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Reema Singh
The Machan Resort, Private Road, Lonavala Road, Atvan. Pune, Maharashtra, India

Manzoor Ahmed
CSIR- Indian Institute of Integrative Medicine (IIIM Jammu), India

Corresponding Author:
Reema Singh
The Machan Resort, Private Road, Lonavala Road, Atvan. Pune, Maharashtra, India

A report on butterfly diversity in a regenerated forest area in Atvan, Lonavala, Maharashtra, India

Reema Singh and Manzoor Ahmed

Abstract
Present study is based on private land that was an earlier barren land with fewer plants. The land has been converted into the forest through natural seeding and seed dispersal, and hence called as Regenerated or a Secondary Forest. A study has been done to understand the health of this regenerated forest area, and the data has been compared to the nearest study area Mulshi, Maharashtra, where a comparative study has been done forming landscapes that include natural forest area or primary forest. Three different landscapes and trail along the property has been created and butterflies were documented. Butterflies act as a "model" organism to study the richness of a forest. The data was used to understand the abundance of butterflies in a regenerated forest area as well as whether the forest patch can be considered a suitable habitat for the species to thrive. A total of 90 species of butterflies were documented from the survey area where butterflies of family Nymphalidae (35) were found to be dominant, followed by Lycaenidae (18), Pereidae (14), Hesperiidae (14), Papilionidae (8), Riodinidae (1).

Keywords: Butterfly, regenerated forest, natural forest, northern western ghats, human impact

Introduction
Regenerated Forest or secondary forest is the area where re-establishment of plants has been done either artificially or naturally. The Main Goal of Reforestation is the recovery of biodiversity and environmental protection (Sgró, C.M., A. J. Lowe and A. A. Hoffmann, 2011) [22]. Degraded forest sites within protected areas which have been cleared for agriculture can be a high priority as the natural forest or the "climax forest" work as a seed source for the restoration of plants [Stanturf, John A. (2005) [23], Lamb, David (2011) [14]].
Insects are known to form the most diversified group in the animal kingdom and play a major role in the ecosystem. They are one of the important links of the food web, pollination, useful agricultural pest predators, and many more. Studies on insects have been done in various fields among which butterflies have been chosen to study the effect of climate change, habitat loss, and other biological research. The Western Ghats is one of the 8 hotspots "biodiversity hotspots" in the world (Myers *et al.* 2000). Roughly 6000 species of insects are found in the Western Ghats (Mathew George and Binoy C.F). A total of 334 species of butterflies are found in the Western Ghats (Kunte *et al.* 2000) [12]. In recent years, the depleting population of butterflies has gained a lot of interest for their conservation by developing natural habitats, butterfly gardens, or butterfly conservatory. As butterflies indicate a wide variety of habitat ranges, they can also indicate other invertebrate richness, as well as plant species richness as wide species of butterflies, have wide ranges of host plants. Butterflies have clear taxonomy their biology and life history are well defined (Nelson SM, Anderson DC.1994). According to Dobson, 2012, in the last ten years, 72% of butterfly and moth species have declined. Butterflies react quickly to minor changes in the environment, providing an alarming signal for other reductions in wildlife and making them a good indicator of biodiversity. So, they are the best-monitored group of insects in the world.
The land (Study area) was an agricultural land when taken, connected to a climax forest. Crops of finger millets (Nachini) were harvested here. Once the land was taken Karvy (Strobilanthes callosus) (weed) were uprooted, medication for termites was given to the tree affected, and the land was left for the plants to take over by maintaining the Karvy population which grows wild in this region (Sharfuddin Khan, M. D.2010), fencing the land to prevent grazing, allowing natural seeding (Shono, K., E. A. Cadaweng and P. B. Durst, 2007) [21] It took decades, nearly

25 years, and many more to go, the plants reached the height of 25-30 ft, plant species kept almost like the climax or natural forest flora.

