A CLADISTIC ANALSIS OF THE FAMILY SPHINGIDAE (LEPIDOPTERA) FROM PAKISTAN AND AZAD KASHMIR

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Abstract

The cladistic analysis of 29-species of 21-genera of three sub-families were attempted using apomorphic characters from Pakistan and Azad Kashmir. A cladogram is also constructed and included taxa are discussed using above characters.

Introduction

The representatives of the family Sphingidae are commonly known as Hawk moth (Bell and Scott 1937) and are distributed throughout the world. Kamaluddin *et al.* (1999) attempted caldistic analysis, key to the genera and distributional ranges of Sphingidae of Pakistan, discussing outgroup and sistergroup relationship among 5- sub-families and 28-genera using their apomorphies. Kamaludddin *et al.* (1997, 2000, 2013a and 2013b) attempted cladistic analysis of the representatives of the family Lymantridae and Trifinae, Noctuinae and Plusinae of the family Noctuidae respectively. The cladistic relationship on various groups of the order Lepidoptera attempted by Kamaluddin (2003), Kamaluddin *et al.* (2003), Kamaluddin and Viqar (2004a and 2004b), Naz *et al.* (2007), Shakira and Kamaluddin (2011) and Shakira *et al.* (2013).

Meerman (1993) discussed the relationships within the *Hyles euphorbiae*- complex of the family Sphingidae with reference to their numerical taxonomy. Kitching (2002) attempted phylogenetic relationship of Morgan's Sphinx, the *Xanthopan morgani* of tribe *Acherontini* of the family Sphingidae with the help of 109-characters derived from morphology of adult and immature stages, biology and behavioural characters. Kitching (2003) characters scanned from adult, larval and pupal morphology and larva host-plant biology.

Hundsdoerfer *et al.* (2005) analysed the genus *Hyles* with reference to its molecular phylogeny and used DNA sequence. Beck *et al.* (2006) studied measuring range sizes of South-East Asian hawkmoths of the family Sphinigdae and they analysed and compared the phylogenetic non-independence of range size data. Kristensen *et al.* (2007) studied the systematics and phylogeny of moths and butterfly of Lepidoptera and also studied the diversity. Kawahara *et al.* (2009) studied the phylogeny and biogeography of Hawkmoths of the family Sphingidae with reference to their molecular study nuclear genes and concluded that broad-scale geographic distribution in hawkmoths is more phylogenetically conserved than previously postulated.

Materials and Methods

During present study the 201 characters were taken from external morphology of entire body as well as genitalia of both sexes from included taxa and are compared with those characters which are found in outgroup within the family Sphingidae. A cladogram is constructed showing relationship of the included taxa. The code a_o, b_o, c_o, d_o, etc. indicate pleisiomorphy which are not discussed where as the states 1, 2, 3, 4 and so on in ascending order reflect derived, more derived, specially derived and specially more derived.

Result

Characters

Body size (a):

a_0. Body medium sized.
a_1. Body stout and thick (In all Sphingidae and Eupterotidae)
a_2. Body usually moderate or shorter, less than 90mm. (*Sataspes* to *Daphnis*)
a_3. Body usually large sized more than 90mm. (*Agrius* and *Acherontia*)

Head (b):

$b_\circ$. Head usually heterocolourous.
b_1. Head usually entire unicolourous. (*Sataspes* to *Daphnis*)
b_2. Head usually with dead marks (*Agrius* and *Acherontia*)

Probosics (c):

- $c_{\circ}$. Probosics medium sized.
- $c_{1.}$ Probosics very weak (All Eupterotidae)
- $c_{2.}$ Probosics strongly developed (All Sphingidae)

Antenna (d):

- $d_{\circ}$. Antennae filliform.
- $d_{1.}$ Antennae pectinated. (All Eupterotidae)
- $d_{2.}$ Antennae fussiform, pointed at tip and always hooked. (All Sphingidae)

Vertex (e):

- $e_{\circ}$. Vertex entire, normal.
- $e_{1.}$ Vertex convex (*Hyles livornica*)
- $e_{2.}$ Vertex raised (*Hyles gallii*)

Size of frons (f):

- $f_{\circ}$. Frons moderate sized.
- $f_{1.}$ Frons short (*Cephonodes* to *Daphnis*)
- $f_{2.}$ Frons very large (*Macroglossum*)
- $f_{3.}$ Frons reduced (*Pergesa acteus*)

Shape of frons (g):

- $g_{\circ}$. Frons entire not produced.
- $g_{1.}$ Frons rounded or sub-rounded (*Cephonodes* to *Daphnis*)
- $g_{2.}$ Frons well developed produced anteriad (*Nephele* to *Daphnis*)
- $g_{3.}$ Frons anteriorly acutely produced (All Macroglossinae)
- $g_{4.}$ Frons about equal or slightly shorter than palpi (*Macroglossum belis* and *M. stellatarum*)
- $g_{5.}$ Frons much shorter than palpi (*Macroglossum nycteris*)
- $g_{6.}$ Frons sub-rounded not passing palpi (*Acosmeryx sericeus*)
- $g_{7.}$ Frons broad large passing palpi (*Acosmeryx anceus*)

Basal segment / 2nd segment of palpi (h):

- $h_{\circ}$. Basal segment slightly shorter than 2nd.
- $h_{1.}$ Basal segment equal to 2nd. (*Nephele* to *Daphnis*)
- $h_{2.}$ Basal segment much shorter than 2nd. (*Pergesa acteus*)
- $h_{3.}$ Basal segment much longer than 2nd. (*Hippotion celerio*)
- $h_{4.}$ Basal segment more than 3X the 2nd. (*Agrius convolvuli*)

Direction of palpus (I):

- $i_{\circ}$. Palpus directed antero-laterad.
- $i_{1.}$ Palpus directed upward (*Acosmeryx* to *Daphnis*)
- $i_{2.}$ Palpus directed anteriad (*Gnathothlibus*)

Shape of 2nd palpus segment (j):

- $j_{\circ}$. 2nd segment of palpus normal.
- $j_{1.}$ 2nd segment of palpus narrowed (*Dielephila elpenor*)
- $j_{2.}$ 2nd segment of palpus thick (*Deilephila rivularis*)

Scales on Palpus (K) :

- k_{o}. 1st segment of palpus entire.
- $k_{1.}$ 1st segment of palpus without scales on inner surface (*Macroglossum* to *Daphnis*).
- $k_{2.}$ 1st segment of palpus with scales on inner surface (*Sataspes* to *Polyptychus*).
- $k_{3.}$ Palpi narrowed with outer area less scaled (*Sataspes* to *Polyptychus*)
- $k_{4.}$ Palpi thick with outer area thickly scaled (*Macroglossum* to *Daphnis*)

3rd joint of palpus (l) :

- $l_{\circ}$. 3rd joint of palpi moderate.
- $l_{1.}$ 3rd joint of palpi very minute covered with scales (All Sphingidae)
- $l_{2.}$ 3rd joint of palpi about 1/6th of the 2nd (*Hippotion rosetta*)
- $l_{3.}$ 3rd joint of palpi about 1/3rd of the 2nd . (*Hippotion celerio*)

Pronotum (m):

m_0. Pronotum rough.
m_1. Pronotum entire without U-shaped marking. (*Acherontia*)
m_2. Pronotum with inverted U-shaped marking. (*Agrius*)

Frenulum (n):

$n_\circ$. Frenulum absent.
n_1. Frenulum present. (Sphingidae and Eupteritidae)

Wings (o):

$o_\circ$. Wings thickly scaled.
o_1. Wings scaled. (*Gnathothlibus* to *Daphnis*)
o_2. Wings membranous devoid of scale. (*Cephonodes*)

Shape of fore wings (p):

$p_\circ$. Fore wings moderate and broad.
p_1. Fore wings large, narrowed and elongated. (All Sphingidae)

Colour lining and fasciae on fore wings (q):

