Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

J E Z S Journal of Entomology and Zoology Studies

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(3): 1596-1607

Received: 09-03-2017
Accepted: 10-04-2017

Sonal Patil
PG Department of Zoology, K T H M College, Nashik, Maharashtra, India

Sujata Magdum
PG Department of Zoology, K T H M College, Nashik, Maharashtra, India

Correspondence
Sonal Patil
PG Department of Zoology, K T H M College, Nashik, Maharashtra, India

Insight into wing venation in butterflies belonging to families Papilionidae, Nymphalidae and Pieridae from Dang Dist Gujarat, India

Sonal Patil and Sujata Magdum

Abstract
The present study was conducted to understand the wing venations in butterflies belonging to all three families, namely Papilionidae, Nymphalidae and Pieridae from Dang District, Gujarat, India between 2013-2015. Dang District is identified as a hot spot for megadiversity of butterflies. Wings of all the three families Papilionidae, Nymphalidae and Pieridae showed considerable variations in shapes and vein patterns reflecting their specific nature. An interesting observation was done in *Delias eucharias* belonging to the family Pieridae. This butterfly showed two veins missing, namely second radial R2 and first cubitus Cu1 from forewing.

Keywords: Papilionidae, Nymphalidae, Pieridae, Dang District, wing shape, vein patterns. second redial R2 and First cubitus Cu1, forewings

1. Introduction
Flight is undoubtedly a key characteristic of all Lepidoptera [1]. The mysterious flight depends on wings which accomplished several kinds of difficult tasks like diving, circling, parachuting, equilibrium, etc., all because of their lightness in nature. Wings are commonly called flight appendage which are subjected to considerable variations in shape, size, markings/spots and vein patterns thus reflecting their specific functional differences Butterfly has four wings- pair of forewing and hindwing attached to the second and third thoracic segments (the meso- and meta-thorax). Strong muscles in the thorax move the wings up and down in a figure eight pattern during flight. Both forewing and hindwing are covered with thousands of minute colourful scales. Due to presence of scales on wings the term for order 'Lepidoptera' has been coined ("lepteron" in ancient Greek means 'scale') [2]. Most scales are lamellar or blade-like and attached with a pedicel, while other forms may be hair like. Besides being responsible for the magnificent colours characteristic of butterflies, scales also protect and insulate butterflies. [3] Butterflies being cold-blooded rely on external sources of heat. Preliminary research shows that scales absorb heat and therefore helps in the thermoregulation [4].
Morphological diversities in butterflies, like size, shape, venation pattern, morphometric analysis, pigmentations etc. plays a significant role in understanding the phylogeny of organism [5]. Comparing many sets of morphological characters gives a comprehensive analysis of phylogenetic relationships between families of butterflies [6]. It has been also found that in the butterflies' wings adapt to different environmental conditions affecting flights [7]. These get influenced by the time factor which affects the speed, foraging, calling, finding places for spawning, avoiding predators thus mimic. Their vibrant colour patterns also help to seek mates. Pattern of the wing is useful in establishing the correlation in adaptation and adaptive change. [8]
Changes both in morphology of the wings and pattern of flight are closely associated with the variation in genetic material [9] Similarly, there is a relationship between wing venation and wing pattern in Lepidoptera [10]. Such type of studies plays a major role in understanding the evolutionary status and also highlights its significance in taxonomical analysis.(R) Wing morphology, their variation is well studied in heliconinae species which establishes its significant taxonomic implications [5].
Unlike other insects, wings of butterflies are thin, membranous appendages. These are nourished and supported by tubular veins. These participate in the exchange of oxygen, i.e. "breathing". Further, venation in butterfly wings has aerodynamic importance and plays a specific role in flight system and adapt to different surroundings [11].

Interestingly, venation patterns differ both in the forewing and hindwing in all the insect species. Such venation pattern can be used as an index to identify the insect as it defines a very specific pattern amongst a particular genus or species. Earlier studies in *Papilio xuthus mutant* reveal the reduced venation which is very unique as compared to other butterflies [12]. More emphasis is given in understanding such functional and architectural constraints which basically reflect stable and conservative patterns amongst lepidopterans. Revaluation of the Intra -and interspecific venational patterns in Elachistiae moths, help in understanding the relative closeness within families and thus reflect its role in describing evolutionary convergence or divergence characteristics [13]. Literature survey reveals pictorial key based on the wing venation of the butterflies for identification of the local nymphalids observed in the forest areas of Chittagong and Cox's Bazar in Bangladesh [14]. As wing venation is one of the most important traits in insect phylogenetic development extensive study was carried out in order Plecoptera [15]

Earlier studies reveal the fact that wing venation or patterns also recruits many unique functions. Forewings of certain orthopteran insects have broad venations at the specialized area called mirror and Harp which helps in amplifying the sound [16]. Further, venation is an important trait in insect phylogenetic development. Six types of venational pattern were recorded in bagworm, *Pteroma plagiophelps*, an important defoliator of trees in India [17]. In the present paper an attempt was made to understand the detail of wings morphology and venation of butterflies belonging to three families –Papilionidae, Nymphalidae and Pieridae from Dang Dist. Gujarat, India.

2. Materials and Methods

The present study was conducted to understand the wing venation in butterflies belonging to three families namely – Papilionidae, Nymphalidae and Pieridae from Dang Dist. Gujarat, India.

The Dang District of Gujarat state, India (Fig.1) lies between North Sahyadris and Konkan coast between Latitude 20º.75'91"N and longitude 73°68'89"E. The collection was done with aerial net in all the three seasons throughout the year between 2013-2015. Collected specimens were transferred to paper envelopes to prevent damage to the wings. Collected butterflies were stretched, pinned and kept for drying at 57^0C for 24 hrs. Later these dried butterflies were placed in insect boxes which are fumigated with naphthalene balls. The identification of the families of Lepidoptera was done using the standard identification key. The wings are cleared from colored scales by the method described by Belkin [18] and Puri [19].

