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Butterflies of Delhi with new additions and an annotated checklist from Delhi, India

[1] Jayita Biswas, [2] Sumit Dookia, [3] M Faisal
[1, 2,] University School of Environment Management, Guru Gobind Singh Indraprastha University, Dwarka, New Delhi, India
[3] Biodiversity Park Programme Centre for Environment Management of Degraded Ecosystem University of Delhi, Delhi, India

Abstract
Delhi, being a national capital faces huge anthropogenic pressure since decades. Ecologically Delhi is nestled between two different types of topology, one is rugged Aravalli hill range and its typical scrub forest, another is the Yamuna River and its fertile alluvial flood plains. This type of topology makes many micro habitat zones in between these two large ecological landscapes. Delhi being a gardened island of greenery in a very extensive semi desert region on one part of Delhi to the semi-flowing River Yamuna on the other side permits an easy and discrete study of sub localities. The present compilation of butterfly fauna is a long term study since 2012 onwards, through various months' long systematic surveys and review of the existing literature on butterfly of Delhi region. It reports total 115 species of butterfly from Delhi till date.

Keywords: lepidoptera, rhopalocera, butterflies, aravalli range, yamuna floodplain, Delhi ridge, Delhi

1. Introduction
Butterflies are one of the most fascinating groups of insects and have always been a center of attraction to humankind. These are scaled wing insects belonging to the order Lepidoptera of class Insecta. No member of the phylum arthropoda is more charismatic than butterflies. They greatly vary in size with a varying range from tiny Blues to the gorgeous birdwing. With their vibrant colour and flickering movement, makes them an attractive group for the naturalist to study. Many studies have been done on their taxonomy, migration, variation, speciation and evolutionary biology. Butterflies act as or are used as indicator species to identify the habitats that are critical and need to be protected and also indicate variation in local climate and environmental degradation. They are among the best rapid indicators of habitat quality and also are sensitive towards any types of habitat change or manipulation; therefore butterflies are an important ecological indicator that can be channelized for various conservation purposes. Venkataramani (1986) [37] describes India as a "butterfly paradise". Butterflies serve as important plant pollinators in the local environment, and help to pollinate more than 50 economically important plant crops (Borges *et al.* 2003) [8]. At present, there are around 18000 species of butterflies in the world and India has about 1501 species of butterflies, which are further segregated into various families viz. Hesperiidae, Lycaenidae, Nymphalidae, Papilionidae, Pieridae and Riodinidae (Kunte *et al.* 2017) [12, 24, 32-34]. Riodinidae is currently treated as a distinct family within the superfamily Papilionoidea, but in the past they were held to be the subfamily Riodininae of the family Lycaenidae. Today, it has been widely accepted and treated as independent family and most systematists prefer to accept even though there are counter arguments about its status (Zhao *et al.* 2013) [41]. Various workers established it through morphological as well as phylogetic studies (Ackery *et al.* 1999, Kristensen *et al.* 2007) [1, 23]. Later, it was validated through molecular phylogenetics (based on homologous DNA sequences) and that establishes it as a sister group relationship between the Riodinidae and the Lycaenidae and accepted almost unanimously (Campbell and Pierce, 2003 [11]; Wahlberg *et al.* 2005 [38] and aria Heikkilä *et al.* 2012). Only 16 species of family Riodinidae found in India and so far none of them have been reported from Delhi.

Delhi with its arid climatic conditions has never been a collector's paradise in term of butterfly diversity as compared to Himalayan regions, Western Ghats or North-East India. Although few studies have been done till date in Delhi on butterflies, the very paucity of species made it possible for part time collector confined to Delhi to study and collect a range that would be difficult in richer areas (Ashton, 1967) [4]. The various habitat matrix nestled between alluvial Yamuna flood plain and semi arid Aravalli hills, makes many micro habitat zones in between these two large ecological landscapes.

