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Research Article

Moth diversity (Lepidoptera: Heterocera) of Banaras Hindu University, Varanasi, India: a preliminary checklist

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Abstract

A study was conducted at the Banaras Hindu University (BHU) campus of Varanasi, Uttar Pradesh, India to assess the moth fauna of the area. A preliminary checklist was compiled as a base-line contribution to the status of the Lepidoptera diversity of the campus. The campus was surveyed from January to December 2019 and moths were recorded through 83-night surveys and a large number of opportunistic visits in 18 different sites of the campus. The study has recorded a total of 1248 individual moths belonging to 99 morphospecies, 84 genera, and 11 families across different parts of the study area. The most species rich family was Erebidae with 35 species under 30 genera followed by Crambidae (33 species; 28 genera), Geometridae (15 species; 11 genera), Noctuidae (seven species; six genera), and others. However, family-wise abundance data indicated that Crambidae (38.70%) was the most abundant family having highest proportion of moths recorded followed by Erebidae (34.85%), Geometridae (10.73%), Noctuidae (6.81%) and others. This illustrated checklist and the results will improve our understanding of Varanasi's biodiversity and can be used for improvement of the campus planning and developing strategies for conservation of moth diversity.

Keywords: BHU; checklist; conservation; Erebidae; moth; urbanization; Varanasi
Abbreviations: BHU-Banaras Hindu University; DNA-Deoxyribonucleic acid; LED-Light Emitting Diode; WHO-World Health Organization; VF-Very Frequent; F-Frequent; IF-Infrequent

Introduction

Moths are conspicuous terrestrial invertebrates, that represent the majority of the insect order Lepidoptera with over 165,000 described species (Regier *et al.*, 2009). Being a prominent element of terrestrial ecosystems, they function as pollinators of flowers, herbivores of crops and wild plants and prey for numerous species of rodents, birds, and bats (Regier *et al.*, 2009; Bates *et al.*, 2014). Many moth species are nocturnal plant-feeding insects and are almost entirely associated with angiospermous plants that largely depend on animal-assisted pollination (Wahlberg *et al.*, 2013). These polyphyletic groups of insects represent more than 90% of all lepidopterans of the earth and a large number of moth species are still waiting to be discovered and named, mostly from the tropical regions of the world (Heppner, 2008). These ectothermic animals occupy a wide range of habitats around the world and are sensitive to environmental pressures. Therefore, monitoring

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the changes in the patterns of moth distribution and abundance in an area can be used as potent ecological indicators for the conservation of biodiversity (Dennis *et al.*, 2019).

However, recent reports suggest that moth diversity and abundance around the world has declined significantly in the past few decades (Hallmann *et al.*, 2020). Several factors can be attributed to the worldwide decline in moth population including habitat loss, degradation and fragmentation, agricultural intensification, changes in woodland management, urbanization, chemical pollution, artificial light at night and climate (Dennis *et al.*, 2019). A number of plant species depend exclusively on one or a small number of moth species for pollination and a decline in those moth population and their diversity might lead to a negative impact in the plant communities they pollinate (Young *et al.*, 2017).

India exhibits a very rich moth assemblage with nearly 10,000 species (Smetacek, 2013). Several studies have explored the moth diversity from different states of north India. However, different areas of Himalaya have undoubtedly received more attention than anywhere else because of its extremely rich biodiversity (Hampson, 1892, 1894, 1895, 1896; Smetacek, 2008; Sanyal *et al.*, 2011; Sondhi and Sondhi, 2016; Sanyal *et al.*, 2017). Most of these studies have been made in the states of Uttarakhand and Himachal Pradesh. To date, no comparable studies on moth diversity have been conducted in Varanasi and other parts of the Uttar Pradesh state of India.

In this study, we investigated the moth diversity in the Banaras Hindu University (BHU) campus of Varanasi, Uttar Pradesh, India. Although some studies (Verma *et al.*, 2007) have reported the floral diversity of the university campus, the status of the Lepidoptera diversity of the vast land still remains unknown. A preliminary checklist was generated from the results of the survey for one year. Here we report for the first time, the occurrence of 99 morphospecies of moths from the study area.