The right undamaged pair of wings (both fore and hind wing) were removed from the dry specimens and processed using the steps described below-

1. The right pair of wings (fore and hind wing) was separated from the thorax by either pressing gently the wings downwards or lifting it upwards with the forcep.
2. Wings were dipped into 95 % alcohol in a sufficiently deep container to wet the scales, veins and membrane.
3. The wet wings were immediately dipped in full strength Clorox (Modern industries, Product code-S06600500M). The wings were left in the Clorox for one to two minutes to bleach. Care was taken not leave the specimen in Chlorox for more than 5 minutes, which may soften thus causing a shrinking of wings.
4. After the desired bleaching, the cleared wings were transferred to another container of 95 % alcohol for a few seconds to wash off the excess bleach and to dehydrate and this helped in neutralization of the wings.
5. The wings were removed from the wash alcohol and subsequently placed on absorbent paper to dry.
6. These were subsequently labelled and kept in butter paper to maintain delicacy.
7. Wings were scanned with the Scanner-Laserjet Pro MPF M435 nw
8. Nomenclature of veins was followed as described by Comstock-Needham system [20]

Fig 1: Map of Gujarat, India (a); Study area - Dang District, Gujrat State, India (b; courtesy:www.veethi.com)

3. Results

3.1 Wing Morphology

The wings were flattened, membranous expansions, strengthened by a system of thickened hollow ribs called veins or nervures. The forewing was attached to the mesothorax and the Hindwing to the metathorax. Region close to the point of attachment to the thorax was called the base or basal area of the wing.

Each wing had a lateral expansion called notum. The generalized structure of the wing is shown in Fig 2. The upper anterior margin or the leading edge of the wing was called the costa. The inner margin or posterior edge or the trailing edge or hind-margin of the wing, extending from the base to the tornus is called dorsum. The distal extremity of the costa or an anterior corner of the wing called apex and the extremity of the inner margin, i.e. the posterior corner of the wings is called as tornus. The edge between the apex and tornus is called the outer margin, distal margin means called termen, this edge of the wing most distant from the body. At rest, wings were usually held vertically upwards with their upper surfaces pressed close together and their undersurfaces exposed. They can be spread out horizontally, and sometimes the forewing was brought back to cover a large part of the Hindwing. Thus shape of the wings was found to be very variable.

3.1.1 Wing Venation

Veins were hollow structures or stripes running in the two thin layers (coupling of the upper and lower walls) of the wings. They played a supportive role for wing surface and provide both rigidity and flexibility to the wing. During development the veins were first laid down as pigment bands in the developing wing-sheath, which were supplied with tracheae arising from two tracheal trunks. These veins formed a strong arch of chitin deposit over the channel of the trachea during metamorphosis.

Venation defines the distribution of veins in the wing surface (Fig.2). In butterflies specific pattern of wing venation was

observed. It consists of a large cell, called either the discodal/ basal or discal cell (Dc), usually closed and surrounded by veins. It can be seen closed or open by veins which appears to radiate from it (Fig. 2a and b). Different systems of notation are in use to describe the venation in the present study notation of veins is used as per described by Comstock-Needham system [15].

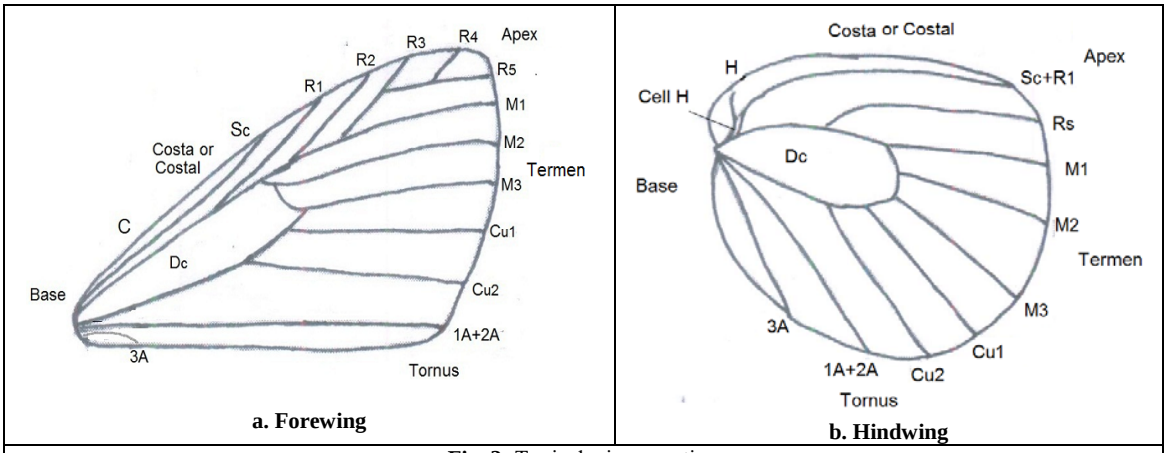
3.1.1.1 Forewing (Fig.2a.)

A typical butterfly forewing contains twelve veins, the first and last arising from the base, the others from the cell or discal cell (Dc) these are as follows-

- Costal or Costa (C) the leading edge of the wing or the true costal vein not found in Butterflies.
- Subcosta (Sc). the most anterior vein bordering the upper edge of cell from the base, subcosta never branched in butterfly.
- Radius (R1) at the leading wing marginal, fused or very close for most of the length,
- Radius (R2-R5) radius divides into branches beyond the middle of the wing R2,R3,R4 and R5 five branches reach the wing margin
- Median (M1-M3) three branches of the median- M1, M2, and M3 reach the wing margin.
- Cubitus (Cu1 and Cu2) anterior Cu1and posterior one is Cu2 reach the wing margin.
- Anal veins which are usually considered as one, starts from base 1A+ 2A and 3A, 1A is usually absent in butterflies

3.1.1.2 Hindwing (Fig.2b.)

- Hindwing shows the presence of 8 veins, of which the first and last vein arises from the base and the remaining others from the Dc (Fig 3). These veins are
- Subcostal (Sc) vein fuses with R1 first Radial vein and it becomes (Sc+R1)
- The rest of all radial veins i.e.R2, R3, R4 and R5 are fused to form a Radial sector, Rs, which reach the wing margin.
- Median (M1-M3) –three branches of median M1, M2, and M3 reach the wing margin.
- Cubitus anterior Cu1and posterior Cu 2 reach the wing margin.
- Anal veins which are usually considered as one, starts from base 1A+ 2A and 3A, 1A is usually absent in butterflies.
- Humeral vein (H) – The Hindwing of most butterflies had the precostal or humeral vein H