$q_\circ$. Fore wings without linings or fasciae.
q_1. Fore wings with horizontal linings. (*Acherontia* to *Daphnis*)
q_2. Fore wings with ventral fasciae from base to apex. (*Thretra* to *Deilephila*)
q_3. Fore wings with more than 3-transverse fasciae or without. (*Marumba* to *Smerinthinae*)
q_4. Fore wings with 3- transverse fasciae (*Polyptychus dentatus*)
q_5. Fore wings with pink band on costal margin. (*Leucophlebia lineata*)
q_6. Fore wings with 4- irregular cross bands (*Clanidopsis exausta*)

Veins of fore wings (r):

$r_\circ$. Fore wings with many veins.
r_1. Fore wings with 9-veins (*Leucophlebia* and *Clanidopsis*)
r_2. Fore wings with 10/11-veins (*Clanis* and *Polyptychus*)
r_3. Fore wings with 12-veins (*Theretra alecto*)
r_4. Fore wings with 11-veins (*Smerinthus* kindermannii)
r_5. Fore wings with 10-veins (*Marumba dyras*)

Posterior margin of fore wings (s):

$s_\circ$. Posterior margin of fore wings always straight.
s_1. Posterior margin of fore wings convex or straight (*Leucophlebia* and *Clanidopsis*)
s_2. Postrior margin of fore wings distinctly sinuated (*Clanis* to *Polyptychus*)

Apical margin of fore wings (t):

$t_\circ$. Fore wings with apical margin straight.
t_1. Fore wings with apical margin convex (*Pergesa* to *Daphnis*)
t_2. Apical margin of fore wings crenulated (*Marumba* to *Polyptychus*)
t_3. Fore wings with apical margin distinctly sinuated. (*Acosmeryx*)
t_4. Apical margin of fore wings entire. (*Clanis deucalion*)

Apical angle of fore wings (u):

u_0. Fore wings with apical angle broad.
u_1. Fore wings with apical angle sub-rounded. (*Hyles*)
u_2. Fore wings with apical angle sub-acute (*Deilephila*)

Veins R_2 and R_3 of fore wings (v):

$v_\circ$. Fore wings with veins R_2 and R_3 anastomosing.
v_1. Fore wings with veins R_2 and R_3 separated. (*Thretra* to *Daphnis*)
v_2. Fore wings with veins R_2 and R_3 largely stalked (*Gnathothlibus* erotus)

Veins R_3 and R_4 of fore wings (w):

w_0. Fore wings with veins R_3 and R_4 anastomosing.

$w_{1.}$ Fore wings with veins R_3 and R_4 shortly stalked. (*Macroglossum belis*)
$w_{2.}$ Fore wings with veins R_3 and R_4 largely stalked. (*Macroglossum stellatarum*)
$w_{3.}$ Fore wings with veins R_3 and R_4 very largely stalked. (*Hippotion celerio*)
$w_{4.}$ Fore wings with veins R_3 and R_4 stalked and further stalked with R_5 and originating from upper angle of cell. (*Nephele*)
$w_{5.}$ Fore wings with veins R_3 and R_4 largely stalked further stalked with R_5 and originating from upper angle of cell. (*Daphnis*)

Fore wings with veins R_4 and R_5 (x):

$x_{\circ}$. Fore wings with veins R_4 and R_5 originates above upper angle of cell.
$x_{1.}$ Fore wings with veins R_4 and R_5 largely stalked (*Acherontia styx*)
$x_{2.}$ Fore wings with veins R_5 directly originates from upper angle of cell.(*Hyles gallii*)
$x_{3.}$ Fore wings with veins R_5 originates from upper angle of cell by stalk. (*Hyles livornica*)

Anal veins of fore wings (y):

$y_{0.}$ Fore wings with 3-anal veins.
$y_{1.}$ Fore wings with 2-anal vein (*Hippotion*)
$y_{2.}$ Fore wings with 1-anal vein. (*Hyles* to *Deilephila*)

Colouration of hind wings (z):

$z_{0.}$ Hind wings without any markings.
$z_{1.}$ Hind wings with or without bands. (*Acosmeryx* to *Daphnis*)
$z_{2.}$ Hind wings with rosaceous or ochraceous basal patch. (*Thretra* to *Deilephila*)
$z_{3.}$ Hind wings with sub-apical margin brown. (*Deilephila*)
$z_{4.}$ Hind wings with sub-apical margin black. (*Hyles*)

Apical margin of hind wings (za):

$za_{0.}$ Hind wings with apical margin straight.
$za_{1.}$ Hind wings with apical margin convex or sinuated. (*Pergesa* to *Daphnis*)
$za_{2.}$ Hind wings with apical margin sinuated (*Leucophlebia* to *Polyptychus*)
$za_{3.}$ Hind wings with apical margin somewhat convex. (*Nephele*)
$za_{4.}$ Hind wings with apical margin convex. (*Dolbina gresia*)
$za_{5.}$ Hind wings with apical margin distinctly sinuated. (*Daphnis*)

Hind wings with anal angle (zb):

$zb_{\circ}$. Hind wings with anal angles not prominent.
$zb_{1.}$ Hnd wings with anal angles rounded. (*Hippotion* to *Dielephila*)
$zb_{2.}$ Hind wings with anal angle distinctly lobed. (*Theretra*)

Number of veins in hind wings (zc):

$zc_{\circ}$. Hind wings with more than 9-veins.
$zc_{1.}$ Hind wings with 9-veins. (*Theretra alecto*)
$zc_{2.}$ Hind wings with 8-veins. (*Theretra oldenlandiae*)

Anal veins on hind wings (zd):

$zd_{\circ}$. Hind wings with more than 3-anal veins.
$zd_{1.}$ Hind wings with 2 or 3 anal veins. (*Marumba* to *Polyptychus*)
$zd_{2.}$ Hind wings with 2-anal veins. (*Hyles* to *Deilphila*)
$zd_{3.}$ Hind wings with 1 or 2-anal veins. (*Theretra* to *Daphnis*)
$zd_{4.}$ Hind wings with 3-anal veins. (*Gnathothlibus*)
$zd_{5.}$ Hind wings with only 1- anal vein. (*Clanis*)

Position of anal veins in hind wings (ze):

$ze_{\circ}$. Hind wings with both anal veins stalked.
$ze_{1.}$ Hind wings with both anal veins wide apart. (*Dolbina* to *Polyptychus*)
$ze_{2.}$ Hind wings with anal veins meeting at base. (*Sataspes*)

Position of Sc + R_1 on hind wings (zf):

$zf_{\circ}$. Hind wings with Sc + R_1 close to costal margin.
$zf_{1.}$ Hind wings with Sc + R_1 connected with cell by cross vein.(All Sphingidae)

$zf_{2.}$ Hind wings with Sc + R_1 parallel to Rs. (*Deilephila*)
$zf_{3.}$ Hind wings with Sc + R_1 unite with Rs directly or by cross vein.(*Hyles*)
$zf_{4.}$ Hind wings with Sc + R_1 wide apart. (*Acosmeryx sericeus*)
$zf_{5.}$ Hind wings with Sc + R_1 fused with Rs. (*Hyles gallii*)
$zf_{6.}$ Hind wings with Sc + R_1 separated from Rs. (*Leucophlebia*)
$zf_{7.}$ Hind wings with Sc + R_1 unite with Rs by cross vein. (*Polyptychus*)
$zf_{8.}$ Hind wings with Sc + R_1 largely stalked with Rs. (*Clanidopsis*)
$zf_{9.}$ Hind wings with veins Sc + R_1 anastomosing with Rs and originating from upper angle of cell.(*Acosmeryx anceus*)

Position of veins Rs and M_1 on hind wings (zg):

$zg_{\circ}$. Hind wings with veins Rs and M_1 wide apart.
$zg_{1.}$ Hind wings with veins Rs & M_1 anastomosing. (*Hippotion celerio*)
$zg_{2.}$ Hind wings with veins Rs & M_1 stalked. (*Hippotion rosetta*)
$zg_{3.}$ Hind wings with Rs & M_1 originating from upper angle of cell. (*Acosmeryx sericeus*)