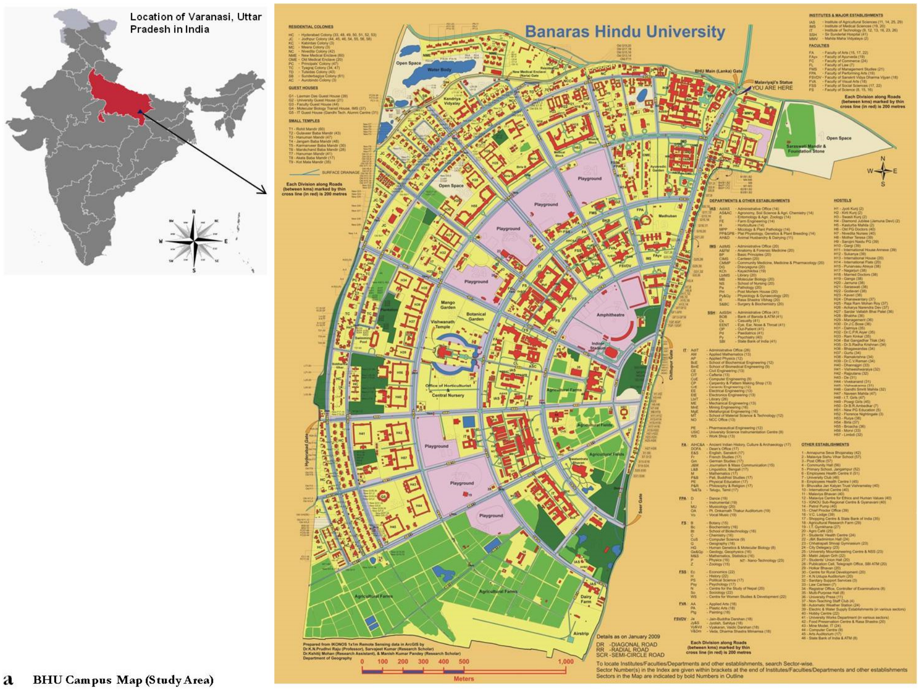
Materials and Methods

Study area

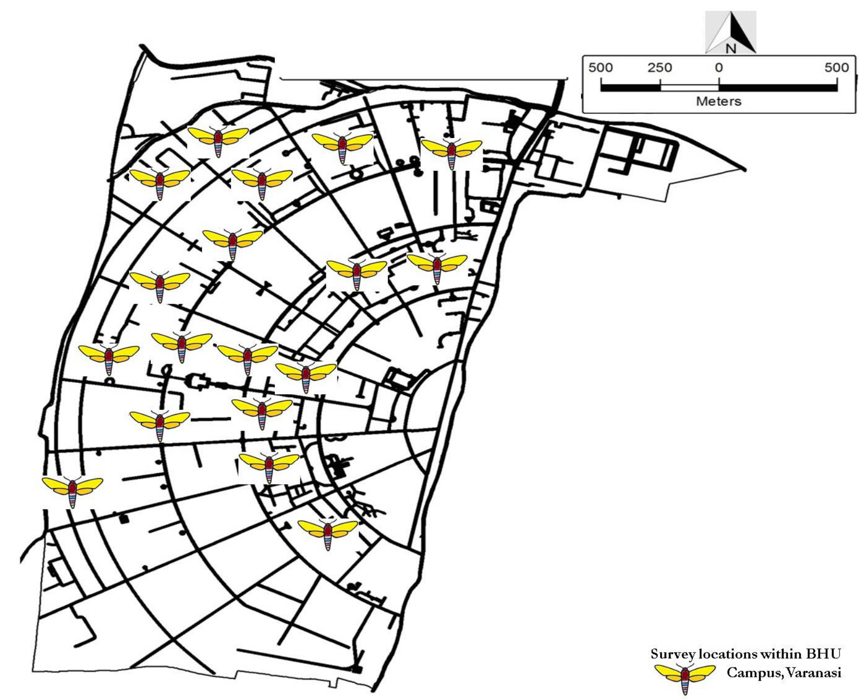
The study was conducted in the campus area of BHU, the largest residential university in Asia, located in Varanasi city of Uttar Pradesh, India (Figure 1a). The University is an urban campus covering an area of approximately 1,300 acres (5.3 km^2), which is about 5 km south of Varanasi City on the western bank of the river Ganga. The city is located between 82°39′ and 83° 11′ E longitude and between 25°10′and 25°34′ N latitude. The climate is a humid subtropical climate characterized by dry winters with temperatures between 3 and 18 °C and summers with a constant rainfall with a mean temperature of nearly 22 °C (Nistor *et al.*, 2020). The soils in the study area have been described as alluvial, well-drained, pale brown, silty loam and inceptisol with moderately fertility (Verma *et al.*, 2015). Although representing a very small part of the Varanasi city (4.24%), BHU campus exhibits an enormous diversity of habitats including garden, lake, agricultural land, grassland, bushes having a large number of trees, shrubs, herbs and climbers (Figure 2). The campus gardens and streets are filled with a wide variety of vascular and medicinal plant species like *Azadirachta indica*, *Dalbergia sissoo*, *Madhuca longifolia*, *Mangifera indica*, *Pterygota alata*, *Tamarindus indica*, *Tectona grandis*, *Ziziphus glaberrima* etc (Verma *et al.*, 2007; Verma *et al.*, 2015).

