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# Temporal diversity of urban butterflies: A case study in the campus of Ramakrishna mission Vivekananda centenary College, Rahara, West Bengal

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**Abstract**
Butterflies constitute key indicators that enable the monitoring of the impact of urbanization on plant and animal diversity. Present study focuses on the butterfly diversity and their seasonal variation in the campus of Ramakrishna Mission Vivekananda Centenary College (RKMVCC) Rahara, an urban area situated very close to Kolkata Metropolitan city. Present study suggested that RKMVCC campus is rich in butterfly diversity (57 species, 48 genera and 5 families) and harbors 43.18% of total known species from Kolkata. According to Wilson-Shmida beta index, the highest value was found between monsoon and winter (0.51) which indicates most contrasting species composition between these two seasons.

**Keywords:** Diversity, butterflies, urban landscape, Ramakrishna mission Vivekananda centenary College. West Bengal

## 1. Introduction
Biodiversity in urban area is decreasing due to the increase of residential, industrial and commercial area associated with the disruption of natural environment. Plants and animals have frequently experienced local extinction in urban area due to habitat loss, habitat degradation, and fragmentation (McKinney, 2002 [1]; Clark *et al.*, 2007 [2]). In urban ecosystems, monitoring species diversity can be used as a tool to reduce human mismanagement and pollution in urbanized, industrial, rural, and managed areas (Wilson, 1997) [3]. This puts a spotlight on butterflies, because among of all insects, butterflies are probably the best known and taxonomically and ecologically well studied groups (Thomas, 2005) [4]. Moreover, butterflies and their caterpillars are dependent on specific host plants for food, thus the diversity of butterflies indirectly reflects the overall plant diversity especially that of shrubs and herbs in the given area (Padhye *et al.*, 2006) [5].
Several studies were undertaken to understand the impact of urbanization on butterfly fauna and their diversity in Kolkata and it's adjacent areas. Probably, the first publication on butterflies of Kolkata metropolitan region was made by Moore in the year 1882[6] from Barrackpore and afterwards Niceville (1885) [7] reported some species from Kolkata. Ghosh and Siddique (2005) [8], Ghosh (2009) [9] and Ghosh (2010) [10] studied on variation in diversity of butterflies in seventeen impact zones across natural and semi natural vegetation types in and around the Kolkata metropolis and reported 85 species of butterflies under 5 families. In another study, Chowdhury and Chowdhury (2007) [11] reported 33 species of butterflies from Mudiali Nature Park of South Kolkata. Thereafter, Chowdhury and Das (2007) [12] reported 64 Species from the Indian Botanic Garden in Howrah. During their study in East Calcutta Wetland, a total of 74 species of butterflies representing 6 families were recorded by Chowdhury and Soren (2011) [13]. Basu Roy (2011) [14] documented 76 butterflies under 05 families from Tollygaunge Club. Afterwards, Biswas *et al.* (2012) [15] reported 42 species of butterfly from Salt Lake City. A total of 49 species of butterflies under 5 families and 36 genera were recorded by Nair *et al.* (2014) [16] from the Sarojini Naidu College campus, Dum Dum, Kolkata. A study was conducted by Biswas *et al.* (2014) [17] to determine the seasonal and population variation of butterflies and documented 49 species under 04 families from South Kolkata. Apart from this, Mukherjee *et al.* (2016) [18] reported 54 species under 5 families of butterflies from Dum Dum Metro station, Nalban and Ballygaunge Phanri area. 60 species under 5 families of butterflies were reported by Maity *et al.* (2016) [19] from Salt Lake City. In the year 2016 [20],

Biswas *et al.* published a list of 132 species under 92 genera belonging to 6 families of butterflies from the Kolkata Metropolitan Region. Chakraborty Thakur *et al.* (2017) [21] observed 43 species under 5 families in the campus of Lady Brabourne College. A small study on the generic diversity (61 genera) of the butterflies was done by Saha (2017) [22] in the campus of West Bengal State University (WBSU).

Apart from these, butterfly diversity was also documented from two sanctuaries adjacent to Kolkata metropolitan city. 79 species under 6 families of butterflies were reported by Mitra *et al.* (2015) [23] from Bhibhutibhusan wild life sanctuary, situated 100 km away from Kolkata and 105 species under 06 families of butterflies from Chintamani Kar Bird Sanctuary, situated within the city limit of Kolkata (Mitra *et al.*, 2018) [24].