According to the existing ecosystem patterns, the population of a given species develops more or less a degree of adaptive radiation within its definitive range of geographical distribution (Mondal *et al.* 1997) [29]. Donahue (1996) mentioned two well defined habitats in the form of the arid xerophytic Aravalli Ridge and mesophytic urban nursery area. Such a difference of these two large habitat accounts for high faunal diversity in a highly urbanized area of Delhi.

In recent past, Delhi Development Authority in collaboration with Centre for Environment Management of Degraded Ecosystem (CEMDE), launched two very important ecological restoration projects, i.e., in 2002 launched Yamuna Biodiversity Park (YBP), for restoration of Yamuna river ecosystem in North Delhi region and in the year 2004 launched Aravalli Biodiversity Park (ABP) in South West Delhi region, to restore biodiversity of Aravalli mountainous

ecosystem. These ecosystem restoration projects have been a great success and have completly transformed highly degraded landscape into functional ecosystems in the form of forest communities, grasslands and wetland habitats having assemblage of native species. Buoyed by their success in the year 2015, new Biodiversity enrichment and restoration projects were initiated at Northern Ridge, Tilpath valley, Neela Hauz and Tughlaqabad. Now total area covered under Biodiversity Parks Programme is around 700 hectares.

The pioneering work on butterflies of Delhi started back in 1912 when Longstaff (1912) [28] recorded a total of 14 species. Apart from that, Jandu (1941, 1942 and 1943) [18-20], Donahue (1966, 1967) [13, 14] and Ashton (1967) [4] have also greatly contributed to the butterfly studies in Delhi. More recently in chronological order, Kalpvriksha Foundation (1991) [21] published a book titled "The Delhi Ridge- Decline and Conservation" which included a list of 60 species of butterflies present in the Ridge forest only, whereas the studies by Mondal *et al.* (1997) [29], Ghosh and Varshney (1997) [16], Gupta (1997) [17] and finally Larsen (2002) [27] compiled a cumulative list of 86 species from all over Delhi. In year 2010 (Zaidi, 2010) [40] a pictorial book was published with a list of only 24 species of butterflies, for a general populace.

After Larsen's (2002) [27] annotated and detailed checklist of 86 species, later on Biswas (2012) [6] documented 62 species from Yamuna Biodiversity Park alone, Faisal (2016) [15] reported 31 species from Northern Ridge and recently a veteran naturalist Dr. Surya Prakash (Anonymous, 2017) [32] compiled and documented total 98 species of butterflies with 13 new records after 14 years' long observations. This have further enriched our knowledge on butterfly diversity in Delhi, with an area of 1483 sq. km. and situated between two major ecological zones, namely, the Yamuna river system and Aravalli range, in the heart of the Indian sub-continent, have good diversity as compared with any other such area in entire country.

A long term student based field survey was started by Guru Gobind Singh Indraprastha University, New Delhi, and Rajlaxmi (2011) [31] reported only 33 species from Aravalli Biodiversity Park, Biswas (2012) [6] reported a total of 62 species of butterflies from Delhi's region from North and North-West Delhi and brown field sites, agricultural fields and maintained parks of Dwarka Sub City, Delhi.

2. Methodology

Butterflies are excellent indicators for urban pollution and urban development gradient (Blair and Launer, 1995) [7]. The present study was conducted to find the relation between the butterfly diversity in various urban green spaces of Delhi with different management intervention and strategies. Delhi is a metropolis highly urbanized city, located in northern India between the latitudes of 28˚24'17" and 28˚53'00" N and longitudes of 76˚50'24" and 77˚20'37" E. Delhi shares boundary with the States of Uttar Pradesh, Haryana with an area of only 1,483 km^2. The Yamuna River bisects Delhi in two odd parts and large unclaimed flood plains, and terminal part of the Aravalli Range of Hills is the two main geographical features of the city. The Aravali hills are covered with forest and ecological known as Ridge Forest and treated as a largest carbon sink and green lungs and lends a helping hand in maintaining the environment. The River Yamuna is the main source of drinking water and a sacred river for most of the inhabitants.

