

**“EVALUATING THE BUTTERFLY COMMUNITY IN AND
AROUND P. G. DEPARTMENT OF BIOSCIENCES, ANAND
CITY, GUJARAT, INDIA”**

A

DISSERTATION THESIS SUBMITTED TO

B. R. D. SCHOOL OF BIOSCIENCES

SARDAR PATEL UNIVERSITY

VALLABH VIDHYANAGAR

GUJARAT, INDIA



FOR THE PARTIAL FULFILLMENT OF DEGREE OF

MASTER OF SCIENCE IN

ZOOLOGY

SUBMITTED BY

MAYUR H. VARIYA

EXAMINATION NO.: 20

APRIL 2018

UNDER THE GUIDANCE OF

DR. SUJATA S. BHATT &

PROF. UJJVAL B. TRIVEDI

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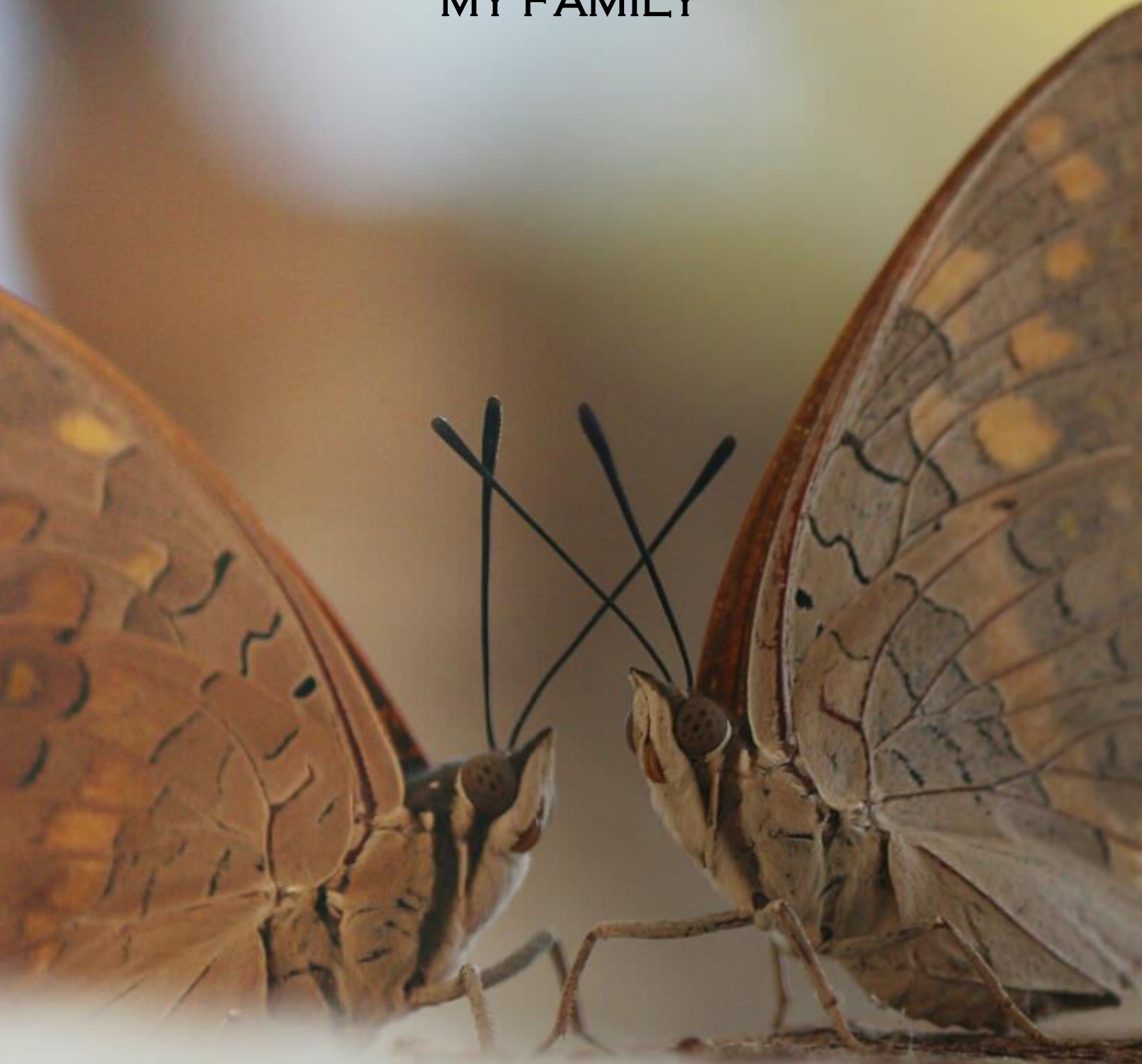
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DEDICATED TO
THE MOTHER NATURE AND
MY FAMILY



DECLARATION

I, Mayur H. Variya, declare that the dissertation work which is being submitted for the degree of Master of Science (M. Sc.) in Zoology of Sardar Patel University was carried out under the supervision of Dr. Sujata S. Bhatt and Prof. Ujjval B. Trivedi at B. R. D. School of Biosciences, Vallabh Vidhyanagar, Gujarat. It is an original work and has not been submitted previously for degree/diploma of any other institute.

Mayur H. Variya

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Date:

Place:

(Mayur H. Variya)

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I. INTRODUCTION

1. BACKGROUND

1.1 General introduction: Butterflies

Butterflies are one of the most beautiful insects, evoking curiosity and fondness among children, naturalist and scientist alike. Many species are strictly seasonal, preferring only a particular set of habitats. In spite of this, butterflies have been generally neglected by community ecologists and there are very few studies available on their community structures, population dynamics and the eco-climatic factors which affect them (Kunte, 1997). Butterflies are generalists, able to exist in a wide variety of habitats. Most butterflies, however, are far more specialized, each species having its own particular requirements regarding habitats, temperature, humidity, larval food plants and adult food sources (Sharma & Sharma, 2013).

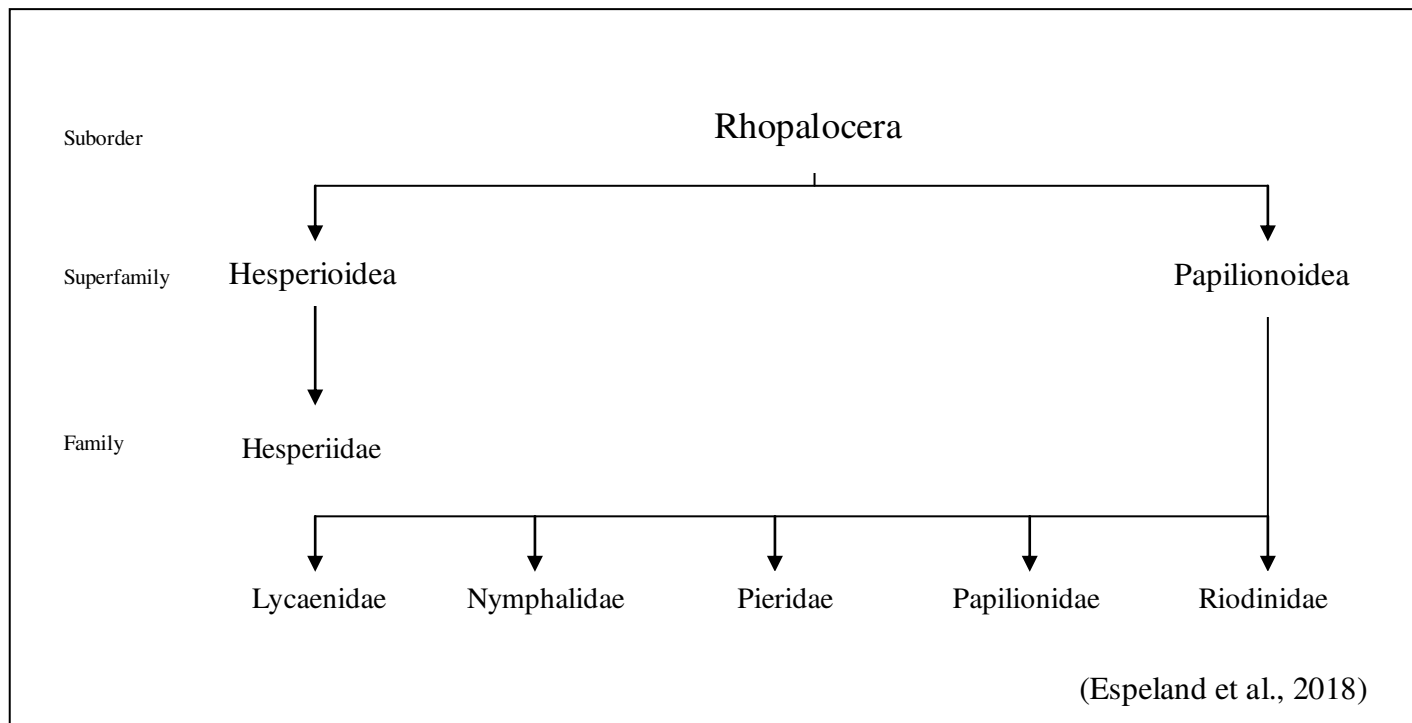
Butterflies are often considered opportunistic foragers that visit a wide variety of available flowers with no random choice. However, their choice of flower is not random and they exhibit a distinct flower preference, which can differ between species (Jennersten, 1984). The adults visit flowers to find food, usually in the form of pollen or nectar. The plants obtain the services of pollinators in pollen transport from one flower to another (Proctor, Yeo, & Lack, 1996).

There are more than 18,000 species of butterflies in the world. In the India 1,318 species of butterflies are known to occur (Varshney & Smetacek, 2015). In Gujarat 193 species have been reported (Parasharya & Jani, 2007). Earlier literature instructs that the Anand region may harbor about 77 species of butterflies (Aldrich, 1946; Rohit, 2001; Vasava et al., 2007 & Chudasama, 2011). Being good indicators of climatic conditions as well as seasonal and ecological changes, they can serve in formulating strategies for conservation. Butterfly diversity indirectly shows the plant diversity of that area (Kunte, 1997). Therefore, the change in the land pattern and habitat leads to the change in the butterfly diversity. The present study was started with a view to examine the dynamics of butterfly population and various habitats in the vicinity of Anand City, Gujarat.

1.1.1 Classification of butterflies

PHYLUM : Arthropoda
 SUBPHYLUM : Hexapoda
 CLASS : Insecta
 ORDER : Lepidoptera
 SUBORDER : Rhopalocera

Suborder Rhopalocera includes two Superfamily Hesperioidea and Papilionoidea. Hesperioidea includes only one family HesperIIDae and Papilionoidea includes five families Papilionidae, Pieridae, Lycaenidae, Nymphalidae and Riodinidae. Out of these six families except Riodinidae, butterflies of remaining families were reported during the study.



(A) Family HesperIIDae

The butterflies included in this family are commonly called as skippers because of their rapid and bounding flight. Often mistaken for moths, Skippers are generally distinguished from ‘true butterflies’ by their relatively stout bodies compared to their wings, relatively small angular wings, and a thin extension or curved hook of the antennae club, called apiculus. Skippers are of two types: one holds its wings completely open and flat across when settled, while the other usually alights with its wings completely closed or with its hind wings more or less completely open, but the fore wings only partially open. Several species have an exceptionally long proboscis that makes their access to nectarines of tubular flowers a lot easier. The forelegs are fully developed and used for walking (Kehimkar, 2016).

Altogether 3,500 species (Kehimkar, 2016) of Skippers occur throughout the world, and the Indian region has around 277 species (Varshney & Smetacek, 2015). In Gujarat total 41 species (Parasharya & Jani, 2007) have been reported.



Figure 1: *Parnara bada* representing family HesperIIDae.

(B) Family Lycaenidae

The butterflies of this family are usually known as 'Blues' as the majority of these butterflies have typical shades of blue on the upper side, though there are species with different colors as well. Several species in this group are known for their thread-like tails on the hind wings, ranging from small tufts to elongated fluffy tails. Often their hind wings are lobed. A dark spot at the base of the tail makes the decoy perfect to confuse a potential predator from attacking the real head, resulting in early detection and escape. Many Lycaenid butterflies use only four legs out of six as their forelegs are non-functional and smaller. Females have six normal legs (Kehimkar, 2016).

With more than 5,000 species the world over, this group of butterflies has some of the prettiest and smallest butterflies. In India, there are 380 species (Kehimkar, 2016) and in Gujarat, 61 species (Parasharya & Jani, 2007) have been reported.



Figure 2: *Jamides celeno* representing family Lycaenidae.

(C) Family Nymphalidae

The butterflies of this group are called ‘Bush-footed butterflies’, as the first pair of forelegs is small and covered with hairs that appear like brushes. They only use only four of their six legs to perch and to walk (Kehimkar, 2016).

This is the largest family of butterflies, with 6,000 species worldwide. In India 461 species are known to occur (Kehimkar, 2016) and in Gujarat, 55 species have been reported (Parasharya & Jani, 2007).



Figure 3: *Charaxes solon* representing family Nymphalidae.

(D) Family Pieridae

They are commonly called as ‘Whites and Yellows’ and this name was given because the majority of butterflies in this group have white or yellow wings, with black, red, orange, or yellow markings. The undersides of the wings of some of these butterflies have cryptic coloration. When at rest, in some species, the fore wing is covered by the hind wing that has cryptic markings, with only the tip or apex of the fore wing visible. Sexual dimorphism occurs in most of the species. Male butterflies of most species congregate on wet patches near rivers or streambeds for mudpuddling, while females are of retiring habits and therefore less seen. Being sun-loving, they are often seen basking in the sun with their wings partially open (Kehimkar, 2016). They are identified as all of them have six developed legs and abdomen is always covered by the hind wings.

In all, 92 species occur in India (Kehimkar, 2016) and in Gujarat, 25 species have been reported (Parasharya & Jani, 2007) .



Figure 4: *Belenois aurota* representing family Pieridae.

(E) Family Papilionidae

They are commonly called as ‘swallowtails’ and most of them occur in the tropical areas and also found in temperate regions of the Himalaya. The majority of the butterflies of this family have tailed hind wings and they cannot cover their abdomen with the hind wings. All swallowtail caterpillars have a forked organ known as osmeterium, situated at the base of the head on the back. When the caterpillar is alarmed, the osmeterium pops out to give off a pungent smell of butyric acid, mainly to ward off ants, parasitic wasps, and flies (Kehimkar, 2016).

Worldwide, there are 573 known species of Swallowtails, and 101 species are found in the Indian region (Kehimkar, 2016). In Gujarat, total 11 species (Parasharya & Jani, 2007) have been reported.



Figure 5: *Graphium doson* representing family Papilionidae.

(F) Family Riodinidae

Like the lycaenids, the males of this family have reduced forelegs while the females have full-sized, fully functional forelegs. The foreleg of males is often reduced and has a uniquely shaped first segment (the coxa) which extends beyond its joint with the second segment, rather than meeting it flush. They have a unique venation on the hind wing: the costa of the hind wing is thickened out to the humeral angle and the humeral vein is short (Saunders, 2010).



Figure 6: *Abisara echerius* representing family Riodinidae.

