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Research Article

Moth Biodiversity in Central Kerala: A Comprehensive Examination of Urban and High-Altitude Habitats With New Distribution Record of Palaeosetidae

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Abstract

The order Lepidoptera, encompassing both butterflies and moths, many species within lepidoptera plays a pivotal role in ecosystem dynamics as key pollinators. Moths, constituting the vast majority within this order, serve as essential contributors to biodiversity in the Indian subcontinent, with over 12,000 known species. Despite their ecological significance, our understanding of moth diversity in India remains incomplete. This study addresses this knowledge gap by conducting a focused survey of moths in central Kerala between May 2019 and December 2021. Utilizing a standardized methodology involving moth trapping with white cloth and mercury vapor bulbs, we recorded and analyzed 483 moth species spanning 44 families. Notably, this investigation documented the presence of the family Palaeosetidae in Kerala for the first time including two species previously reported only from the Khasi Hills. Additionally, the first-ever sighting of Corgatha semipardata in India and the presence of Cirrhochrista fuscusa in South India were reported. Temporal activity patterns of moths revealed intriguing variations, and a meticulous identification process resulted in classifications at various taxonomic levels. Erebidae emerged as the most speciose family, predominantly in urban areas, while Crambidae, Geometridae, and Noctuidae thrived in high-altitude regions, indicating habitat diversity. Furthermore, this study sheds light on the challenge of identifying moths without specimen collection, particularly for microlepidoptera, which needs further research in this area. The observation of *Macroglossum* genus caterpillars suggests the possibility of migration, opening avenues for future investigations into moth movement patterns. In conclusion, our research highlights the rich diversity of moths in central Kerala and emphasizes the importance of conserving ecosystems and host plants in urban areas. While providing valuable insights, this study acknowledges its limitations due to a limited duration and calls for extensive research to comprehensively assess moth species richness in the region, offering a crucial foundation for future studies focused on moth diversity.

Keywords: Moth, Kerala, diversity, palaeosetidae, western ghats.

1. Introduction

The order Lepidoptera, encompassing both butterflies and moths, species within lepidoptera play a pivotal role in ecosystem dynamics as key pollinators. Within this order, moths, constituting the vast majority, take on multifaceted roles within the natural world. With over 12,000 known species documented in the Indian subcontinent alone [1,2], moths emerge as vital contributors to biodiversity. They serve as essential nocturnal pollinators, a primary dietary source for a myriad of vertebrates and invertebrate insectivores, and occasionally as pests for crop plants [3]. 20% TO 100% of the population of forest lepidoptera is fed on very efficient predators that are the insectivorous birds [4-9]. 95% of the lepidoptera are consumed at the late instar larval stage, which the birds generally prefer [5,7,8,10]. Moths are known pollinators for many important herbivores crops and wild plants, and are ubiquitous in vegetated terrestrial environments. And they are food for numerous species of rodents, birds, and bats [11-18]. Moreover, they hold a prominent position as model organisms in scientific research [19]. While our knowledge of understanding the moth diversity in India has evolved over time, the pioneering works conducted during the pre-independence period by eminent researchers such as Moore [20], Hampson [21-24], Fletcher [25], Bell and Scott

[26] laid the foundation for our knowledge. However, in light of the continuous advancements in taxonomy and the emergence of modern research tools, there exists a compelling need to update and expand upon these foundational studies [27]. The Western Ghats, recognized as one of the world's biodiversity hotspots, stands as a treasure trove of unique flora, fauna, and fungi as acknowledged by Myers et al. [28]. Despite the Western ghat's significance, the moth diversity of Kerala is poorly documented, which limits our understanding of this region's ecological richness. Recent efforts have sought to rectify this gap in our knowledge. For instance, Alex et al. [29] published a comprehensive checklist, detailing the records of 503 moth species from the Kaveri River basin in Kerala. Similarly, Sondhi et al. [30] recorded 282 moth species in the Shendurney Wildlife Sanctuary, Ponmudi and Agasthyamalai Biosphere Reserve, Kerala. Subsequent updates in this checklist were made by Sondhi et al. [31], which introduced 79 new species, which needs further research in this area. Additionally, Das et al. [32] offered a checklist of moths found in the Western Ghats, enriching our understanding of their distribution across this ecologically significant landscape. Supplementary literature from South India, including works by Iyer and Kitching [33], Chandra et al. [34], Kirti et al. [35] and Iyer et al. [36], has also contributed valuable insights into moth diversity. In the context of this paper, we present a comprehensive account of 483 moth species recorded from various sites in Central Kerala, thereby augmenting our knowledge of moth diversity within this region.