Study Site

The Machan is in Jambulne (18°40'10.6"N 73°24'26.7"E), a small village in Maval taluka towards the west of Pune district, Maharashtra, India. It is a hilly region and located in Northern western Ghats, 616m/above sea level, with a tropical climate, summers have a good deal of rainfall, while winter has less comparatively. The average annual temperature in Lonavala is 24.4℃ with an average rainfall of 1799mm/ 70.8 inch per year. The forest type is moist deciduous. The local tribes in this area are Katkari and Thakar. The forest area in the property (Survey area) is called a secondary forest, as this part of the forest is regenerated, and the trees and shrubs are grown from the old root stalks, natural seeding, or by collecting seeds of native trees and spreading them. The whole area of the land is 25 acres, and the land is used as an eco-resort. Human-dominated patches within the land were also included in the survey area to study butterfly dominance in human habitation. The area is divided into 3 parts on the base of the landscape for the study. As it took 25 years to conserve the flora and fauna, a model species has been chosen to understand the current ecosystem of the place. A survey was done to record the diversity of butterflies and compare them to the nearest study site i.e., Tamhini, Mulshi.

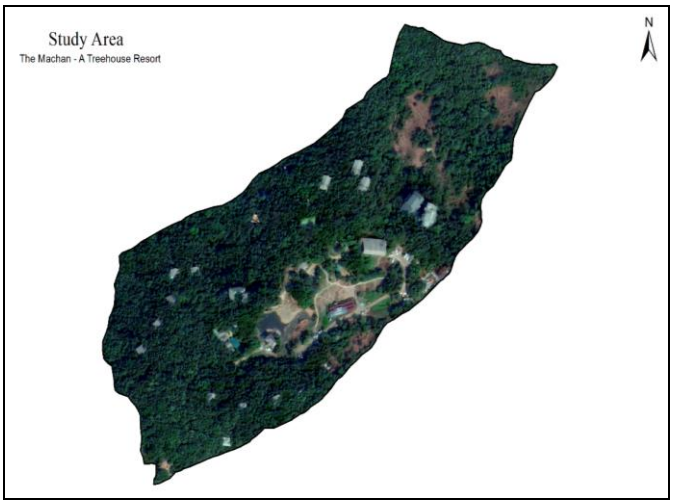

Fig 1: Satellite view of the study area (The Machan, Lonavala, Maharashtra, India)

Tamhini is a small village located in Mulshi (18° 26′ 57.62″ N, 73° 25′ 21.79″ E), Maharashtra. It is in Northern Western Ghats. The average altitude is 600-700m with an average rainfall of 255.905in (6500mm). The study site chosen by AD Padhye includes reserved forest areas, private farmlands, scrubland, grassland, and human habitation.

Methods

The land is divided into 3 landscapes before carrying out the survey. The land is 25 acres with regenerated forest areas, few patches are dominated by human presence, with few grass patches. Based on this land has been divided into 3 landscapes for a better understanding of the forest and the effect of human presence on the species. Landscape 1: forested areas, Landscape 2: Human-dominated area, Landscape 3: Mixed area (Grassy patch, Forest patches, with little human disturbance). A survey trail has been laid across the property passing through the 3 major landscapes covering most of the part of the regenerated forest (Fig2). Fig 2 shows the forest cover with human habitat and survey trails along with the property. The trails have been created which passes through forest, streams, grassy patch, and human-dominated areas. A 10-meter buffer has been laid on the survey trails (fig3). 4 artificial feeders were placed at different human habitation areas in which two of them were in sunlight and two in semi-shade. Butterflies are not only known for their beautiful color but also known for their love for alcohol. A bamboo tray was hung to the tree and overripe fruits such as Banana, Apple, and Papaya were placed along with the honey syrup. These artificial nectars are placed to attract the butterflies as the fermented fruit release the smell of alcohol and attracts the butterflies. Fruits have been replaced in a gap of 2-3 days after 5:30 pm. A photographic observation was made by taking photos of butterflies in their natural habitat apart from attracting them towards the feeders. A walk in the area between 7 am to 10:30 am and 4:30-6:00 pm has been conducted on survey trails to document butterfly presence. Butterflies have been identified using field guides (Butterflies of Mumbai by Nelson Rodrigues) and (Butterflies of India by Peter Smetacek), along with this basic identification has been done using the iNaturalist app and Butterflies of India website.