Moth surveys and identification

The above-mentioned areas of the campus were surveyed from January to December 2019. Moths were recorded through light trapping and frequent opportunistic visits to light sources of several hostels, departments and streets of the campus at night. Most of the moths were recorded from the light traps created by mounting a high power (23-Watt) LED lamp in front of a white house wall located at different floors of multi-storey buildings. In addition, a large number of moths were also documented from the hostel premises and street light towers equipped with high power sodium (250-Watt) and mercury vapour lamps (150-180-Watt) as well as LED lamps.



a BHU Campus Map (Study Area)



b

Figure 1. a. Map of BHU campus in Varanasi, Uttar Pradesh, India (Map data: India from Wikipedia; Campus map from the university website). b. Survey locations within BHU campus (Map data: Campus map from Raju *et al.*, 2015)

Figure 2. Different types of habitats found within the study area of BHU, Varanasi campus. a. The lawn in front of department of Zoology; b. A street in the university campus; c. Vegetation around the hostel area & d. A pond of Institute of Agricultural Sciences

A total of 83 nocturnal surveys and a large number of opportunistic visits were done over a period of one year in 18 different sites of the campus including seven hostels, 10 academic departments and within the premises of Shri Kashi Vishwanath Temple of BHU (Figure 1b). The maximum number of surveys (47) was carried out during the period from August to November. The remaining 21 surveys were conducted from April to July and 15 from December to March. The majority of the surveys were done in the departments, hostels, temple premises, streets and the surrounding areas whereas gardens, lakes and other parts of the campus were some of the least visited places during the diurnal survey. In all the sampling sites moths were recorded from 19.00h to 22:00h except one student residential area where most of the surveys were conducted up to 1 to 2 am. Moth counts were recorded and photographed using a smartphone camera (Xiaomi Redmi Note 5 Pro) to support further identification. Some of the moths were also recorded and photographed during daylight hours. The moth photographs were identified based on physical features with the help of available literatures including Hampson (1892-1896), Bell and Scott (1937), Holloway (1987, 1999, 2005), Schintlmeister and Pinratana (2007), Kononenko and Pinratana (2013) and Kirti and Singh (2015). The classification system used in the present study was adapted from the work of van Nieukerken *et al.* (2011). In addition, a number of web resources including *www.jpmoths.org*; Moths of India (*http://www.mothsofindia.org/*; Sondhi *et al.*, 2020), *https://www.flickr.com/groups/mothsofindia/* and iNaturalist (*https://www.inaturalist.org*) were used for the purpose of identification. All the graphs were generated using Microsoft Office Excel, 2010. None of the species was captured or killed during the entire period of the study.

Results

The present study has documented a total of 1248 individual moths belonging to 99 morphospecies, 84 genera, 11 families across different parts of the study area (Table 1, Plates 1-4). Among these 81 moth species were identified to species level and another 18 to generic level. The most species rich family was Erebidae with 35 species under 30 genera followed by Crambidae (33 species; 28 genera), Geometridae (15 species; 11 genera), Noctuidae (seven species; six genera), and others (Figure 3, Table 2).

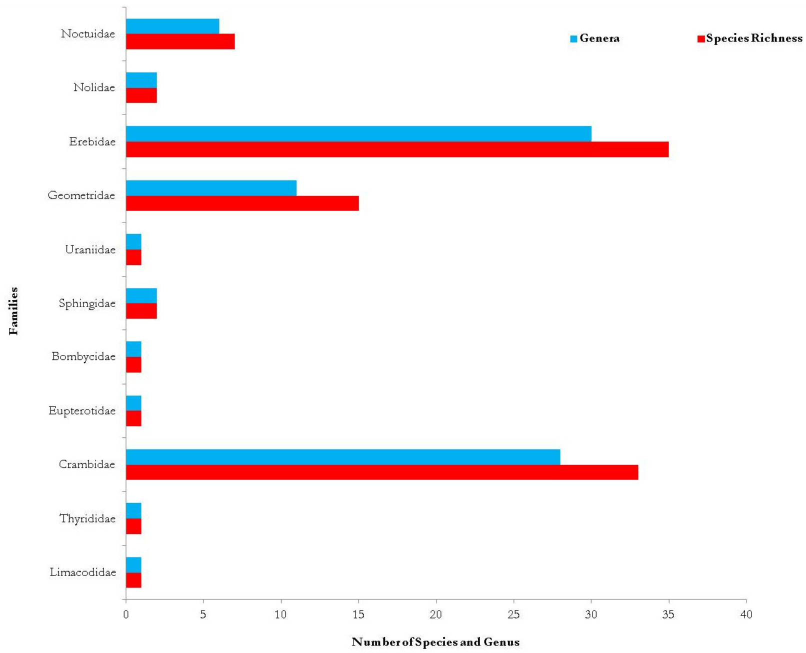


Figure 3. Family wise patterns of moth species richness and number of genera recorded in different habitats of BHU, Varanasi campus

Table 1. Preliminary checklist of moth fauna recorded during the study
Status: VF-very frequent (>20% specimens recorded); F-frequent (10-20% specimens recorded) and IF-infrequent (<10% specimens recorded)