2. Material and method

In this study, a comprehensive survey of moths was undertaken between May 2019 and December 2021 in various regions of central Kerala, namely Ernakulam (9.9343658° N, 76.3503151° E) in Kochi, Nelliyampathy (10.4566946° N, 76.6821422° E) in Palakkad, and Yellapetty (10.1142704° N, 77.2080902° E) in Munnar (Figure 2).

The primary objective of this research was to document the diversity of moths in these areas. To achieve this, we employed a standardized methodology consisting of the following key elements:

1. Sampling Equipment: Moth trapping was carried out using a 4x5 feet white cloth and a 240-Watt mercury vapor bulb, and its setup is shown in (Figure 1). This combination effectively attracted moths during the sampling period.

Figure 1. Moth trapping was carried out using a 4x5 feet white cloth and a 240-Watt mercury vapor bulb.

2. Sampling Hours: Moth trapping was conducted from 19:00 to 4:00, allowing for nocturnal moths to be efficiently captured.

3. Sampling Sites: Multiple samples were collected from Ernakulam, while Nelliyampathy and Yellapetty were sampled twice. These sites were selected based on their varying elevations and due to its richness in fauna and flora (Figure 3).

4. Sampling Criteria: Sampling occurred on nights with no moon or close to new moon days, in conjunction with rainy conditions, as these conditions yielded the highest observation rates of moths (personal observation). Due to the constraints imposed by the ongoing pandemic, regular surveys were not feasible.

5. Data Collection: Specimens were not physically collected but were instead identified through live observations and photographic documentation to minimize the environmental impact. The Nikon D3300 camera equipped with an 18-55 mm lens and mobile phones were used for photographing moths.

6. Taxonomic Identification: Moth specimens were identified using standard taxonomic keys and references, including the works by Moore [37], Hampson [21-24], Bell and Scott [26], Kendrick [38], and Kriti and Singh [39, 40]. For higher-level classification, the system proposed by Van Nieukerken et al. [41] was adopted.

This meticulous methodology allowed for the collection of valuable data on moth diversity in central Kerala over a span of two and a half years. The absence of specimen collection, though unconventional, contributed to a non-invasive approach to moth research and yielded valuable insights into the region's moth fauna. These findings will further improve our understanding of moth ecology in this region and can be used for conservation and ecological studies.

3. Results and Discussion

This study comprehensively examined moth diversity in central Kerala, resulting in valuable findings. A total of 483 moth species, spanning 44 families, were meticulously analyzed (Table 1). This investigation unveiled a significant discovery, as the family Palaeosetidae was documented for the first time within the region.