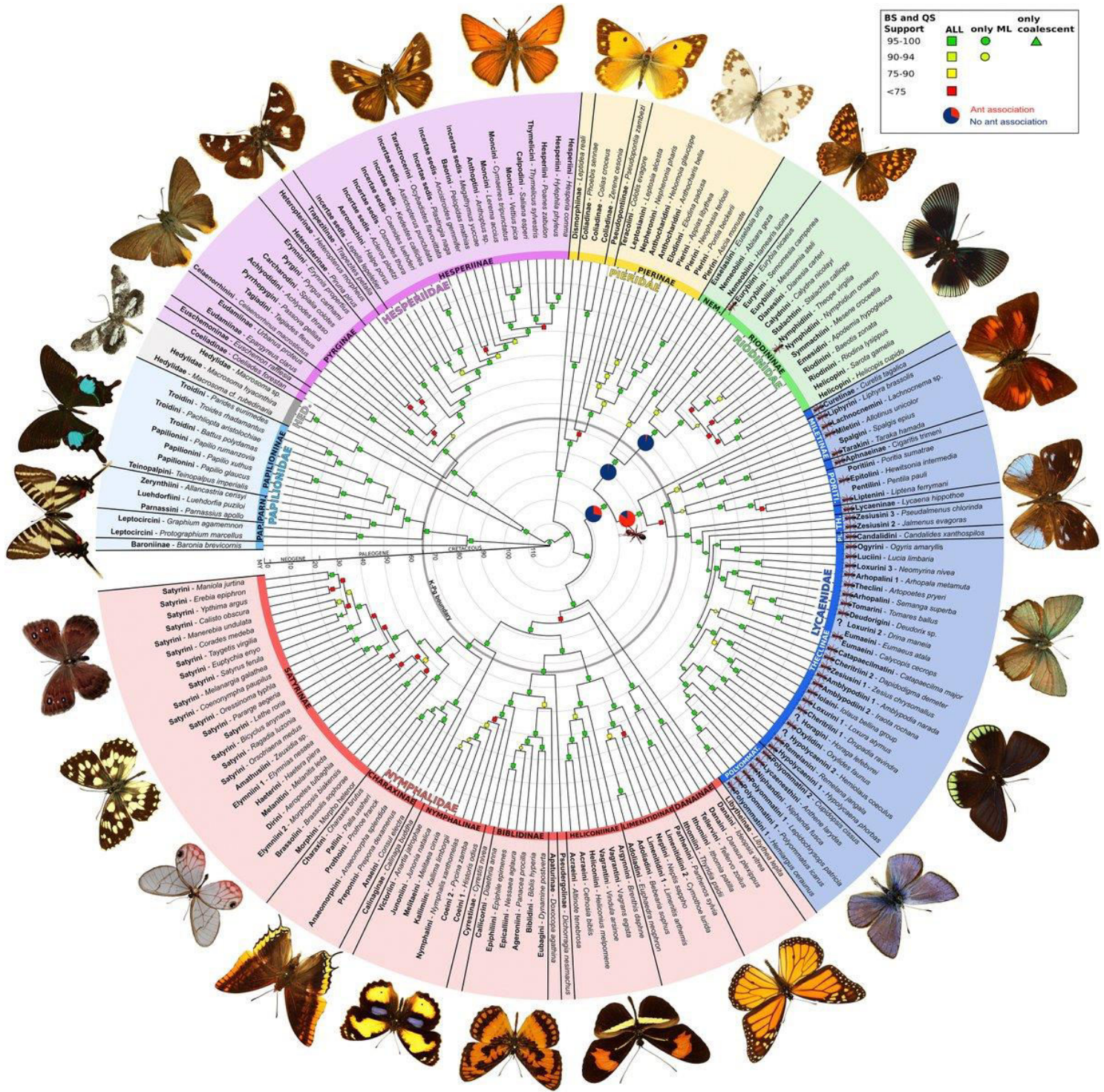


Figure 7: Phylogeny of butterflies

(Espeland et al., 2018)

1.1.2 Life cycle

The life cycle of plants, caterpillars and butterflies has closely evolved to ensure the continuation of various plant and animal species. Most species of caterpillars and butterflies only populate on specific plant families (Sharma & Sharma, 2013). Female and male reproductive production mainly depends on resources acquired during the larval stage (Karlsson & Wickman, 1990). During its lifespan, a butterfly undergoes complete metamorphosis, consisting of four distinct stages: egg, larva or caterpillar, pupa or chrysalis, and adult (Kehimkar, 2016).

(A) The Eggs:

The eggs are fertilized after mating. Depending on the species, eggs are laid singly or in clusters, generally on the upper surface of the leaves of larval plants. The female butterfly recognizes the larval food plants by means of chemical & visual clues. The eggs may be spherical, cylindrical or ovate, depending upon the species. The eggs of some lycaenids have most beautiful sculpturing when seen when seen under microscope (Haribal, 1992).

(B) The caterpillar:larva or

The larva caterpillar eats through the top of the egg, creating a vent through which it emerges. The larva has an elongated body of soft integuments, consisting of 13 segments. The segments are divided into thoracic segments consisting of three pairs of legs, and the abdominal segments consisting of 5 pairs of prolegs or sucker feet. The function of the larva is to feed and grow, since this is the only growing stage in a butterfly's life, it has to consume as much food and store as much energy as possible. A butterfly caterpillar casts off its outer skin layers five times in its life. However, in some cases, as in satyrine, there may be four moulting. The caterpillar stage between two moulting is called as "Instar". In many butterfly species, the caterpillar also changes coloration (Kunte, 2000).

The caterpillar may be smooth or clothed with hair or provided with bristles. They come in varied colors, however the coloring is usually such that the larva is well camouflaged. Once the larva is ready to pupate, it stops eating and growth is halted. Once it finds a safe place to pupate, it weaves a dense pad of silk to which the pupa is fixed (Kunte, 2000).

(C) Pupa or Chrysalis stage:

This stage is often known as the resting stage, but during this a great many changes are taking place within the cocoon. The rearrangement of tissues, disappearance of earlier organs and development of new organs takes place. The prolegs and biting mouth-parts vanish and the wings, proboscis, and compound eyes appear. Head, thorax and abdomen become distinct (Kunte, 2000).

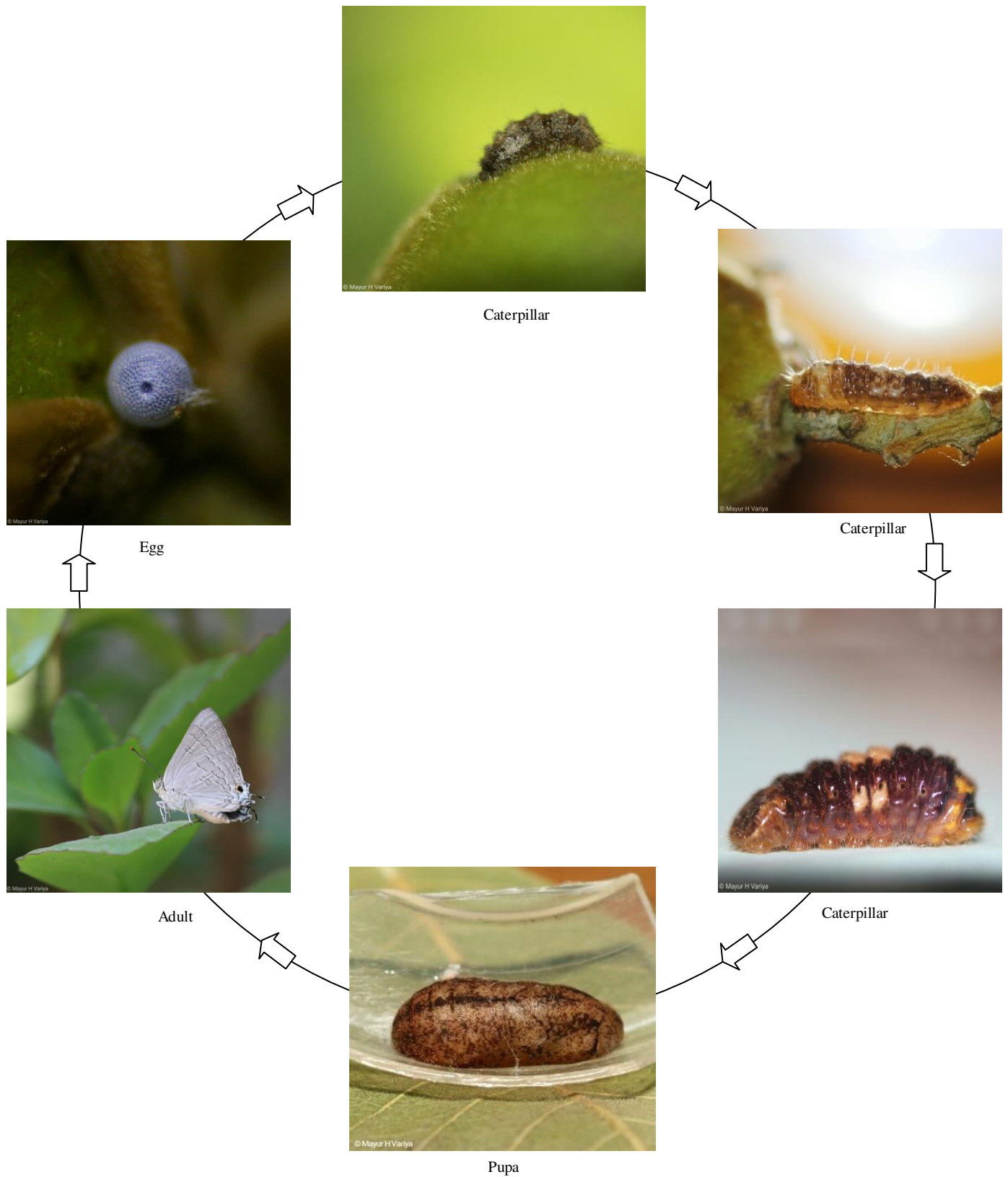


Figure 8: Lifecycle of Common Guava Blue (*Virachola isocrates*)

1.1.3 External morphology of an adult butterfly

(A) Head

The head has a pair of club-ended antennae which act as receptors to smell: a pair of compound eyes UV light enables several similar colored species to with a large number of hexagonal lenses covering the visual cones or ommatidia. A long tubular proboscis made up of two modified mouth parts held together by a series of hooks and spikes, rather like a zip-chain, and a pair of sensory pads or palps, one on each side of the antennae, which besides being the organs of touch also shield the eyes and, often, forelegs are cleaned on it (Kehimkar, 2016).

The size of the eyes is larger in the male, with more cones present in each eye. This is probably because the male needs keener eyesight to seek out the female for courtship and mating. They can sense movement over a very small degree of arc as well as movement across a wide area. Butterflies have well developed color vision. Except red, butterflies can see most other colors and even the ultraviolet fraction. Sensitivity to recognize their own kind. Wing surfaces, particularly the upper wing surface of male butterflies, reflect UV light as recognition signals for both females and males (Kehimkar, 2016).

(B) Thorax

Thorax is middle portion of butterfly body, and it is made up of three fused segments, each carries a pair of legs on ventral side and first two segments of them carry a pair of forewings and hindwings on lateral side. The thorax contains a portion of the digestive tract, and rudimentary heart-like tubes (Parasharya & Jani, 2007).

(C) Abdomen

Abdomen of butterfly is cylindrical, thin, and long with ten segments. The spiracles (openings of trachea) are located laterally on both sides of the abdomen and supplies oxygen to the internal organs. Seven to eight segments are externally visible as the last two or three segments are modified to form reproductive organs which leads to the lock and key arrangement of reproductive organs of male and female (Kehimkar, 2008).

1.1.4 Variation

Variation in size, shape, color and behavior patterns within species of butterfly is quite common. This variation is attributable to both genetic and non-genetic factors. Genetic variation is found in specimens of the same group, creating diverse individuals, Offspring of the same brood differs from each other, despite their common origin and fundamental heredity, mainly due to changes in the genetic make- during the course of development and evolutionary processes. Environmental factors such as geography, climate and season can also have their impact by influencing the movement, distribution and life cycle of butterflies, thus resulting in different forms. The four major types of variation found among butterflies are individual variability, sexual dimorphism, seasonal variability and geographical variability (Kehimkar, 2016).

Some butterflies show seasonal variation, with two forms, the dry season form (DSF) and the wet season form (WSF). The Common Evening Brown is recognized by a series of eyespots on the wing border during the monsoon, while in the summer it is almost invisible among the leaves due its mottled brown colors without the eyespots. The Bushbrowns too have such seasonal forms. The undersides of the Peacock Pansy lose their eyespots and become paler in the DSF, additionally its wings assume a leaf-like shape. Such seasonal variation is known as polyphenism. It results from varying environmental factors like temperature, day-length and rainfall affecting the immature stages during development (Kehimkar, 2016).

1.1.5 Behavior

(A) Basking

Unlike warm-blooded animals, butterflies do not have a constant body temperature. Their body temperature depends on the surrounding temperature. A lower ambient temperature slows down their physiological processes. Butterflies need to regulate their temperature and therefore they may bask in the sunlight to increase their temperature or withdraw underneath a leaf to lower their temperature. Most butterflies just spread their wings flat and align themselves for maximum exposure to sunlight. However, butterflies like the Satyrs in the Himalaya do not open their wings to bask, but tilt their bodies to expose one underside of the wings (Kehimkar, 2016).

Wing color determines the amount of heat absorbed. Dark colors absorb heat faster. Hence, among Pierids, the wing veins are dark and if the rest of the wing is lighter in color then the base of the wings are dusted with black on the upper surface. Also, white or shining metallic Wings act as excellent reflectors, and when held at a 10-60 degree angle in a V-shape they direct the sun's rays towards the body effectively. Warming up of the flight muscles is of utmost importance to escape predators. In the absence of sunlight, butterflies vibrate their wings to warm up and fly (Kehimkar, 2016).

(B) Patrolling

Males patrol for females in different ways. Some like the Common Crows, with their abdominal hair pencils extruded, fly along linear pathways such as forest paths searching for mates. A male Great Eggfly will perch in a forest opening, chase away rival males, go on brief sorties to locate females and return to its perch. Males of some species like Pansies or Tortoiseshells are quite pugnacious and territorial. Males also keep circling around food plants where female butterfly caterpillars are present or where females are likely to emerge from the pupae Males of Grass Yellows and Tawny Costers will often try to mate with the female pupa itself (Kehimkar, 2016).

(C)Courtship

To acquire a mate, male butterflies have to first gather resources to become the most desirable and then find a mate. Therefore, newly hatched males often gather in large numbers to mudpuddle and take in salts. Later, these salts- an essential requirement in the production of healthy eggs - get concentrated as nutrients in compact capsules that form part of the spermatophore which is passed on to the female during mating. In Milkweed butterflies like Crows and Tigers, the males cluster around alkaloid-rich plants like *Crotalaria*, *Heliotropium*, and *Agerotum*. The males swarm over the damaged parts of the plant to suck the oozing sap rich in pyrrolizidine alkaloids that are essential as precursors for the production of mate attracting chemicals or sex pheromones (Kehimkar, 2016).

The search for a mate is usually accomplished by taking up strategic perches as lookout points, patrolling the area, and actively searching around food plants for newly hatched females. After locating a female, the courtship may involve a complex series of visual displays of wing colors, dispersal of pheromones, followed by actual touching of wings that have brands of specialized scent scales to the female's antennae either in flight or while perched. A male Common Crow patrols his territory by flying up and down with his abdominal hair pencils extruded to disperse the scent. In Swallowtails like the Mormons, the male flies around the female in vertical circles. If the female is receptive, the pair will settle and mate. The mating male will fly off, carrying the female suspended upside down. In Pierids, if the female is non-receptive, she will flap her wings while spreading them flat and lift the entire abdomen upwards to reject the male. Once mated, the female begins to search for food plants to lay her eggs (Kehimkar, 2016).

(D)Mudpuddling

Mudpuddling usually involves newly hatched males. It is often a social activity where at times several hundred butterflies, especially males of one or more species, can be seen on damp sand or mud banks. Mudpuddling males often spend a long time on these damp patches, where they suck salts along with water. Except for a few species, most butterflies mudpuddle. Among Swallowtails, the Common Bluebottle, Common Jay, Glassy Bluebottle, Spot Swordtail, Chain Swordtail, Fivebar Swordtail, and Zebras are avid mudpuddlers and are often seen together in large congregations of a single species. In Pierids, Common and Mottled Emigrants, Grass Yellows, Sawtooths, Gulls, Puffins, and Albatrosses are very often seen on damp patches. However, the Common Jezebel does not seem to mudpuddle. Almost all Brush-footed butterflies, including Tigers, Crows, and Browns are mudpuddlers. Blues are also seen congregating on damp patches. Skippers too mudpuddle, but unlike other butterflies, they are never seen in single-species congregations (Kehimkar, 2016).

1.1.6 Adaptations

(A) Defense

Butterflies are threatened in their early stages by parasitoids and in all stages by predators, diseases and environmental factors. They protect themselves by a variety of means. Chemical defenses are widespread and often based on chemicals of plant origin. In many cases the plants themselves have evolved these toxic substances to reduce attacks on them. These defense mechanisms are effective only if they are also well advertised. As caterpillars, many defend themselves by freezing and appearing like sticks or branches. Some papilionid caterpillars (e.g. Lime butterfly) resemble to bird dropping in their early instars. Some caterpillars have hairs and bristly structures that provide protection while others are gregarious and form dense aggregations. Some species also form associations with ants and gain their protection. Behavioral defenses include perching and wing positions to avoid being conspicuous. Some female Nymphalid butterflies are known to guard their eggs from parasitoid wasps. Eyespots and tails are found in many lycaenid butterflies which divert the attention of predators from the more vital head region. An alternative theory is that these cause ambush predators such as spiders approach from the wrong end and allow for early visual detection (Parasharya & Jani, 2007).