Majority of these studies were made in central, southern, eastern and western side of the Kolkata city. As there are no previous studies on butterfly diversity in the northern sphere of Kolkata metropolitan, therefore, the present study was undertaken to document the temporal diversity of butterfly fauna in Ramakrishna Mission Vivekananda Centenary College (RKMVCC) campus, Rahara, situated on the northern end of Kolkata metropolis. The present work will definitely help in order to create a base line data for further research.


**Fig 1:** Overview of the study site

## 2. Materials & Methods

### 2.1 Study Area

Ramakrishna Mission Vivekananda Centenary College (RKMVCC), Rahara, Khardaha, North 24 Parganas district of West Bengal is lying in between 22°43'34.3"N and 88°22'51.7"E at an elevation of 15 metres and approximately 19 kilometres away from the Kolkata metropolitan city. The campus is spreaded over an area of 16187.4 square meters with open plots, water bodies, man-made gardens, cultivated lands as well as concrete buildings (Fig.-1). The College campus is encompassing with residential buildings, high voltage power station, waste disposal ground and a small agricultural landscape. A total of 52 species of herbs, shrubs and trees were recorded in one social forestry and one seasonal flower garden of the College campus among which *Aegle marmelos*, *Citrus* sp., *Mangifera indica*, *Polyalthia longifolia*, *Cocos nucifera*, *Cleome rutidosperma*, *Mimosa pudica*, *Oxalis corniculata*, *Tridax procumbens* etc. were predominant.

### 2.2 Collection Methodology

**Table 1:** Environmental parameters throughout the survey

| Seasons | Average temperature (ºC) | Average relative humidity (%) | Average Rainfall (mm) |
|---|---|---|---|
| Winter | 22 | 62.9 | 17 |
| Spring | 29.1 | 66.7 | 39 |
| Pre-monsoon | 31.3 | 71.5 | 214.5 |
| Monsoon | 31 | 79.8 | 316 |
| Post- monsoon | 25 | 74.6 | 81.5 |

Field sampling started in January 2017 and continued up to December 2017 in the campus and adjacent areas of RKMVCC. A regular survey was carried out four days in a week during morning period (8:00 am- 11:30 am) and observations were made by visual encounter method. During each sampling whenever butterflies were encountered always tried to identify them according to field guide books and other standard published literatures (Kunte, 2000 [25]; Kehimkar, 2008 [26]; Basu Roy, 2011; Smetacek, 2017 [27]) in field and photographs were also taken using digital camera (Canon EOS 1300D) for future cross checking. Methodology was followed after the hand book on collection, preservation and identification published by Zoological Survey of India, Kolkata (Jonathan & Kulkarni, 1986) [28].

Three environmental parameters such as average temperature (in degree Celsius), average relative humidity of the air (in percentage) and average rainfall (in millimetre) data were also recorded from available daily newspapers (Table-1). According to these environmental variables the entire study period was divided into five seasons, i.e. winter (December and January), spring (February and March), pre-monsoon (April, May and June), monsoon (July, August and September), post monsoon (October and November).

### 2.3 Data analysis

As all environmental data recoded were the count data, those were at first transformed (square root transformation) and then t-test was carried out to observe whether any significant

level of variations exist among them or not (Zar, 2009) [29]. Butterfly species which were encountered during that/those month/months under above mentioned particular season were listed as species observed on that particular season in the present checklist (table-2). Number of butterfly species under a specific taxonomic family within a particular season was also calculated. As all data calculated were the count data, those were again transformed (square root transformation) and then one way ANOVA was performed to observe whether any significant level of variation exist among five different seasons in respect of number of species under various taxonomic families (Zar, 2009) [29]. As the present study was mainly based on presence absence data of butterflies among different seasons, Wilson-Shmida beta diversity index (Wilson, 1984 [30] and Cramer, 2005 [31]) calculation was also carried out between each of the two respective seasons to estimate the qualitative similarity of species composition between any of the two selected seasons. One sample t-test was again done to see the variation among all index values. All statistical tests (one sample t-test and one way ANOVA) were carried out through SPSS 17.00 software.

