*	22	Temple	Ambasamudram Roost 2	N 08º42.284' E 077º27.531'	RB/RA/AF/UA/CB
5	*Hipposideros speoris*	58	Bridge	Athalanallur Roost 1	N 08º43.323' E 077º29.583'	RA/AF/UA/NP
6	*Megaderma lyra*	113	Temple	Athalanallur Roost 2	N 08º43.323' E 077º29.583'	RA/AF/UA/NP
7	*Tadarida brasiliensis*	17	Temple	Brahmadesam	N 08º43.934' E 077º26.708'	AF/RA/NP/CB
8	*Megaderma lyra*	5	Temple	Cheranmahadevi Roost 1	N 08º45.855' E 077º33.768'	UA/RB/RA/AF/CB
9	*Megaderma lyra*	76	Temple	Cheranmahadevi Roost 2	N 08º41.518' E 077º34.336'	UA/RB/RA/AF/CB
10	*Hipposideros fulvus*	3	Temple	Cheranmahadevi Roost 3	N 08º41.884' E 077º33.898'	UA/RB/RA/AF/CB
11	*Hipposideros speoris*	87	Stone Building	Cheranmahadevi Roost 4	N 08º42.676' E 077º34.197'	UA/RB/RA/AF/CB
12	*Megaderma lyra*	2	Temple	Cheranmahadevi Roost 5	N 08º41.378' E 077º33.938'	UA/RB/RA/AF/CB
13	*Hipposideros speoris*	65	Temple	Cheranmahadevi Roost 6	N 08º42.001' E 077º34.720'	UA/RB/RA/AF/CB
14	*Rhinopoma hardwickii*	33	Temple	Courtallam	N 08°56.226' E 077°16.454'	HA/CB/UA
15	*Hipposideros speoris*	54	Temple	Durgapuram	N 09º12.146' E 077º24.715'	RA/AF/NP
16	*Taphozous melanopo-gon*	92	Temple	Gangaikondan	N 08º51.392' E 077º46.504'	RB/RA/AF
17	*Hipposideros speoris*	25	Abandoned Building	Idaiyangudi	N 08º18.838' E 077º52.944'	UA/RA
18	*Hipposideros speoris*	261	Temple	Kalakkad	N 08º30.960' E 077º33.074'	AF/UA/RA/NP/CB
19	*Pipistrellus tenuis*	4	Abandoned Building	Kalkurichi	N 08°47.124' E 077°46.397'	RB/AF/NP/RA
20	*Megaderma lyra*	34	Temple	Kallidaikurichi Roost 1	N 08º41.259' E 077º28.209'	CB/RB/RA/AF/UA

