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INSECT POPULATIONS IN AGROECOSYSTEMS: THE BAT'S CONTRIBUTION TO INTEGRATED PEST MANAGEMENT STRATEGIES

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ABSTRACT

Insect capture was conducted across various agroecosystems to assess their abundance and evaluate insect populations within different agricultural environments in the study area. Several agroecosystems were examined, with a focus on four major cultivable crops: paddy, plantain, sugarcane, and cotton fields. Insect sampling occurred at different growth stages of these crops. The captured insects predominantly belonged to eight orders: Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Orthoptera, Odonata, and Isoptera.Repeated captures totaled 65 pests, with 27 found in paddy fields, 14 in sugarcane fields, 11 in plantain fields, and 13 in cotton fields. To evaluate the consumption rate of insects by bats, the percentage volume of each insect order consumed by bats was calculated through fecal pellet analysis. Pellets were collected from night roosts and diurnal roosting sites and analyzed for insect remnants.The examination of insect remnants in bat fecal pellets revealed varied dietary preferences across different seasons. Bats were observed to prey upon the insects they sought at their foraging perches, displaying varying prey preferences. Considering their feeding habits on prey items and insect pests, bats serve as valuable agents in integrated pest management (IPM) for pest control.

***Keywords:** Bats, Agroecosystem, IPM, Pest Control*

INTRODUCTION

Insectivorous bats play a vital role in ecosystems by consuming a diverse array of arthropods, including many notorious agricultural pests worldwide (Kunz *et al.*, 2011; Maine and Boyles, 2015; McCracken *et al.*, 2012; Williams Guillen *et al.*, 2008). Their potential to significantly enhance agricultural productivity through pest suppression is considerable. This ecosystem service is estimated to contribute billions of dollars to global agriculture by mitigating insect damage to crops and increasing yields (Cleveland *et al.*, 2006). However, few studies have explicitly examined the composition and abundance of dietary prey items or evaluated the proportion of pest insects consumed by bats.

Understanding the dietary preferences of organisms provides fundamental insights into their ecology and behavior within their environment, crucial for effective species management. For insectivorous bats, the hours of twilight leading into darkness represent optimal feeding times. The night comes alive with these elegant and intriguing nocturnal creatures, the bats, which play a significant role in fostering sustainable ecosystems and agricultural practices, thereby bolstering economies worldwide. While insectivorous bats typically select from available food sources, they can become more opportunistic when prey demand increases (Whitaker, 1995).

The interaction between bats and insects, as well as bat prey selection, was observed through fecal pellet analysis. While it has been noted that only a small fraction of stomach contents escape reduction to an unidentifiable state (Gould, 1955), most bats thoroughly chew their food, making it possible to identify the majority of prey remains to a reasonable taxonomic level, typically at least to the Order level (Whitaker, 1978).

This study aimed to explore the species-level dietary preferences of an insectivorous bat community across various agricultural landscapes. Specifically, we investigated the impact of local land use on the activity and species composition of aerial insectivorous bat species within the four predominant crop types in the Tirunelveli region, Tamil Nadu, India: paddy, plantain, sugarcane, and cotton. We conducted extensive insect population surveys in the area, focusing on these agroecosystems using insect traps. Additionally, we analyzed bat fecal pellets to discern the dietary preferences of bats and their role in controlling insect pests within agricultural systems.

MATERIALS AND METHODS

The insect populations across different agroecosystems in the study area, including paddy, plantain, sugarcane, and cotton fields, were assessed using insect light traps. Insect identification was carried out up to the order level. Additionally, the dietary habits of bat species in the study area were analyzed through fecal pellet analysis.