(B)Mimicry

Batesian and Mullerian mimicry in butterflies are common. Batesian mimics imitate other species to enjoy the protection of an attribute they do not share (aposematism in this case). The Common Mormon of India has female morphs which imitate the unpalatable red-bodied swallowtails, the Common Rose and the Crimson Rose. Female Danaid Eggfly mimics Plain Tiger. Mullerian mimicry occurs when aposematic species evolve to resemble each other, presumably to reduce predator sampling rates. Wing markings called eyespots are present in some species (e.g Pansies). These may have an automimicry role for some species. In others, the function may be intraspecies communication, such as mate attraction. In several cases, however, the function of butterfly eyespots is not clear, and may be an evolutionary anomaly related to the relative elasticity of the genes that encode the spots. (Parasharya & Jani, 2007).

1.1.7 Migration

Butterflies move or migrate from one place to another, over a considerable distance, for several reasons. One of them is to seek optimum conditions that will ensure survival of the migrating adults as well as their successive generations. Such movements could be very local or to a distant habitat. Butterfly migrations are known to take place mainly due to seasonal changes or shortage of food plants. Day length, rainfall, and temperature changes are known to trigger their movement. Butterfly migration could be broadly seen as three different types - short distance (local movement), long distance, and dispersal. (Kehimkar, 2016).

1.1.8 Hibernation

At every stage in their life cycle, butterflies can go into a resting period or diapauses, which is similar to hibernation or aestivation. Several species in the alpine region lay eggs at the end of summer and caterpillars in their first instars or after growing fully go into hibernation, hidden among the plant-bases or other shelters. The caterpillar wakes up only after the temperature warms up in the spring. Butterflies like the Apollos pass the harsh alpine winter in the egg stage; several other species lay their eggs at the bases of dormant leaf buds and hatch in spring when the leaf buds open. Only fully-grown caterpillars of Apollos hibernate, pupation occur in the following spring. Wall butterflies pupate at the end of summer and spend the winter in the pupal stage, emerging as adults in the spring. Some butterflies hibernate as adults too, especially species like the Indian Tortoiseshell and Eastern Comma. This adaptation is mainly to avoid unsuitable climate when neither food plants nor nectar sources are available. Usually, butterflies in tropical climates do not aestivate, but in case unsuitable conditions prevail, butterflies like the Lime are known to prolong the pupal stage, especially during the winter (Kehimkar, 2016).

1.1.9 Lifespan

Butterflies as adults are short-living, but ecologically important insects. The majority of butterflies survive up to two to four weeks, if not attacked or consumed by predators. However, some Blues may live for a few weeks, while large butterflies like Swallowtails and several Brush-footed butterflies may live for as long as eight months. The major task of the butterfly is to propagate its species, and this they accomplish it within the first week of emergence. Occasionally, ecological factor such as temperature, availability of food, and suitability of habitat have an impact on the lifespan of an adult butterfly (Kehimkar, 2016).

1.2 Importance of studying butterflies

Butterflies are wonderful insects with attractive color patterns, hence, of great aesthetic value and they are strongly influenced by local weather and highly responsive to environmental changes (Spitzer et al., 1997) through change in their coloration from dark to pale or other diverse color markings or patterns (Gupta & Mondal, 2005). Hence, butterflies like any other insect, indicates changes in ecosystems (Samways, 1994) and helps in understanding and developing conservation aspects. Apart from this, they are natural pollinators and have a close association with the flowering plants. Their existence in a habitat provides the information regarding the existence of other species of plants and animals. They are of great economic value as during the developmental stages, their larvae or caterpillars feed on a variety of food plants - crops, fruits, vegetables, forest trees, etc. (Gupta & Mondal, 2005). Apart from having an aesthetic demand butterflies form an important component of the food web, being mainly herbivores on one hand and prey for their predators like birds, reptiles, spiders and predatory insects (Kunte, 2000).

1.3 Why this study was carried out in and around P. G. Department of Biosciences, Anand City?

Anand has agro-forestry type of habitats with scattered wetlands and scrublands. The water sources are available throughout the year, which is a basic need of healthy ecosystem. The area is rich in floral diversity and there are extensive hedges over the roads, which could support many insect lives.

The rapid change in landscape and landscape pattern offers a very good chance of understanding diversity of butterflies and the comparison of this study with earlier studies to know, whether changes in landscape patterns have affected the butterfly community or not.

1.3.1 History of P. G. Department of Biosciences.

Between 2003-05, an area with a huge pond (a water body) was converted to land, which resulted in the establishment of our prestigious and unique infrastructure now called as P.G. Department of Biosciences and affiliated Sardar Patel Maidan.

An environmental friendly campus developed as a result of tree plantation programs that were conducted with time, which have been urging the establishment of flora and fauna, consequently enhancement in number of floral and faunal species. Presently it has been serving as an ecotone for a number of biologically important species, which is being revealed by students and faculties of the department.

2. REVIEW OF LITRATURE

2.1 Butterfly fauna of India

The study of butterflies of Gujarat state has been ignored as compared to the other state of India. A lot of work is done on the butterflies of Western Ghats, Eastern Ghats, northeast India, Himalayas and many other regions of India by Niceville, 1890; Bingham, 1905 & 1907; Antram, 1924; Evans, 1932; Talbot, 1939; Winter-Blyth, 1957; Sevastopulo, 1973; Mani, 1986; Larsen, 1987 & 1988; Gay, Kehimkar & Punetha, 1992; Haribal, 1992; Varshney, 1993, 1994 & 1997; Gunathilagaraj et al, 1998; Kunte, 2000; Smetacek, 2000 & 2017; Gupta & Mondal, 2005; Varshney, 2006; Varshney & Smetacek, 2015 and Kehimkar, 2008 & 2016.

2.2 Butterfly fauna of Gujarat state

Very few studies were conducted in Gujarat state by Nurse, 1900; Mosse, 1928; Aldrich, 1946; Shull, 1963; Patel, 1987; Rohit, 2001; Suresh et al., 2001; Bhalodiya et al., 2002; Ahir & Parikh, 2006; Parasharya & Jani, 2007; Vasava, 2007 and Chudasama, 2011. The very first study of the butterflies of Gujarat was carried by Nurse (1900) in the Kachchh region of Gujarat, whose study reported about 46 species of butterflies and Bhalodiya et al. (2002) have listed 34 species from Narayan Sarovar Wildlife Sanctuary and 44 species from Ratanmahal Wildlife Sanctuary. Mosse (1928) carried out the study on the butterflies of Bhavnagar region, Gujarat state & identified 78 different species while Ahir and Parikh (2006) have reported 44 species from Gir Forest, the largest protected area of Saurashtra. Aldrich (1946) identified 59 species of butterflies from Nadiad, Gujarat. Rohit (2001) reported 47 species, Vasava (2007) reported 58 species and Chudasama (2011) reported 36 species from Anand District. Shull (1963) carried a detailed study of the butterflies from Surat-Dangs south Gujarat Region and reported about 145 species of the butterfly from the South Gujarat region Bhalodiya et al. (2002) have also reported 62 species from Vansda

National Park.. There is only one study on butterflies of North Gujarat by Suresh et al. (2001) and they have listed 26 butterfly species from Jessore Sloth Bear Sanctuary of Banaskantha District. Parasharya & Jani (2007) had reviewed all the checklists from different parts of Gujarat and prepared the checklist of butterflies of Gujarat, which includes 193 species of butterflies.

2.3 Butterfly fauna of Anand district

The first study of the butterfly fauna of Kheda was done by Aldrich (1946) and he collected 56 species from Nadiad, Kheda district (20 km NW from Anand) of five families, which includes four species of butterflies of Hesperidae, five of Papilionidae, 15 Nymphalidae, 16 Lycaenidae and 16 Pieridae.

Rohit (2001) studied the biodiversity of butterflies in the Anand district. He collected 47 species belonging to four families (updated as per latest classification, Page no.3 & 10). He reported the dominance and abundance of the Pieridae family (16 species) followed by the Nymphalidae (16 species), Lycaenidae (10 species) and Papilionidae is representing five species.

Vasava (2007) also studied butterflies of Anand district and had reported a total of 58 species of butterflies belonging to five families, including Nymphalidae, the largest one represented by 21 species, followed by Lycaenidae (17 species), Pieridae (14 species), Papilionidae (4 species) and Hesperidae representing two species.

Chudasama (2011) had reported 36 species of butterflies from Anand in winter season. She had reported five families of butterflies including Nymphalidae with 12 species, 12 species of Pieridae, seven species of Lycaenidae, four species of Papilionidae and one species of Hesperidae.

3. AIMS & OBJECTIVES

- 3.1** Comparative study of butterflies with previous studies in Anand City, Gujarat, India.
- 3.2** Diversity study of butterflies in and around P. G. Department of Biosciences, Anand City, Gujarat.
- 3.3** To evaluate the plants utilized by butterflies in and around P. G. Department of Biosciences, Anand City, Gujarat.

II. METHODS AND MATERIALS

1. STUDY AREA

1.1 Anand City

The butterfly fauna of Gujarat state are not as much of known and only a few studies have been done in and around forested regions of Anand district. Hence, we took step forward studying butterflies of urban regions of Anand and it was the main reason for the selection of this particular area.

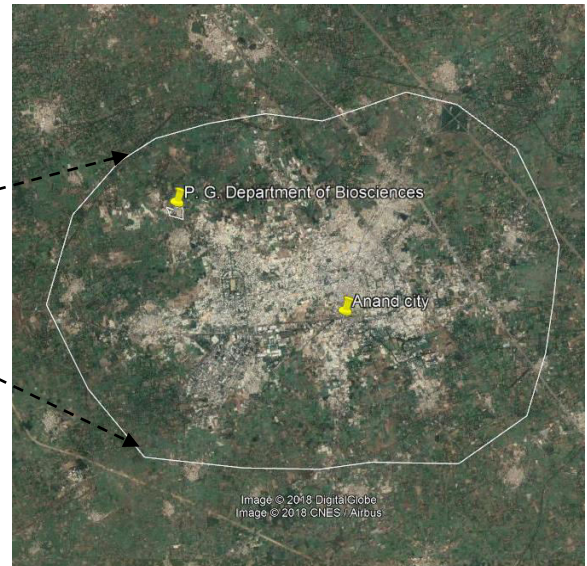
The Anand district is a part of central Gujarat. It is located between 22°07' (N) and 22°57' (N) latitude and 72°15' (E) and 73°28' (E) longitude. The total area of the district is 3,204 km², which is about 1.63 % of Gujarat state.

Anand City has agro-forestry types of habitats with scattered wetlands and scrublands. Anand is primarily an agricultural district with tobacco and paddy as the predominant crops. The other major crops cultivated are wheat, banana and some vegetables. However, this region harbors a lot of plant species, some of the common trees which are grown on the borders of agriculture farms and road side are Babul, Neem, Asopalav etc..

The following figure (MAP 2) shows Anand City- the study site of present work.



MAP 1: Gujarat



MAP 2: Anand City



MAP 3: P. G. department of Biosciences. (22.5700° N, 72.9090° E)

Figure 9: Study site maps.

1.2 P. G. Department of Biosciences and surroundings.

P. G. Department of Biosciences is located in Vallabh Vidhyanagar. The campus has the main building with UV Sports complex on right side and university ground on left side, and there is a government hostel behind the department. Opposite to the department, there is a pond and village called Bakrol. Surrounding the backside area, are farmlands, which play an important role by providing a site to study habitat of different floral and faunal species diversity.

1.2.1 Ecological diversity

(A) Floral diversity

The department is rich in floral diversity and composed of various trees, herbs, shrubs, weeds and climbers. In and around Bioscience department, total 149 species of plants representing 59 genus have been reported (Patel, 2018). (Appendix- 3)

(B) Faunal Diversity

(a) Avian Diversity

Many bird species have been reported at our department campus because of the rich floral diversity, which provides them breeding, nesting and foraging site. Faculties of P. G. Department of Biosciences are also passionate about the biodiversity. Professor Ujjval Trivedi has been studying and documenting birds at our department and elsewhere since long time and have contributed to explore the richness. (Appendix- 4)

(b) Reptile Diversity

List includes Spectacled Cobra, Rat Snake, Skinks, Calotes, Monitor Lizard etc..

(c) Arthropod Diversity

It is known that Arthropoda is largest phylum in the animal kingdom. They are adapted to live in all different types of habitats and possess cosmopolitan distribution. At our department many different types of arthropod have been found which includes sub-phylum Myriapoda, Chelicerata and Hexapoda. Chelicerata with class Arachnida and Hexapoda with class insecta. Class insecta includes order Coleoptera, Dermaptera, Diptera, Hemiptera, Homoptera, Hymenoptera and Lepidoptera.

2. METHODOLOGY

The fieldwork was carried out from July 2016 to March 2018 in and around Anand City as well as at P. G. Department of Biosciences. The natural vegetation consisting of trees, shrubs, herbs, climbers and grasses was observed along with butterflies. The observations were made between 07:00 to 11:00 hrs in the morning and 17:00 to 19:00 hrs in the evening, throughout the Anand City. Butterfly species were documented and identified by using standard books of Kehimkar, 2008 & 2016 and Smetacek, 2017. The specimens were observed with keen patience and compared with the plates given in the books. The descriptions and characters were also compared. Identification was also done by taking help from experts. The butterflies were also photographed using Samsung Galaxy Grand Neo Plus mobile phone at initial stage and later Canon EOS 700D DSLR with Canon EFS 55-250mm and Canon EFS 18-55mm lenses were used.

III. RESULT AND DISCUSSION

1. Comparative study of butterflies with previous studies in Anand City, Gujarat, India.

This study was carried out in order to see the constancy of butterfly community. We were not able to find some species, which were reported earlier, but we also recorded some species, which were not reported in earlier studies.

Aldrich (1946) collected 56 butterfly species from Nadiad, Kheda district (20 km NW from Anand), of five families, which includes four species of butterflies of Hesperidae, Papilionidae with five species, Nymphalidae (15 species), Lycaenidae (16 species) and Pieridae (16 species).

Rohit (2001) studied the biodiversity of butterflies in the Anand district. He collected 47 species belonging to four families (updated as per latest classification, Page no. 3 & 10) the Papilionidae representing five species, Lycaenidae (10 species), Pieridae (16 species) and followed by the Nymphalidae (16 species).

Vasava (2007) also studied butterflies of Anand district and had reported a total of 58 species of butterflies belonging to five families, including Hesperidae representing two species, Papilionidae with four species, Pieridae (14 species), Lycaenidae (17 species) and Nymphalidae was the largest one represented by 21 species.

Chudasama (2011) had reported 36 species of butterflies from Anand in winter season. She had reported five families of butterflies including Hesperidae representing one species, Papilionidae with four species, Lycaenidae seven species, Nymphalidae with 12 species, and Pieridae with 12 species.

During the present study, total 77 species of butterflies were recorded in and around Anand City belonging to five families, Papilionidae five species, Hesperidae (13 species), Pieridae (15 species), Nymphalidae (16 species) and the largest one was Lycaenidae with 28 species. However, we could not record 23 species, which were previously recorded, but we also recorded 19 species of butterflies not reported in earlier studies and one species was unidentified.

While comparing present study with earlier studies, we found some new records and also some species was not found.

The new records includes *Spialia galba*, *Telicota bambusae*, *Telicota colon*, *Suastus gremius*, *Pelopidas thrax*, *Pelopidas agna*, *Parnara bada*, and *Cephrenes acalle* from family Hesperidae; *Freyeria putli*, *Prosotas dubiosa*, *Tajuria cippus*, *Tajuria jehana*, *Zesius chrysomallus*, *Anthene lycaenina*, *Zizula hylax*, *Spindasis schistacea*, *Tarucus balkanicus*, and *Tarucus indicus* from family Lycaenidae; *Eurema andersoni* from family Pieridae.