Position of veins M_3 and Cu_1 on hind wings (zh):

$zh_{\circ}$. Hind wings with veins M_3 and Cu_1 parallel to each other.
$zh_{1.}$ Hind wings with veins M_3 & Cu_1 wide apart. (*Gnathothlibus* to *Daphnis*)
$zh_{2.}$ Hind wings with veins M_3 & Cu_1 wide apart only M_3 originating from lower angle of cell. (*Macroglossum belis* & *M. stellatarum*)
$zh_{3.}$ Hind wings with veins M_3 & Cu_1 anastomosing and originating from lower angle of cell. (*Macroglossum nycteris*)

Abdomen (zi):

$zi_{\circ}$. Abdomen narrowed.
$zi_{1.}$ Abdomen stout and thick. (Sphingidae & Eupterotidae)
$zi_{2.}$ Abdomen distally narrowed without tuft of hairs. (*Dolbina* to *Polyptychus*)
$zi_{3.}$ Apex of abdomen broad. (Eupterotidae)
$zi_{4.}$ Abdomen with medium vertical dark-line. (*Dolbina gresia*)
$zi_{5.}$ Abdomen distinctly broad with tuft of hairs. (*Sataspes infernalis*)

Symmetry of paramere (zj):

$zj_{1.}$ Paramere symmetrical with process. (*Gnathothlibus* to *Daphnis*)
$zj_{2.}$ Paramere asymmetrical. (*Cephonodes*)

Shape and structure of paramere (zk):

$zk_{\circ}$. Paramere entire.
$zk_{1.}$ Paramere unilobed. (*Dolbina* to *Polyptychus*)
$zk_{2.}$ Apex of paramere rounded without spine. (*Leuco[phlebia* & *Clanidopsis*)
$zk_{3.}$ Apex of paramere very wide & spinose at base. (*Clanis* to *Polyptychus*)
$zk_{4.}$ Apex of paramere broadly rounded. (*Hyles livornica*)
$zk_{5.}$ Apex of paramere narrowed. (*Hyles gallii*)
$zk_{6.}$ Paramere distally divided (*Sataspes*)
$zk_{7.}$ Apex of paramere broad with a spine-like process at outer basal margin. (*Theretra oldenlandiae*)
$zk_{8.}$ Apex of paramere narrowed with a spine-like process at inner margin. (*Theretra alecto*)

Hairs on paramere (zl):

$zl_{\circ}$. Paramere without hairs.
$zl_{1.}$ Paramere besets with hairs. (*Deilephila rivularis*)
$zl_{2.}$ Paramere besets with large hairs and setae. (*Deilephila elpenor*)

Frictional scales on paramere (zm):

$zm_{\circ}$. Paramere without frictional scales.
$zm_{1.}$ Paramere with 2 or 3-frictional scales at inner apical margin. (*Hippotion* to *Deilephila*)
$zm_{2.}$ Paramere with 2-friction scales. (*Hippotion rosetta*)
$zm_{3.}$ Paramere with 3-friction scales. (*Hippotion celerio*)

Process on paramere (zn):

- $zn_{\circ}$. Paramere entire and smooth.
- $zn_{1.}$ Paramere with thorn-like or dentated process at inner margin. (*Pergesa* to *Daphnis*)
- $zn_{2.}$ Paramere with two or more spines at base. (*Acherontia*)
- $zn_{3.}$ Paramere with an Axe-shaped process at base. (*Acosmeryx*)
- $zn_{4.}$ Paramere with curved process at base. (*Nephele*)
- $zn_{5.}$ Paramere with sclerotized serrated plate. (*Daphnis*)

Process at margins of paramere (zo):

- $zo_{\circ}$. Paramere entire without process.
- zo_{1}. Paramere with one or without any process at inner margin. (*Leucophlebia* to *Polyptychus*)
- $zo_{2.}$ Paramere with thorn-like process at inner basal margin. (*Macroglossum nycteris*)
- $zo_{3.}$ Large sickle shaped process at ventro-outer margin of paramere. (*Marumba*)
- $zo_{4.}$ Large blunt process at ventro-outer margin of paramre. (*Smerinthus*)
- $zo_{5.}$ Paramere with 3-tooth like process at inner apical margin. (*Dolbina)*
- $zo_{6.}$ Paramere with club-shaped apex of thorn-like process. (*Macroglossum stellatarum*)
- $zo_{7.}$ Paramere with narrowed apex of thorn-like process. (*Macroglossum belis*)
- $zo_{8.}$ Paramere with cross shaped spines at outer proximal margin. (*Acherontia lachesis*)

Uncus (zp):

- $zp_{\circ}$. Uncus simple broad.
- $zp_{1.}$ Uncus unilobed. (*Hyles* to *Deilephila)*
- $zp_{2.}$ Uncus bilobed. (*Canidopsis exausta*)
- $zp_{3.}$ Uncus bifurcated. (*Marumba dyras*)

Length of uncus and gnathos (zq):

- $zq_{\circ}$. Uncus equal to gnathos.
- $zq_{1.}$ Uncus slightly longer than gnathos. (*Macroglossum belis* & *M. stellatarum*)
- $zq_{2.}$ Uncus much longer than gnathos. (*Macroglossum nycteris*)

Shape of uncus (zr):

- $zr_{\circ}$. Uncus straight.
- $zr_{1.}$ Uncus simple slightly curved. (*Gnathothlibus* to *Daphnis*)
- $zr_{2.}$ Uncus slightly curved. (*Acherontia styx*)
- $zr_{3.}$ Uncus curved beak-shaped. (*Cephonodes hylas*)

Margin of uncus (zs):

- $zs_{\circ}$. Outer and inner margin of uncus straight.
- $zs_{1.}$ Uncus outer margin convex inner margin concave. (*Daphnis nerii*)
- $zs_{2.}$ Uncus outer and inner margin sinuated. (*Nephele*)

Apex of uncus (zt):

- $zt_{\circ}$. Uncus with blunt apex.
- $zt_{1.}$ Uncus with narrowed apex. (*Acherontia*)
- $zt_{2.}$ Apex sharply pointed. (*Hyles livornica*)
- $zt_{3.}$ Truncated apex. (*Agrius*)

Gnathos (zu):

- $zu_{\circ}$. Gnathos broad and entire.
- $zu_{1.}$ Gnathos narrowed entire. (*Deilephila elpenor*)
- $zu_{2.}$ Gnathos dentated inner apical margin. (*Macroglossum stellatarum*)
- $zu_{3.}$ Gnathos broad with dentitions on inner apical margin. (*Deilephila rivularis*)

Saccus (zv):

- $zv_{\circ}$. Saccus reduced.
- $zv_{1.}$ Saccus u-shaped proximally dilated. (*Hippotion* to *Deilephila*)
- $zv_{2.}$ Saccus V- or U-shaped. (*Gnathothlibus* to *Daphnis*)
- $zv_{3.}$ Saccus V-shaped, proximally narrowed. (*Theretra*)
- $zv_{4.}$ Saccus globular. (*Cephonodes hylas*)
- $zv_{5.}$ Saccus proximally with prominent lobe. (*Dolbina gresia*)

Aedeagus (Theca) (zw):

- $zw_{\circ}$. Simple without thecal appendage.
- $zw_{1.}$ Aedeagus rod-like and narrowed. (*Acherontia*)
- $zw_{2.}$ Aedeagus short and thick. (*Agrius*)
- $zw_{3.}$ Aedeagus with plate-like thecal appendage. (*Canidopsis exausta*)
- $zw_{4.}$ Aedeagus with theca bifurcated. (*Leucophlebia lineata*)
- $zw_{5.}$ Enclosed medially by membrane.(*Acosmeryx anceus*)
- $zw_{6.}$ Theca with beak-shaped thecal appendage. (*Polyptychus dentatus*)
- $zw_{7.}$ Aedeagus with crenulated thecal appendage. (*Hippotion rosetta*)