Selection of Sampling Site

To investigate the dietary preferences of bats, fecal pellets were collected from various roosts in and around the study area, including village limits, foothills, isolated areas, farmlands, and small hillocks. The selected bat roosts were situated either within an agroecosystem or near agricultural fields.The first colony was located in a village limit, isolated at (AMB - Elev; 245ft N: 8° 43.635' E: 077° 31.202') in Ambasamudram, housing *H. speoris*. The second and third colonies were residential, with one situated in an unused chamber of Sri Paramakalyani College (SPKC-Elev; 249ft N: 8042.67' E: 0750 198') in Alwarkurichi (Bat colony: *P. mimus*), and the next colony on a small hillock in Kallidaikurichi (KKC - Elev; 192ft N: 08 0 42.701' E.077° 43.776') hosting *H. ater*. The fourth and fifth colonies were positioned within agricultural settings, with the fourth colony situated in farmland in Cheranmahadevi (CDV - Elev; 319ft N: 8042.665' E: 077° 34.202') inhabited by *M. lyra*, and the fifth colony located in Kadayam (KM - Elev; 124ft N: 80 44.083 E: 077° 41.854') housing *P. dormeri*. Additionally, two other colonies were identified: one in a cave at Anavankudiyiruppu (AKP - Elev; 260ft N: 10° 40.565' E: 056° 30.103') with *R. hardwickii*, and the other in farmland in Kovilkulam (KVK - Elev; 120ft N: 9° 41.625' E: 073° 29.204') inhabited by *T. melanopogon*.

Insect sample collection using a light trap

Insect light traps were strategically positioned at the center of various agricultural habitats, including paddy, banana, cotton, and sugarcane fields. These custom-made light traps featured a fiberglass cone placed inside a 20-L plastic bin, with a strip of 12-V LED light affixed to attract flying invertebrates. The LEDs were powered by a 12-V battery for continuous operation. The traps operated from 6:00 PM to 6:00 AM, and all collected insects were promptly preserved in 70% ethanol and dried at 40°C in the laboratory before being identified up to the order level.

Sample collection – Bat Faecal pellets

Fresh fecal pellets were collected from day roosts by placing polythene sheets at regular intervals (weekly) throughout the study period. Approximately 50 pellets were randomly selected and weighed using a digital balance (ROY -INDIA). These pellets were then stored in 80% alcohol, transferred to petri dishes, and examined for insect remnants under a microscope. Identification of insects was conducted using authenticated literature (Mani, 1990 and Borror *et al.,* 1992) on Indian insects, with each slide systematically inspected for identifiable insect parts under a binocular microscope (Olympus CH20i, India).

RESULTS

Insect population survey using a light trap

The insect population within the study area was surveyed using light traps. Insects captured were predominantly classified into eight orders: Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Orthoptera, Odonata, and Isoptera (Table 1).

Table 1: Insect population collected in the study area

Insect order	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coleoptera	17± 8.52	12± 5.81	16± 7.91	15± 7.68	10± 4.67	20± 9.37	15± 7.54	17± 8.47	22± 10.94	27± 12.96	18± 8.94	14± 6.49
Diptera	15± 7.11	10± 4.95	15± 7.26	18± 9.02	14± 6.92	18± 8.64	16± 7.89	21± 10.28	18± 8.48	19± 9.47	20± 9.57	19± 9.36
Hemiptera	20± 9.52	15± 7.24	17± 8.35	10± 4.52	21± 10.35	17± 8.96	14± 6.18	23± 11.65	16± 7.61	21± 10.26	19± 9.37	25± 12.51
Hymenoptera	14± 6.90	8± 3.65	11± 5.41	7± 3.78	11± 5.32	15± 7.43	12± 5.81	14± 6.74	20± 9.15	13± 6.27	14± 6.87	18± 8.63
Lepidoptera	17± 8.52	13± 6.34	15± 7.26	19± 9.54	20± 10.02	19± 9.02	16± 7.89	18± 8.63	19± 9.31	17± 8.37	16± 7.89	22± 10.74
Orthoptera	16± 7.82	10± 4.95	9± 4.10	10± 4.52	10± 4.67	12± 5.47	14± 6.18	14± 6.74	16± 7.61	19± 8.97	11± 5.32	13± 6.26
Odonata	16± 7.82	9± 4.27	17± 8.35	15± 7.68	15± 7.36	20± 9.37	12± 5.81	10± 4.87	15± 7.24	15± 7.40	13± 6.48	11± 5.18
Isoptera	20± 9.52	8± 3.65	11± 5.41	9± 4.12	12± 5.46	11± 5.67	10± 4.73	15± 7.24	12± 5.38	13± 6.27	10± 4.62	9± 4.37

To assess the abundance and distribution of insects across various agroecosystems, insect captures were conducted. A preliminary reconnaissance survey identified several agroecosystems in the study area, with a focus on those of comparable size in terms of land area. Four major cultivable crops were sampled, namely paddy, plantain, sugarcane, and cotton, reflecting the intensive management practices typical of the region, including the use of inorganic fertilizers, weedicides, and insecticides/pesticides.