## 3. Results

A total of 57 species of butterflies under 48 genera belonging to 5 families were recorded during the course of the study, of them three species (*Telicota* sp., *Tarucus* sp. and *Mycalesis* sp.) identified upto generic level (Table-2). The WPA status of each family was recorded. Three species (marked with *) are coming under the Wildlife (Protection) Act, 1972 under different schedules (Table-2).

**Table 2:** List of species and their availability in different seasons (W = winter, Sp = spring, PrM = pre monsoon, Mo = monsoon, PoM = post monsoon; + = present; * = under Wildlife (Protection) Act, 1972

| | **Family Hesperiidae** | **W** | **Sp** | **PrM** | **Mo** | **PoM** |
|---|---|---|---|---|---|---|
| 1 | *Ampittia dioscorides* (Fabricius, 1793) | | | | + | |
| 2 | *Borbo cinnara* (Wallace, 1866) | | | | + | + |
| 3 | *Hasora chromus* (Cramer, 1780) | | | | + | |
| 4 | *Iambrix salsala* (Moore, 1866) | + | | | + | + |
| 5 | *Pelopidas mathias* (Fabricius, 1798) | + | + | | | + |
| 6 | *Spialia galba* (Fabricius, 1793) | | | | | + |
| 7 | *Suastus gremius*(Fabricius, 1798) | | + | | + | |
| 8 | *Telicota* sp. | | | | + | |
| 9 | *Udaspes folus* (Cramer, 1775) | | | + | + | + |
| | **Family Lycaenidae** | | | | | |
| 10 | *Abisara echerius* (Stoll, 1790) | | | | | + |
| *11 | *Castalius rosimon* (Fabricius, 1775) | + | + | + | + | + |
| 12 | *Catochrysops strabo* (Fabricius, 1793) | + | + | | | |
| 13 | *Chilades lajus* (Stoll, 1780) | | + | + | + | + |
| 14 | *Chilades pandava* (Horsfield, 1829) | | + | + | + | + |
| 15 | *Euchrysops cnejus* (Fabricius, 1798) | | | + | | |
| 16 | *Loxura atymnus* (Stoll, 1780) | | | | + | |
| 17 | *Neopithecops zalmora* (Butler, 1870) | | | | + | |
| 18 | *Pseudozizeeria maha* (Kollar, 1844) | + | + | + | | |
| 19 | *Rathinda amor* (Fabricius, 1775) | | | | + | + |
| 20 | *Spalgis epius* (Westwood, 1852) | | | | + | |
| 21 | *Spindasis vulcanus* (Fabricius, 1775) | | | | | + |
| 22 | *Tarucus* sp. | + | + | | | |
| 23 | *Zizula hylax* (Fabricius, 1775) | + | + | + | + | |
| 24 | *Zizeeria karsandra* (Moore, 1865) | + | + | + | | |
| 25 | *Zizina otis* (Fabricius, 1787) | | + | + | | |
| | **Family Nymphalidae** | | | | | |
| 26 | *Acraea violae* (Fabricius,1793) | | | + | + | |
| 27 | *Ariadne merione*(Cramer, 1777) | | + | + | + | + |
| 28 | *Danaus chrysippus*(Linnaeus,1758) | + | + | + | + | + |
| 29 | *Elymnius hypermnestra* Linnaeus, 1763 | + | + | + | + | + |
| 30 | *Euploea core* (Cramer, 1780) | + | + | | + | + |
| 31 | *Euthalia aconthea* (Cramer, 1777) | + | + | | | |
| 32 | *Hypolimnas bolina* (Linnaeus, 1758) | | | | + | + |
| 33 | *Junonia almana* (Linnaeus, 1758) | | + | + | + | + |
| 34 | *Junonia atlites* (Linnaeus, 1763) | + | | | + | + |
| 35 | *Junonia lemonias* (Linnaeus, 1758) | | | | + | |
| 36 | *Melanitis leda* (Linnaeus, 1758) | + | + | | | + |
| 37 | *Moduza procris* (Cramer, 1777) | | | | | + |
| 38 | *Mycalesis* sp. | | | | + | + |
| 39 | *Neptis hylas* (Linnaeus, 1758) | + | + | | | |
| 40 | *Phalanta phalantha* (Drury, 1773) | | | | + | |
| 41 | *Tirumala limniace* (Cramer, 1775) | | | | + | + |
| 42 | *Ypthipa asterope* (Klug, 1832) | | | | + | + |
| 43 | *Ypthima baldus* (Fabricius, 1775) | + | + | + | + | + |
| 44 | *Ypthima huebneri* Kirby, 1871 | + | + | + | + | + |
| | **Family Papilionidae** | | | | | |
| 45 | *Atrophaneura aristolochiae* (Fabricius, 1775) | | | | | + |