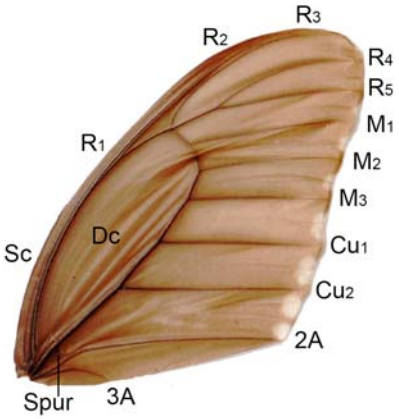
a. Forewing **b. Hindwing**

Fig. 2: Typical wing venation

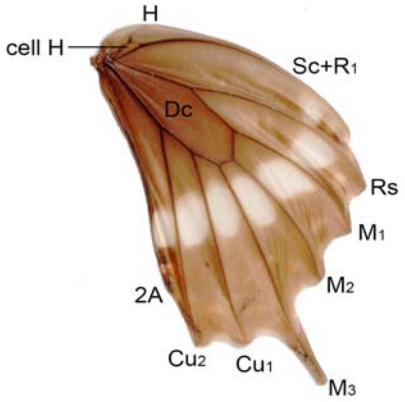
Family: Papilionidae

a. Unclear forewing

b. Unclear hindwing



c. Clear forewing

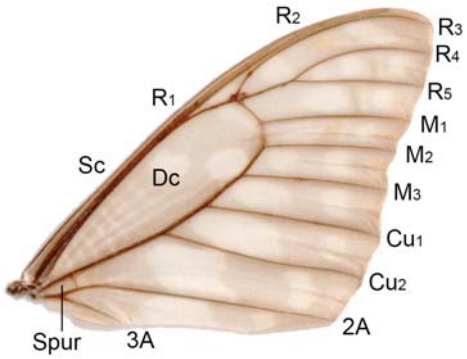


d. Clear hindwing

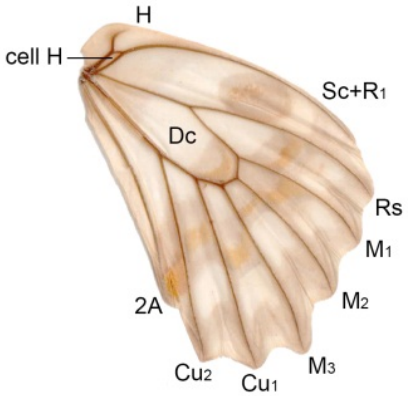
Fig 3: Forewing and Hindwing *of P. polytes.*

a. Unclear forewing

b. Unclear hindwing



c. Clear forewing

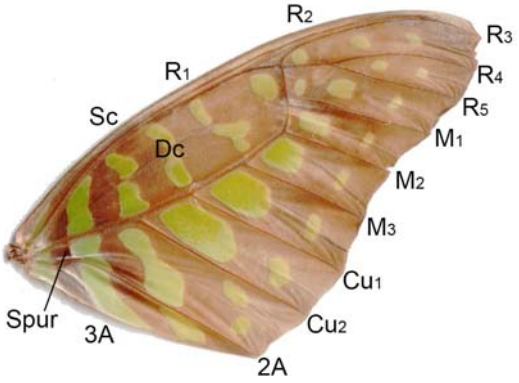


d. Clear hindwing

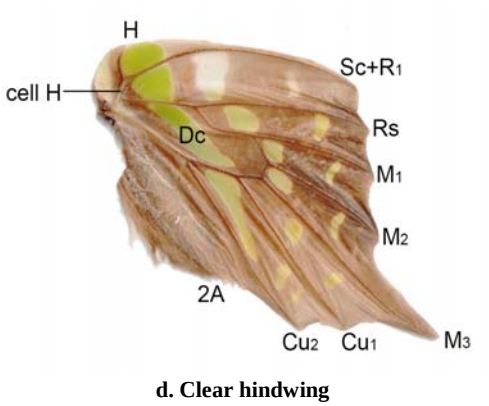
Fig 4: Forewing and Hindwing *P. demoleus.*

a. Unclear forewing

b. Unclear hindwing



c. Clear forewing



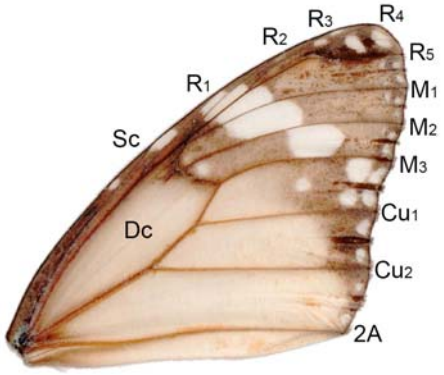
d. Clear hindwing

Fig 5: Forewing and Hindwing of *G. Agamemnon*.

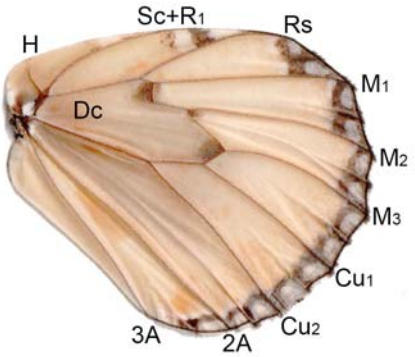
Family- Nymphalidae

a. Unclear forewing

b. Unclear hindwing



c. Clear forewing

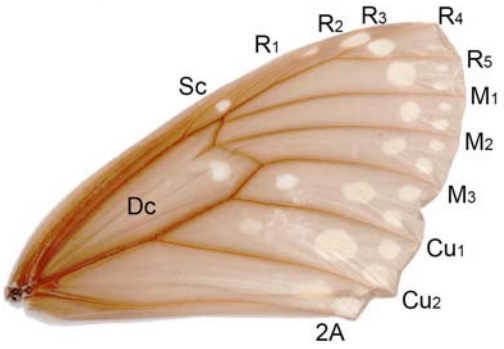


d. Clear hindwing

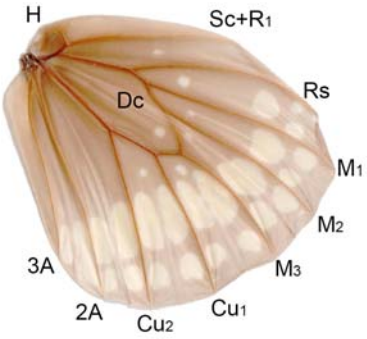
Fig 6: Forewing and Hindwing of *D. chrysippus*.