We did not found *Borbo cinnara* and *Gegenes nostradamus* from family Hesperidae; *Azanius jesous*, *Jamides celeno*, *Jamides bochus*, *Everes lacturnus*, and *Freyeria trochylus* from family Lycaenidae; *Symphaedra nais*, *Junonia atlites*, *Junonia iphita*, *Ypthima baldus*, *Mycalasis perseus*, *Byblia ilithyia*, *Neptis hylas* and *Vanessa cardui* from family Nymphalidae; *Colotis fausta*, *Colotis protractus*, *Eurema blanda*, *Eurema brigitta*, *Appias albino*, and *Appias libythea* from family Pieridae; *Papilio polymnestor* and *Graphium nomius* from family Papilionidae.

Aldrich, Rohit, Vasava and Chudasama did not mention *Graphium doson* but Parasharya & Patel (2015) reported it.

The methodology of citing common and scientific names of butterflies was adopted from a synoptic catalogue by Varshney & Smetacek (2015).

All 77 species of butterflies were documented (Appendix-1).

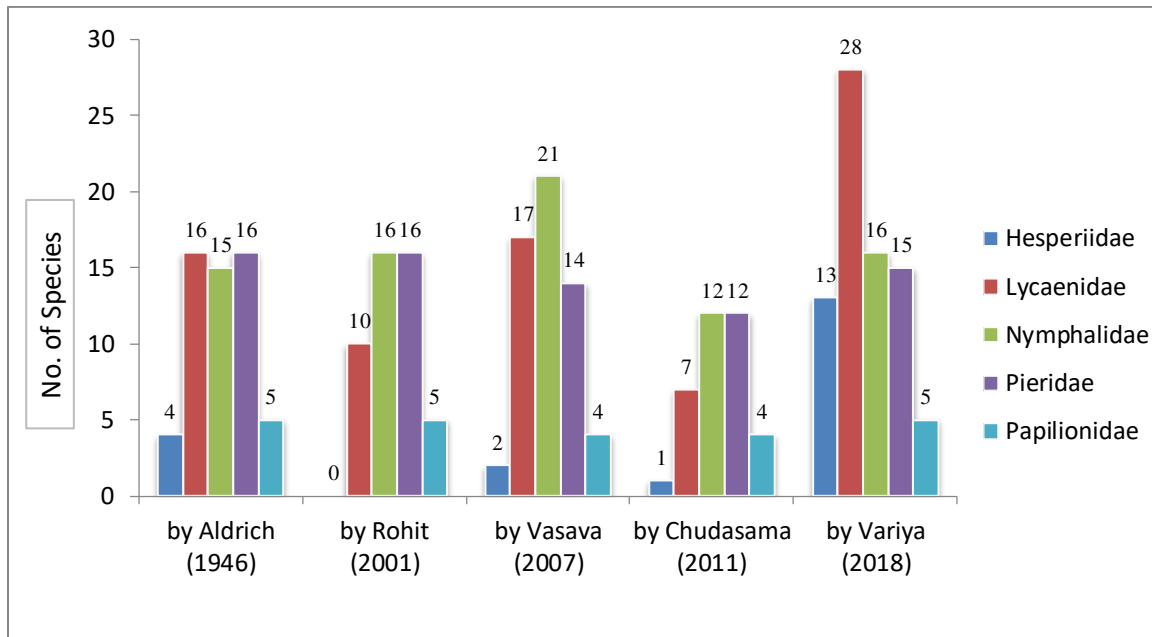


Figure 10: Comparison between all five studies.

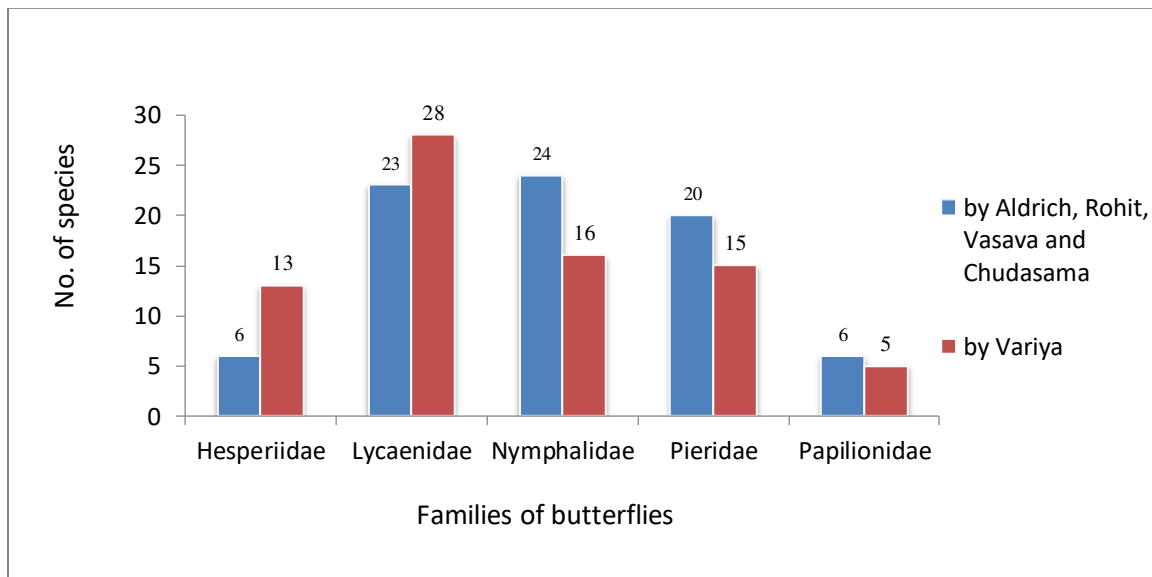


Figure 11: Comparison between earlier (collective) study and present study.

Table 1: Comparison of Checklists.

*Note: R - Rare; UC - Uncommon; C - Common; A – Abundant; Ab – Absent.

No.	Common Name	Scientific Name	Butterflies Recorded					Present Status
			Aldrich (1946)	Rohit (2001)	Vasava (2006)	Chudasama (2011)	Variya (2017)	
Family : Hesperidae								
1	Brown Awl	<i>Badamia exclamationis</i>	x	x	✓	x	✓	UC
2	Rice Swift	<i>Borbo cinnara</i>	x	x	✓	x	x	Ab
3	Borbo spp.	<i>Borbo sp.</i>	x	x	x	x	✓	UC
4	Common Banded Awl	<i>Hasora chromus</i>	✓	x	x	x	✓	C
5	Conjoined Swift	<i>Pelopidas conjuncta</i>	✓	x	x	x	✓	UC
6	Small Branded Swift	<i>Pelopidas mathias</i>	✓	x	x	✓	✓	A
7	Dingy Swift	<i>Gegenes nostrodamus</i>	✓	x	x	x	x	Ab
8	Indian Skipper	<i>Spialia galba</i>	x	x	x	x	✓	C
9	Dark Palm Dart	<i>Telicota bambusae</i>	x	x	x	x	✓	UC
10	Common Palm Dart	<i>Telicota colon</i>	x	x	x	x	✓	UC
11	Indian Palm Bob	<i>Suastus gremius</i>	x	x	x	x	✓	A
12	Small Branded Swift	<i>Pelopidas thrax</i>	x	x	x	x	✓	R
13	Obscure Branded Swift	<i>Pelopidas agna</i>	x	x	x	x	✓	UC
14	Ceylon Swift	<i>Parnara bada</i>	x	x	x	x	✓	C
15	Plain Palm Dart	<i>Cephrenes acalle</i>	x	x	x	x	✓	R
Family : Lycaenidae								
16	African Babul Blue	<i>Azanus jesous</i>	✓	x	✓	x	x	Ab
17	Bright Babul Blue	<i>Azanus ubaldus</i>	✓	✓	✓	x	✓	C
18	Common Cerulean	<i>Jamides celeno</i>	x	✓	✓	x	x	Ab
19	Common Pierrot	<i>Castalius rosimon</i>	x	✓	✓	✓	✓	A
20	Common Silverline	<i>Spindasis vulcanus</i>	x	x	✓	x	✓	A
21	Common Guava Blue	<i>Virachola isocrates</i>	✓	✓	x	x	✓	UC
22	Lime Blue	<i>Chilades lajus</i>	✓	x	x	x	✓	A
23	Gram Blue	<i>Eucharysops cnejus</i>	✓	x	x	x	✓	A
24	Dark Cerulean	<i>Jamidus bochus</i>	✓	x	x	x	x	Ab
25	Indian Red Flash	<i>Rapala iarbus</i>	✓	x	x	x	✓	UC
26	Common Shot Silverline	<i>Spindasis ictis</i>	✓	✓	x	x	✓	C
27	Dark Grass Blue	<i>Zizeeria karsandra</i>	✓	x	✓	x	✓	C
28	Pale Grass Blue	<i>Psuedozizeeria maha</i>	x	x	✓	x	✓	C
29	Lesser Grass Blue	<i>Zizina otis</i>	✓	✓	✓	✓	✓	A
30	Forget Me Not	<i>Catochrysops strabo</i>	✓	x	✓	x	✓	A

31	Indian Cupid	<i>Everes lacturnus</i>	x	✓	✓	x	x	Ab
32	Plains Cupid	<i>Chilades pandava</i>	x	x	✓	x	✓	A
33	Small Cupid	<i>Chilades parrhasius</i>	✓	x	✓	x	✓	C
34	Indian Sunbeam	<i>Curetis thetis</i>	x	✓	✓	✓	✓	C
35	Pea Blue	<i>Lampides boeticus</i>	✓	x	✓	✓	✓	C
36	Striped Pierrot	<i>Tarucus nara</i>	✓	✓	✓	x	✓	C
37	Zebra Blue	<i>Leptotes plinius</i>	✓	✓	✓	✓	✓	A
38	Grass Jewel	<i>Freyeria trochylus</i>	✓	x	✓	x	x	Ab
39	Small Grass Jewel	<i>Freyeria putli</i>	x	x	x	x	✓	C
40	Tailless Lineblue	<i>Prosotas dubiosa</i>	x	x	x	x	✓	A
41	Peacock Royal	<i>Tajuria cippus</i>	x	x	x	x	✓	R
42	Plains Blue Royal	<i>Tajuria jehana</i>	x	x	x	x	✓	R
43	Redspot	<i>Zesius chrysomallus</i>	x	x	x	x	✓	R
44	Pointed Ciliate Blue	<i>Anthene lycaenina</i>	x	x	x	x	✓	UC
45	Tiny Grass Blue	<i>Zizula hylax</i>	x	x	x	x	✓	C
46	Plumbeous Silverline	<i>Spindasis schistacea</i>	x	x	x	x	✓	R
47	Black-spotted Pierrot	<i>Tarucus balkanicus</i>	x	x	x	x	✓	UC
48	Indian Pointed Pierrot	<i>Tarucus indicus</i>	x	x	x	x	✓	UC

Family : Nymphalidae

49	Baronet	<i>Symphaedra nais</i>	x	x	✓	✓	x	Ab
50	Blue pansy	<i>Junonia orithya</i>	✓	✓	✓	✓	✓	C
51	Grey Pansy	<i>Junonia atlites</i>	x	x	✓	x	x	Ab
52	Peacock Pansy	<i>Junonia almana</i>	✓	✓	✓	✓	✓	C
53	Lemon pansy	<i>Junonia lemonias</i>	✓	✓	✓	✓	✓	A
54	Yellow Pansy	<i>Junonia hierta</i>	✓	x	✓	x	✓	UC
55	Chochlate Pansy	<i>Junonia iphita</i>	x	✓	✓	x	x	Ab
56	Common Castor	<i>Ariadne merione</i>	x	✓	✓	✓	✓	C
57	Common Evening Brown	<i>Melanitis leda</i>	✓	✓	✓	x	✓	C
58	Common Fivering	<i>Ypthima baldus</i>	x	x	✓	x	x	Ab
59	Common Fourring	<i>Ypthima huebneri</i>	x	✓	✓	x	✓	A
60	Common Crow	<i>Euploea core</i>	✓	✓	✓	✓	✓	C
61	Danaid Eggfly	<i>Hypolimnas misippus</i>	✓	✓	✓	✓	✓	A
62	Great Eggfly	<i>Hypolimnas bolina</i>	✓	✓	✓	x	✓	C
63	Common Bushbrown	<i>Mycalesis perseus</i>	x	x	✓	x	x	Ab
64	Joker	<i>Byblia ilithya</i>	x	✓	✓	x	x	Ab
65	Common Leopard	<i>Phalanta phalantha</i>	x	x	✓	x	✓	C
66	Plain Tiger	<i>Danaus chrysippus</i>	✓	✓	✓	✓	✓	A
67	Striped Tiger	<i>Danaus genutia</i>	✓	✓	✓	✓	✓	C
68	Blue Tiger	<i>Tirumala limniace</i>	✓	✓	✓	✓	✓	UC
69	Tawny Coster	<i>Acraea violae</i>	✓	✓	✓	✓	✓	A
70	Black Rajah	<i>Charaxes solon</i>	✓	✓	x	x	✓	UC
71	Common Sailer	<i>Neptis hylas</i>	✓	x	x	x	x	Ab
72	Painted Lady	<i>Vanessa cardui</i>	✓	x	x	x	x	Ab

Family : Pieridae

73	Common Emigrant	<i>Catopsillia pomono</i>	✓	✓	✓	✓	✓	A
74	Common Grass Yellow	<i>E urema hecabe</i>	✓	✓	✓	✓	✓	A
75	Common Gull	<i>Cepora nerissa</i>	✓	✓	✓	✓	✓	A
76	Crimson Tip	<i>Colotis danae</i>	✓	✓	✓	✓	✓	C
77	Large Salmon Arab	<i>Colotis fausta</i>	✓	✓	✓	✗	✗	Ab
78	Motteled Emigrant	<i>Catopsillia pyranthe</i>	✓	✓	✓	✓	✓	A
79	Pioneer	<i>Belenois aurota</i>	✓	✓	✓	✓	✓	C
80	Plain Orange Tip	<i>Colotis aurora</i>	✗	✓	✓	✗	✓	C
81	Small Orange Tip	<i>Colotis etrida</i>	✓	✓	✓	✓	✓	C
82	Small Salmon Arab	<i>Colotis amata</i>	✓	✓	✓	✓	✓	C
83	White Arab	<i>Colotis phisadia</i>	✓	✓	✗	✗	✓	UC
84	Blue Spotted Arab	<i>Colotis protractus</i>	✓	✗	✗	✗	✗	Ab
85	Spotless Grass Yellow	<i>Eurema laeta</i>	✓	✗	✗	✗	✓	UC
86	Three Spot Grass Yellow	<i>Eurema blanda</i>	✗	✓	✗	✗	✗	Ab
87	Small Grass Yellow	<i>Eurema brigitta</i>	✓	✓	✗	✗	✗	Ab
88	One-spot Grass Yellow	<i>Eurema andersoni</i>	✗	✗	✗	✗	✓	R
89	Common Albatross	<i>Appias albina</i>	✗	✗	✗	✓	✗	Ab
90	Western Striped Albatross	<i>Appias libythea</i>	✓	✗	✓	✗	✗	Ab
91	White Orange Tip	<i>Ixias marianne</i>	✓	✓	✓	✓	✓	C
92	Yellow Orange Tip	<i>Ixias pyrene</i>	✗	✓	✓	✓	✓	C
93	Common Jezebel	<i>Delias eucharis</i>	✓	✓	✓	✓	✓	C

Family : Papilionidae

94	Common Mormone	<i>Papilio polytes</i>	✓	✓	✓	✓	✓	C
95	Common Rose	<i>Pachliopta aristolochiae</i>	✓	✓	✓	✓	✓	UC
96	Lime Swallowtail	<i>Papilio demoleus</i>	✓	✓	✓	✓	✓	C
97	Tailed Jay	<i>Graphium agamemnon</i>	✓	✓	✓	✓	✓	A
98	Blue Mormone	<i>Papilio polymnestor</i>	✓	✗	✗	✗	✗	Ab
99	Spot Swordtail	<i>Graphium nomius</i>	✗	✓	✗	✗	✗	Ab
100	Common Jay	<i>Graphium doson</i>	✗	✗	✗	✗	✓	A

The species disappearance could be because of the deforestation, urbanization and loss of natural habitats due to residential, commercial and agricultural development , which led to major landscape changes (Clark, Reed, & Chew, 2007). In addition, anthropogenic activities causing environmental pollution must have played a key role as with minimal change in the environment, the immediate response is shown by butterflies (Samways, 1994; Gupta & Mondal, 2005).

The invasion of new butterfly species could be because of the urbanization and roadside gardening that introduced some new flora species, which were not native to this area, but several habitats in Anand are still rich in floral diversity, which would have supported the constancy of butterfly community. With the presence of the variety of larval host plants which are necessary for butterflies to complete their life-cycle is one of the major reason behind the invasion.