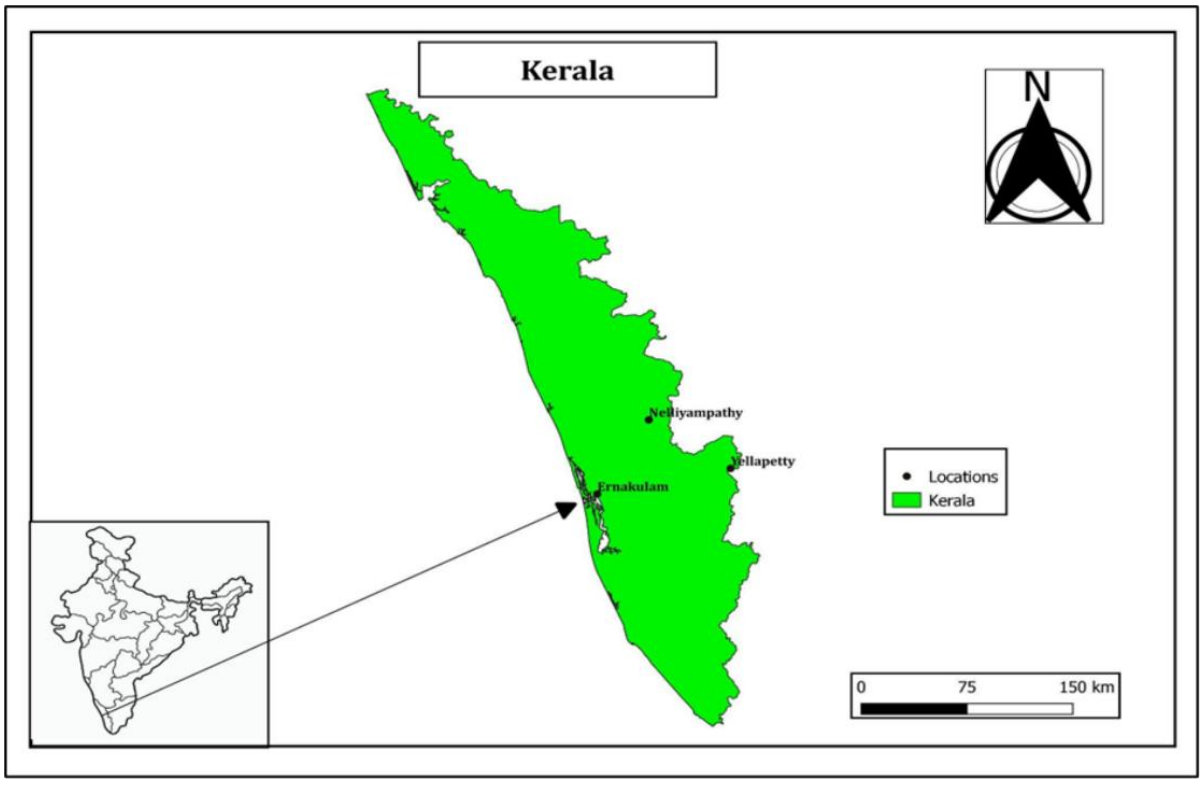
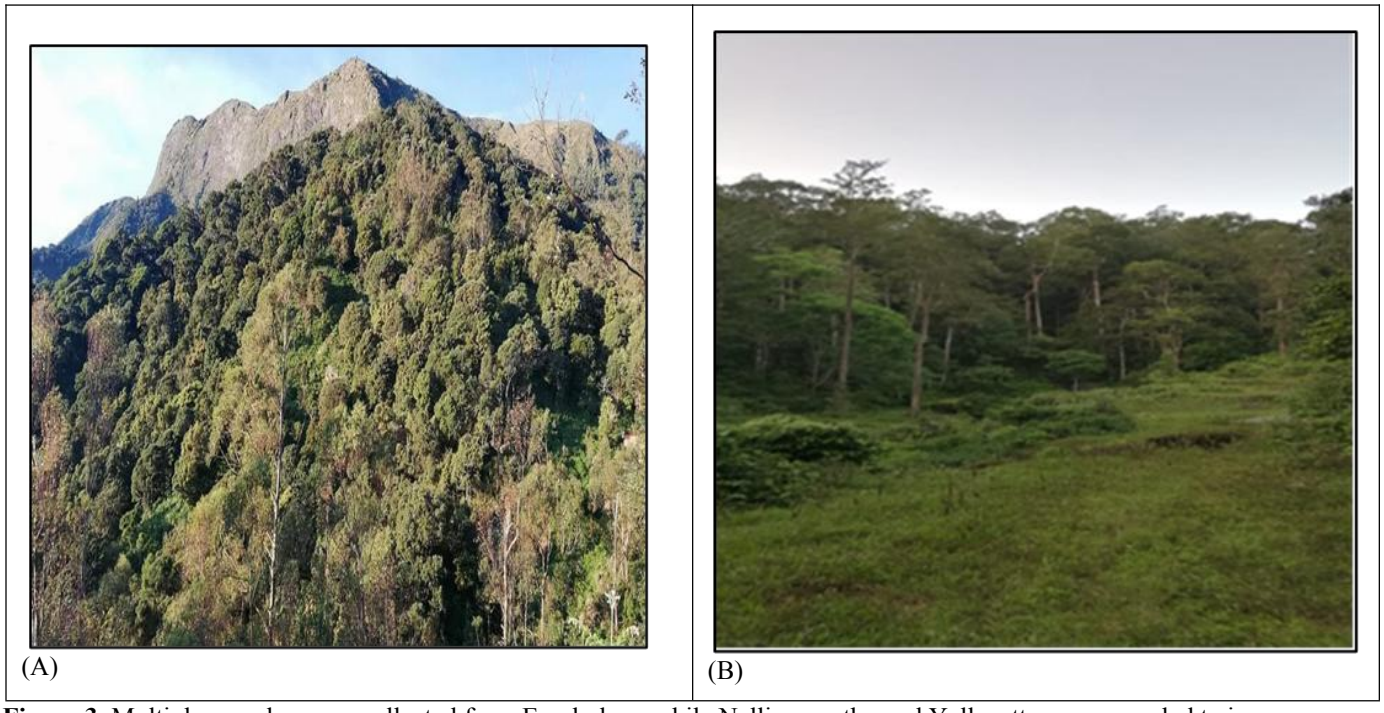