a. Unclear forewing

b. Unclear hindwing



c. Clear forewing

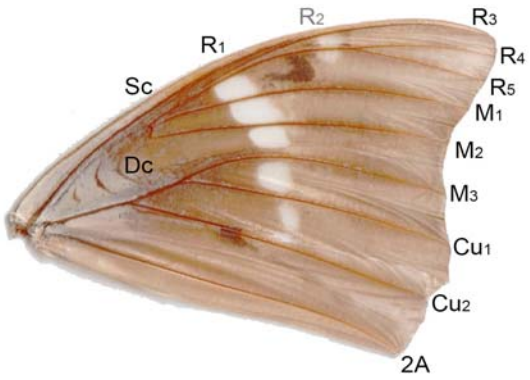


d. Clear hindwing

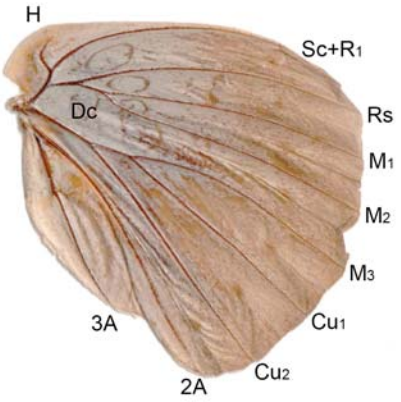
Fig 7: Forewing and Hindwing of *E. Core*.

a. Unclear forewing

b. Unclear hindwing



c. Clear forewing



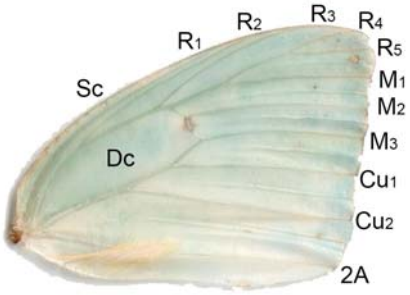
d. Clear hindwing

Fig 8: Forewing and Hindwing of *E. aconthea*.

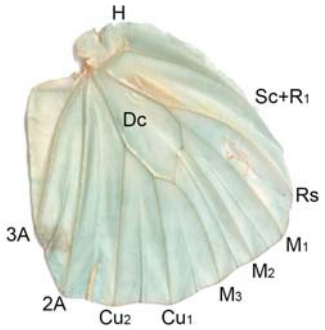
Figs.4. Family-Pieridae

a. Unclear forewing

b. Unclear hindwing



c. Clear forewing

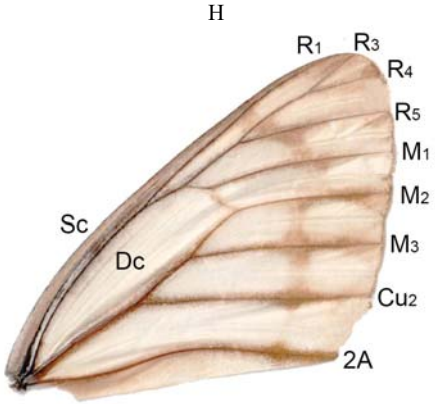


d. Clear hindwing

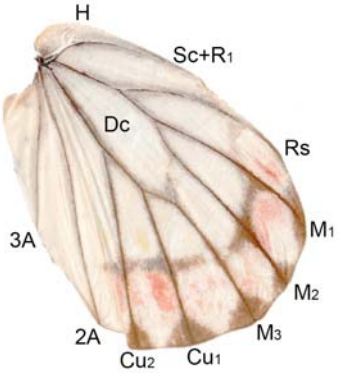
Fig 9: Forewing and Hindwing of *C. pyranthe*.

a. Unclear forewing

b. Unclear hindwing



c. Clear forewing

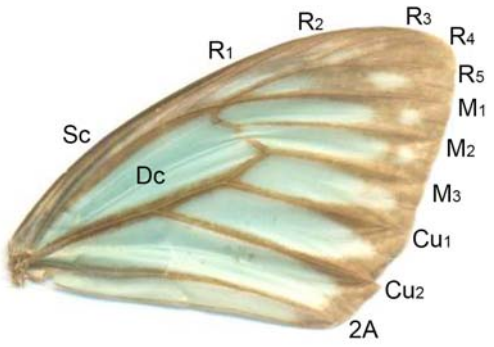


d. Clear hindwing

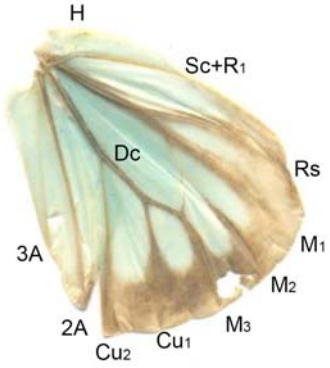
Fig 10: Forewing and Hindwing of *D. eucharis*.

a. Unclear forewing

b. Unclear hindwing



c. Clear forewing



d. Clear hindwing

Fig 11: Forewing and Hindwing of *P. Valeria*.

3.2 Family Papilionidae

Family Papilionidae is a worldwide family, commonly seen in tropical conturies and includes many largest and the most beautiful butterflies, commonly known as Swallowtails. The family comprises about 550 species. The adults were mostly medium-sized to large butterflies, often colorful and strikingly patterned. Despite their common group name, many are without tails. The commonly found papillionids in Dangs are as follows:

3.2.1 *P. polytes*

Forewing (Fig. 3 a. and c.)

Forewing was large, triangular in shape. Costa was slightly arched. Dc was closed; extending elongated more than half length of the wing. Sc vein bordering the upper edge of Dc arises from the base and extend up to the three forth of the costal margin of the wing. R1 emitted at one half of costal margin close to Sc and R2 before the Dc, terminating at the apex. The R3 arises from the anterior corner of the Dc separately and form an arch at the apex. The R4 starts from the same point to which R3, and runs straight and bifurcate into two veins i.e. R4 and R5. R2 to R5 directed towards apex which was rounded. After R5 immediate vein starts from the first median M1 then from middle the vein M2 and M3 begins with the lower apex of the Dc. Thus, all three medians were roughly equal in length, forming terman, which is obtuse and scalloped.

The Cu1 and Cu2 begin separately from the Dc runs straight towards tornus. Anal vein 2A arises from the posterior or axillary initially runs along the margin of Dc and turn towards the tornus. There was a short, stout transverse vein, median spur, present near the base of wing between the base of the wing between the Dc and the vein 2A. First anal vein 1A was absent. 3A was very short curved and runs distally.

Hindwing (Fig. 3 b. and d.).