The world of digitization has led to a great advantage that such a complex criteria has now been an ease, such as advance features of camera with high resolution and magnification has played a key role in order to record the maximum number of butterfly species.

Photographic plates is with Appendix- 1.

2. Diversity study of butterflies in and around P. G. Department of Biosciences, Anand City, Gujarat.

Campus of the P. G. Department of Biosciences is rich in floral diversity (Table 4; Appendix- 3) which supports about 67 butterfly species (Table 3; Appendix- 2). The larval stages relays on host plants and adults on the flowering plants for nectar.

While comparing (Table 2) butterfly diversity of P. G. Department of Biosciences and its surroundings with previous study its found that 11 new species records of family Hesperidae, 19 new species records of family Lycaenidae, five new species record of family Nymphalidae, three new species records of family Pieridae and one new species record of family Papilionidae. In total 39 butterfly species have been reported for the first time.

Also we could not record *Symphaedra nais* from family Nymphalidae, *Appias albino* from family Pieridae and *Pachliopta aristolochiae* from family Papilionidae, in total three butterfly species which were earlier mentioned by Chudasama (2011).

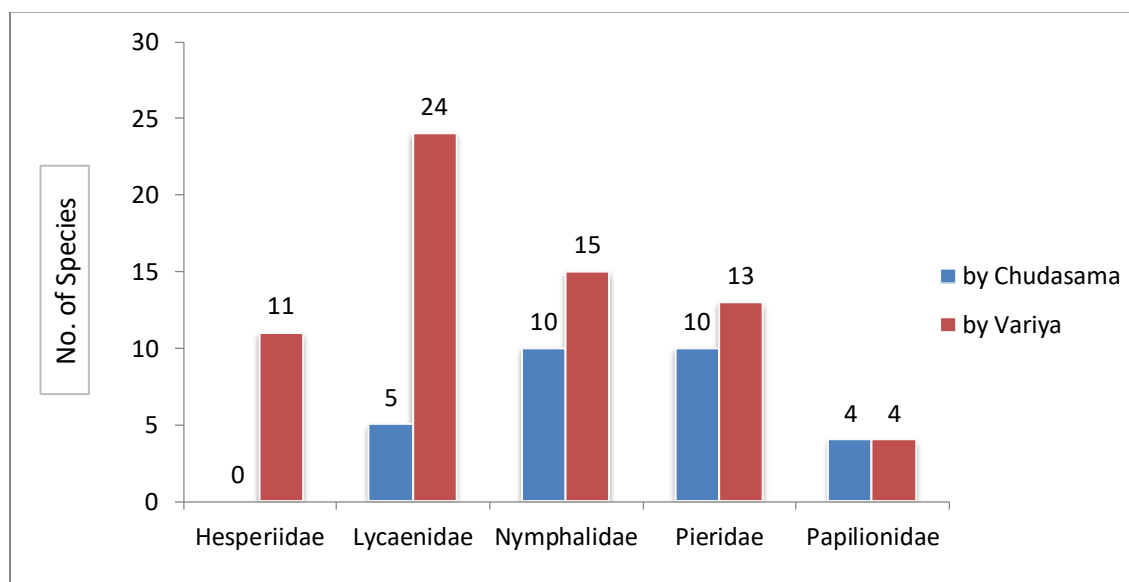


Figure 12: Comparison of checklist of butterflies at P. G. Department of Biosciences.

Table 2: Comparitive study of butterflies at P. G. Department of Biosciences, Vallabh Vidhyanagar, Anand.

Sr No.	Common Name	Scientific Name	Butterflies Recorded	
			Chudasama (2011)	Variya (2016-18)
Family : Hesperidae				
1	Borbo spp.	<i>Borbo sp.</i>	x	✓
2	Common Banded Awl	<i>Hasora chromus</i>	x	✓
3	Conjoined Swift	<i>Pelopidas conjuncta</i>	x	✓
4	Small Branded Swift	<i>Pelopidas mathias</i>	x	✓
5	Indian Skipper	<i>Spialia galba</i>	x	✓
6	Dark Palm Dart	<i>Telicota bambusae</i>	x	✓
7	Common Palm Dart	<i>Telicota colon</i>	x	✓
8	Indian Palm Bob	<i>Suastus gremius</i>	x	✓
9	Obscure Branded Swift	<i>Pelopidas agna</i>	x	✓
10	Ceylon Swift	<i>Parnara bada</i>	x	✓
11	Plain Palm Dart	<i>Cephrenes acalle</i>	x	✓
Family : Lycaenidae				
12	Bright Babul Blue	<i>Azanus ubaldus</i>	x	✓
13	Common Pierrot	<i>Castalius rosimon</i>	✓	✓
14	Common Silverline	<i>Spindasis vulcanus</i>	x	✓
15	Common Guava Blue	<i>Virachola isocrales</i>	x	✓
16	Lime Blue	<i>Chilades lajus</i>	x	✓
17	Gram Blue	<i>Eucharysops cnejus</i>	x	✓
18	Indian Red Flash	<i>Rapala iarbus</i>	x	✓
19	Shot Silverline	<i>Spindasis ictis</i>	x	✓
20	Dark Grass Blue	<i>Zizeeria karsandra</i>	x	✓
21	Pale Grass Blue	<i>Psuedozizeeria maha</i>	x	✓
22	Lesser Grass Blue	<i>Zizina otis</i>	✓	✓
23	Forget Me Not	<i>Catochrysops strabo</i>	x	✓
24	Plains Cupid	<i>Chilades pandava</i>	x	✓
25	Small Cupid	<i>Chilades parrhasius</i>	x	✓
26	Indian Sunbeam	<i>Curetis thetis</i>	✓	✓
27	Pea Blue	<i>Lampides boeticus</i>	✓	✓
28	Striped Pierrot	<i>Tarucus nara</i>	x	✓
29	Zebra Blue	<i>Leptotes plinius</i>	✓	✓
30	Small Grass Jewel	<i>Freyeria putli</i>	x	✓
31	Tailless Lineblue	<i>Prosotas dubiosa</i>	x	✓
32	Pointed Ciliate Blue	<i>Anthene lycaenina</i>	x	✓
33	Tiny Grass Blue	<i>Zizula hylax</i>	x	✓

34	Plumbeous Silverline	<i>Spindasis schistacea</i>	x	✓
35	Black-spotted Pierrot	<i>Tarucus balkanicus</i>	x	✓
Family : Nymphalidae				
36	Baronet	<i>Symphaedra nais</i>	✓	x
37	Blue pansy	<i>Junonia orithya</i>	✓	✓
38	Peacock Pansy	<i>Junonia almana</i>	✓	✓
39	Lemon pansy	<i>Junonia lemonias</i>	✓	✓
40	Common Castor	<i>Ariadne merione</i>	✓	✓
41	Common Evening Brown	<i>Melanitis leda</i>	x	✓
42	Common Fourring	<i>Ypthima huebneri</i>	x	✓
43	Common Indian Crow	<i>Euploea core</i>	✓	✓
44	Danaid Eggfly	<i>Hypolimnas misippus</i>	✓	✓
45	Great Eggfly	<i>Hypolimnas bolina</i>	x	✓
46	Common Leopard	<i>Phalanta phalantha</i>	x	✓
47	Plain Tiger	<i>Danaus chrysippus</i>	✓	✓
48	Striped Tiger	<i>Danaus genutia</i>	✓	✓
49	Blue Tiger	<i>Tirumala limniace</i>	x	✓
50	Tawny Coster	<i>Acraea violae</i>	✓	✓
51	Black Rajah	<i>Charaxes solon</i>	x	✓
Family : Pieridae				
52	Common Emigrant	<i>Catopsillia pomono</i>	✓	✓
53	Common Grass Yellow	<i>Eurema hecabe</i>	✓	✓
54	Common Gull	<i>Cepora nerissa</i>	✓	✓
55	Crimson Tip	<i>Colotis danae</i>	x	✓
56	Mottled Emigrant	<i>Catopsillia pyranthe</i>	✓	✓
57	Pioneer	<i>Belenois aurota</i>	✓	✓
58	Plain Orange Tip	<i>Colotis aurora</i>	x	✓
59	Spotless Grass Yellow	<i>Eurema laeta</i>	x	✓
60	Small Salmon Arab	<i>Colotis amata</i>	✓	✓
61	One-spot Grass Yellow	<i>Eurema andersoni</i>	x	✓
62	Common Albatross	<i>Appias albina</i>	✓	x
63	White Orange Tip	<i>Ixias marianne</i>	✓	✓
64	Yellow Orange Tip	<i>Ixias pyrene</i>	✓	✓
65	Common Jezebel	<i>Delias eucharis</i>	✓	✓
Family : Papilionidae				
66	Common Mormone	<i>Papilio polytes</i>	✓	✓
67	Common Rose	<i>Pachliopta aristolochiae</i>	✓	x
68	Lime Swallowtail	<i>Papilio demoleus</i>	✓	✓
69	Tailed Jay	<i>Graphium Agamemnon</i>	✓	✓
70	Common Jay	<i>Graphium doson</i>	x	✓

Plant and butterfly diversities are positively correlated (Hawkins & Porter, 2003). With time floral diversity of Biosciences campus has been increasing with increase in butterfly diversity.

We also came across some rarely seen species like *Cephrenes acalle*, *Spindasis schistacea* and *Eurema andersoni*. Among these, *C. acalle* and *E. andersoni* are new records for Gujarat. Identification of these species was done by taking help from experts. Photographic records are with Appendix- 1, in respective families.

3. To evaluate the plants utilized by butterflies in and around the P. G. Department of Biosciences, Anand City, Gujarat.

(A) Larval food/host plants.

Host plants are the types of plants that butterflies choose to populate with their larvae (Sharma & Sharma, 2013) and they play a major role in presence of good number of butterfly species. List of host plants (Table 5; Appendix- 3).

Virachola isocrates is pest to many flora species. We have documented life cycle of *V. isocrates* on *Sapindus trifoliatus* (Figure 8, Page no. 13), which is new host plant record.

(B) Adult food /nectar plants.

❖ Reporting food (nectar) plants of Lesser Grass Blue *Zizina otis* (Fabricius, 1787).

The floral diversity of P. G. Department of Biosciences comprises of many flowering and non-flowering plants which appear during monsoon and in other seasons as well. *Z. otis* was observed on many weed species, which were found in throughout the study area.

This study was started from December 2017 to March 2018 at P. G. Department of Biosciences and surroundings. Butterflies were observed in morning, noon and in evening on working days.

❖ Why Lesser grass blue was preferred for this study?

Because,

- I. they were most abundant species during the study period.
- II. they visits variety of flora, especially weeds for the nectar.
- III. nothing is known about nectar plants of *Z. otis* in India.

As *Z. otis* flies close to the ground it visits the flowering plants which are close to the ground i.e. Weeds. Earlier reported food plants for *Z. otis* are *Eupatorium odoratum*, *Cosmos bipinnatus*, *Clerodendrum infortunatum*, *Gomphrena pulchella*, *Salvia* sp., *Rauwolfia serpentina* (Begum et al., 2015) at Dhaka, Bangladesh.

We were able to record 11 new food plants. It includes *Vernonia cinerea*, *Tridax procumbens*, *Indigofera linnaei*, *Aerva lanata*, *Gomphrena celosioides*, *Achyranthes aspera*, *Convolvulus arvensis*, *Parthenium hysterophorus*, *Sida rhombifolia*, *Sida glutinosa*, *Sida* sp. and *Peristrophe bicalyculata*. We also documented the *Z. otis* taking up nectar from above mentioned herbs with its proboscis inside the flowers, as proof of this study (Figure 13-28).



Figure 13 : *Zizina otis* on *Vernonia cinerea*



Figure 14 : *Zizina otis* on *Vernonia cinerea*



Figure 15: *Zizina otis* on *Tridax procumbens*



Figure 16: *Zizina otis* on *Tridax procumbens*



Figure 17: *Zizina otis* on *Indigofera linnaei*



Figure 18: *Zizina otis* on *Indigofera linnaei*



Figure 19: *Zizina otis* on *Aerva lanata*



Figure 20: *Zizina otis* on *Aerva lanata*



Figure 21: *Zizina otis* on *Gomphrena celosioides*



Figure 22: *Zizina otis* on *Achyranthes aspera*



Figure 23: *Zizina otis* on *Convolvulus arvensis*



Figure 24: *Zizina otis* on *Parthenium hysterophorus*



Figure 25: *Zizina otis* on *Sida rhombifolia*



Figure 26: *Zizina otis* on *Sida glutinosa*



Figure 27: *Zizina otis* on *Sida sp.*



Figure 28: *Zizina otis* on *Peristrophe bicalyculata*

The selection of plants as nectar sources by butterflies depends on various factors, including innate color preference, corolla depth, clustering of the flowers from which nectar can be extracted (Dennis, 1992). The differences between flower color influences butterfly flower choice (Bergerot, Fontaine, Renard, Cadi, & Julliard, 2010). We observed that *Z. otis* visited flowers with yellow, white, pink and purple color.

The scent of flowers is an important signal for butterflies initially to identify and subsequently to recognize and distinguish among rewarding plants (Sharma & Sharma, 2013). Pollen plays a part in pollinator attraction, particularly in the emission of scents (Bergerot et al., 2010). This supports our study as by observing an individual we found that they visit same species of plant at a time.

Preference for nectar amino acids could be either sex or species-specific or may be influenced by larval conditions as alterations in the larval diet result in changes in adult preferences for nectar amino acids (Mevi-Schütz, Goverde, & Erhardt, 2003). One needs to analyze the nectar properties of flowers in order to conclude that why *Zizina otis* prefers wide variety of herbs.

IV. CONCLUSION

There are several reasons for the increase in butterfly community and through this study it has been concluded that the enhancement and the growth of various floral species in and around P. G. Department of Biosciences has led to increase in number of butterfly species.

The possible reasons for such an increase are due to proper maintenance of trees, carrying out suitable plantation programs and treating the whole habitat with utmost care and dignity.

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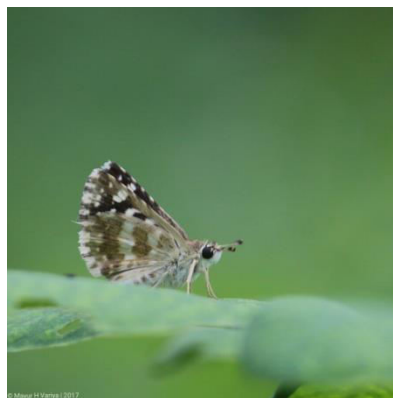
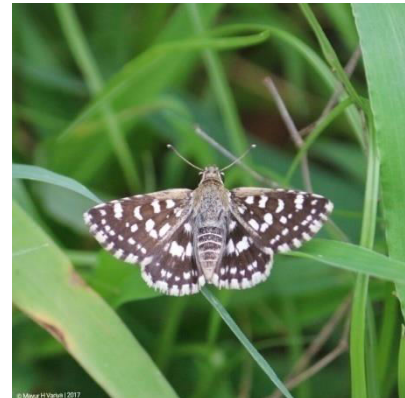
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VI. APPENDICES

Appendix – 1: Plates (Butterflies of Anand City)

Hesperiidae

Brown Awl (*Badamia exclamationis*)Borbo spp (*Borbo sp.*)Common Banded Awl (*Hasora chromus*)Conjoined Swift (*Pelopidas conjuncta*)Conjoined Swift (*Pelopidas conjuncta*)Small Branded Swift (*Pelopidas mathias*)Small Branded Swift (*Pelopidas mathias*)Indian Skipper (*Spialia galba*)Indian Skipper (*Spialia galba*)



Dark Palm Dart (*Telicota bambusae*)



Dark Palm Dart (*Telicota bambusae*)



Common Palm Dart (*Telicota colon*)



Common Palm Dart (*Telicota colon*)

showing UPH apex, key to differentiate it from *T. bambusae*.