Insects collected in Paddy field

In the paddy fields, insects were collected during two distinct cultivation seasons, with captures revealing a diverse composition across different growth stages. Notable insect orders included Diptera, Odonata, Hemiptera, Lepidoptera, Coleoptera, Isoptera, Orthoptera, and Hymenoptera. Variations in insect abundance were observed throughout the growth stages, with Hemiptera, Diptera, and Odonata dominating during the early stages, while Coleoptera, Lepidoptera, and Odonata were more prevalent during the milky stage. The harvesting stage saw increased presence of Diptera, Lepidoptera, Orthoptera, and Isoptera (Table 2).

Table 2: Insects collected in Paddy field agroecosystem

Order	1st month	2nd month	3rd month
Coleoptera	17± 4.64	22± 2.8	19± 6.18
Diptera	21± 6.5	18± 2.82	22± 6.60
Hemiptera	23± 4.04	21± 3.86	16± 4.78
Hymenoptera	14± 3.16	24± 5.47	12± 5.31
Lepidoptera	18± 6.18	19± 5.90	22± 5.31
Orthoptera	14± 6.94	16± 3.30	22± 4.83
Odonata	20± 1.14	22± 8.77	19± 6.48
Isoptera	18± 2.36	15± 4.76	21± 7.13

Insects captured in Plantain field

Plantain cultivation, the second most prominent crop, spanned seven months, with insects captured monthly throughout the cultivable period. The dominant insect orders included Odonata, Hemiptera, Lepidoptera, Coleoptera, Diptera, Orthoptera, Isoptera, and Hymenoptera. Fluctuations in insect abundance were noted across the cultivation period, with variations in predominant orders observed monthly (Table 3).

Table 3: Insects captured in plantain field

Order	**1st month**	**2nd month**	**3rd month**	**4th month**	**5th month**	**6th month**	**7th month**
Coleoptera	19±3.36	23±7.16	20±2.62	12±8.45	17±11.72	19±13.19	21±14.58
Diptera	18±3.16	20±3.86	18±4.69	21±14.78	21±14.48	16±11.11	14±9.72
Hemiptera	18±3.14	21±6.65	17±7	16±11.26	23±15.86	28±19.44	22±15.27
Hymenoptera	11±4.65	16±2.62	17±3.5	19±13.38	14±9.65	12±8.33	11±7.63
Lepidoptera	21±2.16	22±6.23	19±8.22	26±18.30	18±12.41	21±14.58	17±11.80
Orthoptera	16±3.76	18±3.59	17±6.24	16±11.26	14±12.41	20±13.88	20±13.88
Odonata	22±6.55	23±7.27	23±4.42	18±12.67	20±13.79	16±11.11	24±16.66
Isoptera	16±4.20	19±2.98	11±3.87	14±9.85	18±12.41	12±8.33	15±10.41

Insects captured in sugarcane field

Similarly, sugarcane cultivation, lasting seven months, exhibited fluctuations in insect populations across different growth stages. Orders such as Lepidoptera, Hemiptera, Diptera, Coleoptera, Odonata, Isoptera, Hymenoptera, and Orthoptera were prominent. Notable changes in insect abundance were observed during distinct stages of sugarcane growth (Table 4).