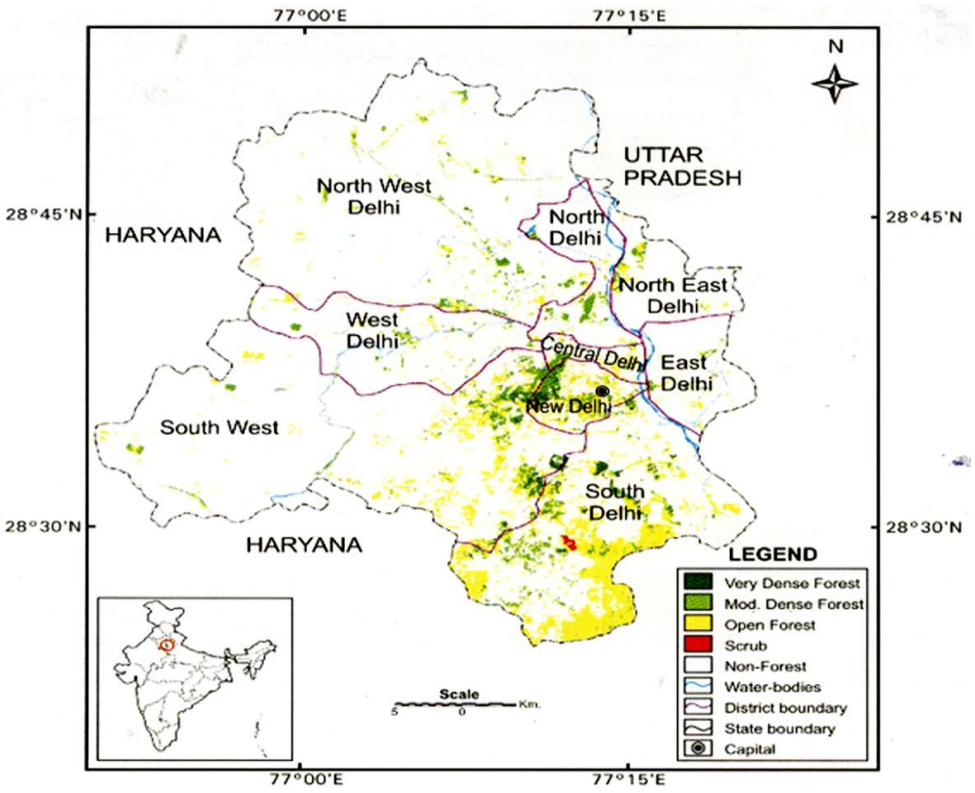

Fig 1: Map of Delhi region

The average annual rainfall in Delhi is 714mm, three fourth of which precipitates in July, August and September. Heavy rainfall in the catchment area of the Yamuna can result in a dangerous flood situation for the city. During summer months of April, May and June the temperatures can rise to 40-45˚Celsius; winter are typically cold with minimum temperatures during December and January falling to 4-5˚Celsius. February and March, October and November are climatically the best months. The forest and green cover has increased from 0.76% of total area in 1980-81 20.20% in 2009.

Butterfly diversity and density was assessed quantitatively across different habitats like natural but degraded, managed with horticultural approach and managed with ecosystem approach green types of habitats. Stratified random sampling was done with a slightly modified line transect count as per Kunte (1997) [26], was used to determine butterfly richness and abundance. In this method transects of 500 m was laid in the selected study area. Transects in each habitat were traversed at a uniform standard pace during good weather period (no heavy rain/fog or strong winds). Butterfly species was recorded around a radius of 2.5m from the observer covering either side, above and front (Van Swaay, 2000) [35]. This is the best suitable method for surveying butterflies in a wide range of habitats (Walpole and Sheldon, 1999; Caldas and Robbins, 2003; Koh and Sodhi, 2004) [39, 10, 22].