21	*Hipposideros ater*	91	Temple	Kallidaikurichi Roost 2	N 08º41.780' E 077º27.468'	CB/RB/RA/ AF/UA
22	*Pipistrellus tenuis*	13	Abandoned Building	Kandiyaperi	N 08°44.517' E 077°40.570'	AF/NP/RA
23	*Hipposideros speoris*	20	Temple	Kilankadu	N 09º01.076' E 077º20.299'	NP/AF
24	*Hipposideros speoris*	522	House	Kondanagaram	N 08º42.592' E 077º37.659'	RA/AF/NP
25	*Megaderma lyra*	32	Abandoned Building	Murappanadu Roost 1	N 08º42.994' E 077º49.963'	RB/NP/AF/RA
26	*Megaderma lyra*	64	Stone Building	Murappanadu Roost 2	N 08º42.862' E 077º49.856'	
27	*Megaderma lyra*	23	Stone Building	Murappanadu Roost 3	N 08º42.893' E 077º49.939'	
28	*Hipposideros speoris*	551	Temple	Nanguneri Roost 1	N 08º29.574' E 077º39.738'	NP/AF/RA/UA
29	*Rhinopoma hardwickii*	18	Hill Rock	Nanguneri Roost 2	N 08º27.399' E 077º42.990'	HA/AF/NP
30	*Megaderma lyra*	8	Abandoned Building	Nanthankulam	N 08º20.096' E 077º50.766'	RA/NP/AF
31	*Hipposideros ater*	621	Abandoned Building	Narasinganallur	N 08º42.110' E 077º39.012'	RA/AF/NP
32	*Pipistrellus tenuis*	5	House Crevices	NGO Colony	N 08°41.254' E 077°44.171'	UA/RA
33	*Hipposideros ater*	44	Temple	Palavoor (Radhapuram)	N 08º12.346' E 077º34.486'	NP/AF/RA
34	*Pipistrellus tenuis*	23	House Crevices	Palayam Chettikulam	N 08°44.135' E 077°46.321'	AF/RA/NP
35	*Hipposideros ater*	91	Abandoned Building	Palayamkottai Roost 1	N 08º43.683' E 077º26.047'	UA/RA
36	*Hipposideros speoris*	264	Abandoned Theatre	Palayamkottai Roost 2	N 08º43.437' E 077º44.103'	UA/RA
37	*Pipistrellus tenuis*	12	House Crevices	Palayamkottai Roost 3	N 08º43.323' E 077º44.141'	UA/RA
38	*Pipistrellus tenuis*	21	House Crevices	Palayamkottai Roost 4	N 08º43.323' E 077º44.141'	UA/RA
39	*Taphozous melanopo-gon*	33	Temple	Palayamkottai Roost 5	N 08º43.403' E 077º44.157'	UA/RA
40	*Taphozous melanopo-gon*	22	Temple	Palayamkottai Roost 6	N 08º43.377' E 077º44.123'	UA/RA
41	*Taphozous nudiventris*	89	Temple	Palayamkottai Roost 7	N 08º43.455' E 077º44.095'	UA/RA
42	*Pipistrellus tenuis*	7	House Crevices	Pallamadai	N 08°51.972' E 077°40.562'	NP/AF/RA

43	*Pipistrellus tenuis*	4	House Crevices	Pallikottai	N 08°51.338' E 077°42.457'	NP/AF/RA
44	*Hipposideros speoris*	211	Temple	Panagudi	N 08º19.473' E 077º34.737'	RA/UA/AF/NP
45	*Hipposideros speoris*	57	Temple	Pazhavoor (Kondanagaram)	N 08º41.636' E 077º36.296'	RA/AF/NP
46	*Pipistrellus tenuis*	6	Church Window Crevices	Perumalpuram	N 08°42.237' E 077°44.286'	UA/RA
47	*Taphozous nudiventris*	231	Temple	Pettai Roost 1	N 08º43.369' E 077º39.764'	UA/RA
48	*Pipistrellus tenuis*	11	House Crevices	Pettai Roost 2	N 08º43.247' E 077º39.534'	UA/RA
49	*Megaderma lyra*	55	Temple	Ponnakudi Roost 1	N 08º37.034' E 077º42.074'	NP/AF/RA
50	*Pipistrellus tenuis*	5	Wooden Box Crevices	PonnakudiRoost 2	N 08º36.151' E 077º40.926'	NP/AF/RA
51	*Hipposideros speoris*	8	Temple	Rajavallipuram Roost 1	N 08º47.052' E 077º45.015'	RB/NP/AF/RA
52	*Taphozous melanopogon*	86	Temple	Rajavallipuram Roost 2	N 08º47.065' E 077º45.002'	RB/NP/AF/RA
53	*Rhinopoma hardwickii*	6	Hill Rock	Reddiarpatti	N 08º39.718' E 077º48.241'	HA
54	*Hipposideros ater*	140	Motor Room	Sembigulam	N 08º13.411' E 077º36.192'	AF/NP
55	*Hipposideros ater*	143	Motor Room	Sivagiri Roost 1	N 09º21.646' E 077º24.053'	NP/AF/CB
56	*Hipposideros speoris*	478	Abandoned Building	Sivagiri Roost 2	N 09º20.316' E 077º25.791'	NP/AF/CB/RA/UA
57	*Hipposideros speoris*	468	Temple	Sivalaperi Roost 1	N 08º47.059' E 077º48.563'	RB/NP/AF/RA
58	*Taphozous melanopogon*	292	Temple	Sivalaperi Roost 2	N 08º47.047' E 077º48.573'	RB/NP/AF/RA
59	*Hipposideros speoris*	77	Temple	Sivasailam	N 08º47.348' E 077º20.689'	NP/AF
60	*Pipistrellus coromandra*	3	Wooden Box Crevices	Thenkalam	N 08°48.536' E 077°42.183'	NP/AF/RA
61	*Hipposideros ater*	632	Abandoned Building	Thinai Uvari	N 08º27.189' E 077º47.450'	NP/AF/RA
62	*Hipposideros speoris*	43	Temple	Tiruppudaimarudur	N 08º43.673' E 077º29.910'	RB/NP/AF/RA
63	*Hipposideros ater*	113	Temple	Urkad	N 08º42.386' E 077º28.110'	RB/RA/AF/UA/CB