Sl. No	Family	Subfamily	Species	Author, Year	Status
1	Limacodidae	Chrysopolominae	*Altha subnotata*	(Walker, 1865)	VF
2	Thyrididae	Striglininae	*Banisia myrsusalis*	(Walker, 1859)	IF
3	Crambidae	Acentropinae	*Elophila* sp.		F
4	Crambidae	Acentropinae	*Parapoynx fluctuosalis*	(Zeller, 1852)	F
5	Crambidae	Acentropinae	*Parapoynx diminutalis*	Snellen, 1880	IF
6	Crambidae	Pyraustinae	*Orphanostigma abruptalis*	(Walker, 1859)	VF
7	Crambidae	Pyraustinae	*Ostrinia* sp.		F
8	Crambidae	Pyraustinae	*Pardomima distortana*	(Strand, 1913)	IF
9	Crambidae	Pyraustinae	*Pyrausta phoenicealis*	(Hübner, 1818)	IF
10	Crambidae	Schoenobiinae	*Scirpophaga incertulas*	(Walker, 1863)	VF
11	Crambidae	Spilomelinae	*Agrotera posticalis*	Wileman, 1911	IF
12	Crambidae	Spilomelinae	*Antigastra catalaunalis*	(Duponchel, 1833)	IF
13	Crambidae	Spilomelinae	*Botyodes diniasalis*	(Walker, 1859)	VF
14	Crambidae	Spilomelinae	*Botyodes asialis*	Guenée, 1854	VF
15	Crambidae	Spilomelinae	*Cirrhochrista brizoalis*	(Walker, 1859)	F
16	Crambidae	Spilomelinae	*Cnaphalocrocis medinalis*	(Guenée, 1854)	VF

17	Crambidae	Spilomelinae	*Cnaphalocrocis bilinealis*	(Hampson, 1891)	IF
18	Crambidae	Spilomelinae	*Conogethes punctiferalis*	(Guenée, 1854)	F
19	Crambidae	Spilomelinae	*Diaphania indica*	(Saunders,1851)	VF
20	Crambidae	Spilomelinae	*Eurrhyparodes bracteolalis*	(Zeller, 1852)	IF
21	Crambidae	Spilomelinae	*Glyphodes bicolor*	(Swainson, [1821])	VF
22	Crambidae	Spilomelinae	*Glyphodes actorionalis*	(Walker, 1859)	VF
23	Crambidae	Spilomelinae	*Haritalodes derogata*	(Fabricius, 1775)	VF
24	Crambidae	Spilomelinae	*Herpetogramma licarsisalis*	(Walker, 1859)	VF
25	Crambidae	Spilomelinae	*Hodebertia testalis*	(Fabricius, 1794)	IF
26	Crambidae	Spilomelinae	*Maruca vitrata*	(Fabricius, 1787)	VF
27	Crambidae	Spilomelinae	*Metoeca foedalis*	(Guenée, 1854)	F
28	Crambidae	Spilomelinae	*Nausinoe pueritia*	(Cramer, [1780])	F
29	Crambidae	Spilomelinae	*Omiodes indicata*	(Fabricius, 1775)	VF
30	Crambidae	Spilomelinae	*Omiodes diemenalis*	(Guenée, 1854)	VF
31	Crambidae	Spilomelinae	*Parotis* cf. *marginata*	(Hampson, 1893)	VF
32	Crambidae	Spilomelinae	*Pygospila tyres*	(Cramer, 1780)	VF
33	Crambidae	Spilomelinae	*Sameodes cancellalis*	(Zeller, 1852)	VF
34	Crambidae	Spilomelinae	*Spoladea recurvalis*	Fabricius, 1775	VF
35	Crambidae	Spilomelinae	*Synclera traducalis*	(Zeller, 1852)	IF
36	Eupterotidae	Eupteroptinae	*Eupterote bifasciata*	Kishida, 1994	VF
37	Bombycidae	Bombycinae	*Trilocha varians*	(Walker, 1855)	VF
38	Sphingidae	Macroglossinae	*Hippotion* cf. *rosetta*	(Swinhoe, 1892)	IF
39	Sphingidae	Macroglossinae	*Theretra clotho*	(Drury, 1773)	IF
40	Uraniidae	Epipleminae	*Phazaca theclata*	(Guenée, 1857)	IF
41	Geometridae	Ennominae	*Chiasmia eleonora*	(Cramer, 1780)	IF
42	Geometridae	Ennominae	*Chiasmia fidoniata*	(Guenée, 1858)	F
43	Geometridae	Ennominae	*Cleora* sp.1		IF
44	Geometridae	Ennominae	*Cleora* sp.2		F
45	Geometridae	Ennominae	*Gonodontis clelia*	(Cramer, [1780])	IF
46	Geometridae	Ennominae	*Hyperythra lutea*	(Stoll, 1781)	VF
47	Geometridae	Ennominae	*Petelia medardaria*	Herrich-Schäffer, [1856]	IF
48	Geometridae	Geometrinae	*Agathia laetata*	(Fabricius, 1794)	IF
49	Geometridae	Geometrinae	*Thalassodes* cf. *immissaria*	Walker, 1861	IF
50	Geometridae	Sterrhinae	*Chrysocraspeda faganaria*	(Guenée, 1858)	F
51	Geometridae	Sterrhinae	*Antitrygodes cuneilinea*	(Walker, 1863)	F
52	Geometridae	Sterrhinae	*Scopula emissaria*	(Walker, 1861)	F
53	Geometridae	Sterrhinae	*Scopula pulchellata*	(Fabricius, 1794)	IF
54	Geometridae	Sterrhinae	*Scopula* sp.		VF
55	Geometridae	Sterrhinae	*Traminda mundissima*	(Walker, 1861)	VF
56	Erebidae	Aganainae	*Asota caricae*	(Fabricius, 1775)	VF
57	Erebidae	Aganainae	*Asota ficus*	(Fabricius, 1775)	VF
58	Erebidae	Arctiinae	*Amata passalis*	(Fabricius, 1781)	VF
59	Erebidae	Arctiinae	*Argina astrea*	(Drury, 1773)	VF
60	Erebidae	Arctiinae	*Creatonotos transiens*	(Walker, 1855)	F
61	Erebidae	Arctiinae	*Eilema* sp.1		F
62	Erebidae	Arctiinae	*Eilema* sp.2		VF
63	Erebidae	Arctiinae	*Pericallia ricini*	(Fabricius, 1775)	VF
64	Erebidae	Arctiinae	*Spilarctia* sp.		IF
65	Erebidae	Arctiinae	*Spilosoma* sp.		IF