Butterflies were identified upto species, if possible, otherwise to genus or family. During survey, binocular with short focal length was used to assist in the identification. Only sighted unidentified butterflies were caught by insect net and then released after identification. All individuals were identified using standard scientific guides of Kehimkar (2008) and Kunte (2008).

More than 300 transects were traversed during the entire study period in all three seasons. These transects were walked every week on each site between the optimal time when butterflies remain most active and this time varied as per the season and local weather condition.

3. Result and Discussion

The present paper is a compilation and review of various studies, all the earlier published papers, research reports and personal observations of all three authors since last 6 years with a complete list of total 115 species from all types of available habitats in the entire Delhi region (Table 1). Total 17 new records were listed after the last available list of Prakash (2017) [30], out of these new records, interestingly a Himalayan butterfly species Indian Tortoiseshell *Aglais caschmirensis* was observed and photographed in Yamuna Biodiversity Park by one of the author (M. Faisal) in the winters of year 2011 and 2012 consecutively. During the study, it was found that the dominating family of butterflies was of Family Lycaenidae commonly known as the blues with 36 species followed by Pieridae with 26 species, Nymphalidae with 28 species, Hesperiidae with 15 species and least number of species was found from the family Papilionidae with only nine species, whereas none of the butterfly found from newly form Riodinidae family (Fig. 2).

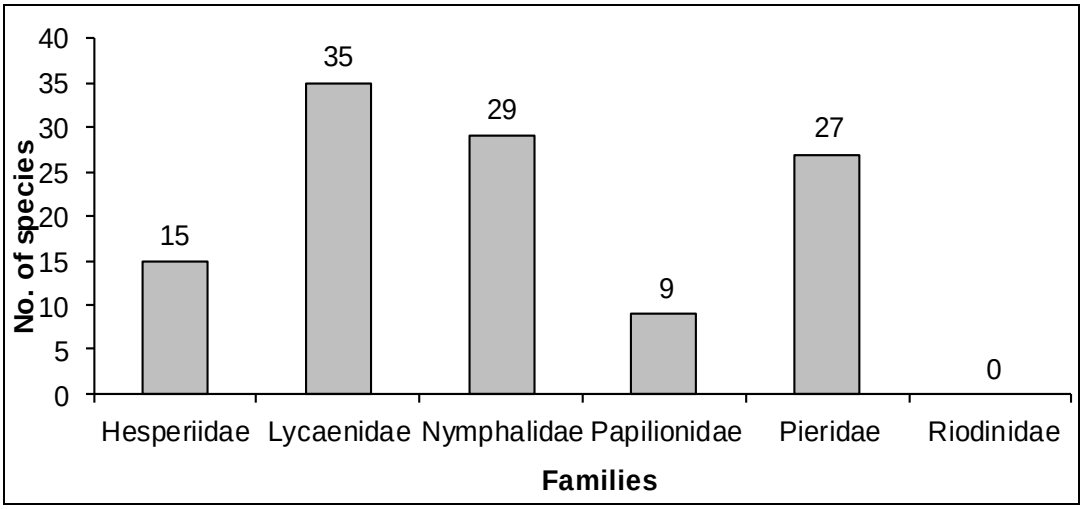

Fig 2: Family wise diversity of butterfly fauna in Delhi

It is interesting to understand that in many pictorial hand books of Indian Butterflies, which are referred widely mentioned few name of butterfly wrongly and that creates confusion. The Plain Orange-tip (*Colotis aurora*) butterfly has been mentioned as *Colotis eucharis*, whereas this species became *C. aurora* and turned junior primary homonym of *Papilio* (now *Delias*) *eucharis* and the correct name is now *Colotis aurora* (Saji, 2017) [12, 24, 32-34]. Whereas in the case of Oriental Cupid (*Everes lacturnus*), mistakenly it has been mentioned as Indian Cupid in most Indian books (Churi, 2017) [12].