Membranous conjunctival appendage (zx):

- $zx_{\circ}$. Membranous conjunctiva simple without appendages.
- $zx_{1.}$ Entire or small appendage. (*Cephonodes* to *Daphnis*)
- $zx_{2.}$ One pair of large rod-like appendage. (*Macroglossum*)
- $zx_{3.}$ Thread like membranous conjunctival lobe (*Sataspes*)
- $zx_{4.}$ Membranous conjunctival lobe with two group of dot-like cornuti. (*Smerinthus*)
- $zx_{5.}$ Membranous conjunctival lobe with 3-dentated cornuti. (*Deilephila rivularis*)
- $zx_{6.}$ Membranous conjunctival lobe with one group of dot-like cornuti with a pair of small hook-like appendage. (*Marumba dyras*)
- $zx_{7.}$ Membranous conjunctival lobe with dot-like cornuti and a pair of antennae shaped appendage. (*Leucophlebia lineata*)
- $zx_{8.}$ Membranous conjunctival lobe with cornuti distally two small, two large horn-like lobe. (*Clanidopsis exausta*)

Papillae anales (zy):

- $zy_{\circ}$. Papillae anales large simple.
- $zy_{1.}$ Papillae anales moderate. (*Theretra* to *Daphnis*)
- $zy_{2.}$ Papillae anales large rectangular shaped. (*Gnathothlibus erotus*)
- $zy_{3.}$ Papillae anales trapaezoid shaped. (*Nephele hespera*)
- $zy_{4.}$ Papillae anales with posterior margin convex. (*Hyles gallii*)
- $zy_{5.}$ Papillae anales sub-rounded. (*Acherontia styx*)
- $zy_{6.}$ Papillae anales with posterior margin sinuated. (*Hyles livornica*)
- $zy_{7.}$ Papillae anales truncated. (*Acherontia lachesis*)
- $zy_{8.}$ Papillae anales with sclerotized process at dorsal side. (*Clanis deucalion*)

Apophysesses (zz):

- $zz_{\circ}$. Apex of both apophysesses pointed and moderate sized.
- $zz_{1.}$ Apex of apophysis anterior dilated. (*Hyles gallii*)
- $zz_{2.}$ Apex of apophysis anterior moderate club-shaped. (*Pergesa acteus*)
- $zz_{3.}$ Both apophysis very large with apex club-shaped. (*Gnathothlibus*)
- $zz_{4.}$ Apex of apophyisis anterior pointed. (*Nephele hespera*)
- $zz_{5.}$ Apex of apophysis anterior truncated. (*Daphnis nerii*)

Ductus bursae (zza):

- $zza_{\circ}$. Ductus bursae short and narrowed.
- $zza_{1.}$ Ductus bursae straight. (*Marumba* and *Smerinthus*)
- $zza_{2.}$ Ductus bursae twisted distally dilated. (*Polyptychus dentatus*)
- $zza_{3.}$ Ductus bursae short. (*Gnathothlibus*)
- $zza_{4.}$ Ductus bursae short and broad. (*Theretra alecto*)
- $zza_{5.}$ Ductus bursae elongated and narrowed. (*Theretra oldenlandiae*)

Corpus bursae (zzb):

- $zzb_{\circ}$. Corpus bursae short.
- $zzb_{1.}$ Corpus bursae large balloon-shaped cornuti. (*Gnathothlibus* to *Daphnis*)
- $zzb_{2.}$ Corpus bursae usually elongate cornuti. (*Theretra* to *Daphnis*)
- $zzb_{3.}$ Corpus bursae moderate proximally straight. (*Nephele* to *Daphnis*)
- $zzb_{4.}$ Corpus bursae with U-shaped and many dot-like cornuti. (*Clanis deucalion*)
- $zzb_{5.}$ Corpus bursae bifurcated large cornuti. (*Theretra oldenlandiae*)
- $zzb_{6.}$ Corpus bursae large proximally hook-shaped. (*Pergesa acteus*)

Character States

Body size (a): Body stout and thick in all Sphingids and Eupterods shows their synapomorphic condition (a_1). *In Sataspes, Dolbina, Leucophlebia, Clanidopsis, Clanis, Marumba, Smerinthus, Polyptychus, Macroglossum, Cephonodes, Gnathothlibus, Theretra, Hippotion, Hyles, Deilephila, Acosmeryx, Pergesa, Nephele* and *Daphnis* the body usually moderate or shorter, less than 90mm, show their derived synapomorphic state (a_2). The body usually large sized more than 90mm in *Agrius* and *Acherontia* shows their more derived synapomorphic condition (a_3).

Head (b): Head usually entire and unicolourous from *Sataspes* to *Daphnis* shows their synapomorphic condition (b_1). In *Agrius* and *Acherontia* the head is usually with dead marks show their derived synapomorphic characters (b_2).

Probosics (c): Probosics very weak in all Eupterods shows their synapomorphic condition (c_1). In all Sphingids proboscis is strongly developed shows their derived synapomorphic characters (c_2).

Antenna (d): Antennae pectinated in all the representatives of the family Eupterotidae shows their synapomorphic condition (d_1). In all the representatives of the family Sphingidae the antennae fussiform, pointed at tip and always hooked shows their derived synapomorphic condition (d_2).

Vertex (e): Vertex convex in *Hyles livornica* shows its synapomorphic condition (e_1). In *Hyles gallii* vertex is raised shows its derived synapomorphic characters (e_2).

Size of frons (f): Frons short from *Cephonodes* to *Daphnis* shows their synapomorphic condition (f_1). The frons very large in *Macroglossum* shows its derived synapomorphic condition (f_2). In *Pergesa acteus* the frons is reduce shows autapomorphic condition (f_3).

Shape of frons (g): Frons rounded or sub-rounded from *Cephonodes* to *Daphnis* shows their synapomorphic state (g_1). In *Nephele hespera* and *Daphnis nerii* frons well developed produced anteriad shows their derived synapomorphic condition (g_2). The frons anteriorly acutely produced in *Macroglossum belis, M. nycteris, and M. stellatarum* shows their more derived synapomorphic condition (g_3). In *M. belis* and *M. stellatarum* the frons is about equal or slightly shorter than palpi shows their specially derived synapomorphic condition (g_4). Frons much shorter than palpi in *Macroglossum nycteris* shows its autapomorphic condition (g_5). In *Acosmeryx sericeus* the frons is sub-rounded but not passing palpi shows its derived autapomorphic condition (g_6). The frons is broad large and passing palpi in *Acosmeryx anceus* shows its more derived autapomorphic condition (g_7).

Basal versus 2nd segment of palpi (h): The basal segment of palpi equal to 2nd segment from *Nephele* to *Daphnis* shows their synapomorphic condition (h_1). In *Pergesa acteus* the basal segment of palpi much shorter than 2nd segment shows its autapomorphic condition (h_2). The basal segment of palpi much longer than 2nd segment in *Hippotion celerio* shows its derived autapomorphic condition (h_3). In *Agrius convolvuli* the basal segment of palpi more than 3X the 2nd segment shows its more derived autapomorphic condition (h_4).

Direction of palpus (i): The palpus directed upward from *Acosmeryx* to *Daphnis* shows their synapomorphic condition (i_1). In *Gnathothlibus erotus* the palpus directed anteriad shows its autapomorphic condition (i_2).

Shape of 2nd palpus segment (j): Second segment of palpus narrowed in *Deilephila elpenor* shows its autapomorphic condition (j_1). In *Deilephila rivularis* the second segment of palpus thick shows its derived autapomorphic state (j_2).