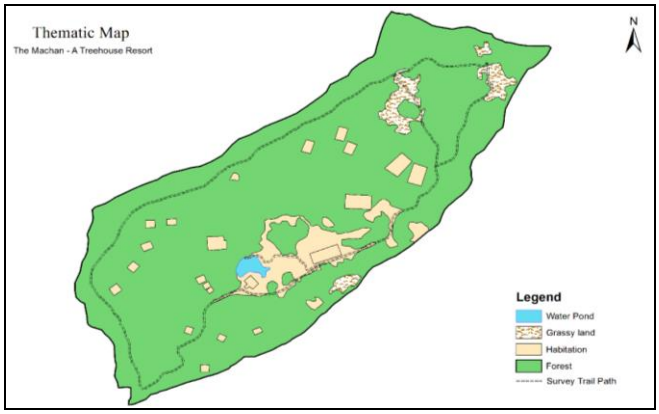

Fig 2: Map showing land use and survey trail (The Machan, Lonavala, Maharashtra, India)

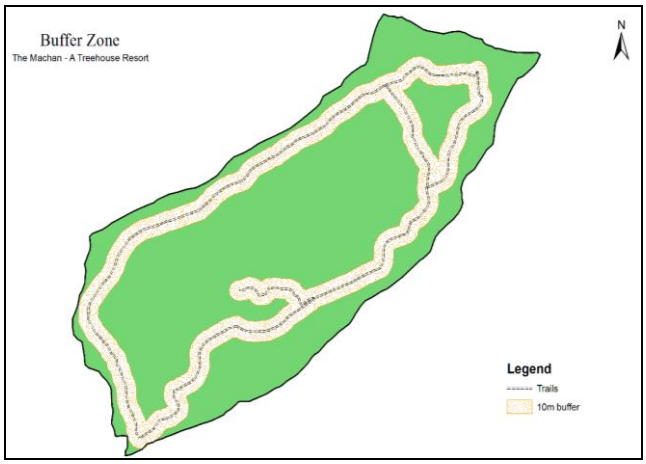

Fig 3: 10 Meter-buffer along the survey trail (The Machan, Lonavala, Maharashtra, India)

Result

Out of 334 species of butterflies in the Western Ghats (Kunte, 2000) [12] a total of 90 butterflies have been recorded in the regenerated forest. According to the survey in Tamhini 69

species were recorded in 2006 by A.D Padhye in primary forest. A total of 90 butterfly species were recorded in our study site belonging to 67 genera and 6 families. 35 belong to Nymphalidae, 8 Papilionidae, 14 Pieridae, 14 Hesperiidae, 18 Lycaenidaea, 1 Riodinidae.

Table 1: showing total list of Butterflies recorded:

Scientific Name	Common name	Abundance	Landscape (LS)
Papilionidae			
Pachliopta aristolochiae	Common Rose	C	1,2
Pachliopta hector	Crimson Rose	C	1
Papilio demoleus	Lime Butterfly	C	1,2,3
Papilio helenus	Red Helen	C	1,2
Papilio polymnestor	Blue Mormon	C	1
Papilio polytes	Common Mormon	C	1,2
Graphium serpedon	Common Blue Bottle	O	2
Graphium agamemnon	Tailed Jay	O	1
Nymphalidae			
Ariadne ariadne	Angled Castor	C	1,2
Ariadne merione	Common Castor	C	1,3
Kallima horsfieldi	Blue Oak leaf	C	1
Junonia orithya	Blue Pansy	C	1,3
Junonia almana	Peacock Pansy	C	1,2,3
Junonia iphita	Chocolate Pansy	C	1,2,3
Junonia hierta	Yellow Pansy	C	3
Junonia lemonias	Lemon Pansy	C	1,2,3
Tirumala limniace	Blue Tiger	O	1
Euthalia aconthea	Common Baron	C	2
Mycalesis perseus tabitha	Dakhan Common Bush Brown	C	1
Mycalesis mineus polydecta	Dakhan Dark-branded Bushbrown	O	1
Euploea core	Common Indian Crow	C	1,2,3
Melanitis leda	Common Evening Brown	C	1
Ypthima baldus	Common Five Ring	C	1,2,3
Ypthima Hubnery	Common Four Ring	C	1,2
Phalanta phalantha	Common leopard	C	1,3
Cyrestis thyodamas	Common Map	C	1
Polyura athamas	Common Nawab	C	1
Elymnias hypermnestra	Common Palm fly	C	2
Neptis hylas	Common Sailor	C	1,2
Lethe rohria	Common Tree Brown	C	1
Hypolimnas missipus	Danaid Egg fly	C	2
Parantica aglea	Glassy Tiger	C	1,2
Hypolimnas bolina	Great Egg fly	C	1,2
Junonia atlites	Grey Pansy	C	1,2,3
Vanessa cardui	Painted Lady	C	2
Danaus chrysippus	Plain Tiger	C	1
Danaus genutia	Striped Tiger	C	1,2
Charaxes bernardus	Tawny Rajah	R	1,2
Cupha erymanthis	Rustic	O	1
Lethe europa	Bamboo Tree Brown	C	1
Athyma perius	Common Sergeant	C	1
Rohana parisatis atacinus	Sahyadri Black Price	R	1
Melanitis phedima varaha	Sahyadri Dark Evening Brown	O	1
Pieridae			
Pieris canidia	Indian Cabbage White	C	2
Catopsilia Pomona	Common Emigrant	C	1,2
Catopsilia pyranthe	Mottled Emigrant	C	1,2
Eurema hecabe	Common Grass Yellow	C	1,3
Eurema laeta	Spotless grass yellow	C	1
Cepora nerissa	Common Gull	C	1
Cepora nadina remba	Sahyadri Lesser Gull	O	1
Delias eucharis	Common Jezebel	O	1
Pareronia hippia	Common Wonderer	O	1
Hebomoia glaucippe	Great Orange Tip	O	1
Ixias marianne	White Orange Tip	O	1
Leptosia nina	Oriental Psyche	C	2
Belenois aurota	Pioneer	C	2
Appias indra	Plain Puffin	C	2
Hesperiidae			

Caltoris kumara	Sahyadri Blank Swift	O	1
Badamia exclamationis	Brown Awl	O	1
Hasora chromus	Common Banded Awl	C	1
Sarangesa dasahara	Common Small Flat	C	1
Sarangesa purendra	Spotted small flat	C	2
Telicota ancilla	Dark Palm Dart	C	1
Celaenorrhinus ambareesa	Malabar Spotted Flat	C	1
Iambrix salsala	Chestnut Bob	C	1
Barbo cinnara	Rice Swift	C	2
Taractrocera ceramas	Tamil Grass Dart	C	2
Tagiades litigiosa	Water Snow Flat	C	1
Celaenorrhinus leucocera	Common Spotted Flat	C	1
Udaspes folus	Grass Demon	C	1,2
Arnetta vindhiana	Vindhyan Bob	C	1
Lycaenidae			
Spindasis abnormis	Abnormal Silver Line	R	2
Caleta decidia	Angled Pierrot	C	1,3
Jamides celeno	Common Cerulean	C	1,2,3
Acytolepis puspa	Common Hedge Blue	C	1
Castalius rosimon	Common Pierrot	C	1,3
Zizula hylax	Tiny Grass Blue	C	3
Neopithecops zalmora Dharma	Sri Lankan Common Quaker	O	2
Euchrysops cnejus	Gram Blue	C	1
Curetis thetis	Indian Sunbean	O	1
Spindasis lohita	Long Banded Silverline	O	2
Nacaduba kurava	Transparent 6-line blue	O	1
Prosotas nora	Common Line blue	C	1
Rathinda amor	Monkey Puzzel	O	1
Telicada nyseus	Red Pierrot	C	1,2,3
Iraota timoleon	Silverstreak Blue	O	1
Zizinia otis	Lesser Grass Blue	C	1
Catochrysops strabo	Forget-me-not	O	1,2
Laptotes plinius	Zebra Blue	C	2,3
Riodinidae			
Abisara bifasciata suffusa	Suffused Double-Banded Judy	C	1,2,3