Hindwing was small in proportion to that of forewing. It was sub triangular in shape. Costal margin lightly arched, Dc was closed. The spur vein at the anterior most of the wing was the humeral vein was very short and it forms cell H at the base of main 1st vein; (SC+R1) which was a fusion of Sc and R1 and it arises from the axillary region of the wing and runs along with the costal margin towards the apex. Next vein was Radial sector, Rs, which starts along with the anterior margin of Dc and point towards apex. The median veins extends from the Dc as anterior M1, middle M2 and posterior M3. This M3 gets projected at the termen and extend or prolong into a tail like projection.

The Cu1 and Cu2 were start from the posterior of Dc and runs towards tornus. Tornus was scalloped. Only second anal vein 2A was present recurved at dorsum.

3.2.2 P. demoleus

Forewing (Fig. 4 a. and c.)

Forewing of *P.demoleus* was elongated; triangular in shape Costa was arched. Dc was closed; it was broad, long, extending two third of the wing. Sc bordering the costal margin. R1emitted parallel to sc and ends before apex the costal margin. R2 emitted from the half at costal margin and ends just before the apex. R3 and R4 emerge from the anterior most corner of the Dc and runs towards the apex such a way to form the rounded shape of the apex, R5 runs straight, branch of form the vein R4. Radials give shape to apex which was slightly pointed. Medians M1 starts from the mid anterior part of Dc then M2 runs, it was short and then M3. All these medians run towards the termen which was slightly scalloped. The Cu1 runs straight and Cu2 slightly curved runs separately from the Dc runs towards tornus. There was a short, stout transverse vein, median spur, present near the base of wing between the Dc and the vein 2A, which was second anal vein, third anal vein3A was distally short.

Hindwing (Fig. 4 b. and d.)

Hindwings were smaller in proportion as compared to forewing. It was triangular in shape. Costal margin was arched. Dc was closed; large, oblique and covers the maximum portion of the wing. The spur vein at the anterior region of the wing. Humeral vein H was curved and pointed towards the apex and forms cell H at the base of 1st vein-(Sc+R1). It arises from the axillary region of the wing and runs along with the costal margin. The 2ndvein was Radial Sector Rs which starts along with the anterior margin of Dc and longer than 1st vein.Sc+R1 and Rs forms apex which is scalloped. The veins extending from the Dc were anterior M1, middle M2 and posterior M3. M3 was less projected than other venues. The Cu1 and Cu2 start from the posterior of cell, and run towards tornus. All the medians and cubitus were present/ the termen and tornus hightly scalloped. And there was only one anal vein 2A at the dorsum.

3.2.3 *G. agamemnon*

Forewing (Fig.5 a. and c.)

Forewing was triangular in shape. Costa was slightly arched. Dc closed, large oblique covers the maximum portion of the forewing. Sc looked like fused with R1.R2 Also runs parallel to the R1 towards the apex. R3 and R4 emitted from the same point and R4 bifurcate into R5 all these veins form the apex which was oblongate to form the obtuse angle. Then the median veins which have three branches M1, M2 and M3 starts from the mid portion of Dc runs straight towards the

terman. The termen was curved and less wavy; The veins, Cu1 and Cu2 were straight and more in length than medians form the tornus, and the last vein was the Anal vein 1A was absent, Second anal vein 2A present. There was a short transverse vein, median spur, present near the base of wing between the base of the wing between the Dc and the vein 2A.The third anal vein 3A was distally short.

Hindwing (Fig 5 b. and d.)
Hindwing mostly narrow.Costal margin slightly arched.The spur vein at the anterior most of the wing was the humeral vein H long, curved, pointed towards apex and it forms cell H at the base of 1st vein. First radial vein was fused. The 2nd vein was Radial Sector Rs which starts along with the anterior margin of Dc.M1 stats from the Dc giving shape to the Dc M2 starts from the Dc and M3 starts from the lower middle of Dc. M3 get elongated at the terman and extend or elongate small in to tail like projection the Cubital veins- Cu1and Cu2, Cu1 was more elongated at tornus than Cu2. Only one Anal vein; 2A present.

3.3 Family Nymphalidae
The butterflies of this family were usually of medium or large size, and many of them were brightly coloured. This family comprises over 6000 species and includes many familiar species. They were sometimes referred to as Brush footed butterflies because in both sexes the non-functional front pair of legs is reduced in size, often covered with tufts of hair-like scales. In Dangs we get following species commonly.

3.3.1 *D. chrysippus*
Forewing (Fig.6 a. and c.)
Forewing was triangular in shape, slightly longer than Hindwing. Costa widely arched. Dc closed, elongated, well over half length of wing. Sc arises from the axillary of the wing and terminates in the middle of the costal margin. R1 and R2 arise separately from the anterior margin of Dc and ends before the apex ends. R3 arise from anterior angle and bifurcate in to R3 and R4+ R5 at apex. Apex was lightly rounded. R4 ending at the apex of the Dc, R5 ending at the terminal margin, M1 begins from the upper angle of Dc, M2 begins from the middle of the Dc, M3 begins from a lower angle of the Dc, runs towards termen, which was slightly concave. Cu1 and Cu2 begin separately from the posterior of Dc, having unequal distance, and runs towards tornus, which was round. 2A arises from the axillary region, separately from the Dc up to the tornus of the wing.

Hindwing (Fig 6 b. and d.)
Hindwings were pear shaped, costa straight. Dc closed, it was more than half length of the wing. 1st vein Sc+ R1 arises from the axillary region, short and separated from the Rs, Rs runs at the costal margin. Apex round. Humeral vein, h, curves toward the proximal region. M1, M2 and M3 originate from upper angle, middle angle and lower angle of the Dc, respectively and run towards termen. Termen was sinuated. Cu1 was parallel to Cu2 arises from Dc runs to form tornus which was round. Two anal veins 2A and 3A arise from the axillary of the wing, 2A ending at the tornus of the wing, 3A ending at dorsal margin.

3.3.2 *E. core*
Forewing (Fig.7 a. and c.)
They run towards the apex which was rounded. Forewing was subtriangular in shape. Costa was straight and oblique. Dc was close and extends towards apex up to half of the length of the wing. Sc starts in the axillary region, ending in the middle third margin of the costal margin. The narrow radial R1 begins next to and parallel to the Sc, R1 ends before the Apex. R2 and R3 emitted from the same point from the upper angle of Dc, R2 was short runs separately. R3 was stalked, get separated. R4 and R5 further run towards apex on the same stalk which was round and therefore forms an inward angle. M1 and M2 begins separately from the upper angle of Dc while the M3 begins separately from the previous lower angle of the Dc. Medians run towards the termen, lightly curved. Latter Cu1 and Cu2 were begins separately from the Dc from the equal distances. 2A was the only anal vein, begins from the axillary region, separated from the Dc and close to anal angle of the wing, this vein curved and recurved towards tornus.