| | | | | | | |
|---|---|---|---|---|---|---|
| *46 | *Chilasa clytia* Linnaeus, 1758 | | | + | + | |
| 47 | *Graphium agamemnon* (Linnaeus, 1758) | + | + | + | + | + |
| 48 | *Graphium doson* (C. & R. Felder, 1864) | | | + | + | |
| 49 | *Papilio demoleus* (Linnaeus, 1758) | + | + | | + | + |
| 50 | *Papilio polymnestor* (Cramer, 1775) | | | | | + |
| 51 | *Papilio polytes* Linnaeus, 1758 | + | + | + | + | + |
| | **Family Pieridae** | | | | | |
| *52 | *Appias libythea* (Fabricius, 1775) | + | + | + | + | + |
| 53 | *Catopsilia pomona* Fabricius, 1775 | | + | + | + | |
| 54 | *Catopsilia pyranthe* (Linnaeus, 1758) | | | | + | + |
| 55 | *Delias eucharis* (Drury, 1773) | + | | | + | + |
| 56 | *Eurema hecabe* (Linnaeus, 1758) | + | + | + | + | + |
| 57 | *Leptosia nina* (Fabricius, 1793) | + | + | + | + | + |

The maximum number of butterfly species were recorded under family Nymphalidae (33%) followed by Lycaenidae (28%), Hesperiidae (16%), Papilionidae (12%) and Pieridae (11%) (Fig.2). Considering the generic diversity, the family Nymphalidae and Lycaenidae are having the highest number of genus (31%), followed by Hesperiidae (19%), Pieridae (11%) and Papilionidae (8%) (Fig.3).

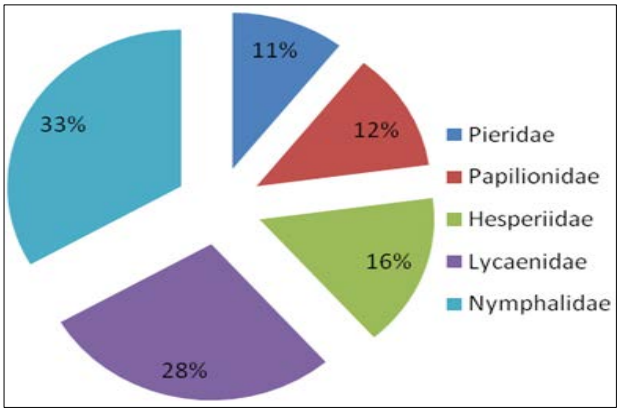


**Fig 2:** Family-wise species diversity (in percent)

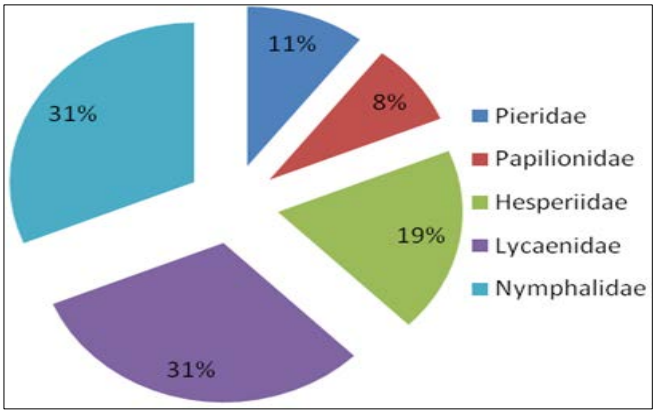


**Fig 3:** Family-wise generic diversity (in percent)

Genera-wise distribution clearly shows that majority of the genus were distributed having single species (42 genera). Whereas, *Ypthima* and *Junonia* (Nymphalidae) and *Papilio* (Papilionidae) are the most dominant genera with 3 species, followed by *Graphium* (Papilionidae), *Chilades* (Lycaenidae) and *Catopsilia* (Pieridae) with 2 species (Fig.4). During this present survey, *Leptosia nina*, *Eurema hecabe*, *Appias libythea* (Pieridae),*Graphium agamemnon*, *Papilio polytes* (Papilionidae), *Danaus chrysippus*, *Elymnius hypermnestra*, *Ypthima huebneri*, *Ypthima baldus* (Nymphalidae) and *Castalius rosimon* (Lycaenidae) were found as very common butterflies in RKMVC college campus.