64	*Hipposideros ater*	92	Temple	Uvari Roost 1	N 08º17.178' E 077º53.980'	CA/RA/UA
65	*Hipposideros ater*	78	Abandoned Building	Uvari Roost 2	N 08º17.188' E 077º54.003'	CA/RA/UA
66	*Hipposideros speoris*	525	Temple	V. K. Pudur	N 08º56.071' E 077º26.948'	CB/AF/RA/NP
67	*Hipposideros speoris*	110	Temple	Veeravanallur	N 08º58.864' E 077º31.566'	RA/UA/AF/NP
68	*Megaderma lyra*	7	Unused Wooden Chariot	Vijayanarayanam	N 08º25.334' E 077º47.214'	NP/RA/AF
69	*Taphozous melanopogon*	123	Temple	Vittilapuram	N 08º41.060' E 077º49.772'	RA/AF/NP/CB
70	*Rhinopoma hardwickii*	8	Temple	Tirukurungudi	N 08º30.951' E 077º33.036'	UA/AF/NP/RA/ CB
71	*Tadarida brasiliensis*	23	Temple	Kalakad Roost 2	N 08º43.540' E 077º53.551'	AF/UA/RA/NP/ CB

Topography: RB-River Bank, CB-Canal Bank, NP-Nearby Pond, AF-Agriculture field, RA- Residential Area, UA-Urban Area, HA-Hills Area, and CA- Coastal Area.

Table 2. Diversity Indices (Margalef's Index) of microchiropteran bats found in Tirunelveli and Tenkasi Districts

S.No	Bat species	Margalef's values	Total no. of roosts	No of individuals recorded	Range
1	*Hipposideros speoris*	2.546	19	3884	8-551
2	*Pipistrellus tenuis*	2.314	12	116	4-23
3	*Megaderma lyra*	1.793	12	461	2-113
4	*Hipposideros ater*	1.202	12	2262	22-632
5	*Taphozous melanopogon*	0.7723	06	648	22-292
6	*Rhinopoma hardwickii*	0.5112	04	65	6-33
7	*Taphozous nudiventris*	0.3435	02	320	89-231
8	*Tadarida brasiliensis*	0.2289	02	40	17-23
9	*Pipistrellus coromandra*	*	01	03	03
10	*Hipposideros fulvus*	*	01	03	03
11	*Rousettus leschanaulti*	*	01	558	558

*Only one colony located in the study area

greater species richness in agricultural landscapes as reported by Liv Monck *et al*., (2017).

In the present study, Habitat preference of ten species of microchiropteran species in southern districts of Tamilnadu, south India revealed that some preference exist in habitat selection. City limit habitat was the most favoured by bats like *H.* speoris*, T. melanopogon*, and *P. mimus*, whereas species like *R. hardwickaii* and *T. nudiventris* prefers hillock habitats*. M. lyra* and *H. ater* prefers agricultural field as their habitat (Swamidoss *et al*., 2012).A colony of *P. coromandra* is noticed in a village close to paddy field irrigated by a perennial pond. The choice of roost preference by *P. tenuis* is usually found in undisturbed microhabitat in human habitation (Ganesh *et al*., 2022).

In the present study, michrochiropteran bats recorded with in areas where agricultural practice is high surrounded by irrigation. Bats showcase themselves as excellent indicators of habitat quality and maintain a sustainable ecosystem by foraging on pest insects. Agricultural intensification in Tirunelveli and Tenkasi districts offer a good foraging area for Hipposidrid bats, as they provide a good foraging resources (Swamidoss *et al*., 2012) Parvathiraj *et al*., (2019). The survey reveals that *H. speoris* ranks first in its population followed by *H. ater*. *P. coromandra* and *H. fulvus*.