Table 4: Insects captured in Sugarcane field

Order	**1st month**	**2nd month**	**3rd month**	**4th month**	**5th month**	**6th month**	**7th month**
Coleoptera	17±12.5	21±14.0	20±13.3	17±11.5	27±18	18±13.2	12±7.89
Diptera	15±11.1	18±12.08	15±10	25±17	19±12.6	22±16.17	19±12.5
Hemiptera	20±14.81	16±10.73	20±13.3	17±11.56	21±14	19±13.97	25±16.44
Hymenoptera	14±10.37	18±12.08	16±10.6	20±13.60	13±8.66	19±13.97	18±11.84
Lepidoptera	17±12.59	25±16.77	30±20	21±14.28	17±11.33	16±11.76	22±14.47
Orthoptera	16±11.85	13±8.72	14±9.33	14±9.52	19±12.66	11±8.08	16±10.52
Odonata	16±11.85	17±11.40	21±14	16±10.88	21±14	13±9.55	20±13.15
Isoptera	20±14.81	21±14.09	14±9.33	17±11.56	13±8.66	18±13.23	20±13.15

Insects captured in Cotton field

Cotton cultivation, occurring over two months, saw variations in insect populations across different growth stages, including germination and seeding, true leaves, cotton squares, and cotton boll stages.

Predominant insect orders included Lepidoptera, Coleoptera, Diptera, Hemiptera, Odonata, Isoptera, Hymenoptera, and Orthoptera, with fluctuations observed monthly (Table 5).

Table 5: Insects captured in Cotton field

Order	1st month	2nd month
Coleoptera	19±13.57	23±15.97
Diptera	23±16.42	15±10.41
Hemiptera	21±15	17±11.80
Hymenoptera	12±8.57	18±12.5
Lepidoptera	20±14.28	26±18.05
Orthoptera	14±10	13±9.02
Odonata	15±10.71	17±11.80
Isoptera	16±11.42	15±10.41

Insects captured in various agroecosystems during the development stages of crops

Overall, a varied proportion of insects belonging to different orders were captured across paddy, plantain, sugarcane, and cotton fields. The composition and abundance of insect populations were influenced by the specific growth stages of each crop, highlighting the complex interactions within agroecosystems.

Insect trap studies conducted in various agroecosystems revealed a total of 65 pests, with varying numbers captured in paddy, sugarcane, plantain, and cotton fields. These pests belonged to eight different orders: Lepidoptera, Hemiptera, Hymenoptera, Odonata, Orthoptera, Coleoptera, Diptera, and Isoptera (Table 6).

Table 6: Insects captured in various agriculture fields

Order	Paddy field (%)	Plantain (%)	Sugarcane field (%)	Cotton field (%)
Coleoptera	12.40	12.84	12.95	14.78
Diptera	13.40	12.54	13.05	13.38
Hemiptera	13.18	14.21	13.54	13.38
Hymenoptera	10.98	9.80	11.57	10.56
Lepidoptera	12.96	14.11	14.52	16.19
Orthoptera	11.42	11.86	10.10	9.50
Odonata	13.40	14.31	12.16	11.26
Isoptera	11.86	10.29	12.07	10.91

Dietary preference by bats through a faecal analysis

Upon analyzing the insect remnants found in bat fecal pellets within the study area, it becomes evident that bats exhibit varying dietary preferences across different seasons. Notably, species such as *H. ater*, *H. speoris*, and *M. lyra* showed a greater inclination towards feeding on coleopterans, with preference rates of 17.76%, 17.56%, and 17.39% respectively. Conversely, *T. melanopogon*, *P. mimus*, *P. dormeri*, *H. speoris*, and *R. hardwickii* displayed a higher preference for lepidopterans. This diversity in dietary preferences underscores the adaptability of bats and their varied prey selection patterns.