Hindwing (Fig 7 b. and d.)
Hindwing was rounded with the slightly broad Dc which runs up to the half-length of the wing. Dc was closed. (Sc + R1) runs from the axillary region to the rounded apex of the wing. The humeral vein H curves toward the proximal region of the costal margin. M1, M2, and M3 were medial veins, these were closer to each other than the rest of veins and runs towards termen; it was rounded. Cu1 and Cu2 starts from a lower angle of Dc, Cu2 was more elongated than Cu1, runs towards tornus, it was round. Anal veins were separated from the Dc at their bases. 2A ending at the anal angle of the wing, 3A ends at the posterior third of the anal margin

3.3.3 *E. aconthea*
Forewing (Fig.8 a. & c.)
Forewing was triangular in shape. Costa was strongly arched. Dc completely open and narrow. Sc arises from the axillary region runs towards the costal margin and ends after the one half of the costal margin. The first radial R1 was short near the vein Sc and ends at the two third of the coastal margin before the apex of Dc. R2 in not clearly noticed. R3 starts from the half of costal and runs throughout the apex. R4 emitted from the point before R3 rises and runs towards the apex bifurcate into R5 all the radials runs to the apex, which was pointed, acute and obtuse. M1 and M2 starts from two different point runs straight to the termen; it was slightly shifted inward.
M3 vein itself was an extension of the lower margin of the open Dc, runs wide apart and recurved opposite towards the termen. Cu1 and Cu2 from the distal of Dc runs straight the first cu1 was shorter than Cu2 which was elongated outwards the tornus. Tornus was shifted outward, forming slight acute shape. 2A was only the anal vein runs towards tornus.

Hindwing (Fig 8 b. &d.)
Hindwing was somewhat oval in shape. Costa was straight. Dc was completely open. A short spur vein at the anterior most of the wing was the humeral vein H, and excurved towards apex. Sc fuses with R1 (Sc+R1), runs throughout the costa. Radial Sector, a fusion of remaining branches of Radial veins Rs, first Medial vein M1 and M2 were emitted from the same point at the anterior base of Dc base runs obliquely towards the termen, it was outcurved. The third M3 starts from the posterior base point of the Dc looks like giving branch of Cu1and Cu2 which runs outwardly M3 and Cu1 reaches termen and Cu2 runs apart towards the tornus, it was acute. Two anal veins 1A and 2A starts from the axillary region runs towards the anal margin. The third 3A anal vein was absent.

3.4 Family Pieridae

The Whites and Yellows belong to this family of butterflies, most of which were tropical and widely distributed. This family comprising about 1000 species placed in four subfamilies and 85 genera. Abundance of following three members belonging to this family was observed in Dang Dist Gujrat, India

3.4.1 *C. pyranthe*

Forewing (Fig. 9 a. & c.)

Forewing was subtriangular in shape. Costa nearly straight, slightly arched. Dc was closed, extends about less than half length of the wing which was oblique. Sc emitted at more than half before the end of the apex. R1 and R2 both arising separately from Dc, runs towards the costal margin. R3 and M1 arise from same point, they get fused for some distance, then further runs as M1,and R3 forked in to R4 and R5at the apex, This apex was slightly acute. M2 starts from the middle angle and M3 was from a lower angle of Dc all these were well separated towards the termen, it was straight and slightly inwards

Cubitus Cu1 and Cu2 were farthest from medians and even from each other's. Cu2 more in length than the veins emitted from the Dc runs towards tornus it was slightly rounded. Last one anal vein was emerges from the posterior of the Dc which wasA2 runs towards tornus and it was recurved. Fine tuft of silky hair was present along the distal margin of the wing.

Hindwing (Fig 9 b. and d.)

Hindwing broad and conical in shape. Dc was closed. It was regular oval and broad, seen up to 2/3rd the length of the wing. Humeral vein was very short, pointed towards proximal. Sc+R1 starts from axillary and reach to one third before the end of Dc and middle of the costa. Apart from Sc, Rs the radial sector emitted from the Dc and reaching the apex, it was rounded. M1 and M2 were emitted from the Dc which runs towards the terman, the third median M3 was apart from the M2 and runs towards the terman, which was straight. Cubital branches Cu1 and Cu2, it was longer than Cu1.These were starts from the distal of Dc runs at termen forming the slightly wavy shape of termen. Anal veins start separately from the posterior the cell at the base. First anal vein A2 arises separately from the base, straight towards the tornus, it was slightly waved and second anal vein A3 was slightly curved, forming the anal angle. On the wing in between veins the folds or furrows were visible.

3.4.2 *D. eucharis*

Forewing (Fig.10 a. and c.)

Triangular, elongated, narrow. Costa was obliquely straight. Dc was Closed; it was broad extending to more than half of the length of wing. Sc vein was extending to more than two third of the costal margin. R1 emitted just before the Sc ends, and runs throughout the costal margin, end before the apex. R2 was missing. R3 starts from the Dc runs towards the apex and gives out a branch vein, which further runs into R4 and shorter found to be round at the apex. R5 stalked from the same vein (R3) and more in length than other radials and runs towards the upper termen, it was very oblique. The median branches M1, M2 and M3 originates from the anterior of Dc and were roughly equal in length, runs to the terman and oblique in shape. First cubitus vein Cu1 was absent, Cu2 was starts from the lower part of Dc and this vein runs to tornus which was larger than radial and medians. Only one anal vein 2A arises separately from the base which was slightly curved medially. This runs to the tornus and was obtusely rounded.

Hindwing (Fig 10 b. and d.)

It was oval, elongated in shape. The Dc was oval, slightly occupying the half of wing area. Humeral vein was straight, curved at tip. The first vein Sc+R1 was short and much arched. The second Radial sector Rs emitted before the one third of Dc and runs towards the upper costal margin. It was arched.

Three round medial branches M1 and M3 emitted from the lower angles and M2 from the middle upper angle of Dc. All medians runs towards the termen. Upper cubitus vein cu1 and lower cubitus Cu2 emitted from the lower edge of Dc and runs toward tornus, it was also rounded. Anal veins 2A and 3A were arises separately from the base, slightly curved and runs to form the tornus and anal angle respectively.