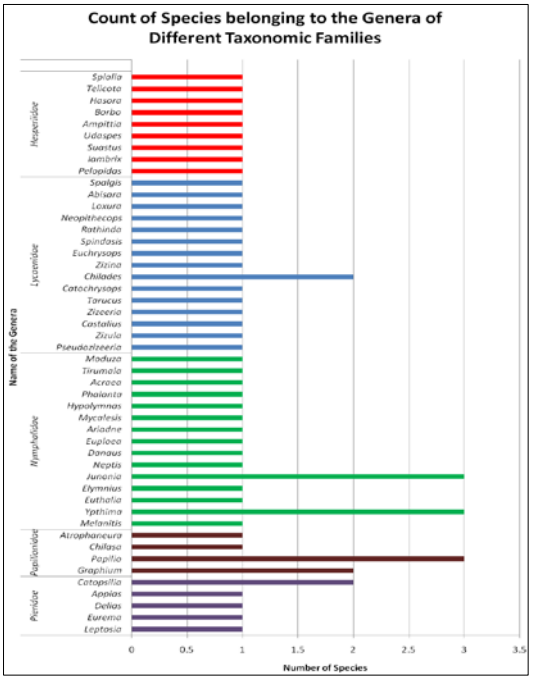


**Fig 4:** Number of species from each genera

During five successive seasons like winter, spring, pre monsoon, monsoon and post monsoon 24 butterfly species were recorded followed by 28 species, 24 species, 41 species and 35 species respectively (Table- 2). One sample t-test indicates number of species under different seasons varied significantly ($t = 9.141$, $df = 4$, $p < 0.01$). One way ANOVA indicates that the number of species under different taxonomic families also varies significantly ($F = 10.896$, $p < 0.01$) among five respective seasons.

Average temperature, average relative aerial humidity of the air and average rainfall of five seasons are listed in Table-1 and the t-tests for all the three environmental variables in respect of five different seasons showed the significant levels of variations, i.e. for temperature ($t = 29.906$, $df = 4$, $p < 0.05$), for relative humidity ($t = 48.054$, $df = 4$, $p < 0.05$) and for rainfall ($t = 4.05$, $df = 4$, $p < 0.05$).

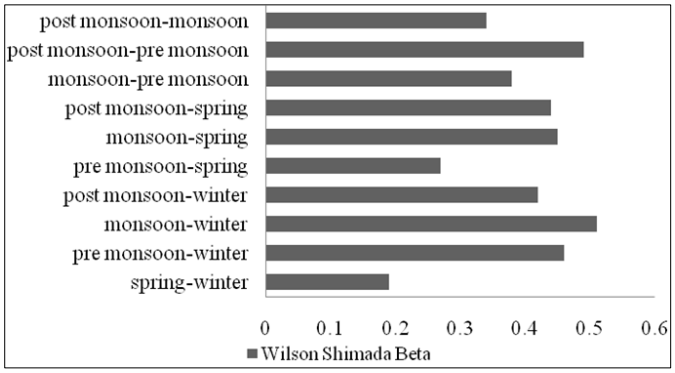


**Fig 5:** Wilson – Shmida beta index values of different combinations of seasons

Ten different Wilson-Shmida beta values were achieved as ten different combinations were emerged out from any two of five selected seasons (Figure-5). Highest value of Wilson-Shmida beta index was found between monsoon and winter (0.51) indicates most contrasting species composition between these two seasons. Between these two seasons the average number of species available was 32.5 but 8 species were not recorded in monsoon which were available during winter and 25 species were recorded in monsoon but not observed during winter. Lowest value of Wilson-Shmida beta index was found between spring and winter (0.19) indicates least contrasting species composition between these two seasons. Between these two seasons the average number of species available was 26 but 3 species were not recorded in spring which were available during winter and 7 species were recorded in spring which was not recorded during winter. One sample t-test indicates Wilson-Shmida beta values varies significantly ($t = 12.285$, $df = 9$, $p < 0.01$) among ten different combinations of five seasons.