Scales on palpus (k): First segment of palpus without scales on inner surface from *Macroglossum* to *Daphnis* shows their synapomorphic condition (k_1). In *Sataspes* to *Polyptychus* the first segment of palpus with scales on inner surface shows their derived synapomorphic condition (k_2). Palpi narrowed with outer area less scaled in *Sataspes* to *Polyptychus* shows their more derived synapomorphic condition (k_3). In *Macroglossum* to *Daphnis* the palpi thick with outer area thickly scaled shows their specially derived synapomorphic state (k_4).

Third joint of palpus (l): Third joint of palpi very minute covered with scales in all the representatives of the family Sphingidae shows their synapomorphic condition (l_1). In *Hippotion celerio* the third joint of palpi about 1/3rd the length of second segment shows its autapomorphic condition (l_2). The third joint of palpi about 1/6th the length of second segment in *Hippotion rosetta* shows its derived autapomorphic state (l_3).

Pronotum (m): Pronotum entire without U-shaped marking in species of Acherontia shows their synapomorphic condition (m_1). In *Agrius convolvuli* the pronotum with inverted U-shaped markings shows its autapomorphic state (m_2).

Frenulum (n): The frenulum present in all the representatives of the family Sphingidae and Eupterotidae shows their synapmorphic condition (n_1).

Wings (o): Both wings scaled in *Gnathothlibus* to *Daphnis* shows their synapomorphic condition (o_1). In *Cephonodes hylas* the wings are membranous devoid of scales shows its autapomorphic condition (o_2).

Shape of fore wings (p): Fore wings large, narrowed and elongated in all the representatives of the family Sphingidae shows their synapomorphic condition (p_1).

Colour and lining on fore wings (q): Fore wings with horizontal linings from *Acosmeryx* to *Daphnis* shows their synapomorphic condition (q_1). In *Theretra* to *Deilephila* the fore wings with ventral fasciae from base to apex shows their derived synapomorphic condition (q_2). The fore wings with more than 3-fasciae or sometimes without fasciae from *Marumba* to *Smerinthus* shows their more derived synapomorphic condition (q_3). In *Polyptychus dentatus* fore wings with three transverse fasciae shows its autapomorphic condition (q_4). In *Leucophlebia lineata* the fore wings with pink band on costal margin shows its derived autapomorphic condition (q_5). The fore wings with four irregular cross bands in *Clanidopsis exausta* shows more derived autapomorphic condition (q_6).

Veins of fore wings (r): Fore wings with 9-veins from *Leucophlebia* and *Clanidopsis* shows their synapomorphic condition (r_1). In *Clanis*, *Marumba*, *Smerinthus* and *Polyptychus* the fore wings with 10 or 11-veins shows their derived synapomorphic condition (r_2). The fore wings in *Theretra alecto* the froe wings with 12-veins shows its autapomorphic condition (r_3). In *Smerinthus kindermannii* the fore wings with 11-veins shows its derived autapomorphic condition (r_4). In *Marumba dyras* the fore wings with 10-veins shows its more derived autapomorphic condition (r_5).

Posterior margin of fore wings (s): Posterior margin of fore wings convex or straight in *Leucophlebia* and *Clanidopsis* shows their synapomorphic condition (s_1). In *Clanis*, *Marumba*, *Smerinthus* and *Polyptychus* the posterior margin of fore wings distinctly sinuated shows their synapomorphic condition (s_2).

Apical margin of fore wings (t): Fore wings with apical margin convex from *Pergesa* to *Daphnis* shows their synapomorphic condition (t_1). In *Marumba*, *Smerinthus* and *Polyptychus* the apical margin of fore wings crenulated shows their derived synapomorphic condition (t_2). The apical margin of fore wings distinctly sinuated in both species of *Acosmeryx* shows their derived synapomorphic condition (t_3). In *Clanis* deucalion the apical margin of fore wings entire shows its autapomorphic condition (t_4).

Apical angle of fore wings (u): Apical angle of fore wings sub-rounded in both species of *Hyles* shows their synapomorphic condition (u_1). In both species of *Deilephila* the apical angle of fore wings sub-acute shows their derived synapomorphic condition (u_2).

Veins R_2 and R_3 of fore wings (v): Fore wings with veins R_2 and R_3 separated from *Theretra* to *Daphnis* shows their synapomorphic condition (v_1). In *Gnathothlibus erotus* the fore wings with veins R_2 and R_3 largely stalked shows its autapomorphic condition (v_2).

Fore wings with veins R_3 and R_4 (w): Fore wings with veins R_3 and R_4 shortly stalked in *Macroglossum belis* shows its autapomorphic condition (w_1). In *Macroglossum stellatarum* the fore wings with veins R_3 and R_4 largely stalked shows its derived autapomorphic condition (w_2). Fore wings with veins R_3 and R_4 very largely stalked in *Hippotion celerio* shows its more derived autapomorphic condition (w_3). In *Nephele hespera* the fore wings with veins R_3 and R_4 stalked and further stalked with R_5 and originating from upper angle of cell shows its specially derived autapomorphic condition (w_4). The fore wings with veins R_3 and R_4 largely stalked with R_5 and originating from upper angle of cell shows its specially more derived autapomorphic conditions (w_5).

Fore wings with veins R_4 and R_5 (x): Fore wings with veins R_4 or R_5 originates from above upper angle of cell in *Acherontia styx* shows its autapomorphic condition (x_1). In *Hyles gallii* the fore wings with veins directly originates from upper angle of cell shows its derived autapomorphic condition (x_2). The fore wings with veins

R_5 originates from upper angle of cell by stalk in *Hyles livornica* shows its more derived autapomorphic condition (x_3).

Anal veins of fore wings (y): Fore wings with two anal veins in *Hippotion celerio* and *H. rosetta* shows their synapomorphic condition (y_1). In *Hyles gallii*, *H. livornica*, *Deilephila elpenor* and *D. rivularis* the fore wings with simple anal vein shows their derived synapomorphic condition (y_2).

Colouration of hind wings (z): Hind wings with or without bands from *Acosmeryx* to *Daphnis* shows their synapomorphic condition (z_1). In *Theretra* to *Deilephila* the hind wings with rosaceous or ochraceous basal patch shows their derived synapomorphic condition (z_2). Hind wings with sub-apical margin brown in *Deilephila elpenor* and *D. rivularis* shows their more derived synapomorphic condition (z_3). In *Hyles gallii* and *H. livornica* the hind wings with sub-apical margin black shows specially derived synapomorphic condition (z_4).

Apical margin of hind wings (za): Hind wings with apical margin convex in *Pergesa* to *Daphnis* shows their synapomorphic condition (za_1). In *Leucophlebia* to *Polyptychus* the hind wings with apical margin sinuated shows their derived synapomorphic condition (za_2). Hind wings with apical margin somewhat convex in *Nephele hespera* shows its autapomorphic condition (za_3). In *Dolbina gresia* the hind wings with apical margin broadly convex shows its derived autapomorphic condition (za_4). The hind wings with apical margin distinctly sinuated shows its more derived autapomorphic condition (za_5).

Hind wings with anal angles (zb): Hind wings with anal angle rounded in *Hippotion* to *Deilephila* shows their synapomorphic condition (zb_1). In the both species of the genus *Theretra* the hind wings with anal angles distinctly lobed shows their derived synapomorphic condition (zb_2).

Number of veins in hind wings (zc): The hind wings with 9-veins in *Theretra alecto* shows its autapomorphic condition (zc_1). In *Theretra oldenlandiae* the hind wings with 8-veins shows its derived autapomorphic condition (zc_2).

Anal veins on hind wings (zd): Hind wings with one or two anal veins in *Theretra* to *Daphnis* shows their synapomorphic condition (zd_1). In *Hyles* to *Deilephila* the hind wings with two anal veins shows their derived synapomorphic condition (zd_2). Hind wings with two to three anal veins in *Marumba* to *Polyptychus* shows their more derived synapomorphic condition (zd_3). In *Gnathothlibus erotus* the hind wings with three anal veins shows its autapomorphic condition (zd_4). The hind wings with only one anal veins in *Clanis deucalion* shows its derived autapomorphic condition (zd_4).