3.4.3 *P. valeria*

Forewing (Fig.11 a. and c.)

Forewing was triangular with costa strongly arched. Dc was closed; it extends up to half of the length of the wing, elongated, somewhat narrow. Sc and R1 emerge close to each other about three-fourths length of costa. R2 emerges from the Dc before it ends and runs towards the apex, but ends before apex starts. Radials R3, R4 and R5 all were stalked and the branch emitted close together, and runs at the apex which was blunt. These radial veins were shorter in length than other veins. M1 arises from the upper angle of Dc, M2 emerges from the middle, and then from lower angle M3, it was shorter than upper two medians. All appear to be slightly round, sinuate and concave, run towards termen. Cu1 and Cu2 emitted from the lower edge of Dc and runs toward tornus; it was rounded. Anal vein 2A was present, which was arisen separately from the posterior end of Dc which curved and forms the anal angle

Hindwing (Fig 11 b. and d.)

Hindwing was subtriangular in shape, Costa slightly rounded. Dc was long, over half length of wing. Humeral vein H was long, turned slightly curved upward. (Sc+R1) much curve towards its end at the apex, but was shorter, ends before half of the costal margin. Rs start from the Dc and curved to form rounded apex. Medians emitted from the Dc as M1, M2 and M3 and ends at the rounded termen. Of these three medians M1 is longer in length and M2 was longer than the M3. Cu1 and Cu2 emitted from the lower edge of Dc and runs toward tornus; it was rounded. Anal veins 2A and 3A arise separately from the base, runs straight to form the tornus and the anal angle respectively.

4. Discussion

The present study reinforces the understanding of butterfly wing venation belonging to three families from Dang Dist. Gujrat, India. During the collection abundance of *P. polytes, P. demoleus, G. agamemnon* belongs to Family Papillionidae; *D. chrysippus, E. aconthea* and *E. core* from family Nymphalidae; *D. eucharias, C. pyranthe* and *P. valeria* of family Pieridae was found. Butterflies are the best studied higher group of invertebrates whose systematic has been well studied over a century. It's noted that order Lepidoptera comprises of only a few well defined families [21] which includes 18,771 species in 1815 genera [22]. In this context a relative low number of species belonging to family Pieridae for a mega-diverse group was observed .As a result, their higher phylogeny has proved to be hard to resolve. Further no major taxonomical revision in Indian butterflies has been carried out after [23]. In the present study, an attempt was made

to keep the homologization of butterfly wing venation in three families – Papillionidae, Nymphalidae and Pieridae.

It's commonly seen that in all the specimens, both forewing and Hindwing shows a network of longitudinal veins and few cross-sectional veins which divides the wing-surface into characteristic numerous smaller membrane cells. Moreover, veins and venation patterns on these (fore and hind wing) wings of the butterflies are tapering which appears to be a natural adaptation. Interestingly, the bending is due to aerodynamic loading of the wing, which decreases along the wing margin. Tapering of the veins tends to minimize mass and moments of inertia and provide rigidity. Thus, these are important in oscillating structures and particularly in winged species, where energy conservation is necessary.

However, the form of the taper is highly non-linear and must also have a significant influence on the precise form of butterfly family. This is well seen in Family Papillionidae, the true swallowtails, where hindwings are more bent as compared to other two families in studies

The species from family Papillionidae namely *P. Polytes*, G. *Agamemnom* and *P. Demoleus* collected from Dang dist, Gujarat India First vein Sc in butterflies belong to this group is closer to R1, and appears to be fused with R1.The R1, R2 andR3 runs separately and R4+R5 are stalked. Transverse and clear median spur is present between Dc and anal vein 2A. 3A was found to be present in reduced form which does not go with studies reported earlier [20], two anal veins were noted-2A is long while the other 3A is short, curved and do not reach to wing margin at the tornus. In Hindwings of three species under study vein H is present and form small cell at the base of (SC+R1). This (SC+R1) vein runs along the whole costal margin. 2A is only the anal vein recurved at dorsum. Further on Hindwing some noticeable differences in third medians were observed. In *P. Polytes,* vein M3 is larger to form a tail like structure. In G. *agamemnom*M3 form along projection and *P. Demoleus* M3 is long, but less as compared to both above species.

Family Nymphalidae is most diverse within butterflies, both objectively in terms of species and subjectively in terms of the morphological and biological diversity [21]. In spite of this there has not been the same focus on Nymphilidae compared to Papilionidae [25]. Recently thorough understanding in the morphological studies of 12 subfamilies of Nymphilidae is carried out with three genes in the last decades [24, 25]. Moreover, literature survey revealed that more morphological detailing is carried out in Nymphalidae [26] In *D. chrysippus* and *E. core* from collection in belonging to Nymphilidae, the discal cellis found to be completely closed but is opened completely in *E. aconthea* on the both fore and Hindwing s. In the forewing s of these species, Sc is clearly visible. R1 and R2 arises separately and are visible but R2 is not clear in *E. aconthea.*R3 and R4+R5 are staked on R3. Median spur is absent in all three species. In Hindwings of species collected belonging to this family, humeral vein H is found. All veins run in the usual manner. Two anal veins are present 2A and 3A in *D. chrysippus* and *E. core*. In *E. aconthea* 1A and 2A are observed.

Pieridae butterflies are white, yellow, or orange in coloration, often with black spots. The pigments that give the distinct coloring to these butterflies are derived from waste products in the body and are a characteristic of this family. The wing venation of genus *Delias* from family Pieridae [27] stated fore wing with all the veins but in this study *D. eucharias* belonging to this family, showed more variability in the forewing venation as compared to other species of two families under consideration. Forewing of *D. eucharias* revealed an upward movement of the veins, resulting in the fusion and apparent loss of some veins. Radials are diverted in these species. Second radial R2 is missing. Similarly Cu1 is absent in *D. eucharias* whereasCu1 and Cu2 is present in both *C. pyranthe* and *P. valeria* of family Pieridae. Only one anal vein 2A is runs and recurved on margin. Median spur is absent. Hindwings of this family showed the presence of Humeral vein, H in all three species. Other veins run in the usual manner. Two anal veins are present 2A and 3A in all species.