## 4. Discussion

Present study suggested that RKMVCC campus is rich in butterfly diversity and harbors 43.18% of total known species from Kolkata (Biswas *et al.*, 2016) [20].

The preference of butterflies for particular habitats is often linked with the larval (host plant) or adult food source (nectar plant). The more number of species of the nymphalids (19) and lycaenids (15) in RKMVC college campus indicates a varied assemblage of floral species, particularly shrubs and herbs. Majority of genera with single species also indicates rich butterfly diversity in the RKMVCC campus instead of anthropogenic disturbance and heterogeneous diversity of habitats. This findings support the recent work of Nieves Barranco-León (2016) [32]. In their study, they observed that urban protected areas including a mixture of natural and man-made habitats can preserve higher butterfly diversity than reserves composed only by relics of natural habitats.

According to Cody (1975) [33] Wilson Shmida beta diversity measurement often reflects towards species turnovers as it calculates the gain and loss of the species along a gradient. In the present study species turnovers along temporal gradient scale (seasons) were clearly observed. These qualitative changes in butterflies highly related with the change of the floral communities within the study site which in turn indicates towards habitat heterogeneity hypothesis (Tews *et al.*, 2004) [34] where species diversity increases with the increase of habitat types.

Butterflies occur seasonally being common for a few months and seen rarely or not at all in other months (Chakraborty Thakur *et al.*, 2017). But the present communication records the availability of *Eurema hecabe* (Pieridae) and *Papilio polytes* (Papilionidae) throughout the year in the study sites.

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## 6. References

1. McKinney ML. Urbanization, biodiversity, and conservation. Bioscience. 2002; 52:883-890.
2. Clark PJ, Reed JM, Chew FS. Effects of urbanization on butterfly species richness, guild structure, and rarity. Urban Ecosyst. 2007; 10:321-337.
3. Wilson EO. Introduction. In Biodiversity II, Edited by Reaka-Kudla ML, Wilson DE, Wilson EO. Washington, D.C: Henry Press, 1997, 1-3.
4. Thomas JA. Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups. Philosophical Transactions of the Royal Society B: Biological Sciences. 2005; 360:339-357.
5. Padhey AD, Dahamukar N, Paigankar M, Deshpande M, Deshpande D. Season and Landscape wise distribution of butterflies in Tamhini, northern Western Ghats, India. ZOO'S Print Journal. 2006; 21(3):2175-2181.
6. Moore F. A list of butterflies captured in Barrackpore Park. In: Entomologists Monthly Magazine (ED.) G.A.J. Rothney. 1882; 19:33-36.
7. Niceville De L. List of butterflies of Calcutta and its neighbourhood with notes on habits and food plants. Journal of Asiatic Society of Bengal. 1885; 54(2):39-54.
8. Ghosh S, Siddique S. Butterfly Diversity in and Around Urban Kolkata, Rec. zool. Surv. India. 2005; 104(3-4):111-119.
9. Ghosh S. Birds and butterflies in the grounds of the Raj Bhavan, Kolkata. Raj Bhavan publication. Occ. Paper. 2009; 6:1-52.
10. Ghosh S. Urban biodiversity of Calcutta: Flowering plants, butterflies, birds and mammals West Bengal, India. Records of the Zoological Survey of India.