Indian Palm Bob (*Suastus gremius*)



Indian Palm Bob (*Suastus gremius*)



Small Branded Swift (*Pelopidas thrax*)



Small Branded Swift (*Pelopidas thrax*)



Obscure Branded Swift (*Pelopidas agna*)



Obscure Branded Swift (*Pelopidas agna*)



Ceylon Swift (*Pamara bada*)



Ceylon Swift (*Pamara bada*)



Plain Palm Dart (*Cephrenes acalle*)



Plain Palm Dart (*Cephrenes acalle*)

Lycaenidae



Bright Babul Blue (*Azanus ubaldus*)



Common Pierrot (*Castalius rosimon*)



Common Pierrot (*Castalius rosimon*)



Common Silverline (*Spindasis vulcanus*)



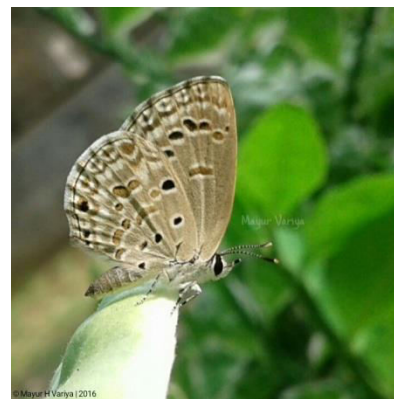
Common Silverline (*Spindasis vulcanus*)



Common Silverline (*Spindasis vulcanus*)



Common Guava Blue (*Virachola isocrates*)



Lime Blue (*Chilades lajus*)



Lime Blue (*Chilades lajus*)



Gram Blue (*Eucharysops cnejus*)



Indian Red Flash (*Rapala iarbus*)



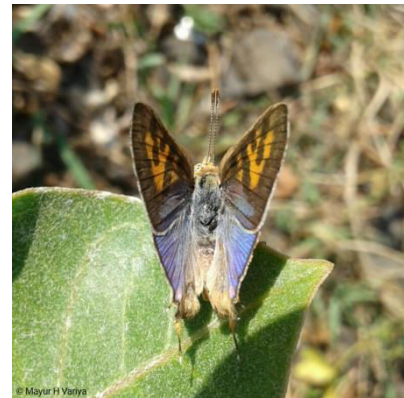
Indian Red Flash (*Rapala iarbus*) MALE



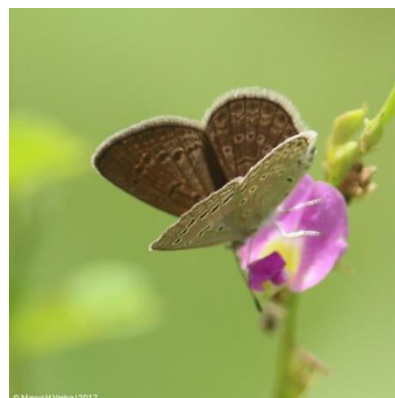
Common Shot Silverline (*Spindasis ictis*)



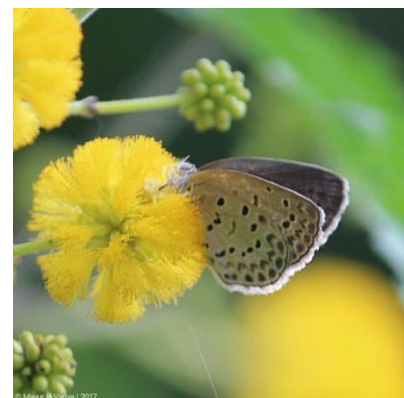
Common Shot Silverline (*Spindasis ictis*) Spring form MALE



Dark Grass Blue (*Zizeeria karsandra*)



Dark Grass Blue (*Zizeeria karsandra*)



Pale Grass Blue (*Psuedozizeeria maha*)



Lesser Grass Blue (*Zizina otis*)



Lesser Grass Blue (*Zizina otis*) MALE



Lesser Grass Blue (*Zizina otis*) FEMALE



Forget-me-not (*Catochrysops strabo*) MALE



Forget-me-not (*Catochrysops strabo*) MALE



Forget-me-not (*Catochrysops strabo*) FEMALE



Forget-me-not (*Catochrysops strabo*) FEMALE



Plains Cupid (*Chilades pandava*)



Plains Cupid (*Chilades pandava*)



Small Cupid (*Chilades parrhasius*)



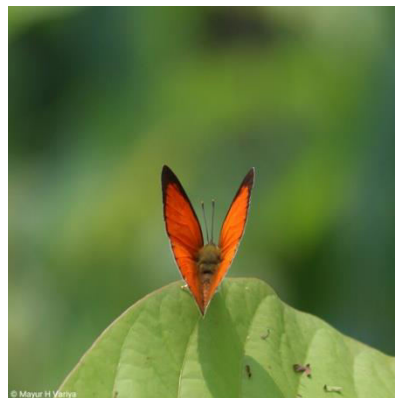
Small Cupid (*Chilades parrhasius*)



Small Cupid (*Chilades parrhasius*)



Indian Sunbeam (*Caretis thetis*) MALE



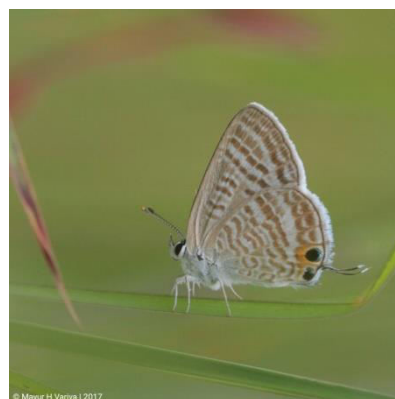
Indian Sunbeam (*Caretis thetis*) MALE



Indian Sunbeam (*Caretis thetis*) FEMALE



Indian Sunbeam (*Caretis thetis*) FEMALE



Pea Blue (*Lampides boeticus*)



Striped Pierrot (*Tarucus nara*) MALE



Striped Pierrot (*Tarucus nara*) MALE



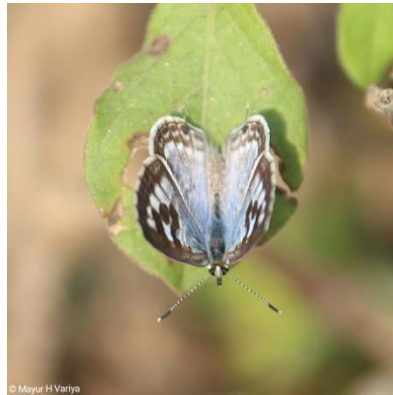
Striped Pierrot (*Tarucus nara*) FEMALE



Zebra Blue (*Leptotes plinius*)



Zebra Blue (*Leptotes plinius*) MALE



Zebra Blue (*Leptotes plinius*) FEMALE



Small Grass Jewel (*Freyeria putli*)



Small Grass Jewel (*Freyeria putli*)



Small Grass Jewel (*Freyeria putli*)



Tailless Lineblue (*Prostos dubiosa*)



Peacock Royal (*Tajuria cippus*)



Peacock Royal (*Tajuria cippus*)



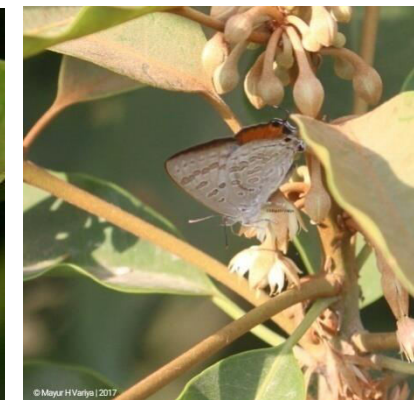
Peacock Royal (*Tajuria cippus*)



Plains Blue Royal (*Tajuria jehana*)



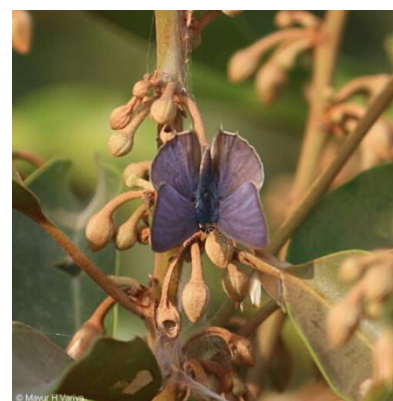
Redspot (*Zesius chrysomallus*)



Redspot (*Zesius chrysomallus*)



Pointed Ciliate Blue (*Anthene lycaenina*)



Pointed Ciliate Blue (*Anthene lycaenina*) MALE



Tiny Grass Blue (*Zizula hylax*)



Plumbeous Silverline (*Spindasis schistacea*)



Plumbeous Silverline (*Spindasis schistacea*)



Black-spotted Pierrot (*Tarucus balkanicus*)



Black-spotted Pierrot (*Tarucus balkanicus*)

MALE



Black-spotted Pierrot (*Tarucus balkanicus*)

MALE



Indian Pointed Pierrot (*Tarucus indicus*)

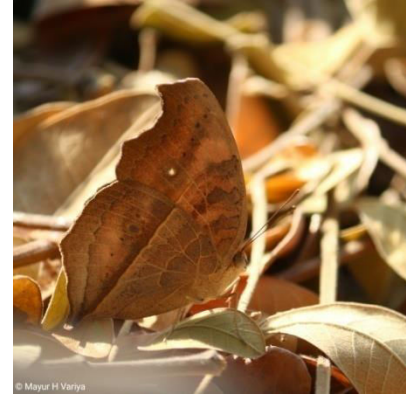
Nymphalidae



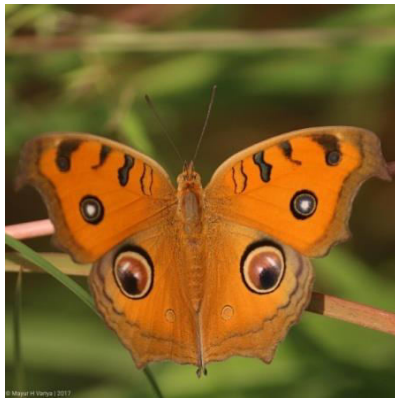
Blue Pansy (*Junonia orithya*)



Blue Pansy (*Junonia orithya*)



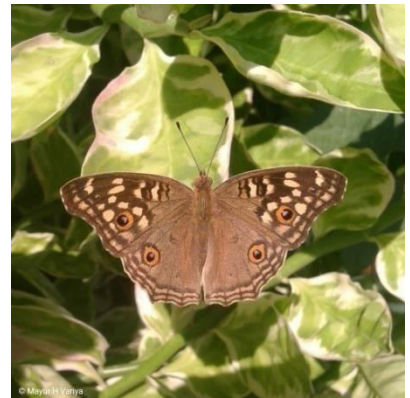
Peacock Pansy (*Junonia almana*)



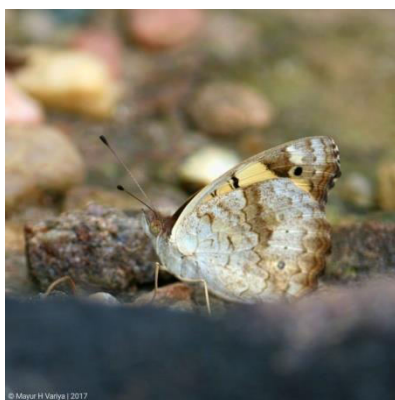
Peacock Pansy (*Junonia almana*)



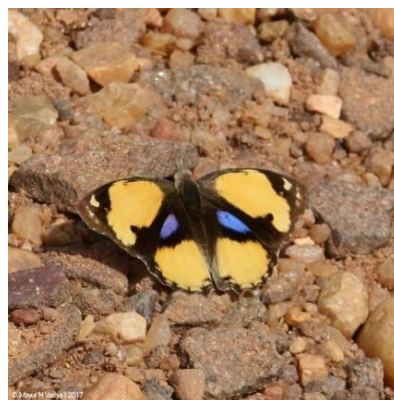
Lemon pansy (*Junonia lemonias*)



Lemon pansy (*Junonia lemonias*)



Yellow Pansy (*Junonia hierta*)



Yellow Pansy (*Junonia hierta*)



Common Castor (*Ariadne merione*)



Common Castor (*Ariadne merione*)



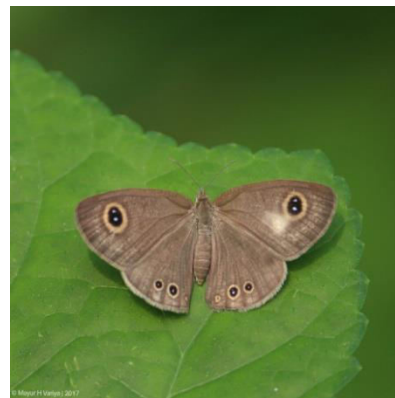
Common Evening Brown (*Melanitis leda*)



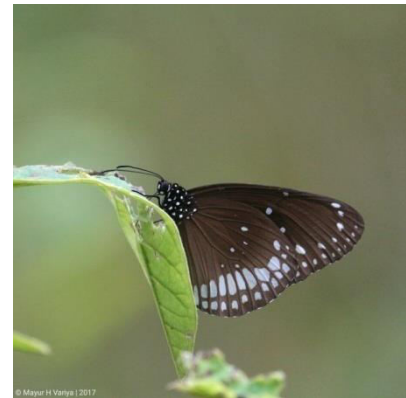
Common Evening Brown (*Melanitis leda*)



Common Fourring (*Ypthima huebneri*)



Common Fourring (*Ypthima huebneri*)



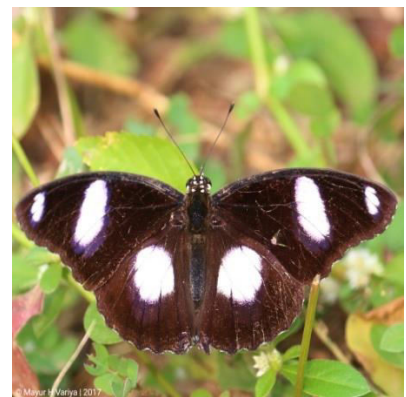
Common Crow (*Euploea core*)



Common Crow (*Euploea core*)



Danaid Eggfly (*Hypolimnas misippus*) MALE



Danaid Eggfly (*Hypolimnas misippus*) MALE



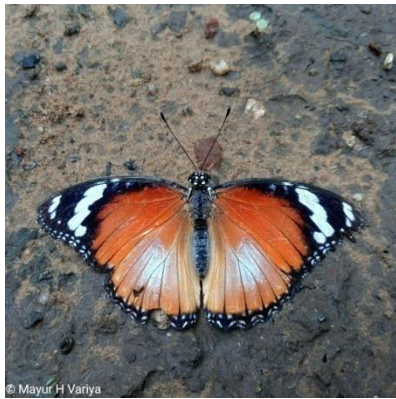
Danaid Eggfly (*Hypolimnas misippus*) MALE



Danaid Eggfly (*Hypolimnas misippus*) FEMALE



Danaid Eggfly (*Hypolimnas misippus*) FEMALE



Danaid Eggfly (*Hypolimnas misippus*) FEMALE

form *alcippoides*



Danaid Eggfly (*Hypolimnas misippus*) FEMALE

form *inaria*



Danaid Eggfly (*Hypolimnas misippus*) FEMALE

with orange scales on UPF apex



Great Eggfly (*Hypolimnas bolina*) MALE



Great Eggfly (*Hypolimnas bolina*) MALE



Great Eggfly (*Hypolimnas bolina*) FEMALE



Great Eggfly (*Hypolimnas bolina*) FEMALE



Common Leopard (*Phalanta phalantha*)



Common Leopard (*Phalanta phalantha*)



Common Leopard (*Phalanta phalantha*)



Plain Tiger (*Danaus chrysippus*)



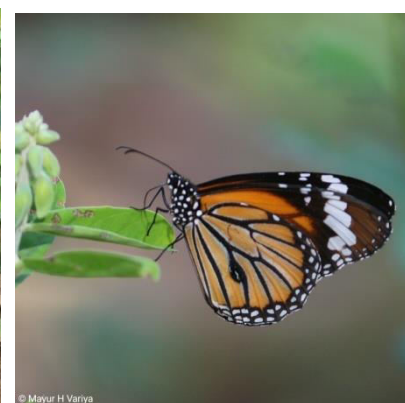
Plain Tiger (*Danaus chrysippus*)



Plain Tiger (*Danaus chrysippus*) MATING



Plain Tiger (*Danaus chrysippus*)



Striped Tiger (*Danaus genutia*)



Blue Tiger (*Tirumala limniace*)



Blue Tiger (*Tirumala limniace*)



Tawny Coster (*Acraea violae*)



Tawny Coster (*Acraea violae*)



Tawny Coster (*Acraea violae*)



Black Rajah (*Charaxes solon*)



Black Rajah (*Charaxes solon*)



Black Rajah (*Charaxes solon*)



Black Rajah (*Charaxes solon*)

Pieridae



Common Emigrant (*Catopsilia pomono*)



Common Emigrant (*Catopsilia pomono*)



Common Grass Yellow (*Eurema hecabe*)

DRY SEASON FORM



Common Grass Yellow (*Eurema hecabe*)



Common Gull (*Cepora nerissa*)



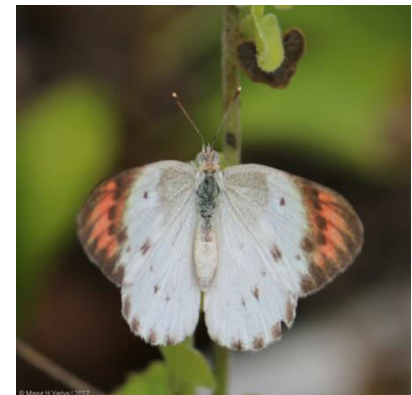
Common Gull (*Cepora nerissa*)



Crimson Tip (*Colotis danae*)



Crimson Tip (*Colotis danae*) MALE



Crimson Tip (*Colotis danae*) FEMALE

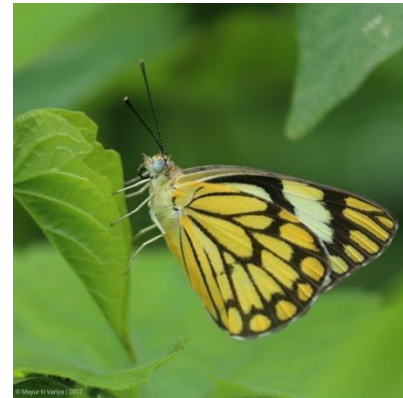


Mottled Emigrant (*Catopsilia pyranthe*)



Mottled Emigrant (*Catopsilia pyranthe*)

Mating pair.