Position of anal veins in hind wings (ze): Hind wings with both anal veins wide apart in *Dolbina* to *Polyptychus* shows their synapomorphic condition (ze_1). In *Sataspes infernalis* the hind wings with anal veins meeting at base shows its autapomorphic condition (ze_2).

Position of Sc + R_1 on hind wings (zf): Hind wings with $Sc+R_1$ connected with cell by cross veins in all the representatives of the family Sphingidae shows their synapomorphic condition (zf_1). In *Deilephila elpenor* and *D. rivularis* the hind wings with $Sc+R_1$ parallel to Rs shows their derived synapomorphic condition (zf_2). Hind wings with $Sc+R_1$ unite with Rs directly or by cross veins in *Hyles gallii* and *H. livornica* shows their more derived synapomorphic condition (zf_3). In *Acosmeryx sericeus* the hind wings with $Sc+R_1$ wide apart shows its autapomorphic condition (zf_4). The hind wings with $Sc+R_1$ fused with Rs in *Hyles gallii* shows its derived autapomorphic condition (zf_5). In *Leucophlebia lineata* the hind wings with $Sc+R_1$ separated from Rs shows its more derived autapomorphic condition (zf_6). The hind wings with $Sc+R_1$ unite with Rs by cross veins in *Polyptychus dentatus* shows its special autapomorphic condition (zf_7). In *Clanidopsis exausta* the hind wings with $Sc+R_1$ largely stalked with Rs shows its specially derived autapomorphic condition (zf_8). The hind wings with veins $Sc+R_1$ anastomosing with Rs and originating from upper angle of cell in *Acosmeryx anceus* shows its specially more derived autapomorphic condition (zf_9).

Position of veins Rs and M_1 on hind wings (zg): Hind wings with veins Rs and M_1 anastomosing in *Hippotion celerio* shows its autapomorphic condition (zg_1). In *Hippotion rosetta* the hind wings with veins Rs and M_1 stalked shows its derived autapomorphic condition (zg_2). The hind wings with Rs and M_1 originating from upper angle of cell in *Acosmeyx sericeus* shows its more derived autapomorphic condition (zg_3).

Position of veinsM_3 and Cu_1 on hind wings (zh): Hind wings with veins M_3 and Cu_1 wide apart from *Gnathothlibus* to *Daphnis* shows their synapomorphic condition (zh_1). In *Macroglossum belis* and *M. stellatarum* the hind wings with veins M_3 and Cu_1 wide apart only M_3 originating from lower angle of cell

shows its derived synapomorphic condition (zh_2). The hind wings with veins M_3 and Cu_1 anastomosing and originating from lower angle of cell in *Macroglossum nycteris* shows its autapomorphic condition (zh_3).

Abdomen (zi): Abdomen stout and thick in all the representatives of the family Sphingidae and Eupterotidae shows their sunapomorphic condition (zi_1). In the species of genera *Dolbina* to *Polyptychus* the abdomen distinctly narrowed without tuft of hairs shows derived synapomorphic condition (zi_2). The apex of abdomen broad in all the representatives of Eupterotidae shows their more derived synapomorphic condition (zi_3). In *Dolbina gresia* the abdomen with median vertical dark line shows its autapomorphic condition (zi_4). Abdomen distinctly broad with tuft of hairs in *Sataspes infernalis* shows its derived autapomorphic condition (zi_5).

Symmetry of paramere (zj): Paramere symmetrical with process in the representatives of the genera *Gnathothlibus* to *Daphnis* shows their synapomorphic condition (zj_1). In *Cephonodes hylas* the paramere are asymmetrical shows its autapomorphic condition (zj_2).

Shape and structure of paramere (zk): Paramere unilobed in the representatives of the genera *Dolbina* to *Polyptychus* shows their synapomorphic condition (zk_1). In *Leucophlebia lineata* and *Clanidopsis exausta* the apex of paramere rounded without spine shows their derived synapomorphic condition (zk_2). Apex of paramere very wide and spinose at base in the representatives of the genera *Clanis* to *Polyptychus* shows their more derived synapomorphic condition (zk_3). In *Hyles livornica* the apex of paramere narrowed shows its autapomorphic condition (zk_4). The apex of paramere narrowed in *Hyles gallii* shows its derived autapomorphic condition (zk_5). In *Sataspes infernalis* the paramere distally divided shows its more derived autapomorphic condition (zk_6). Apex of paramere baroad with a spine-like process at outer basal margin in *Theretra oldenlandiae* shows its sspecially derived autapomorphic condition (zk_7). In *Theretra alecto* the apex of paramere narrowed with a spine-like process at inner margin shows its specially more derived autapomorphic condition (zk_8).

Hiars on paramere (zl): Paramere besets with hairs in *Deilephila rivularis* shows its autapomorphic condition (zl_1). In *Deilephila elpenor* the paramere besets with large hairs and setae shows its derived autapomorphic condition (zl_2).

Frictional scales on paramere (zm): Paramere with two or three frictional scales at inner apical margin in the representatives of the genera of *Hippotion* to *Deilephila* shows their synapomorphic condition (zm_1). In *Hippotion rosetta* the paramere with two frictional scales shows its autapomorphic condition (zm_2). The paramere with three frictional scales in *Hippotion celerio* shows its derived autapomorphic condition (zm_3).

Process on paramere (zn): Paramere with thorn-like or dentated process at inner margin in the representatives of the genera *Pergesa acteus*, *Nephele hespera* and *Daphnis nerii* shows their synapomorphic characters (zn_1). In *Acherontia styx* and *A.lachesis* the paramere with two or more spines at base shows their derived synapomorphic condition (zn_2). Paramere with axe-shaped process at base in *Acosmeryx anceus* and *A. sericeus* shows their more derived synapomorphic condition (zn_3). In *Nephele hespera* the paramere with curved process at base shows its autapomorphic condition (zn_4). The paramere with sclerotized serrated plate in *Daphnis nerii* shows its derived autapomorphic condition (zn_5).

Process at margins of paramere (zo): Paramere withone or without any process at inner margin in *Leucophlebia* to *Polyptychus* shows their synapomorphic condition (zo_1). In *Macroglossum nycteris* the paramere with thorn-like process at inner basal margin shows its autapomorphic condition (zo_2). Paramere with a large sickle shaped process at ventro-outer margin in *Marumba dyras* shows its derived autapomorphic condition (zo_3). In *Smerinthus kindermannii* paramere with a large blunt process at ventro-outer margin shows its more drived autapomorphic condition (zo_4). Paramer with three tooth-like process at inner apical margin in *Dolbina grisea* shows its special autapomorphic condition (zo_5). In *Macroglossum stellatarum* the paramere with club-shaped apex of thorn-like process shows its specially derived autapomorphic condition (zo_6). The paramere with narrowed apex of thorn-like process in *Macroglossum belis* shows its specially more derived autapomorphic condition (zo_7). In *Acherontia lachesis* the paramere with cross shaped spines at outer proximal margin shows its specially peculiar autapomorphic condition (zo_8).

Uncus (zp): Uncus unilobed in the representatives of the genera *Hyles* and *Deilephila* shows their synapomorphic condition (zp_1). In *Clanidopsis exausta* the uncus bilobed shows its autapomorphic condition (zp_2). Uncus bifurcated in *Marumba dyras* shows its derived autapomorphic condition (zp_3).

Length of uncus and gnathos (zq): Uncus slightly longer than gnathos in *Macroglossum belis* and *M. stellatarum* shows their synapomorphic condition (zq_1). In *Macroglossum nycteris* the uncus much longer than gnathos shows its autapomorphic condition (zq_2).

Shape of uncus (zr): Uncus simple slightly curved in the representatives of the genera *Gnathothlibus* to *Daphnis* shows their synapomorphic condition (zr_1). In *Acherontia styx* the uncus slightly curved shows its autapomorphic condition(zr_2). The uncus curved beak-shaped in *Cephonodes hylas* shows its derived autapomorphic condition (zr_3).