Thus, the present paper discusses the trends and differences in butterfly wing venation in three families – Papillionidae, Nymphalidae and Pieridae. These results are suggestive of significant variations in wings of few collected specimens and also agree to the fact that additional comparative quantitative studies must be carried out. This will surely help in assessment to substantially improve our understanding of lepidopterian wing venation.

5. Conclusion

The present paper discusses the trends and differences in butterfly wing venation in three families – papillionidae, nymphalidae and pieridae. The results suggest significant variations in wings of few collected specimens and also agree to the fact that additional comparative quantitative studies must be carried out. This will surely help in assessment to substantially improve our understanding of lepidopterian wing venation.

6. Acknowledgement

The authors are grateful to the forest department, Dang District, Gujrat for premitting to undertake the scientific study.

7. References

1. Davis AK, Holden MT. Measuring Intraspecific Variation in Flight-Related Morphology of Monarch Butterflies (*Danaus plexippus*): Which Sex Has the Best Flying Gear? Journal of Insects. 2015; Article ID 591705, 6 pages http://dx.doi.org/10.1155/2015/591705
2. Shimmi O, Matsuda S, Hatakeyama M. Insights into the molecular mechanisms underlying diversified wing venation among insects. Proc. R. Soc. B 2014; 281:20140264 http://dx.doi.org/10.1098/rspb.2014.0264.
3. Scoble MJ. The Lepidoptera: Form, Function, and Diversity, Page 63. Google book.
4. Natural History Muesum Publication, 1995.ISBN 0198549520,97801985495
5. Roush W. Wing scales may help beat the heat. Science.1995; 269:5232.
6. Strauss RE. Patterns of quantitative variation in Lepidopteran wing morphology: the convergent groups Heliconiinae and Ithomiina (Papilionoidea: Nymphalidae). Evolution. 1990; 44(1):86-103.
7. Simonsen TJ, Jong R, Heikkiläc M, Kaila L. Butterfly morphology in a molecular age - Does it still matter in butterfly systematics? Arthropod Structure and Development. 2012; 41:307-322.
8. Bingbing Cui, Guangchun Liu. Research Significance of Wing and Vein among Insecta. International Journal of Biology January 2011 3(1). 180 ISSN 1916-9671 E-ISSN 1916-968X.
9. McMillan WO, Monteiro A and Kapan DD. Development and evolution on the wing Trends in

Ecology and Evolution. 2002, 17-3.
10. Beldade P, Brakefield PM. The Genetics And Evo–Devo Of Butterfly Wing Patterns. Institute of Evolutionary and Ecological Sciences, Leiden University, 2002; 3:442-452. doi:10.1038/nrg818.
11. Schachat SR, Brown RL. Color Pattern on the Forewing of Micropterix (Lepidoptera: Micropterigidae): Insights into the Evolution of Wing Pattern and Wing Venation in Moths PLOS ONE. 2015; Doi:10.1371/journal.pone.0139972.
12. Yi Bai, Li Bin Ma, Sheng-Quan Xu, Gui-Hu Wang. A geometric morphometric study of the wing shapes of *Pieris rapae* (Lepidoptera: Pieridae) from the Qinling Mountains and adjacent regions: An environmental and distance-based consideration. 98(1):162-169.Published By: Florida Entomological Society. DOI: http://dx.doi.org/10.1653/024.098.0128.
13. Koch PB, Nijhout HF. The role of wing veins in colour pattern development in the buttery *Papilioxuthus* (Lepidoptera: Papilionidae), European Journal of Entomology. 2002; 99:67-72.
14. Albrecht A, kaila L. Variation of wing venation in Elachistidae (Lepidoptera: Gelochioidea): methodology and implications to systematic. Systematic Entomolgy. 1997; 22:185-198.
15. Bashar MA, Mamun HRK, Chowdhury MAK. Wing-venation as a factor for the identification of Nymphalid butterflies in the forests of Chittagong and cox's bazar (Bangladesh) Bangladesh Journal of. Zoology. 2006; 34(2):187-193.
16. Bethoux O. Wing venation pattern of Plecoptera (Insecta: Neoptera). Illiesia. 2005; 1(9):52-81.
17. Desutter GL. Functional forewing morphology and stridulation in crickets (Orthoptera, Grylloidae). J Zool. 1995; 236:243-252. Doi: 10.1111/j. 1469-7998.tb04491.
18. Mathew G. Variation in the wing venations of *Pteroma plagiophleps* Hampson (Lepidoptera: Psychidae) Journal of research on the Lepidoptera. 1985; 24(4):359-36, 86.
19. Belkin JN, Mcdonald WA. Preparing Lepidoptera for class study, The Lepidopterists' News, 1952.
20. Puri VD. On Preparation of wings neurations in Lepidopera, 1956.
21. Miller LD. Nomenclature of wing veins and cells, Journal of research on the Lepidoptera 1969, 1970; 8(2):37-48.
22. Ackery PR, Jong R, Vane-Wright RI. The butterflies: Hedyloidea, Hesperioidea and Papilionoidea. In: Kristensen NP (Ed.), Lepidoptera, Moths and Butterflies. Evolution, Systematics, and Biogeography. Handbook of Zoology; vol. 1. Walter de Gruyter, Berlin, 1999; 4(35):399-436.
23. Van Nieukerken EJ, Kaila L, Kitching IJ, Kristensen NP, Lees DC, Minet J *et al*. Order Lepidoptera Linnaeus, 1758. In: Zhang ZQ. (Ed.), Animal Biodiversity: An Outline of Higher Classification and Survey of Taxonomic Richness. Zootaxa. 2011; 3148:212-221.
24. Talbot G. The Fauna of British India, Ceylon and Burma, Butterflies, Taylor & Francis, London; 1939, 1, 1947 2
25. Wahlberg N, Wheat CW. Genomic outposts serve the phylogenomic pioneers: designing novel nuclear markers for genomic DNA extractions of Lepidoptera. Systematic Biology. 2008; 57:231-242.
26. Wahlberg N, Leneveu J, Kodandaramaiah U, Peña C, Nylin S, Freitas AVL *et al*. Nymphalid butterflies diversify following near demise at the Cretaceous/Tertiary boundary. Proceedings of the Royal Society Series Biological Sciences 2009; 276:4295-4302.
27. Hall LE. Tympanal Ears in Nymphalidae Butterflies: Morphological Diversity and Tests on the Function of Hearing Carleton University Ottawa, Ontario, Canada. 2014, 1-163.
28. Bingham CT. Fauna of British India, Butterflies Taylor & Francis, London, 1907, 2.