Figure 2. Location of Sampling site, where the data were collected.

This family encompasses four genera and nine described species, with two species, Genustes minutus Hampson [24] and G. lutata Issiki & Stringer [42], previously recorded exclusively in the Khasi Hills of Meghalaya. Remarkably, this marks the inaugural documentation of their presence in Kerala. Due to limitations in specimen collection, species-level identification through genitalia dissection was not feasible. In another remarkable revelation, Corgatha semipardata (Walker, 1862) from the Erebidae family, previously known to inhabit Borneo and Peninsular Malaysia, was observed and documented in Nelliyampathy. This report represents the first-ever sighting of this species in India. Furthermore, our research unearthed Cirrhochrista fuscusa Chen, Song & Wu, 2006, a species originally described in Taiwan with only a handful of reported occurrences outside its home country. Notably, a single record from North East India was found on the Moths of India website (https://www.mothsofindia.org/#!/sp/358241/Cirrhochrista-fuscusa). Our study confirms the presence of this species in Nelliyampathy, marking the first report of its occurrence in South India.



(A) (B)

Figure 3. Multiple samples were collected from Ernakulam, while Nelliyampathy and Yellapetty were sampled twice.

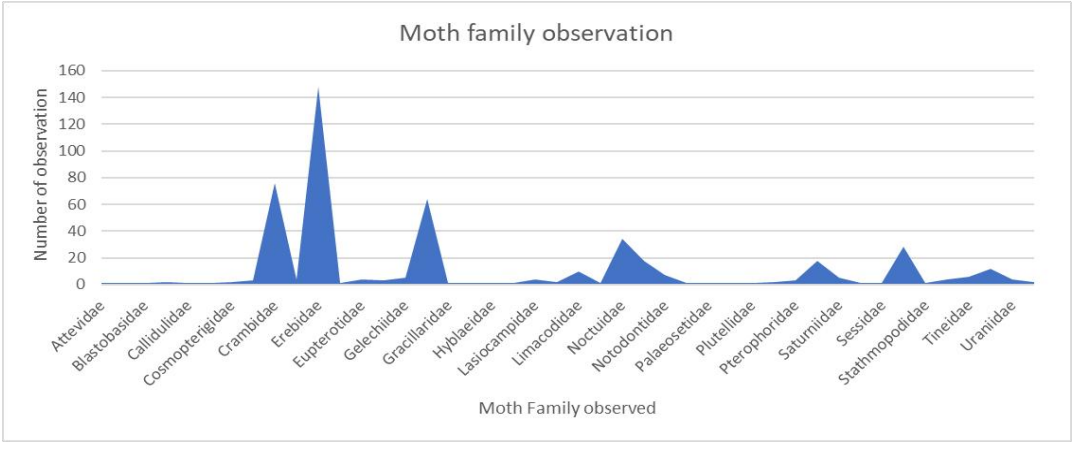


Figure 4. Number of observed moth species.