The Medus Brown is popularly known as Nigger butterfly (*Orsotriaena medus*) in India. The earlier commonly known english name for this butterfly was Nigger, since 1932, but this name is racially offensive and therefore no longer socially acceptable and objected in many scientific literature worldwide. Therefore, recently, three other alternative names have been suggested for it, namely, Jungle brown (Anonymous, 2014; Smith 1989) [3, 35], Dusky Bush-brown and Smooth-eyed Bush-brown (Braby *et al.* 1997 and Barby, 2010) [9, 5], and the name used in this paper Medus Brown was suggested by Saji and Kunte (2017) [12, 24, 32-34] claimed to be

simple and reflects the scientific name of the species, so it is easy to remember.

The Tawny Coster butterfly is also found in to constant taxonomic debate. At many times taxonomist debated on the correct scientific name of Tawny Coster, *i.e.*, *Acraea terpsicore* Linnaeus, 1758 or *Acraea violae* Fabricius, 1775/1793. For clarification, several authors had quoted that they had failed to locate the type of *Papilio terpsicore* Linnaeus, 1758 and found that the name had been erroneously used for several species in Africa and Asia, which created further confusion, so *terpsicore* Linnaeus, 1758 was not defined properly and accepted. As a result, these authors had concluded that *Papilio violae* Fabricius, 1775/1793 would probably the valid name. Further suggested by Saji *et al.* (2017) [12, 24, 32-34] after thorough taxonomic review defined that the type of *terpsicore* Linnaeus, 1758, collected from the Chennai area (erstwhile Madras) in SE India is valid. Following this and suggested by Saji *et al.* (2017) [12, 24, 32-34] *Acraea terpsicore* Linnaeus, 1758 was used as a valid name for this species.

The present paper is a compilation of all the existing publications and reports regarding butterfly diversity of Delhi region and concludes with a list of 115 species of butterflies from Delhi region (Table 1).

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Table 1: Updated list of butterflies of Delhi region

S. No.	Common Name	Scientific Name	Family
Family – Hesperiidae			
1	Oriental Common Banded Awl	*Hasora chromus chromus*	Hesperiidae
2	Common Branded Redeye	*Matapa aria*	Hesperiidae
3	Dark Palm-Dart*	*Telicota bambusae*	Hesperiidae
4	Indian Pale Palm-Dart	*Telicota colon colon*	Hesperiidae
5	Indian Plain Banded Awl*	*Hasora vitta indica*	Hesperiidae
6	Dakhan Small Branded Swift	*Pelopidas mathias*	Hesperiidae
7	Oriental Conjoined Swift	*Pelopidas conjuncta conjuncta*	Hesperiidae
8	Brown Awl	*Badamia exclamationis*	Hesperiidae
9	Indian Grizzled Skipper	*Spialia galba*	Hesperiidae
10	Indian Palm Bob	*Suastus gremius gremius*	Hesperiidae
11	Parnara Swift	*Parnara* sp.	Hesperiidae
12	Rice Swift	*Borbo cinnara*	Hesperiidae
13	Dingy Swift	*Gegenes nostrodamus*	Hesperiidae
14	Oriental Grass Dart	*Taractrocera maevius*	Hesperiidae
15	Indian Bush Hopper	*Ampittia dioscorides dioscorides*	Hesperiidae
Family – Papilionidae			
16	Himalayan Common Jay	*Graphium doson axionides*	Papilionidae
17	Indian Common Mormon	*Papilio polytes romulus*	Papilionidae
18	Indian Common Rose	*Pachliopta aristolochiae*	Papilionidae
19	Crimson Rose	*Pachliopta hector*	Papilionidae
20	Oriental Common Bluebottle	*Graphium sarpedon sarpedon*	Papilionidae
21	Oriental Common Mime	*Papilio clytia clytia*	Papilionidae
22	Northern Lime Swallowtail /Lime Butterfly	*Papilio demoleus demoleus*	Papilionidae
23	Indian Spot Swordtail	*Graphium nomius nomius*	Papilionidae
24	Oriental Tailed Jay*	*Graphium agamemnon agamemnon*	Papilionidae
Family – Pieridae			
25	Oriental Lemon Emigrant/ Common Emigrant	*Catopsilia pomona pomona*	Pieridae
26	Common Grass Yellow	*Eurema hecabe hecabe*	Pieridae
27	Small Grass Yellow	*Eurema brigitta*	Pieridae
28	Common Gull	*Cepora nerissa*	Pieridae
29	Fiery Clouded Yellow*	*Colias eogene*	Pieridae
30	Himalayan Dark Clouded Yellow	*Colias fieldii*	Pieridae
31	Indian Cabbage White	*Pieris canidia indica*	Pieridae
32	Large Cabbage White	*Pieris brassicae*	Pieridae
33	Large Salmon Arab	*Colotis fausta*	Pieridae
34	Mottled Emigrant	*Catopsilia pyranthe pyranthe*	Pieridae
35	One-spot Grass Yellow	*Eurema andersonii jordani*	Pieridae
36	Indian Pioneer	*Belenois aurota aurota*	Pieridae