Pioneer (*Belenois aurota*)

WET SEASON FORM



Pioneer (*Belenois aurota*)

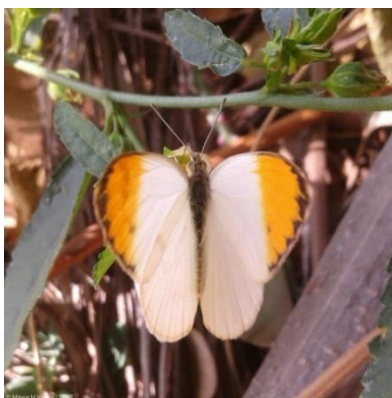
DRY SEASON FORM



Pioneer (*Belenois aurota*)



Plain Orange Tip (*Colotis aurora*) MALE



Plain Orange Tip (*Colotis aurora*) MALE



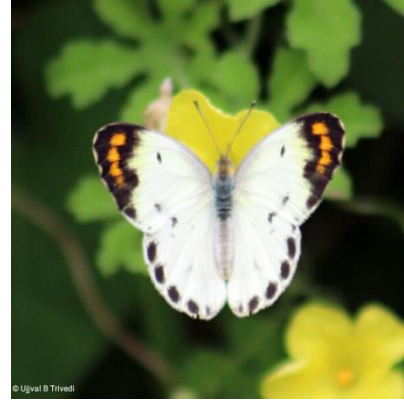
Plain Orange Tip (*Colotis aurora*) FEMALE



Plain Orange Tip (*Colotis aurora*) FEMALE



Plain Orange Tip (*Colotis aurora*) FEMALE



Small Orange Tip (*Colotis etrida*) FEMALE



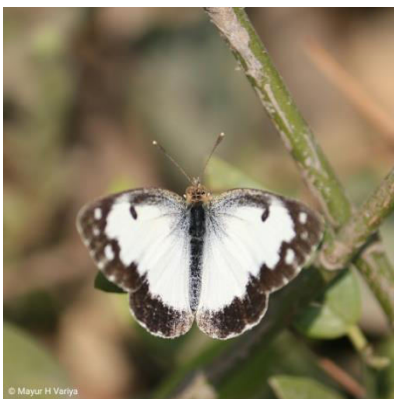
Small Salmon Arab (*Colotis amata*)



Small Salmon Arab (*Colotis amata*)



White Arab (*Colotis phisadia*)



White Arab (*Colotis phisadia*)



Spotless Grass Yellow (*Eurema laeta*)



Spotless Grass Yellow (*Eurema laeta*)



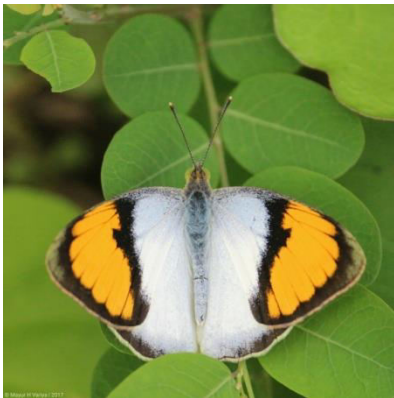
One-spot Grass Yellow (*Eurema andersoni*)



One-spot Grass Yellow (*Eurema andersoni*)



White Orange Tip (*Ixias marianne*) MALE



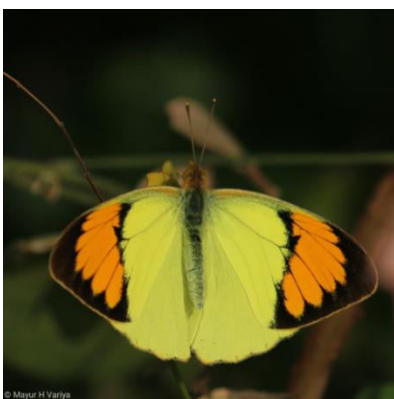
White Orange Tip (*Ixias marianne*) MALE



White Orange Tip (*Ixias marianne*) FEMALE



Yellow Orange Tip (*Ixias pyrene*) MATING



Yellow Orange Tip (*Ixias pyrene*) MALE



Common Jezebel (*Delias eucharis*)



Common Jezebel (*Delias eucharis*)

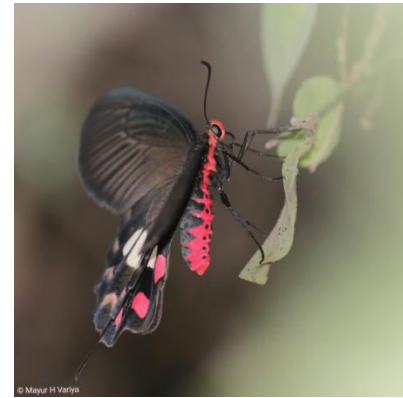
Papilionidae



Common Mormon (*Papilio polytes*)



Common Mormon (*Papilio polytes*)



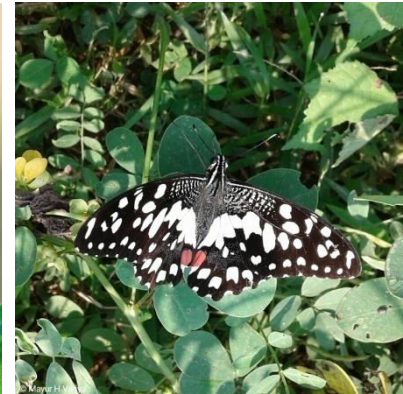
Common Rose (*Pachliopta aristolochiae*)



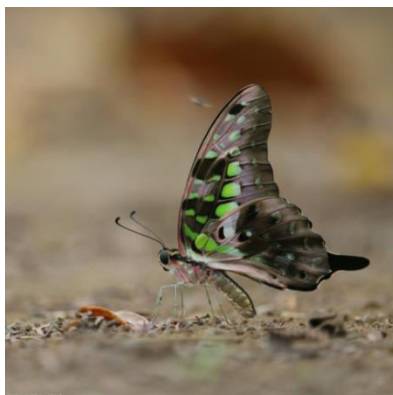
Common Rose (*Pachliopta aristolochiae*)



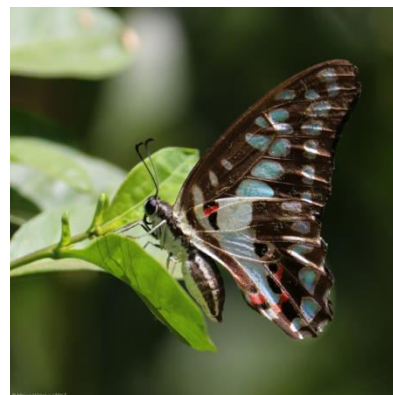
Lime Swallowtail (*Papilio demoleus*)



Lime Swallowtail (*Papilio demoleus*)



Tailed Jay (*Graphium agamemnon*)



Comon Jay (*Graphium doson*)

Appendix – 2 Table 3: Checklist of butterflies in and around P. G. Department of Biosciences (2016-18).

Sr No.	Family	Common Name	Scientific Name	Present Status*
1	Hesperiidae	Borbo spp.	<i>Borbo sp.</i>	UC
2		Common Banded Awl	<i>Hasora chromus</i>	C
3		Conjoined Swift	<i>Pelopidas conjuncta</i>	UC
4		Small Branded Swift	<i>Pelopidas mathias</i>	A
5		Indian Skipper	<i>Spialia galba</i>	C
6		Dark Palm Dart	<i>Telicota bambusae</i>	UC
7		Common Palm Dart	<i>Telicota colon</i>	UC
8		Indian Palm Bob	<i>Suastus gremius</i>	A
9		Obscure Branded Swift	<i>Pelopidas agna</i>	UC
10		Ceylon Swift	<i>Parnara bada</i>	C
11		Plain Palm Dart	<i>Cephrènes acalle</i>	UC
12	Lycaenidae	Bright Babul Blue	<i>Azanus ubaldus</i>	C
13		Common Pierrot	<i>Castalius rosimon</i>	A
14		Common Silverline	<i>Spindasis vulcanus</i>	A
15		Common Guava Blue	<i>Virachola isocrales</i>	UC
16		Lime Blue	<i>Chilades lajus</i>	A
17		Gram Blue	<i>Eucharysops cnejus</i>	A
18		Indian Red Flash	<i>Rapala iarbus</i>	UC
19		Shot Silverline	<i>Spindasis ictis</i>	C
20		Dark Grass Blue	<i>Zizeeria karsandra</i>	C
21		Pale Grass Blue	<i>Psuedozizeeria maha</i>	C
22		Lesser Grass Blue	<i>Zizina otis</i>	A
23		Forget Me Not	<i>Catochrysops strabo</i>	A
24		Plains Cupid	<i>Chilades pandava</i>	A
25		Small Cupid	<i>Chilades parrhasius</i>	C
26		Indian Sunbeam	<i>Curetis thetis</i>	C
27		Pea Blue	<i>Lampides boeticus</i>	C
28		Striped Pierrot	<i>Tarucus nara</i>	C
29		Zebra Blue	<i>Leptotes plinius</i>	A
30		Small Grass Jewel	<i>Freyeria putli</i>	C
31		Tailless Lineblue	<i>Prosotas dubiosa</i>	A
32		Pointed Ciliate Blue	<i>Anthene lycaenina</i>	UC
33		Tiny Grass Blue	<i>Zizula hylax</i>	C
34		Plumbeous Silverline	<i>Spindasis schistacea</i>	UC
35		Black-spotted Pierrot	<i>Tarucus balkanicus</i>	UC

36	Nymphalidae	Blue pansy	<i>Junonia orithya</i>	C
37		Peacock Pansy	<i>Junonia almana</i>	UC
38		Lemon pansy	<i>Junonia lemonias</i>	A
39		Common Castor	<i>Ariadne merione</i>	C
40		Common Evening Brown	<i>Melanitis leda</i>	C
41		Common Fourring	<i>Ypthima huebneri</i>	A
42		Common Indian Crow	<i>Euploea core</i>	C
43		Danaid Eggfly	<i>Hypolimnas misippus</i>	A
44		Great Eggfly	<i>Hypolimnas bolina</i>	C
45		Common Leopard	<i>Phalanta phalantha</i>	C
46		Plain Tiger	<i>Danaus chrysippus</i>	A
47		Striped Tiger	<i>Danaus genutia</i>	UC
48		Blue Tiger	<i>Tirumala limniace</i>	UC
49		Tawny Coster	<i>Acraea violae</i>	A
50		Black Rajah	<i>Charaxes solon</i>	C
51		Pieridae	Common Emigrant	<i>Catopsillia pomono</i>
52	Common Grass Yellow		<i>Eurema hecabe</i>	A
53	Common Gull		<i>Cepora nerissa</i>	A
54	Crimson Tip		<i>Colotis danae</i>	C
55	Mottled Emigrant		<i>Catopsillia pyranthe</i>	A
56	Pioneer		<i>Belenois aurota</i>	C
57	Plain Orange Tip		<i>Colotis aurora</i>	C
58	Spotless Grass Yellow		<i>Eurema laeta</i>	UC
59	Small Salmon Arab		<i>Colotis amata</i>	C
60	One-spot Grass Yellow		<i>Eurema andersoni</i>	R
61	White Orange Tip		<i>Ixias marianne</i>	C
62	Yellow Orange Tip		<i>Ixias pyrene</i>	C
63	Common Jezebel		<i>Delias eucharis</i>	C
64	Papilionidae	Common Mormone	<i>Papilio polytes</i>	C
65		Lime Swallowtail	<i>Papilio demoleus</i>	C
66		Tailed Jay	<i>Graphium Agamemnon</i>	A
67		Common Jay	<i>Graphium doson</i>	A

*Note: R - Rare; UC - Uncommon; C - Common; A - Abundant.

Appendix – 3: Floral Diversity

Table 4: Checklist of plants in and around P. G. Department of Biosciences.

No.	Family	Scientific Name	English Name (Local Name)	Type
1	Acanthaceae	<i>Adhatoda vasica</i>	Malabar Nut (Aradusi)	Shrub
2		<i>Barleria prionitis</i>	Porcupine Flower (Vajradanti)	Herb
3		<i>Peristrophe bicalyculata</i>	Panicled Peristrophe (Kali Adhedi)	Herb
4		<i>Thunbergia erecta</i>	King's Mantle	Shrub
5	Alliaceae	<i>Allium cepa</i>	Onion (Dungali)	Herb
6	Amaranthaceae	<i>Achyranthes aspera</i>	Pricky Chaff Flower (Adhedo)	Herb
7		<i>Aerva lanata</i>	Knot Grass	Herb
8		<i>Alternanthera sessilis</i>	Dwarf Copperleaf (Jalajambo)	Herb
9		<i>Amaranthus hybridus</i>	(Tandaljo)	Herb
10		<i>Amaranthus gracilis</i>	Spiny Amarnath (Dhimado)	Herb
11		<i>Amaranthus spinosus</i>	(Kantalo Dabho)	Herb
12		<i>Gomphrena celosioides</i>	Prostate Gomphrena	Herb
13	Anacardiaceae	<i>Lannea coromandelica</i>	Indian Ash Tree (Moyano)	Tree
14		<i>Mangifera indica</i>	Mango (Aambo)	Tree
15	Annonaceae	<i>Annona reticulate</i>	Netted Custard Apple (Ramfal)	Tree
16		<i>Annona squamosal</i>	Sugar Apple (Sitafal)	Tree
17		<i>Polyalthia longifolia</i>	Ashok (Ashopalav)	Tree
18	Apiaceae	<i>Trachyspermum ammi</i>	Ajwan Caraway (Ajmo)	Herb
19	Apocynaceae	<i>Alstonia scholaris</i>	Scholar Tree (Saptaparni)	Tree
20		<i>Nerium odorum</i>	Oleander (Kanera)	Shrub
21		<i>Plumeria rubra</i>	Frangipani Red (Champo)	Tree
22		<i>Tabernaemontana divarticata</i>	Crape Jasmine (Tagari)	Shrub
23		<i>Vinca rosea</i>	Periwinkle (Baramasi)	Herb
24	Araceae	<i>Dieffenbachia sp.</i>	Dumb Cane	Shrub
25		<i>Colocasia esculenta</i>	Taro (Aaluki)	Herb
26	Arecaceae	<i>Cocos nucifera</i>	Coconut (Nariyer)	Tree
27		<i>Phoenix dactylifera</i>	Date Palm (Khajuri)	Tree
28	Asclepiadaceae	<i>Calotropis gigantea</i>	Calotropis (Aakado)	Shrub
29		<i>Calotropis procera</i>	Calotropis (Aakado)	Shrub
30	Asphodelaceae	<i>Aloe barbadensis</i>	Aloe Vera (Kubar Pathu)	Herb
31	Asteraceae	<i>Bidens bipinnata</i>	Spanish Needles	Herb
32		<i>Blumea lacera</i>	Kakronda (Kapuriyo)	Herb
33		<i>Crysanthemum sp.</i>		Herb
34		<i>Eclipta alba</i>	False Daisy (Bhangaro)	Herb
35		<i>Tridax procumbens</i>	Tridax Daisy	Herb