The temporal activity patterns of moths exhibited intriguing variations. The entire moth family is discussed individually, which is more (graph-1). Erebid and Noctuid moths were observed soon after the lights were turned on, while some less common members of the Crambidae and Geometridae families preferred later hours of the night. Species from the *Actias* genus (Saturniidae) were observed during the early morning hours. The meticulous identification process led to the classification of 372 moth species, 100 at the genus level, 7 at the family level, and 2 at the sub-family level (Table 1). Identifying moths without specimen collection posed significant challenges, particularly for accurate species level identification. Among the families encountered, Erebidae emerged as the most species, with 148 species across 95 genera. Crambidae followed with 76 species and Geometridae with 64 species. Interestingly, the distribution of these families varied between urban areas and high-altitude regions near forest patches of Ernakulam. Erebidae dominated the urban landscape while Crambidae, Geometridae, and Noctuidae prevailed in the high-altitude areas of Ernakulam. The presence of Noctuidae and Notodontidae species within the study areas can be considered indicative of habitat health. Notably, we recorded 26 individuals from the *Eupterote* genus in a single screen from Idukki. Microlepidoptera, due to their small size, presented a challenge in both identification and photography. Nonetheless, some were identified at the family level. Given the scarcity of records on microlepidoptera in Kerala, our findings emphasize the need for further research in this area. A notable discovery during our study was the observation of *Macroglossum* genus caterpillars in substantial numbers from May to July, particularly in coastal areas and their adjacent regions. Intriguingly, some instances of this genus were spotted in high-altitude regions in September and October, suggesting the possibility of migration. This highlights the necessity for future investigations into moth migration, as no prior studies in this context have been conducted in India. In conclusion, our study underscores the significance of safeguarding existing ecosystems and host plants in urban areas, as it reveals a diverse range of moth species in previously unprotected regions. While our research provides valuable insights, it is essential to acknowledge that the duration of our study was limited, and a more extensive examination is required to comprehensively assess the total species richness of central Kerala. Future studies focused on moth diversity will be indispensable in gauging the true abundance of these taxa in additionally displaying 8 plates and a picture collection of 432 moth species **(**Figure 4, Supplementary File Figure 1A-G and Supplementary Table 1).

4. Conclusion

Present study addresses this knowledge gap by conducting a focused survey of moths in central Kerala between May 2019 and December 2021 and utilizing a standardized methodology involving moth trapping with white cloth and mercury vapor bulbs, we recorded and analyzed 483 moth species spanning 44 families. Notably, this investigation documented the presence of the family Palaeosetidae in Kerala for the first time including two species previously reported only from the Khasi Hills. Erebidae emerged as the most species family, predominantly in urban areas, while Crambidae, Geometridae, and Noctuidae thrived in high-altitude regions, indicating habitat diversity. Furthermore, this study sheds light on the challenge of identifying moths without specimen collection, particularly for microlepidoptera, which needs further research in this area. The observation of *Macroglossum* genus caterpillars suggests the possibility of migration, opening avenues for future investigations into moth movement patterns. Our research highlights the rich diversity of moths in central Kerala and emphasizes the importance of conserving ecosystems and host plants in urban areas. While providing valuable insights, this study acknowledges its limitations due to a limited duration and calls for extensive research to comprehensively assess moth species richness in the region, offering a crucial foundation for future studies focused on moth diversity.

Data Availability statement

The data will be available upon justifiable request to the corresponding author.

Conflicts of Interest

The authors declare that they have no conflict of interest.

Author Contributions

Mahesh and Ashley Shaji contributed to the investigation. Methodology was developed by Mahesh, Ashley Shaji, and Moinudheen. Rishi, Mahesh, and Ashley Shaji contributed to the writing. Conceptualization was handled by Moinudheen, Samson, and Rishi. Supervision was provided by Moinudheen and Samson, while review and editing were carried out by Rishi, Moinudheen, and Samson.