R: Rare O: Occasional C: Common LS1: Forest Area LS2: Human Dominated LS3: Mixed area

Table 2: showing butterflies on feeder

Common Name	Scientific Name	Abundance
Tawny Rajah	*Charaxes bernardus*	R
Common Baron	*Euthalia aconthea*	C
Common Evening Brown	*Melanitis leda*	C
Blue Oak leaf	*Kallima horsfieldi*	C
Dakhan Common Bush brown	*Mycaleses perseus tabitha*	C
Common tree brown	*Lethe rohria*	C
Common sailor	*Neptis hylas*	R
Common palm fly	*Elymnias hypermnestra*	R
Blue Mormon	*Papilio polymnestor*	R

Discussion

The whole area of the land is 25 acres, and the land is used as an eco-resort. Although there are few human-dominated patches within the land because of which the area is divided into 3 landscapes for a better understanding of the forest and the effect of human presence on the species.

- Landscape 1 (LS1): forested areas,
- Landscape 2 (LS2): Human dominated area,
- Landscape 3 (LS3): Mixed area (Grassland, Forest patches, with little human disturbance).

The land is spread in 25 acres which includes seasonal streams, grassy patches, and is connected to primary forest. Human-dominated areas are the areas that are quite disturbed although butterflies have been recorded because of the presence of artificial as well as natural mud puddling areas and artificial feeders. Plantation of several flowering and few host plants ex., curry and lemon trees, also attract butterflies. The study of butterflies in LS2 was useful to understand which butterfly family has adapted well in human-dominated areas. Mixed areas are the areas inside the forest with few grassland pockets attached to the forest area with extraordinarily little human interference. A survey trail has been created (Fig2) which includes all three landscapes with a 10-meter buffer area (Fig3) for documenting butterflies. Primary forests are natural forests that were there for a long time. The average height of the tree in the primary forest was approx. 14.39 m whereas in secondary average height is 8.89 m. The diameter of the tree in the primary forest is 40 cm whereas in the secondary the diameter is 20 cm (Unpublished paper). Primary forest with floral diversity and the huge growth of epiphytes indicates a rich place for wildlife to adapt better. Because of continuous fragmentation for domestic as well as agricultural practices and poaching of animals the area faces a loss in wildlife. Increasing deforestation and forest fragmentation and its associated infrastructure development make remote areas of forest increasingly accessible (Benítez-López *et al.*). A study was needed to understand the health of the growing forest and a comparison can be done on the presence or absence of species in natural forest and regenerated forest and to estimate the abundance of those species in both the forest types to understand whether a regenerated forest can be considered to support life back or not.

The study was compared with the checklist of A.D Padhye *et al.* (2006) [2] conducted in primary forest in and around