66	Erebidae	Boletobiinae	*Eublemma dimidialis*	(Fabricius, 1794)	IF
67	Erebidae	Calpinae	*Calyptra minuticornis*	(Guenée, 1852)	IF
68	Erebidae	Calpinae	*Eudocima materna*	(Linnaeus, 1767)	VF
69	Erebidae	Calpinae	*Eudocima phalonia*	(Linnaeus, 1763)	VF
70	Erebidae	Calpinae	*Oraesia emarginata*	(Fabricius, 1794)	IF
71	Erebidae	Calpinae	*Rhesala* sp.		IF
72	Erebidae	Erebinae	*Achaea janata*	(Linnaeus, 1758)	F
73	Erebidae	Erebinae	*Artena dotata*	(Fabricius, 1794)	VF
74	Erebidae	Erebinae	*Bastilla angularis*	(Boisduval, 1833)	IF
75	Erebidae	Erebinae	*Bastilla arctotaenia*	(Guenée, 1852)	VF
76	Erebidae	Erebinae	*Chalciope mygdon*	(Cramer, 1777)	IF
77	Erebidae	Erebinae	*Ercheia cyllaria*	(Cramer, 1779)	IF
78	Erebidae	Erebinae	*Ericeia inangulata*	(Guenée, 1852)	VF
79	Erebidae	Erebinae	*Mocis frugalis*	(Fabricius, 1775)	VF
80	Erebidae	Erebinae	*Mocis undata*	(Fabricius, 1775)	VF
81	Erebidae	Erebinae	*Spirama* cf. *retorta*	(Clerck, 1764)	VF
82	Erebidae	Erebinae	*Thyas coronata*	(Fabricius, 1775)	IF
83	Erebidae	Eulepidotinae	*Anticarsia irrorata*	(Fabricius, 1781)	IF
84	Erebidae	Herminiinae	*Simplicia* sp.		F
85	Erebidae	Hypocalinae	*Hypocala* sp.		IF
86	Erebidae	Lymantriinae	*Euproctis* sp.		IF
87	Erebidae	Lymantriinae	*Nygmia icilia*	(Stoll, [1790])	F
88	Erebidae	Lymantriinae	*Orvasca* sp.		IF
89	Erebidae	Lymantriinae	*Somena* sp.		IF
90	Erebidae	Scoliopteryginae	*Anomis flava*	(Fabricius, 1775)	IF
91	Nolidae	Nolinae	*Nola analis*	(Wileman & West, 1928)	IF
92	Nolidae	Nolinae	*Selepa celtis*	Moore, [1860]	VF
93	Noctuidae	Condicinae	*Condica* sp.		IF
94	Noctuidae	Heliothinae	*Helicoverpa* sp.		F
95	Noctuidae	Noctuinae	*Leucania loreyi*	(Duponchel, 1827)	VF
96	Noctuidae	Noctuinae	*Leucania* sp.		F
97	Noctuidae	Noctuinae	*Polytela gloriosae*	Fabricius, 1781	IF
98	Noctuidae	Noctuinae	*Spodoptera litura*	(Fabricius, 1775)	VF
99	Noctuidae	Plusiinae	*Ctenoplusia agnata*	(Staudinger, 1892)	VF

Table 2. Family wise number of species recorded during the survey

Sl No	Family	Number of Species recorded
1	Limacodidae	1
2	Thyrididae	1
3	Crambidae	33
4	Eupterotidae	1
5	Bombycidae	1
6	Sphingidae	2
7	Uraniidae	1
8	Geometridae	15
9	Erebidae	35
10	Nolidae	2
11	Noctuidae	7
	Total	99