Margin of uncus (zs): Uncus with outer margin convex and inner margin concave in *Daphnis nerii* shows its autapomorphic condition (zs_1). In *Nephele hespera* the outer and inner margin of uncus sinuated shows its derived autapomorphic condition (zs_2).

Apex of uncus (zt): Uncus with narrowed apex in *Acherontia styx* and *Acherontia lachesis* shows their synapomorphic condition (zt_1). In *Hyles livornica* the apex of uncus sharply pointed shows its autapomorphic condition (zt_2). Uncus with truncated apex in *Agrius convolvuli* shows its derived autapomorphic condition (zt_3).

Gnathos (zu): Gnathos narrowed and entire in *Deilephila elpenor* shows its autapomorphic condition (zu_1). In *Macroglossum stellatarum* the inner apical margin centated shows its derived autapomorphic condition (zu_2). Gnathos broad with inner apical margin sharply dentated in *Deilephila rivularis* shows its more derived autapomorphic condition (zu_3).

Saccus (zv): Saccus V- or U-shaped in the representatives of the genera from *Gnathothlibus* to *Daphnis* shows their synapomorphic condition (zv_1). In the species of the genera *Hippotion*, *Hyles* and *Deilephila* saccus U-shaped proximally shows their derived synapomorphic condition (zv_2). Saccus V – shaped and proximally narrowed in *Theretra alecto* and *T. oldenlandiae* shows their more derived synapomorphic condition (zv_3). In *Cephonodes hylas* the saccus is globular shows its autapomorphic condition (zv_4). Saccus proximally with prominent lobe in *Dolbina grisea* shows its derived autapomorphic condition (zv_5).

Aedeagus (zw): Aedeagus rod-like and narrowed in *Acherontia styx* and *Acherontia lachesis* shows their synapomorphic condition (zw_1). *In Agrius convolvuli* aedeagus short and thick shows its autapomorphic condition (zw_2). Aedeagus with plate-like thecal appendage in *Clanidopsis exausta* shows its derived autapomorphic condition (zw_3). In *Leucophlebia lineata* aedeagus with theca bifurcated shows more derived autapomorphic condition (zw_4). Theca enclosed medially by membrane in *Acosmeryx anceus* shows its specially autapomorphic condition (zw_5). In *Polyptychus dentatus* the theca with beak-shaped thecal appendage shows its specially derived autapomorphic condition (zw_6). Aedeagus with crenulated thecal appendage in *Hippotion rosetta* shows its specially more derived autapomorphic condition (zw_7).

Membranous conjunctival appendage (zx): Membranous conjunctival lobe entire or with small appendage in all the species of the genera *Cephonodes* to *Daphnis* shows their synapomorphic condition (zx_1). In all species of the genus *Macroglossum* membranous conjunctival lobe with one pair of rod-like appendages shows their derived synapomorphic condition (zx_2). Membranous conjunctival lobe thread-like in *Sataspes infernalis* shows its autapomorphic condition (zx_3). In *Smerinthus kindermannii* membranous conjunctival lobe with two groups of dot-like cornuti shows its derived autapomorphic condition (zx_4). Membranous conjunctival lobe with three dentated cornuti in *Deilephila rivualris* shows its more derived autapomorphic condition (zx_5). In *Marumba dyras* membranous conjunctival lobe with one group of dot-like cornuti with a pair of small hook-like appendage shows its specially autapomorphic condition (zx_6). Membranous conjunctival lobe with dot-like cornuti and a pair of antennae shaped appendage in *Leucophlebia lineata* shows its specially derived autapomorphic condition (zx_7). In *Clanidopsis exausta* the membranous conjunctival lobe with cornuti distally two small and two large horn-like lobe shows its specially more derived autapomorphic condition (zx_8).

Papillae anales (zy): Papillae anales moderate in the species of the genera *Theretra* to *Daphnis* shows their synapomorphic condition (zy_1). In *Gnahtothlibus erotus* papillae anales large rectangular shaped shows its autapomorphic condition (zy_2). Papillae anales trapaezoid shaped in *Nephele hespera* shows its derived autapomorphic condition (zy_3). In *Hyles galli* the papillae anales with posterior margin convex shows its more derived autapomorphic condition (zy_4). Apex of papillae anales sub-rounded in *Acherontia styx* shows its specially autapomorphic condition (zy_5). In *Hyles livornica* the papillae anales with posterior margin sinuated shows its specially derived autapomorphic condition (zy_6). The papillae anales with posterior margin truncated in *Acherontia lachesis* shows its specially more derived autapomorphic condition (zy_7). In *Clanis deucalion* the papillae anales with sclerotized process at dorsal side shows its peculiar autapomorphic condition (zy_8).

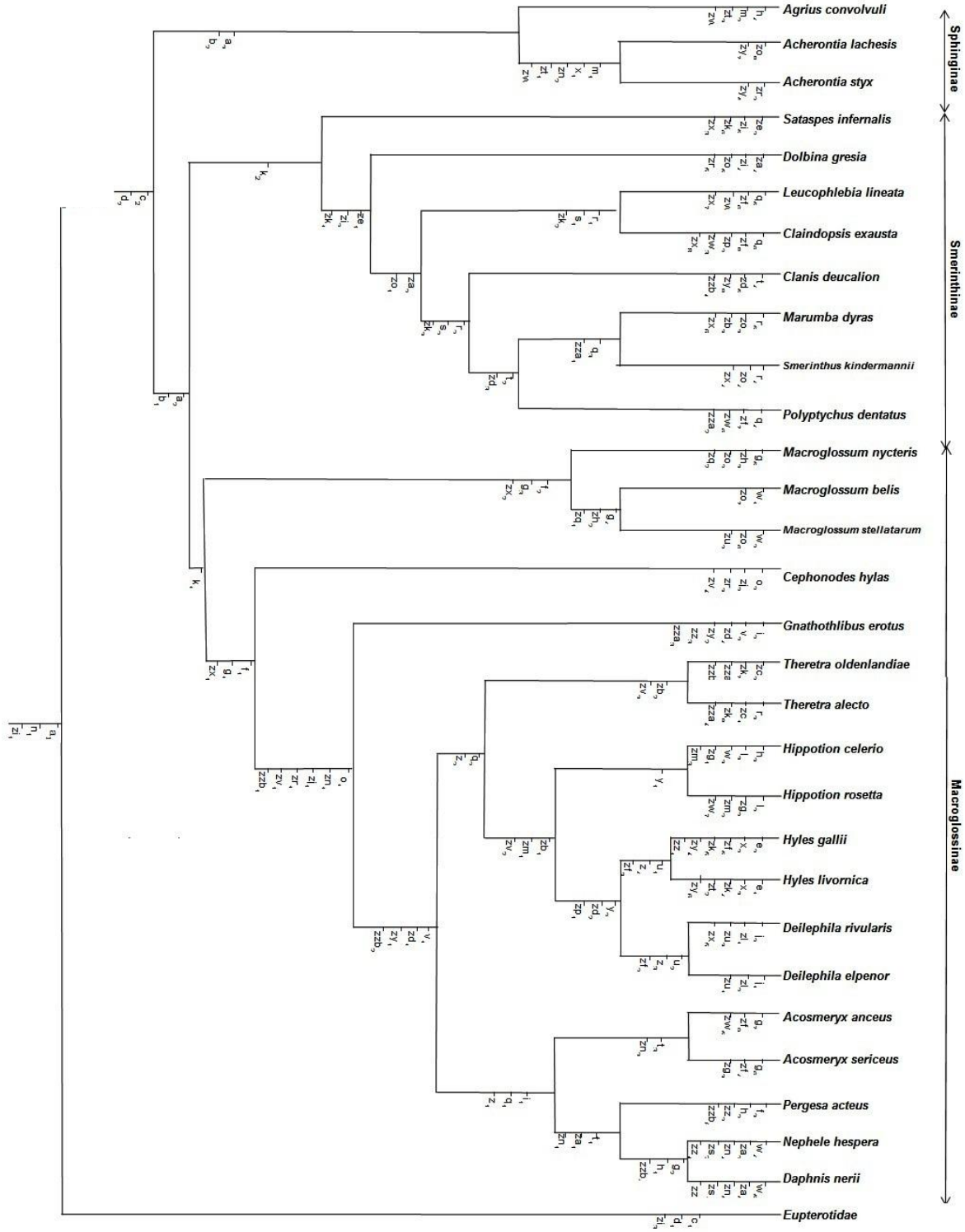

Fig. 1. Cladogram showing relationship of included taxa

Discussion on cladogram. (Fig. 01):