Tamhini Ghat, Mulshi to determine the richness of the regenerated forest and to understand if this forest type can be considered as a suitable habitat for species to thrive. A total of 69 species have been recorded by A.D Padhye *et al*. whereas 11 were recorded which were out of their survey area and have not been included. However, when compared to their checklist some butterflies have not been recorded in our documentation. Common three-ring and, Plum Judy (Riodinidae), Dark cerulean (Lycaenidae), Chestnut angle, Tricolored pied flat, and Indian skipper (Hesperiidae). But some new species have been recorded in our study and are found to be rare like Abnormal silver line (Spindasis abnormis) which were seen just once during the survey. Little is known about this butterfly species, which was thought to be endemic to Southern Western Ghats, specimen taken from Coonor (Moore 1883, Wynter-Blyth 1957) [25]. Gaonkar has mentioned sightings of Abnormal Silverline from Karnataka (Kodagu), Tamil Nadu (Coonor), and Maharashtra but no proper evidence was found from the Maharashtra region. Due to lack of records, the species was considered "Extremely local" and "very rare" (Evans 1932, Wynter-Blyth 1957) [5, 25]. In 2007 the species was recorded in Kumbharli Ghat which is situated in Northern Western Ghats. (Parthenos, Newsletter of Diversity India- Jan 2011), after which it was concluded that this species is not restricted to Southern Western Ghats. More sightings have been observed afterward in Maharashtra. The abnormal silver line in our survey was recorded once while laying eggs on the fig tree trunk, on 22 April 2020 at 1:02 pm. Suffused double-banded Judy has been found quite common in the survey area, whereas plum Judy has not been recorded. Artificial feeders proved to be little effective as it attracts a limited number of species. Feeders were placed in an open sunny area and semi-shaded areas to see the preference of butterflies. Most visits have been recorded under semi-shaded areas. Species like Common baron, Common tree brown, Blue Oak Leaf preferred semi-shaded feeders. Common Bush Brown has been observed frequently under feeders that were kept in an open sunny area. Tawny Rajah has been observed thrice during the study out of which once was seen on the artificial feeder. Great Orange-tip has been recorded once within the survey area.

Common butterflies that were recorded from all three-study area which includes Lime butterfly, Junonia Species (Lemon pansy, Chocolate Pansy, Peacock Pansy, lemon Pansy), Common Five Ring, Common Cerulean, Red perriot and Suffused Double-banded Judy. Butterflies recorded from Landscape 1 (Forest area) are most species like crimson rose was not seen in the human-dominated area during the survey. Tailed Jay, Bamboo tree Brown, Common Map, Blue Oak Leaf, Tawny Rajah, Sahyadri Dark evening Brown, Sahyadri Black Prince were also recorded from these areas. Landscape 2 is the site that has the most human activity, this area includes few patches of flowering trees, an artificial pond, and a natural mud puddling area. This site was useful to study the butterfly species that have adapted themselves in human-dominated areas. Nymphalidae proved to adapt themselves successfully in such areas. Nymphalidae contains around 6000 species (van Nieukerken EJ, Kaila L, Kitching IJ, Kristensen NP, Lees DC, Minet J, *et al*.), and several members are considered model organisms in evolutionary biology (Joron M, Jiggins C, *et al*.), (Willmott KR, Freitas AVL), (Brakefield PM, Beldade P, Zwaan BJ), because of its abundance in most of the places and easy visibility Nymphalids have been used as model systems to understand the complexity of life on this planet. Landscape 3 is the site that has some grassy patches within the forest patch with little human interference. Butterflies like Tiny Grass blue, Angled Pierrot, Junonia Species were recorded in these areas. Blues and pansies are quite abundant in these areas.

Conclusion

The abundance of butterflies in the regenerated forest is directly proportional to the abundance of plant species in the area. Butterflies depend on larval host trees for most of the important transition in their life cycle, and an adult depends on plant sap and nectar. Nectar Collection by butterflies from various plant species induces genetic variation in plants. Some butterflies migrate far distances to pollinate flowers which are at a far distance that help plants to recover against various diseases and increase chances of better survival (Kearney, L.2015) [26]. The abundance of butterflies in regenerated forest areas shows a healthy ecosystem for other organisms. Butterflies are the primary food source of many birds, wasps, reptiles, and amphibians. Stephen Dickie explains: "Birds plan their whole breeding season around when caterpillars will be most abundant. If butterflies and caterpillar are depleted, then there will be less food for developing chicks". A declining population of butterflies affects the food web of the whole ecosystem.

A good diversity of butterflies in the region shows species diversity and indicates good health of the forest and can be considered a suitable habitat for fauna to thrive in.