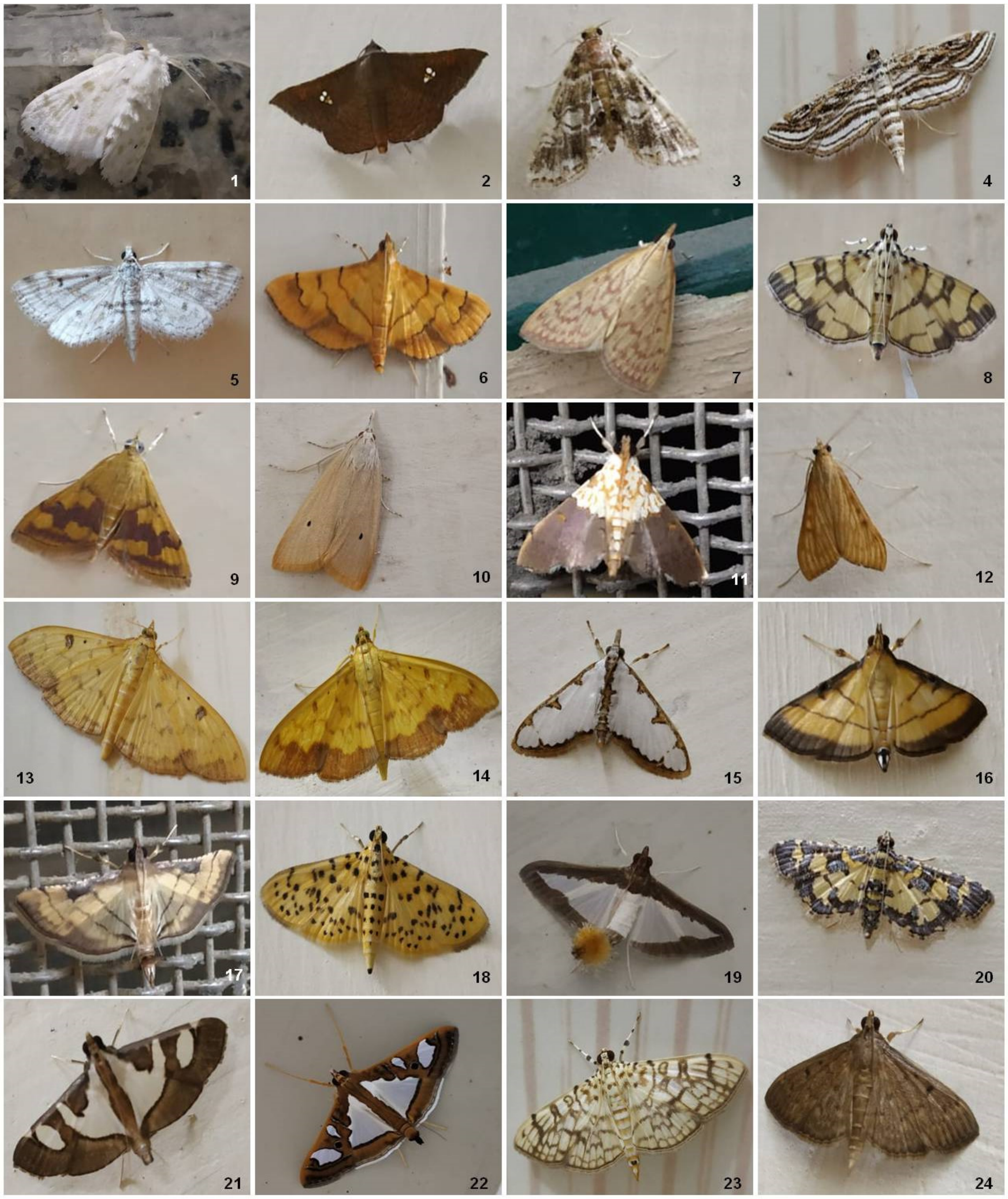


Plate 1. 1–*Altha subnotata*; 2–*Banisia myrsusalis*.; 3–*Elophila sp.*; 4–*Parapoynx fluctuosalis*; 5–*Parapoynx diminutalis*; 6–*Orphanostigma abruptalis*; 7–*Ostrinia* sp.; 8–*Pardomima distortana*; 9–*Pyrausta phoenicealis*; 10–*Scirpophaga incertulas*; 11–*Agrotera posticalis*; 12–*Antigastra catalaunalis*; 13–*Botyodes diniasalis*; 14–*Botyodes asialis*; 15–*Cirrhochrista brizoalis*; 16–*Cnaphalocrocis medinalis*; 17–*Cnaphalocrocis bilinealis*; 18–*Conogethes punctiferalis*; 19–*Diaphania indica*; 20–*Eurrhyparodes bracteolalis*; 21–*Glyphodes bicolor*; 22–*Glyphodes actorionalis*; 23–*Haritalodes derogata*; 24–*Herpetogramma licarsisalis*

Plate 2. 25–*Hodebertia testalis* 26–*Maruca vitrata*; 27–*Metoeca foedalis*; 28–*Nausinoe pueritia*; 29–*Omiodes indicata*; 30–*Omiodes diemenalis*; 31–*Parotis* cf. *marginata*; 32–*Pygospila tyres*; 33–*Sameodes cancellalis*; 34–*Spoladea recurvalis*; 35–*Synclera traducalis*; 36–*Eupterote bifasciata*; 37–*Trilocha varians*; 38–*Hippotion* cf. *rosetta*; 39–*Theretra clotho*; 40–*Phazaca theclata*; 41–*Chiasmia eleonora*; 42–*Chiasmia fidoniata*; 43–*Cleora* sp.1; 44–*Cleora* sp.2; 45–*Gonodontis clelia*; 46–*Hyperythra lutea*; 47–*Petelia medardaria*; 48–*Agathia laetata*