Occasional Paper. 2010; 327:1-250.
11. Chowdhury D, Chowdhury S. Butterfly Fauna in Mudialy Ecological Park, Kolkata, West Bengal. Bionotes. 2007; 9(1):25.
12. Chowdhury S, Das RP. Diversity of Butterflies in the Indian Botanic Garden, Howrah, West Bengal. Bionotes. 2007; 9(4):131-132.
13. Chowdhury S, Soren R. Butterfly Fauna of East Calcutta Wetlands, West Bengal, India. Checklist. 2011; 7(6):700-703.
14. Basu Roy A. Butterflies and Wildflowers of Tollygunge Club. Published by Tollygunge Club, Kolkata, 2011, 1-111.
15. Biswas O, Chakraborti U, Das A, Chatterjee S, Das S, Mahajan B. Lepidoptera and Araneae diversity of Saltlake City, Kolkata. Bionotes. 2012; 14(3):95-96.
16. Nair AV, Mitra P, Aditya Bandyopadhyay S. Studies on the diversity and abundance of butterfly (Lepidoptera: Rhopalocera) fauna in and around Sarojini Naidu college campus, Kolkata, West Bengal, India. Journal of Entomology and Zoology Studies. 2014; 2(4):129-134.
17. Biswas O, Debnath N, Ghosh LK. Comparative analysis of the local butterfly diversity in and around South Kolkata with the growing pollution level. J Exp. Zool. India. 2014; 17(2):703-710.
18. Mukherjee S, Aditya G, Basu P, Saha G. Butterfly diversity in Kolkata metropolis: a synoptic check list. Check List. 2016; 12(2).
DOI: http://dx.doi.org/10.15560/12.2.1858.
19. Maity P, Roy S, Chakraborti U, Biswas O, Ghosh J, Gayen AK, Mitra B. Insect faunal diversity of Salt Lake City – an urbanized area adjacent to Kolkata, India. Bioscience Discovery. 2016; 7(2):101-112.
20. Biswas O, Chakraborti U, Roy S, Kumar J. Butterfly faunal diversity of Kolkata Metropolitan Region, West Bengal. ENVIS News Letter. ZSI. 2016; 22(2):2-5.
21. Chakraborty Thakur D, Chakrabarti P, Chaudhuri A. An approach for butterfly conservation through setting up a garden in an urban area, Kolkata, India. World Scientific News. 2017; 61(2):69-85.
22. Saha SK. Diversity of butterflies (Order: Lepidoptera) in West Bengal State University Campus, West Bengal, India. International Journal of Zoology Studies 2017; 2(5):150-156.
23. Mitra B, Ghosh J, Chakraborti U, Biswas O, Roy S, Basu Roy A. Entomofaunal diversity of Bhibhuti Bhusan Wild Life Sanctuary, West Bengal. Journal of Global Sciences. 2015; 4(7):2795-2807.
24. Mitra B, Basu Roy A, Das A, Shah SK, Baidya S, Roy Chaudhury D *et al*. Insect faunal diversity of Chintamani Kar Bird Sanctuary and other protected areas of West Bengal. Int. Jour. Ent. Res. 2018; 3(2):180-189.
25. Kunte K. India- A Lifescape: Butterflies of Peninsular India. University Press, 2000, 1-254.
26. Kehimkar I. The book of Indian butterflies. Bombay Natural History Society and Oxford University Press, 2008, 1-497.
27. Smetacek P. A natuaralist's guide to the butterflies of India, Pakistan, Nepal, Bhutan, Bangladesh and Sri Lanka. Published by Prakash Books. India Pvt. Ltd, New Delhi, 2017; 1-176.
28. Jonathan JK, Kulkarni PP. Manual: Collection, Preservation and Identification of insects and mites of economic importance (ed. BK. Tikader), Zoological Survey of India, Kolkata, 1986, 1-307.
29. Zar JH. Biostatistical analysis (4th edition). Pearson education in South Asia, 2009, 1-663.
30. Wilson MV, Shmida A. Measuring beta diversity with presence absence data. Journal of ecology. 1984; 72:1055-164.
31. Cramer MJ, Willing MR. Habitat heterogeneity, species diversity and null models. Oikos. 2005; 108: 209-218.
32. Nieves Barranco-León MDL, Luna-Castellanos F, Vergara CH, Badano ET. Butterfly conservation within cities: a landscape scale approach integrating natural habitats and abandoned fields in central Mexico**.** Tropical Conservation Science. 2016; 9(2):607-628.
33. Cody ML. Towards a theory of continental species diversities. In: Cody ML, Diamond JM (eds.). Ecology and evolution of Communites. Belknap press of Harvard University, 1975, 214-258.
34. Tews J, Brose U, Grimm V, Tielboraer K, Wichmann MC, Schwager M, *et al*. Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. Journal of biogeography. 2004; 31(1):79-92.