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Supplementary Material

The Supplementary Material for this article can be found online at:

https://www.jspae.com/index.php/jzs/article/view/342/207

REFERENCES

1. Chandra, K. (2006). Moth diversity of Madhya Pradesh and Chhattisgarh, India, and its conservation measures. In Proceedings of the first South east Asian Lepidoptera conservation symposium, Hong Kong, pp. 49-61.
2. Smetacek, P. (2013). Review of Indian Lepidoptera Collections and their significance in conservation. ENVIS Bulletin: Arthropods and their conservation in India (Insects & Spiders), 14(1), 135-139.
3. Bates, A. J., Sadler, J. P., Grundy, D., Lowe, N., Davis, G., Baker, D., ... & Young, H. (2014). Garden and landscape-scale correlates of moths of differing conservation status: significant effects of urbanization and habitat diversity. PLoS One, 9(1), e86925. https://doi.org/10.1371/journal.pone.0086925
4. Crawford, H.S., Jennings, D.T., 1989. Predation by birds on spruce budworm Choristoneura fumiferana: functional, numerical, and total responses. Ecology 70, 152–163.
5. Whelan, C.J., Holmes, R.T., Smith, H.R., 1989. Bird predation on gypsy moths (Lepidoptera: Lymantriidae) larvae: an aviary study. Environmental Entomology 18, 43–45.
6. Cooper, R.J., Smith, H.R., 1995. Predation on gypsy moths (Lepidoptera: Lymantriidae) egg masses by birds. Environmental Entomology 24, 571–575.
7. Parry, D., Spence, J.R., Volney, W.J.A., 1997. Responses of natural enemies to experimentally increased populations of the forest tent caterpillar, Malacosoma disstria. Ecological Entomology 22, 97–108.
8. Tanhuanpää, M., Ruohomaki, K., Uusipaikka, E., 2001. High larval predation rate in non-outbreaking populations of a geometrid moth. Ecology 82, 281–289.
9. Mols, C.M.M., Visser, M.E., 2002. Great tits can reduce caterpillar damage in apple orchards. Journal of Applied Ecology 39, 888–899.4
10. Kristin, A., Patocka, J., 1997. Birds as predators of Lepidoptera: selected examples. Biologia 52, 319–326.
11. New T R (2004) Moths (Insecta: Lepidoptera) and conservation: background and perspective. Journal of Insect Conservation 8: 79–94.
12. Devoto M, Bailey S, Memmott J (2011) The 'night shift': nocturnal pollen transport networks in a boreal pine forest. Ecological Entomology 36: 25–35.
13. Pettersson MW (1991) Pollination by a Guild of Fluctuating Moth Populations Option for Specialization in Silence-Vulgaris. Journal of Ecology 79: 591 604.
14. Buse A, Dury SJ, Woodburn RJW, Perrins CM, Good JEG (1999) Effects of elevated temperature on multi-species interactions: the case of Pedunculate Oak, Winter Moth and Tits. Functional Ecology 13: 74–82.
15. Calkins CO (1998) Review of the codling moth areawide suppression program in the western United States. Journal of Agricultural Entomology 15: 327–333.
16. Vaughan N (1997) The diets of British bats (Chiroptera). Mammal Review 27: 77–94.
17. Elkinton, J. S., Healy, W. M., Buonaccorsi, J. P., Boettner, G. H., Hazzard, A. M., & Smith, H. R. (1996). Interactions among gypsy moths, white-footed mice, and acorns. Ecology, 77(8), 2332-2342