36		<i>Helianthus annuus</i>	Sunflower (Suraj Mukhi)	Herb
37		<i>Launae acapitata</i>		Herb
38		<i>Parthenium hysterophorus</i>	Carrot Grass (Congress Grass)	Herb
39		<i>Tagetes erecta</i>	Marigold (Yellow/Orange) (Galagota)	Herb
40		<i>Vernonia cinerea</i>	Little Ironweed (Sahadevi)	Herb
41	Bignoniaceae	<i>Kigelia pinnata</i>	Sausage Tree (Gorakh Kakadi)	Tree
42		<i>Millingtonia hortensis</i>	Indian Cork Tree (Jasmine)	Tree
43		<i>Tabebuia rosea</i>	Pink Trumpet Tree	Tree
44	Boraginaceae	<i>Cordia gharaf</i>	Gondani (Nani Gundi)	Tree
45		<i>Cordia sebestena</i>	Geiger Tree	Tree
46	Brassicaceae	<i>Raphanus sativus</i>	Radish (Mulo)	Herb
47	Caesalpinaceae	<i>Bauhinia purpureae</i>	Purple Orchid Tree (Champakati)	Tree
48		<i>Bauhinia ravemosa</i>	(Asotaro)	Tree
49		<i>Bauhinia tomentosa</i>	Yellow Orchid Tree (Pilo Asundro)	Tree
50		<i>Bauhinia variegata</i>	Orchid Tree (Kanchanara)	Tree
51		<i>Cassia angustifolia</i>	East Indian Senna (Aval)	Herb
52		<i>Cassia fistula</i>	Golden Rain Tree (Garmalo)	Tree
53		<i>Cassia occidentalis</i>	Coffee Senna (Kasundari)	Herb
54		<i>Cassia siamea</i>	Cassia Tree (Kasid)	Tree
55		<i>Cassia tora</i>	Sickle Pod (Kunvadiyo)	Herb
56		<i>Hardwickia binata</i>	Indian Blackwood (Anjan)	Tree
57		<i>Piliostigma malabaricum</i>	Malabar Orchid (Khati Chamol)	Tree
58		<i>Tamarind usindicus</i>	Tamarind (Aamli)	Tree
59	Cannaceae	<i>Canna indica</i>	Indian Shot	Herb
60	Caricaceae	<i>Carica papaya</i>	Papaya (Papaiya)	Tree
61	Casuarinaceae	<i>Casuarina equisetifolia</i>	Whistling Pine (Saru)	Tree
62	Combretaceae	<i>Terminalia arjuna</i>	Arjun Tree (Sadado)	Tree
63	Compositae	<i>BlumeaLacera</i>	(Kapurio)	Herb
64	Convolvulaceae	<i>Ipomoea dichroa</i>	(Safed Panavali)	Shrub
65		<i>Ipomoea obscura</i>	Obscure Morning Glory	Shrub
66		<i>Ipomoea fistulosa</i>		Shrub
67		<i>Cuscutareflexa</i>	Amar Bel (Amarvel)	Climber
68	Crassulaceae	<i>Bryophyllum pinnatum</i>	Air Plant (Khatumaro)	Shrub
69	Cucurbitaceae	<i>Coccinia indica</i>	Ivy Gourd (Kadavi Gilori)	Climber
70		<i>Luffa acutangula</i>	Silk Squash (Galka)	Climber
71	Cupressaceae	<i>Thuja occidentalis</i>	(Mayur Pankh)	Shrub
72	Euphorbiaceae	<i>Acalypha indica</i>	Indian Copperleaf	Tree
73		<i>Euphorbia milii</i>	Crown of Thorns	Shrub
74		<i>Euphorbia nivalvia</i>	Leafy Milk Hedge (Kantalo Thor)	Shrub

75		<i>Euphorbia tirucalli</i>	Indian Tree Spurge (Kharasani)	Shrub
76		<i>Jatropha curcas</i>	Physic Nut	Shrub
77		<i>Ricinus communis</i>	Castor Bean Plant (Arando)	Shrub
78	Fabaceae	<i>Abrus precatorius</i>	Gunj (Chanothi)	Herb
79		<i>Butea monosperma</i>	Palash (Keshudo)	Plant
80		<i>Cassia angustifolia</i>	TirunelveliSenna (Aval)	Tree
81		<i>Dalbergia sissoo</i>	Shisham (Shisham)	Tree
82		<i>Pithecellobium dulce</i>	Monkeypods (Goras Amla)	Tree
83		<i>Prosopis spicigera</i>	Cikura Pod (Samadi)	Tree
84		<i>Indigofera linnae</i>	(Bhonyagali)	Herb
85	Lamiaceae	<i>Leucas aspera</i>	CommanLeucas (Kobi)	Shrub
86		<i>Ocimum sanctum</i>	Tulsi (Tulasi)	Herb
87	Lythraceae	<i>Punica granatum</i>	Pomegranate (Dadam)	Shrub
88	Malvaceae	<i>Abelmoschus angulosus</i>	Ladies' Finger (Bhindo)	Shrub
89		<i>Abelmoschus manihot</i>	Sunset Muskmallow (Jangali Bhindo)	Shrub
90		<i>Abutilon indicum</i>	Indian Mallow (Kansaki)	Herb
91		<i>Hibiscus rosasinensis</i>	China Rose (Jasud)	Shrub
92		<i>Sida acuta</i>	Common Wireweed (Khapat)	Herb
93		<i>Sida glutinosa</i>		Herb
94		<i>Sida rhombifolia</i>	(Baladana)	Herb
95		<i>Thespesia populnea</i>	Portia Tree (Paaras Pipalo)	Tree
96	<i>Urena lobata</i>	Cesarweed (Jangali Kapas)	Herb	
97	Martyniaceae	<i>Martynia annua</i>	Devils Claws (Vichudo)	Herb
98	Meliaceae	<i>Azadirachta indica</i>	Neem (Limado)	Tree
99		<i>Melia azadirach</i>	Persian Lilac (Bakam Limdo)	Tree
100	Mimosaceae	<i>Acacia auriculiformis</i>	Earleaf Acacia (Fofa)	Tree
101		<i>Acacia nilotica</i>	TomatoseBabool (Baval)	Tree
102		<i>Albizia lebeck</i>	Siris Tree (Siras)	Tree
103		<i>Samanea saman</i>	Rain Tree (Rato Shiris)	Tree
104	Moraceae	<i>Ficus glomerata</i>	Indian Fig Tree (Goolar) (Umaro)	Tree
105		<i>Ficus pumila</i>	Climbing Fig	Shrub
106		<i>Ficus religiosa</i>	Peepal (Pipalo)	Tree
107		<i>Morus alba</i>	Mulberries (Setur)	Shrub
108		<i>Streblus asper</i>	Sand Paper Tree (Sarelo)	Tree
109	Moringaceae	<i>Moringa oleifera</i>	Drumstick Tree (Saragavo)	Tree
110	Musaceae	<i>Musa paradisiaca</i>	Banana (Kela)	Shrub
111	Myrtaceae	<i>Callistemon sp.</i>	Bottle Brush	Shrub
112		<i>Eucalyptus globulus</i>	Eucalyptus (Nilgiri)	Tree
113		<i>Psidium guajava</i>	Guava (Jamaphal)	Tree

114		<i>Syzygium cumini</i>	Jamun (Jambu)	Tree
115	Nictagineaceae	<i>Boerhavia diffusa</i>	Punarnava (Satodi)	Herb
116	Oleaceae	<i>Nyctanthesarbor-tristis</i>	HarSingar (Parijat)	Shrub
117	Papilionaceae	<i>Clitoria biflora</i>	Bombay Bean (Galani)	Climber
118		<i>Clitoria ternatea</i>	Bombay Bean (Galani)	Climber
119	Pedaliaceae	<i>Sesamum indicum</i>	Sesame (Tal)	Herb
120	Phyllanthaceae	<i>Embllica officinalis</i>	Amla (Amla)	Tree
121		<i>Phyllanthus nirui</i>	BhoyAamali (Bhoy Aamli)	Herb
122	Plumbaginaceae	<i>Plumbago zeylanica</i>	Doctorbrush (Safed Chitaro)	Herb
123	Poaceae	<i>Dendrocalamus strictus</i>	Culcutta Bamboo (Vaas)	Tree
124	Putranajivaceae	<i>Putranajiva roxburghii</i>	(Putranjiva)	Tree
125	Rhamnaceae	<i>Ziziphus mauritiana</i>	Ber (Bor)	Shrub
126	Rosaceae	<i>Rosa centifolia</i>	Rose (Gulab)	Shrub
127	Rubiaceae	<i>Anthocephalus indicus</i>	Kadam (Kadam)	Tree
128		<i>Ixora coccina</i>	Ixora (Vasanti)	Shrub
129	Rutaceae	<i>Aegle marmelos</i>	Bel (Bili)	Tree
130		<i>Citrus acida</i>	Lemon (Limbu)	Shrub
131		<i>Feronia elephantum</i>	Wood Apple (Kothu)	Tree
132		<i>Murraya koenigii</i>	Curry Tree (Kadhi Limdo)	Tree
133	Santalaceae	<i>Santalum album</i>	Sandal Wood (Chandan)	Tree
134	Sapotaceae	<i>Manilkara zapota</i>	Chikoo (Chiku)	Tree
135		<i>Mimusops elengi</i>	Spanish Cherry (Bakul)	Tree
136	Sapindaceae	<i>Sapindus trifoliatus</i>	Soapnut (Aritha)	Shrub
137	Simarubaceae	<i>Alianthus excelsa</i>	Tree of Heaven (Arduso)	Tree
138	Solanaceae	<i>Capsicum annum</i>	Capsicum (Marachu)	Shrub
139		<i>Datura innoxia</i>	Datura (Dhaturo)	Shrub
140		<i>Lycopersicum esculentum</i>	Tomato (Tameta)	Herb
141		<i>Solanum malongena</i>	Brinjal (Ringana)	Shrub
142	Sterculiaceae	<i>Sterculia foetida</i>	Wild Almond Tree (Janali Badam)	Shrub
143	Tiliaceae	<i>Corchorus acutangulus</i>	East Indian Mallow (Chhunchh)	Herb
144	Verbenaceae	<i>Clerodendron inermis</i>	(Kadavi Mahendi)	Shrub
145		<i>Clerodendron phlomoides</i>	(Arani)	Shrub
146		<i>Lantana camara</i>	Tickberry	Shrub
147		<i>Tectona grandis</i>	Teak Wood (Sag)	Tree
148	Vitaceae	<i>Cissu squadrangularis</i>	Veldt Grape (Hadasankal)	Shrub
149	Zingiberaceae	<i>Zingiber officinale</i>	Ginger (Aadu)	Herb

Source : Patel, 2018.

Table 5: List of larval host plants of butterflies in around P. G. Department of Biosciences.

No.	Family	Species	English Name (Local Name)	Type
1	Acanthaceae	<i>Adhatoda vasica</i>	Malabar Nut (Aradusi)	Shrub
2		<i>Barleria prionitis</i>	Porcupine Flower (Vajradanti)	Herb
3	Amaranthaceae	<i>Achyranthes aspera</i>	Pricky Chaff Flower (Adhedo)	Herb
4		<i>Alternanthera sessilis</i>	Dwarf Copperleaf (Jalajambo)	Herb
5		<i>Amaranthus spinosus</i>	(KantaloDabho)	Herb
6	Annonaceae	<i>Annona reticulate</i>	Netted Custard Apple (Ramfal)	Tree
7		<i>Annona squamosal</i>	Sugar Apple (Sitafal)	Tree
8		<i>Polyalthia longifolia</i>	Ashok (Ashopalav)	Tree
9	Apocynaceae	<i>Alstonia scholaris</i>	Scholar Tree (Saptaparni)	Tree
10		<i>Nerium odorum</i>	Oleander (Kanera)	Shrub
11		<i>Tabernaemontana divarticata</i>	Crape Jasmine (Tagari)	Shrub
12	Arecaceae	<i>Cocos nucifera</i>	Coconut (Nariyer)	Tree
13	Asclepiadaceae	<i>Calotropis gigena</i>	Calotropis (Aakado)	Shrub
14		<i>Calotropis procera</i>	Calotropis (Aakado)	Shrub
15	Caesalpiniaceae	<i>Bauhinia purpureae</i>	Purple Orchid Tree (Champakati)	Tree
16		<i>Bauhinia ravemosa</i>	(Asotaro)	Tree
17		<i>Cassia fistula</i>	Golden Rain Tree (Garmalo)	Tree
18		<i>Tamarind usindicus</i>	Tamarind (Aamli)	Tree
19	Euphorbiaceae	<i>Ricinus communis</i>	Castor Bean Plant (Arando)	Shrub
20	Fabaceae	<i>Abrus precatorius</i>	Gunj (Chanothi)	Herb
21		<i>Butea monosperma</i>	Palash (Keshudo)	Plant
22		<i>Dalbergia sissoo</i>	Shisham (Shisham)	Tree
23		<i>Pithecellobium dulce</i>	Monkeypods(GorasAml)	Tree
24		<i>Indigofera linnae</i>	(Bhonyagali)	Herb
25	Lythraceae	<i>Punica granatum</i>	Pomegranate (Dadam)	Shrub
26	Malvaceae	<i>Urena lobata</i>	Cesarweed (Jangali Kapas)	Herb
27	Mimosaceae	<i>Acacia auriculiformis</i>	Earleaf Acacia (Fofa)	Tree
28		<i>Acacia nilotica</i>	TomatoseBabool (Baval)	Tree
29		<i>Albizia lebbeck</i>	Siris Tree (Siras)	Tree
30		<i>Samanea saman</i>	Rain Tree (Rato Shiris)	Tree
31	Moraceae	<i>Ficus religiosa</i>	Peepal (Pipalo)	Tree
32		<i>Streblus asper</i>	Sand Paper Tree (Sarelo)	Tree
33	Myrtaceae	<i>Callistemon</i>	Bottle Brush	Shrub
34		<i>Psidium guajava</i>	Guava (Jamaphal)	Tree
35	Plumbaginaceae	<i>Plumbago zeylanica</i>	Doctorbrush (Safed Chitaro)	Herb
36	Rhamnaceae	<i>Ziziphus mauritiana</i>	Ber (Bor)	Shrub
37	Rutaceae	<i>Aegle marmelos</i>	Bel (Bili)	Tree
38		<i>Feronia elephantum</i>	Wood Apple (Kothu)	Tree
39		<i>Murraya koenigii</i>	Curry Tree (KadhiLimdo)	Tree

40	Sapotaceae	<i>Mimusops elengi</i>	Spanish Cherry (Bakul)	Tree
42	Sapindaceae	<i>Sapindus trifoliatus</i>	Soapnut (Aritha)	Shrub
41	Verbenaceae	<i>Lantana camara</i>	Tickberry	Shrub

Appendix 4:

Table 5: List of birds found at P. G. Department of Biosciences, during the study.

No	Name	No	Name
1	Indian Grey hornbill	21	Oriental white eye
2	Osprey	22	Fkowerpecker
3	Green leaf bird	23	Yellow footed green pigeon
4	Canary headed flycatcher	24	Greater coucal
5	White throated kingfisher	25	Rose-ringed parakeet
6	Coppersmith barbet	26	Red-wattled lapwing
7	Fantail flycatcher	27	Shikra
8	Rufous treepie	28	Oriental honey buzzard
9	Indian scops owl	29	Cuckooshrike
10	Spotted owlet	30	Kite
11	Lesser flamback woodpecker	31	Green bee-eater
12	Yellow wagtail	32	Scaly breasted munia
13	Red naped ibis	33	Plain prinia
14	Black drongo	34	Red-vented bulbul
15	Purple rumped sunbird	35	Indian silverbill
16	Tailor bird	36	Wire tailed swallow
17	Asian koel	37	Jungle babbler
18	Golden oriole	38	Common myna
19	Indian robin	39	Jungle crow
20	Common hoope	40	Cattle egret