37	Small Cabbage White	*Pieris rapae*	Pieridae
38	Indian Little Orange-tip*	*Colotis etrida etrida*	Pieridae
39	Desert Small Salmon Arab	*Colotis amata amata*	Pieridae
40	Sylhet Three-spot Grass Yellow	*Eurema blanda silhetana*	Pieridae
41	Sind White Arab	*Colotis vestalis vestalis*	Pieridae
42	White Orange-tip	*Ixias marianne*	Pieridae
43	Yellow Orange-tip	*Ixias pyrene*	Pieridae
44	Western Striped Albatross	*Appias libythea*	Pieridae
45	Spotless Grass Yellow	*Eurema laeta*	Pieridae
46	Crimson-tip	*Colotis danae*	Pieridae
47	Oriental Psyche	*Leptosia nina nina*	Pieridae
48	Indian Jezebel	*Delias eucharis*	Pieridae
49	Plain Orange-tip*	*Colotis aurora*	Pieridae
50	Common Albatross	*Appias albina*	Pieridae
51	Indian Wanderer*	*Pareronia hippia*	Pieridae
Family – Lycaenidae			
52	Bright Babul Blue	*Azanus ubaldus*	Lycaenidae
53	Common Cerulean*	*Jamides celeno*	Lycaenidae
54	Common Ciliate Blue*	*Anthene emolus*	Lycaenidae
55	Continental Common Pierrot	*Castalius rosimon rosimon*	Lycaenidae
56	Indian Common Silverline	*Spindasis vulcanus vulcanus*	Lycaenidae
57	Dark Grass Blue	*Zizeeria karsandra*	Lycaenidae
58	Oriental Forget-me-not	*Catochrysops strabo strabo*	Lycaenidae
59	Oriental Gram Blue	*Euchrysops cnejus*	Lycaenidae
60	Grass Jewel	*Freyeria trochylus*	Lycaenidae
61	Oriental Grass Jewel*	*Freyeria putli*	Lycaenidae
62	Common Guava Blue	*Virachola isocrates*	Lycaenidae
63	Large Four-Lineblue*	*Nacaduba pactolus*	Lycaenidae
64	Lesser Grass Blue	*Zizina otis*	Lycaenidae
65	Lime Blue*	*Chilades lajus*	Lycaenidae
66	Oriental Plains Cupid	*Chilades pandava pandava*	Lycaenidae
67	Opaque Six-Lineblue*	*Nacaduba beroe*	Lycaenidae
68	Pale Grass Blue	*Pseudozizeeria maha*	Lycaenidae
69	Pea Blue	*Lampides boeticus*	Lycaenidae
70	Pointed Ciliate Blue*	*Anthene lycaenina*	Lycaenidae
71	Indian or Pointed Pierrot	*Tarucus indica*	Lycaenidae
72	Small Cupid	*Chilades parrhasius*	Lycaenidae
73	Tiny Grass Blue	*Zizula hylax*	Lycaenidae
74	Transparent Six-Lineblue*	*Nacaduba kurava*	Lycaenidae
75	Asian Zebra Blue	*Leptotes plinius plinius*	Lycaenidae
76	Red Flash	*Rapala airbus*	Lycaenidae
77	Indian Common Shot Silverline	*Spindasis ictis ictis*	Lycaenidae
78	Striped or Rounded Pierrot	*Tarucus nara*	Lycaenidae
79	Black-spotted or Balkan Pierrot	*Tarucus balkanicus nigra*	Lycaenidae
80	Spotted Pierrot	*Tarucus callinara*	Lycaenidae
81	Dull Babul Blue	*Azanus uranus*	Lycaenidae
82	African Babul Blue	*Azanus jesous*	Lycaenidae
83	Indian Dark Cerulean	*Jamides bochus bochus*	Lycaenidae
84	Oriental or Indian Cupid	*Everes lacturnus*	Lycaenidae
85	Red Pierrot	*Talicada nyseus*	Lycaenidae
86	Common Lineblue	*Prosotas nora*	Lycaenidae
Family – Nymphalidae			
87	Pale Blue Pansy	*Junonia orithya swinhoei*	Nymphalidae
88	Common Castor	*Ariadne merione*	Nymphalidae
89	Oriental Common Evening Brown	*Melanitis leda leda*	Nymphalidae
90	Common Three-ring	*Ypthima asterope*	Nymphalidae
91	Lemon Pansy	*Junonia lemonias*	Nymphalidae
92	Painted lady	*Vanessa cardui*	Nymphalidae
93	Oriental Peacock Pansy	*Junonia almana almana*	Nymphalidae
94	Oriental Plain Tiger	*Danaus chrysippus chrysippus*	Nymphalidae
95	Oriental Striped Tiger	*Danaus genutia genutia*	Nymphalidae
96	Oriental Yellow Pansy	*Junonia hierta hierta*	Nymphalidae
97	Danaid Eggfly	*Hypolimnas misippus*	Nymphalidae