Insectivorous bats provide ecosystem services in agricultural and urban landscapes by consuming arthropods that are considered pests. Bat species inhabiting cities are expected to consume insects associated with urban areas, such as mosquitoes, flying termites, moths, and beetles. From the captured insectivorous bats in the Federal District of Brazil fecal DNA metabarcoding was used to investigate the arthropod consumed by five bat species living in colonies in city buildings, and ascertained whether their predation was related to ecosystem services. These insectivorous bat species were found to consume 83 morphospecies of arthropods and among these 41 were identified to species level, most of which were agricultural pests (Ludmilla *et al*., 2021).

In Tamirabarani river basin of south India, bat species richness and abundance were related to the availability of dark rooms, and number of buildings in the temple (Ganesh *et al*., 2022). In the present study, it is also evident that bats prefer temples (59.15%) which provide suitable micro-habitats, semi-darkness with less anthropogenic disturbance that are located in the vicinity of agricultural landscape. Bats roosting in anthropogenic structures such as temples and old/unused buildings, brings them into conflict with human and makes conservation of bats a challenge. It vital for conservation aspects to provide suitable and alternative habitats like bat houses in the agricultural landscape and develop comprehensive plans to let bats persist in the landscape and provide ecosystem services (Ganesh *et al*., 2022).

REFERENCES

Altringham, J.D. 2011. Bats: From Evolution to Conservation, second ed. Oxford University Press, New York.

Ali 2022. Species diversity of bats (Mammalia: Chiroptera) in Assam, Northeast India. Volume 6 (3): 115-125.https://doi.org/10.5281/zenodo. 6603976.

Bat Conservation International Newsletter (B.C.I). 2003. Volume 2: No. 2 (February 2003) http://www.batcon.org/newsletter/enews-0203/enews-0203-vermin.html.

Boyles, J.G., Cryan, P.M., McCracken, G.F., Kunz, T.H. 2011. Economic importance of bats in agriculture. Science 332: 41-42.https://doi: 10.1126/science.12013.

Ganesh, T., Saravanan, A., Mathivanan, M. 2022. Temple and bats in a homogenous agricultural landscape: Importance of microhabitat availability, disturbance and land use for bat conservation PLOS ONE. 17(7): e0251771. https://doi.org/10.1371/journal.pone.0251771.

Jones, G., Jacobs, D.S., Kunz, T.H., Willig, M.R., Racey, P.A. 2009. Carpe noctem: the importance of bats as bioindicators. Endanger Species Research. 8 (1-2): 93-115.https://doi:10.3354/esr00182.

Kalko, E.K.V., Feriemel, D., Handley, C.O., Schnitzler, H.U.1999. Roosting and foraging behavior of two Neotropical gleaning bats, *Tonatiasilvicoola* and *Trachopscirrhosus* (phyllostomidae). Biotropica 31: 344-353.https://doi.org/10.1111/j.1744-7429.1999.tb00146.x.

Kunz, TH. 2003. 'Ecology of Bats', Plennum Press, New York. ISBN 13: 978-1-4613-3423-1:Pp 1-305.

Kunz, T.H., de Torrez, E.B., Bauer, D., Lobova, T., Fleming, T.H. 2011. Ecosystem services provided by bats. Ann. N. Y. Acad. Sci. 1223: 1-38. https://doi.org/10.1111/j.1749-6632.2011.06004.x.

Liv Monck Whippa., Amanda E. Martina., Charles M. Francisb., Lenore Fahrig. 2018. Farmland heterogeneity benefits bats in agricultural landscapes. Agriculture, Ecosystems and Environment 253: 131–139. https://doi.org/10.1016/j.agee.2017.11.001.