18. Visser, M. E., Holleman, L. J. M. & Gienapp, P. Shifts in caterpillar biomass phenology due to climate change and its impact on the breeding biology of an insectivorous bird. Oecologia 147, 164–-172 (2006).
19. Roe, B. E., & Just, D. R. (2009). Internal and external validity in economics research: Tradeoffs between experiments, field experiments, natural experiments, and field data. American Journal of Agricultural Economics, 91(5), 1266-1271. https://www.jstor.org/stable/20616293
20. Moore, F., 1882-83. The Lepidoptera of Ceylon, Vol 2. London: L. Reeve & Co. Pp. 1-162, Pl. 1-143.
21. Hampson, G. (1892). The Fauna of British India, including Ceylon and Burma. Moths-Volume Saturniidae to Hypsidae. Taylor and Francis, London, 527pp+333fgs.
22. Hampson, G. (1894). The Fauna of British India, including Ceylon and Burma. Moths-Volume Arctiidae, Agrostide, Noctuidae. Taylor and Francis, London, 609pp+325fgs.
23. Hampson, G. (1895). The Fauna of British India, including Ceylon and Burma. Moths-Volume Noctuidae (cont.) to Geometridae. Taylor and Francis, London, 546pp+226fgs.
24. Hampson, G. (1896). The Fauna of British India, including Ceylon and Burma. Moths-Volume. Pyralidae. Taylor and Francis, London, 594 pp+287.
25. Fletcher, T. B. (1920). Life-histories of Indian Insects: Micro-lepidoptera. (No. 1-9). Thacker, Spink & Company.
26. Bell, T. R. D., & Scott, F. B. (1937). The Fauna of British India, including Ceylon and Burma. Moths, Vol. 5, Sphingidae. The Fauna of British India, including Ceylon and Burma. Moths, Vol. 5, Sphingidae.
27. Komal, J., Shashank, P. R., Sondhi, S., Madan, S., Sondhi, Y., Meshram, N. M., & Anooj, S. S. (2021). Moths (Insecta: Lepidoptera) of Delhi, India: An illustrated checklist based on museum specimens and surveys. Biodiversity Data Journal, 9
28. Myers, N., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. Nature, 403(6772), 853-858. https://doi.org/10.1038/35002501
29. Alex, C. J., Soumya, K. C., & Sajeev, T. V. (2021). A report on the moth (Lepidoptera: Heterocera) diversity of Kaveri River basin in Kerala, India. Journal of Threatened Taxa, 13(2), 17753-17779. DOI: 10.11609/jot.4625.13.2.17753-17779
30. Sondhi, Y., Sondhi, S., Pathour, S. R., & Kunte, K. (2018). Moth diversity (Lepidoptera: Heterocera) of Shendurney and Ponmudi in Agasthyamalai Biosphere Reserve, Kerala, India, with notes on new records. Tropical Lepidoptera Research. DOI: 10.5281/zenodo.2027709
31. Sondhi, S., Sondhi, Y., Karmakar, T., & Kunte, K. (2021). Moth diversity (Lepidoptera) of Shendurney and Ponmudi in Agasthyamalai Biosphere Reserve, Kerala, India: an update. Tropical Lepidoptera Research, 166-178. DOI: 10.5281/zenodo.5777146
32. Das, A., Mazumder, A., Pathania, P.C. & Singh, N. (2020) Insecta: Lepidoptera: Heterocera (Moths). In: Chandra, K., Raghunathan, C., Sureshan, P.M., Subramanian, K.A. & Rizvi, A.N. (Eds.), Faunal Diversity of Biogeographic Zones of India: Western Ghats. Director, Zoological Survey of India, Kolkata, pp. 1–36.
33. Iyer, G., & Kitching, I. J. (2019). A preliminary study of the hawkmoth diversity (Lepidoptera: Sphingidae) of Kanyakumari District, Tamil Nadu, India. Journal of Threatened Taxa, 11(5), 13592-13604. DOI: 10.11609/jot.4694.11.5.13592-13604
34. Chandra, K., Gupta, D., Kushwaha, S., Das, P., & Ghosh, J. (2018). Arthropoda: Hexapoda. Faunal Diversity of Biogeographic Zones: Islands of India, 247-320
35. Kirti, J. S., K. Chandra, A. Saxena & N. Singh. 2019. Geometrid Moths of India. Nature Books India, New Delhi. 296 pp.
36. Iyer, G., Stüning, D., & Sondhi, S. (2021). An inventory of geometrid moths (Lepidoptera: Geometroidea: Geometridae) of Kalakad-Mundanthurai Tiger Reserve, India. Journal of Threatened Taxa, 13(13), 19887-