Plate 3. 49– *Thalassodes* cf. *immissaria*; 50– *Chrysocraspeda faganaria*; 51– *Antitrygodes cuneilinea*; 52– *Scopula emissaria*; 53– *Scopula pulchellata*; 54– *Scopula* sp.; 55– *Traminda mundissima*; 56– *Asota caricae*; 57– *Asota ficus*; 58– *Amata passalis*; 59– *Argina astrea*; 60– *Creatonotos transiens*; 61– *Eilema* sp.1; 62– *Eilema* sp.2; 63– *Pericallia ricini*; 64– *Spilarctia* sp.; 65– *Spilosoma* sp. 66– *Eublemma dimidialis*; 67– *Calyptra minuticornis*; 68– *Eudocima materna*; 69– *Eudocima phalonia*; 70– *Oraesia emarginata*; 71– *Rhesala* sp.; 72– *Achaea janata*

Plate 4. 73–*Artena dotata*; 74–*Bastilla angularis*; 75–*Bastilla arctotaenia*; 76–*Chalciope mygdon*; 77–*Ercheia cyllaria*; 78–*Ericeia inangulata*; 79–*Mocis frugalis*; 80–*Mocis undata*; 81–*Spirama* cf. *retorta*; 82–*Thyas coronata*; 83–*Anticarsia irrorata*; 84–*Simplicia* sp.; 85–*Hypocala* sp.; 86–*Euproctis* sp.; 87–*Nygmia* icilia; 88–*Orvasca* sp.; 89–*Somena* sp.; 90–*Anomis flava*; 91–Nola analis; 92–Selepa celtis; 93–Condica sp.; 94–Helicoverpa sp.; 95–Leucania loreyi; 96–*Leucania* sp.; 97–*Polytela gloriosae*; 98–*Spodoptera litura*; 99–*Ctenoplusia agnata*.

The rest of the families were represented by a very low number of species. However, family-wise abundance data indicated that Crambidae (38.70%) was the most abundant family having highest proportion moths recorded followed by Erebidae (34.85%), Geometridae (10.73%), Noctuidae (6.81%) and others. The findings, again, were consistent with prior research that showed the dominance of these moth families in a similar humid subtropical climate like Varanasi (Sondhi and Sondhi, 2016). However, five (Bombycidae, Eupterotidae, Limacodidae, Thyrididae and Uraniidae) of the 11 families showed the least species richness with only one representative species recorded from each of these families. A species accumulation curve was constructed which depicts the cumulative number of observed species as a function of sample efforts (Figure 4a). When a total number of recorded species reached to a value of 99, the species accumulation curve nearly reached saturation. Based on their frequency of occurrence, all the species were classified into three categories (Table 1).

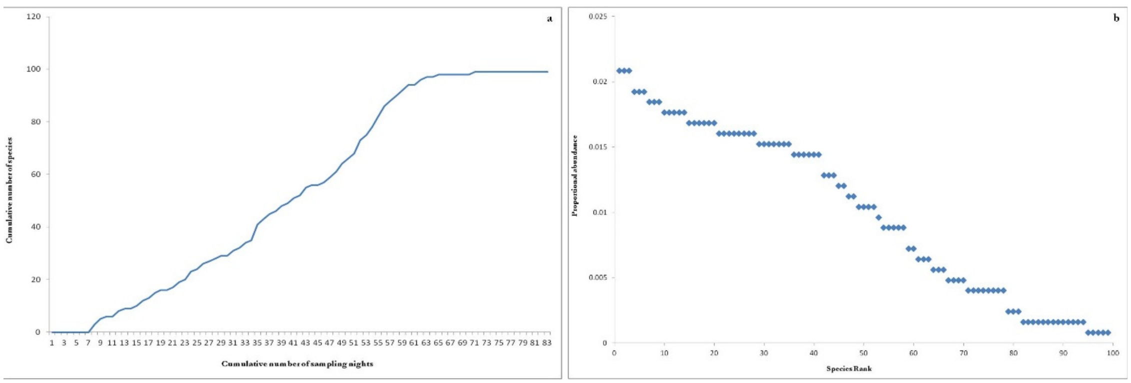


Figure 4. a. Species accumulation curve; x-axis = cumulative number of sampling nights, y-axis = cumulative number of species observed. b. Rank abundance curve displaying relative moth species abundance, for the survey period

The study recorded 41 very frequent, 19 frequent and 39 infrequent species of moths during the survey period. The rank-abundance curve for moths showed that overall, three species are the most abundant in the study area, the *Cnaphalocrocis medinalis* (Guenée,1854), *Spoladea recurvalis* (Fabricius, 1775) and *Pericallia ricini* (Fabricius, 1775) (Figure 4b). The least common members observed were *Antigastra catalaunalis* (Duponchel, 1833), *Bastilla angularis* (Boisduval, 1833), *Chiasmia eleonora* (Cramer, 1780), *Ercheia cyllaria* (Cramer, 1779) and *Condica* sp (Figure 4b). The study has also recorded a number of pests of common crops and fruits of the area e.g. *Achaea janata* (Linnaeus, 1758), *Helicoverpa* sp., *Maruca vitrata* (Fabricius, 1787), *Ostrinia* sp., *Spodoptera litura* (Fabricius, 1775) and others.