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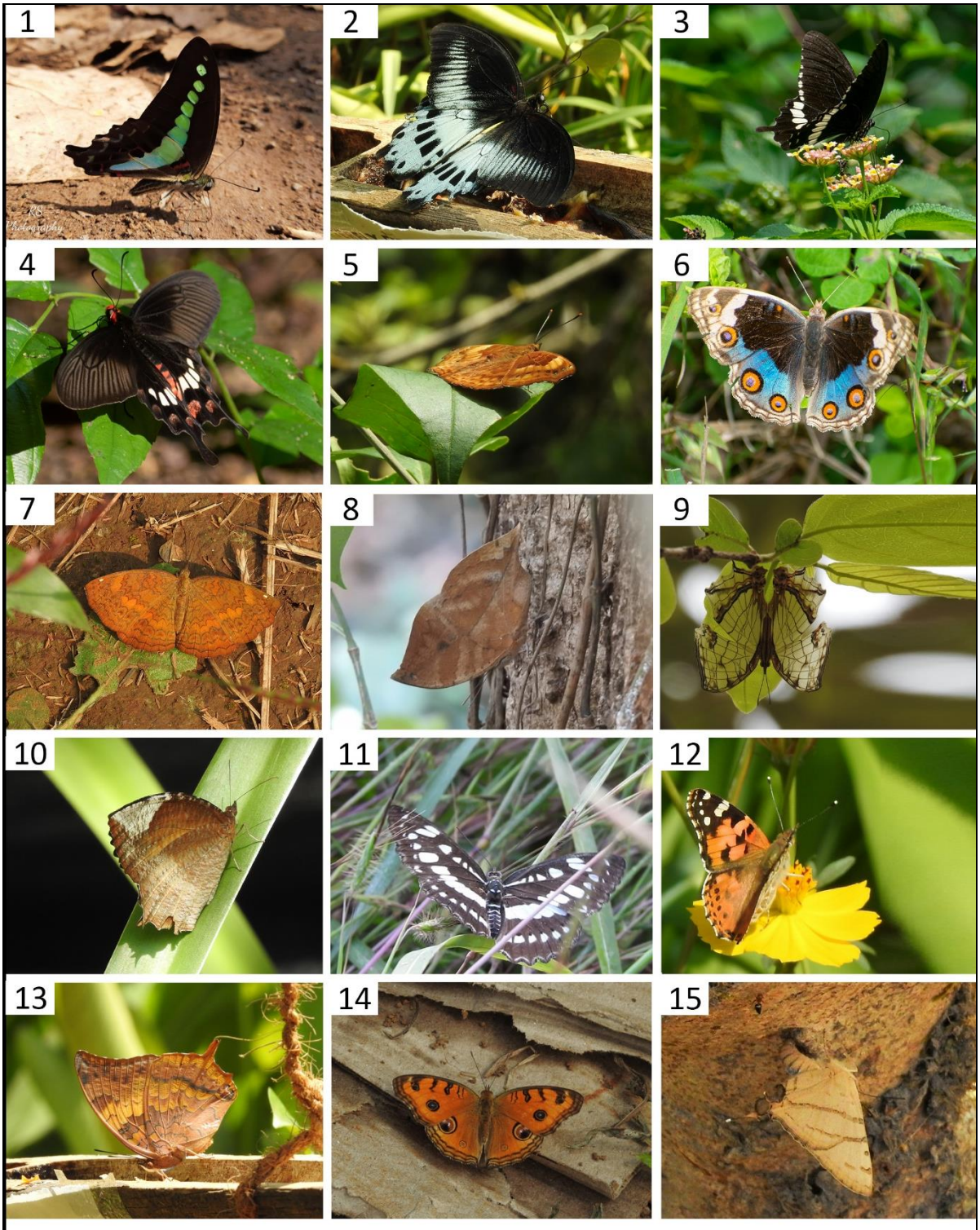

1. Common Bluebottle
2. Blue Mormon
3. Common Mormon
4. Common Rose
5. Black Prince
6. Blue Pansy
7. Common Castor
8. Blue Oakleaf
9. Common Map
10. Common Palmfly
11. Common Sergeant
12. Painted Lady
13. Tawny Raja
14. Peacock Pansy
15. Abnormal Silverline

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