98	Oriental Common Leopard	*Phalanta phalantha phalantha*	Nymphalidae
99	Tropical Fritillary	*Argynnis hyperbius*	Nymphalidae
100	Glassy Tiger*	*Parantica aglea*	Nymphalidae
101	Common Bushbrown	*Mycalesis perseus*	Nymphalidae
102	Medus Brown/Nigger	*Orsotriaena medus*	Nymphalidae
103	Lesser Three-ring	*Ypthima inica*	Nymphalidae
104	Black Rajah	*Charaxes solon*	Nymphalidae
105	Baronet	*Symphaedra nais*	Nymphalidae
106	Baron	*Euthalia aconthea*	Nymphalidae
107	Clear Sailer	*Neptis nata*	Nymphalidae
108	Grey Pansy	*Junonia atlites*	Nymphalidae
109	Chocolate Pansy	*Junonia iphita*	Nymphalidae
110	Great Eggfly	*Hypolimnas bolina*	Nymphalidae
111	Tawny Coster	*Acraea terpsicore*	Nymphalidae
112	Oriental Blue Tiger	*Tirumala limniace exoticus*	Nymphalidae
113	Striped Blue Crow	*Euploea mulciber*	Nymphalidae
114	Common Crow	*Euploea core*	Nymphalidae
115	Indian Tortoiseshell*	*Aglais caschmirensis*	Nymphalidae

* 17 New addition in the butterfly fauna of Delhi region.

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