Discussion

In the present study across different habitats of the campus, we found that members of the two moth families (Crambidae & Erebidae) were very frequent with a less frequent documentation from Geometridae and Noctuidae. The high abundance of the Crambidae family can be attributed to the presence of a large number of agro-ecosystems and grassy habitats throughout the campus. Further, their larvae show a wide range of adaptations with phytophagous, detritivorous, coprophagous, parasitic habits, and can feed on roots, stems or grasses (Zhu *et al.*, 2018). We assume that the lower species richness of the other seven families especially the families with singleton captures could have been improved by repeated sampling in a systematic approach.

Moths constitute an important part of the biodiversity of an area and play a major role in maintaining a healthy environment and ecological balance of the area. Over the last few decades, Varanasi has faced rapid urbanization by expanding in all directions and its population has increased at an unprecedented rate (Kumar *et al.*, 2010). Most of the unplanned urban areas in the city have lost their natural wetlands and green space. The unprecedented rate of urbanization and associated environmental processes pose greatest threats to the native biodiversity and support only highly depauperate insect faunas that can withstand the substantial structural and biotic changes (New, 2018). Previous studies suggest that urban areas exhibit a substantial decline in insect species richness, particularly of Diptera and Lepidoptera in comparison to their surrounding rural areas (Clark *et al.*, 2007; Theodorou *et al.*, 2020). Other works have demonstrated that Lepidoptera assemblage in urbanized locations are negatively affected by urbanization and remains in a disturbed state with a reduced population size and species richness (McGeoch and Chown, 1997; Bates *et al.*, 2014)

Universities are centres for higher education that have a unique potential for adopting a biophilic design in their campus areas and can help for a closer reconnection of urban residents to the biosphere (Colding and Barthel, 2017). Many urban universities all over the world have started to develop their own action plan on monitoring, management, and conservation of biodiversity in their campus area. During the last two decades BHU has taken a number of initiatives to protect and preserve the biodiversity of its south campus (2,700 acres), located in Barkachha of Mirzapur district. A biodiversity park at its South Campus in a piece of 500 acres of land has been established by the Centre for Environmental Science & Technology for the conservation of biodiversity. However, due to space constraints, the university could not take such steps in its main campus at Varanasi.

The study area has a number of disturbances to the moth population and other parts of the campus biodiversity. Anthropogenic disturbances, including collection of medicinal plants, fuel wood and fodder, trampling, scraping and grazing have been reported from the campus area (Verma *et al.*, 2007; Verma *et al.*, 2015). These activities might affect some moth and other invertebrate species that depend on these key structural habitat attributes for their survival. Varanasi has been described as one of the most polluted regional cities on the earth in terms of air quality with air pollutant level 12 times higher than the WHO annual guideline (Mukherjee and Agrawal, 2018). A recent study has reported that besides its negative impacts on human health and local economies, direct or indirect haze exposure can lead to a significant increase in the caterpillar mortality and altered larval development time and pupal weight in a butterfly species (Tan *et al.*, 2018). Another major concern for the moth life is that, many natural or semi-natural habitats in the campus area are experiencing artificial light pollution by inappropriate or excessive use of artificial light which will have some negative impacts on Lepidoptera as well as other nocturnal insect communities of the area. Studies have shown that night time illumination of cities especially the artificial lights from street lamps could potentially turn urban areas into ecological traps for moths (Plummer *et al.*, 2016). Recent studies have reported that artificial light pollution may cause spatial and temporal disorientation, desynchronization of biorhythms and desensitization of the visual systems affecting the physiology and behaviour of various organisms including nocturnal pollinators which in turn may affect several associated ecosystem functions and contribute to a decline in their population (van Langevelde *et al.*, 2011; Owens and Lewis, 2018).

The study unavoidably has some limitations. Moths were not recorded by standard light trapping devices using Mercury vapour lamps. All the moth species were identified by morphological characters using digital colour photographs rather using more sophisticated methods like DNA barcoding or analysis of dissected genitalia structures. Despite these limitations, the study still managed to gather a large number of moth species that has not been previously reported from this region.

Conclusions

The land of BHU campus has remained undisturbed and preserved its biodiversity for more than hundred years since its establishment in 1916. Therefore, the amount of biodiversity observed here can never be seen in other parts of the city. Our data produce a baseline assessment of the current Lepidopteran diversity across the university campus by inventorying a significant number of moth species. In conclusion, we are able to present a preliminary checklist of moths from the BHU campus for the first time based on an opportunity sampling method. Future work in a systematic way is needed to elucidate the complete moth assemblages of the campus. Finally, there is still significant scope for improvement of the campus planning by establishing and maintaining green areas and incorporating meaningful conservation measures for protection of biodiversity of this beautiful academic institution.

Authors' Contributions

AN conceived the study, identified the moths, prepared the tables, plates and figures and wrote and reviewed the manuscript. SG conducted the field work from January to December 2019. Both authors read, discussed and approved the final version of the paper.

Ethical approval (for researches involving animals or humans)

None of the species was captured or killed or subjected to any experimental treatment during the entire period of the study

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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