19920. https://doi.org/10.11609/jott.7105.13.13.19887-19920

37. Moore, F., 1884-87. The Lepidoptera of Ceylon, Vol 3. London: L. Reeve & Co. Pp. 1-578, Pl. 144-215.
38. Kendrick, R. C. (2002). Moths (insecta: lepidoptera) of Hong Kong. HKU Theses Online (HKUTO). http://hdl.handle.net/10722/31688
39. Singh, N., Ahmad, J., & Joshi, R. (2018). Moths (Lepidoptera) diversity of district Koderma, Jharkhand. Journal of Entomology and Zoology Studies, 6(2), 1253-1263.
40. Kirti, J. S., & Singh, N. (2016). Arctiid Moths of India. Nature Books India.Vol. 2.
41. Van Nieukerken, E. J., Kaila, L., Kitching, I. J., Kristensen, N. P., Lees, D. C., Minet, J., ... & Zwick, A. (2011). Order Lepidoptera Linnaeus, 1758. In: Zhang, Z.-Q.(Ed.) Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness. Zootaxa, 3148(1), pp 212-221.
42. Issiki, S. T., & Stringer, H. (1932, April). ON NEW ORIENTAL GENERA AND SPECIES OF THE HEPIALOIDEA (LEPIDOPTERA HOMONEURA) PART II: OBSERVATIONS ON THE SYSTEMATIC POSITION. In Proceedings of the Royal Entomological Society of London. Series B, Taxonomy (Vol. 1, No. 4, pp. 73-80). Oxford, UK: Blackwell Publishing Ltd. https://doi.org/10.1111/j.1365-3113.1932.tb01355.
43. Moinudheen N., Sivasankaran kuppusamy (2020). Preliminary study of moths (Insecta: Lepidoptera) in Coonoor forest area from Nilgiri District Tamil Nadu, India. DOI:10.26438/ijsrbs/v7i3.5261.
44. Holloway, J. D. [1994]. The moths of Borneo Part 11, Family Geometridae: Subfamily Ennominae. Malayan Nature Journal 47: 1-309.
45. Holloway, J. D. 1985. The moths of Borneo Part 14, Family Noctuidae: subfamilies Euteliinae, Stictopterinae, Plusiinae, Pantheinae. Malayan Nature Journal 38: 157-317.
46. Holloway, J. D. 1996. The moths of Borneo Part 9, Family Geometridae: Subfamilies Oenochrominae, Desmobathrinae, Geometrinae. Malayan Nature Journal 49: 147-326.
47. Holloway, J. D. 1997. The moths of Borneo Part 10, Family Geometridae: Subfamilies Sterrhinae, Larentiinae, Addenda to other subfamilies. Malayan Nature Journal 51:1-242.
48. Holloway, J. D. 2003. The moths of Borneo Part 18, Family Nolidae. Kuala Lumpur, Southdene Sdn Bhd. 279.
49. Holloway, J. D. 2005. The moths of Borneo Parts 15 & 16, Family Noctuidae, subfamily Catocalinae. Malayan Nature Journal 58(1): 84-86.
50. Holloway, J. D. 2008. The moths of Borneo Part 17, Family Noctuidae, subfamilies Rivulinae, Phytometrinae, https://doi.org/10.56946/jzs.v2i1.342
51. Herminiinae, Hypeninae and Hypenodinae. Malayan Nature Journal 60(1): 1-268.
52. Holloway, J. D., Miller, S. E. 2003. The composition, generic placement and host-plant relationships of the joviana-group in the Parallelia Generic complex (Lepidoptera: Noctuidae, Catocalinae). Invertebrate Systematics 17(1): 111-128.
53. Komal, J., Shashank, P. R., Sondhi, S., Madan, S., Sondhi, Y., Meshram, N. M., & Anooj, S. S. (2021). Moths (Insecta: Lepidoptera) of Delhi, India: An illustrated checklist based on museum specimens and surveys. Biodiversity Data Journal, 9. 10.3897/BDJ.9e73997
54. Pathania, P. C., Gielis, C., Das, A., & Chandra, K. (2021). Catalogue of superfamily Pterophoroidea Kuznetsov & Stekolnikov (Lepidoptera) of India. Zootaxa, 4915(2), 201-236.
55. Singh, N., Ranjan, R., Talukdar, A., Joshi, R., Kirti, J. S., Chandra, K., & Mally, R. (2022). A catalogue of Indian Pyraloidea (Lepidoptera). Zootaxa, 5197(1), 1-423.

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