Ludmilla, M. S. Aguiar., Igor D. Bueno-Rocha., Guilherme Oliveira., Eder S. Pires., Santelmo Vasconcelos., Gisele L. Nunes., Marina R. Frizzas., Pedro H. B. Togni. 2021. Going out for dinner - The consumption of agriculture pests by bats in urban areas. PLOS ONE 16 (10):e0258066. https://doi.org/10.1371/journal.pone.0258066.

Molur, S., Marimuthu, G., Srinivasulu, C., Mistry, S., Hutson, A.M., Bates, P.J.J., Walker, S., Priya, K.P., Priya, A.R.B. 2002. Status of South Asian Chiroptera: Conservation Assessment and Management Plan (C.A.M.P.) Workshop Report. Zoo Outreach Organization, Conservation Breeding Specialist Group South Asia, and Wildlife Information & Liaison Development Society, Coimbatore, India,154 pp.

Mouillot, D., Villéger, S., Scherer-Lorenzen, M., Mason, N.W.H. 2011. Functional structure of biological communities predicts ecosystem multi functionality. PLOS ONE 6: e17476. https://doi.org/10.1371/journal.pone.0017476

Meyer, C.F., Struebig, M.J., Willig, M.R. 2016. Responses of tropical bats to habitat fragmentation, logging, and deforestation. In: Bats in the Anthropocene: Conservation of Bats in a Changing World. Springer International Publishing, pp. 63–103.

Muthuselvam, S., Essakiammal, B., ParamananthaSwamidoss, D. P., Sudhakaran, M. R. 2021.Agroecosystem: a Preferable Roosting Habitat by Bats. International Journal of Research and Analytical Reviews (IJRAR), Volume 8, Issue 1: PP.884-891.

O'Shea, T.J., Vaughan, T.A. 1977. Nocturnal and seasonal activities of the pallid bat, *Antrozous pallidus*. Journal of Mammalogy. 58: 269-284.https://doi.org/10.2307/1379326.

Paramanatha Swamidoss, D., Sudhakaran, M.R., Parvathiraj, P. 2012. Habitat Preference of Michrochiropteran Bats in three Districts of Tamilnadu, South India. International Research Journal of Biological Sciences. Vol. 1(5): 24-30. Pp 24-30.

Petchey, O.L., Gaston, K.J. 2006. Functional diversity: back to basics and looking forward. Ecol. Lett. 9: 741-758. https://doi.org/10.1111/j.1461-0248.2006. 00924.x.

Robert S. Sikes., John A. Bryan., David Byman., Brent J. Danielson., Janna Eggleston., Michael R. Gannon., William L. Gannon., David W. Hale., Brett R. Jesmer., Daniel K. Odel., ; Link E. Olson., Richard D. Stevens.,

Rahman, A., Choudhury, P. 2017. Status and population trend of chiropterans in Southern Assam, India. Biodiversity International Journal. Vol (1) Issue 4: Pp 121-132.https://doi:10.15406/bij.2017.01.00018.

Sikes, R. S., Gannon, W. H., and the Animal Care and Use Committee of the American Society of Mammalogists. 2011. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. Journal of Mammalogy 92:235-253.

Sophia, E. 2012. Foraging behaviour of the microchiropteran bat, *Hipposideros ater* on chosen insect pests. Journal of Biopesticides 3 (1 Special Issue): 068 - 073 (2010).

Tilman, D. 2001. Functional diversity In: Encyclopedia of Biodiversity. 3. 3, 109-120. https://doi.org/10.1006/rwbd.1999.0154.

Tracy A. Thompson., Robert M. Timm., Stephanie A. Trewhitt., Janna R. Willoughby. 2016. 2016 Guidelines of the American Society of Mammalogists for the use of wild mammals in research and education. Journal of Mammalogy, 97(3):663-688,https://doi:10.1093/jmammal/gyw078.

VishakhaKorad., KarantiYardi., RupeshRaut. 2007. Diversity and Distribution of Bats in the Western Ghats of India. Zoo's Print, 16: pp 629-639. https://doi:10.11609/JoTT.ZPJ.1563.2752-8.

Villéger, S., Mason, N.W.H., Mouillot, D. 2008. New multidimensional functional diversity indices for a multifaceted framework in functional ecology. Ecology 89: 2290 - 2301.https://doi: 10.1890/07-1206.1.