DISCUSSION

Insect light traps were deployed in agricultural fields to assess the availability of insect populations across different agroecosystems. Bats were observed to forage on these insects at a significant rate (Swamidoss *et al.,* 2012). The dietary selection of microchiropteran bats encompasses various insect groups including coleopterans, lepidopterans, dipterans, orthopterans, hymenopterans, isopterans, odonatans, and hemipterans. Many insectivorous bats are known to be opportunistic predators or selective opportunists, favoring specific insect families from a diverse range of taxa (Parvathiraj *et al.,* 2019). . However, few studies have specifically examined the composition and abundance of dietary prey items or evaluated the ratio of pests and beneficial arthropods consumed, hindering a comprehensive assessment of the pest control service provided by bats (Velpandi *et al.*, 2022)

Among the dietary selections, coleopterans and lepidopterans rank high among bats roosted in agroecosystems. Bats actively seek areas with abundant prey sources, particularly during pest outbreaks in agricultural systems. This suggests that insectivorous bats can adjust their predatory activity based on prey abundance. Moreover, bats play a crucial role in controlling common agricultural pests, as evidenced by their consumption of coleopterans and lepidopterans, which are major contributors to crop damage (Muthuselvam and Sudhakaran, 2021)

In conclusion, the findings of this study support the significant role played by bats in pest control within agricultural landscapes. By consuming a wide range of arthropod pests, including those detrimental to major crops, bats contribute to maintaining ecological balance and reducing agricultural losses. Therefore, integrating bat-mediated insect suppression into existing Integrated Pest Management (IPM) strategies by preserving non-crop habitats and roosting sites can enhance the effectiveness of pest control measures and promote sustainable agricultural practices.

REFERENCES

Borror DJ, Johnson NF, and Triplehorn CA, (1992). An introduction to the study of insects.', Saunders college publishing pp 286.Charbonnier, Y Barbaro, L Theillout, A &Jactel, H 2014, 'Numerical and functional responses of forest bats to a major insect pest in pine plantations e109488', *PLoS ONE*, **9**, e109488.

Cleveland CJ, Betke M, Federico P, Frank, JD, Hallam TG, Horn J, and Kunz TH (2006). 'Economic value of the pest control service provided by Brazilian free-tailed bats in south-central Texas', *Frontiers in Ecology and the Environment*, **4**, 238–243.

Gould E (1955). 'Feeding efficiency of insectivorous bats', *Journal Mammal*, 36, 399-407.

Kunz TH, Braun de Torrez E, Bauer D, Lobova T, and Fleming TH (2011). 'Ecosystem services provided by bats', *Annals New York Academy Sciences*.

Maine JJ, and Boyles JG (2015). 'Bats initiate vital agroecological interactions in corn', *Proceedings of the National Academy of Sciences of the United States of America,* **112**, 12438–12443.

Mani M (1990) 'Harmful insects', In: General Entomology, Oxford and IBH publishing, New Delhi. 9. 12

McCracken GF, Westbrook JK, Brown VA, Eldridge M, Federico P, and Kunz TH (2012). Bats track and exploit changes in insect pest populations. *PLoS ONE*, 7, e43839.

Muthuselvam S. and Sudhakaran MR (2021). Agroecosystem; A preferable roosting habitat by bats, *International Journal of Research and Analytical Reviews*. **8,** 1.

Parvathiraj P, Darsana, VG, Sudhakaran MR, Raju G, and Selvaraj D (2019). Prey consumption and dietary composition of four yangochiroptern species in Tirunelveli district. *RJLBPCS*. **5**(1) 932-942. DOI:10.26479/2019.0501.78.

Swamidoss D, and Sudhakaran MR (2012). Habitat preference of microchiropteran bats in three districts of Tamil Nadu, South India. *International Research Journal of Biology Science,* **1**(5) 24-30.

Velpandi S, Muthuselvam S, Parvathiraj P, Paramanantha Swami Doss D and Sudhakaran, M R (2022). Prey consumption by insectivorous bats in agro ecosystem, a study using insect capture and bat faecal pellet analysis. *Journal of Xi'an Shiyou University, Natural Science* Edition. **18**(9) 869-884.
Whitaker JO (1978). Food habit analysis of insectivorous bats *In*: Ecological and behavioural methods for the study of bats, (Eds.) TH Kunz, Smithsonian Press, Washington. 171-189.
Whitaker JO (1995). Food of the big brown bat, *Eptesicus fuscus* from maternity colonies in India and Illinois, *American Midland Naturalist*, **134**(2)346-360.
Williams - Guillen K, Perfecto I and Vandermeer J (2008). 'Bats limit insects in a neotropical agroforestry system', *Science*. 213-215.