Apophysesses (zz): Apex of apophyses anteriors dilated in *Hyles gallii* shows its autapomorphic condition (zz_1). In *Pergesa acteus* the apex of apophysis anteriors moderate club-shaped shows its derived autapomorphic condition (zz_2). Both apophysesses very large with apex club-shaped in *Gnathothlibus erotus* shows its more derived autapomorphic condition (zz_3). In Nephele hespera the apex of apophysis anteriors pointed shows its

specially autapomorphic condition (zz_4). The apex of apophyses anteriors truncated in *Daphnis nerii* shows its specially derived autapomorphic condition (zz_5).

Ductus bursae (zza): Ductus bursae straight in the genera *Marumba* and *Smerinthus* shows its synapomorphic condition (zza_1). In *Polyptychus dentatus* ductus bursae twisted distally dilated shows its autapomorphic condition (zza_2). Ductus bursae short in *Gnathothlibus erotus* shows its derived autapomorphic condition (zza_3). In *Theretra alecto* the ductus bursae short and broad shows more derived autapomorphic condition (zza_4). The ductus bursae elongated and narrowed in *Theretra oldenlandiae* shows its specially derived autapomorphic condition (zza_5).

Corpus bursae (zzb): Corpus bursae large balloon-shaped with cornuti in the species of the genera *Gnathothlibus* to *Daphnis* shows its synapomorphic condition (zzb_1). In the species of genera *Theretra* to *Daphnis* the corpus bursae usually elongated cornuti shows its derived synapomorphic condition (zzb_2). The corpus bursae moderate proximally straight in the species of genera of *Nephele* and *Daphnis* shows their more derived synapomorphic condition (zzb_3). In *Clanis deucalion* the corpus bursae with U-shaped and many dot-like cornuti shows its autapomorphic condition (zzb_4). In *Theretra oldenlandiae* the corpus bursae bifurcated with large cornuti shows its derived autapomorphic condition (zzb_5). The corpus bursae large proximmaly hook-shape in *Pergesa acteus* shows its more derived autapomorphic condition (zzb_6).

In the present studies the family Sphingidae comprises three sub-families, 21-genera and 29- species which plays sister group relationships with the family Eupterotidae by their synapomorphies viz. body stout and thick (a_1), frenulum present (n_1) and abdomen stout and thick (zi_1) and outgroup relationships with the family Eupterotidae in having their synapomorphies like proboscis very weak (c_1), antennae pectinated (d_1) and apex of abdomen broad (zi_3).

Among the family Sphingidae all the species fall into two groups, the first group comprises only three species *Agrius convolvuli, Acherontia lachesis* and *A. styx* which plays sister group relationships to each other by their synapomorphies, body usually large sized more than 90 mm (a_3) and the head usually with a dead marks (b_2) and outgroup relationships with second group by their sunapomorphies like body usually moderate less than 90 mm (a_2) and head usually entire and unicolorous (b_1).

The second group is divided into two sub-groups, the first group includes 8-genera, which plays sister group relationships to each other by their synapomorphies like first segment of palpus with scales on inner surface (k_2) and out group relationship with second group by their synapomorphies like basal segment of palpus without scales on inner surface.

In the first sub-group the *Sataspes infernalis* plays outgroup relationship by its autapomorphies like hind wings with anal veins meeting at base (ze_2) , abdomen distinctly broad with tuft of hairs (zi_5), paramere distally divided (zk_6) and membranous conjunctival lobe thread like (zx_3) and sister group relationship of other seven species of first sub-group by their synapomorphies like hind wings with both anal veins wide apart (ze_1), abdomen distinctly narrowed without tuft of hairs (zi_2), and paramere unilobed (zk_1). Among these the *Dolbina gresia* plays out group relationship in having its autapomorphies like hind wings with apical margin broadly convex (za_4), paramere with three tooth-like process at inner apical margin (zo_5). Among rest of the species the *Clanis deucalion, Marumba dyras, smerinthus kindermannii,* and *Polyptychus dentatus* play sister group relationship by their synapomorphies like fore wings with 10- or 11- veins (r_2), posterior margin of fore wings distinctly sinuated (s_2) and apex of paramere very wide and spinose at base (zk_3) and outgroup relationships with *Leucophlebia lineata* and *Clanidopsis exausta* by their synapomorphies like fore wings with 9- veins (r_1), posterior margin of fore wings concave or straight (s_1) and apex of paramere rounded and entire (zk_2).

In *Clanis deucalion, Marumba dyras, Smerinthus kindermannnii* and *Polyptychus dentatus* the last three species play sister group relationship to each other by their synapomorphies like apical margin of fore wings crenulated (t_2) and hind wings with 2- or 3- anal veins (zd_3) and outgroup relationships with *Clanis deucalion* by its autapomorphies like the hind wings with only one anal vein (zd_5), the papillae anales with sclerotized process at dorsal side (zy_8) and corpus bursae with U-shaped and many dot-like cornuti (zzb_4).

Among rest of the three species *Marumba dyras* and *Smerinthus kindermannii* plays sister group relationship by their synapomorphies like the fore wings with more than three fasciae or sometime without fasciae (q_3) and ductus bursae straight (zza_1) and outgroup relationship with *Polyptychus dentatus* by its autapomorphies like fore wings with three transverse fasciae (q_4), the theca with beak-shaped thecal appendage (zw_6) and ductus bursae twisted and distally dilated (zza_2).

The second sub-group comprises 18-species which further fall into two groups, the first group includes *Macroglossum nycteris, M. belis* and *M. stellatarum*. Among these *M. belis* and *M. stellatarum* plays sister group relationships by their synapomorphies like the frons ids about equal and slightly shorter than palpi (g_4), Hind wings with veins M_3 and Cu_1 wide apart and only M_3 originating from lower angle of cell (h_2) and uncus slightly longer than gnahtos (zq_1) and outgroup relationship with M. nycteris by its autapomorphies frons much shorter than palpi (g_5), Hind wings with veins M_3 and Cu_1 anastomosing and originating from lower angle of

cell (zh_3), paramere with thorn-like process at inner basal margin (zo_2) and uncus much longer than gnahtos (zq_2).

Among second group which comprises 15-species the *Cephonodes hylas* plays outgroup relationship by its autapomorphies wings are membranous devoid of scales (o_2), paramere are asymmetrical (zj_2), uncus curved beak-shaped (zr_3) and saccus is globular (zv_4) and sister group relationship with rest of the species by their synapomorphies like both wings scaled (o_1) , paramere symmetrical with process (zj_1) and corpus bursae large balloon-shaped with cornuti (zzb_1). In rest of the species the *Gnathothlibus erotus* plays outgroup relationship by its autapomorphies like palpi directed anteriad (i_2), hind wings with three anal veins (zd_4), papillae anales large, rectangular shaped (zy_2) and both apophysesses very large and apex clubshaped (zz_3) with sister group relationships of rest of the 13-species by their synapomorphies like fore wings with veins R_2 and R_3 separated (v_1), hind wings with one or two anal veins (zd_1) and corpus bursae usually with elongated cornuti (zzb_2).

The rest of the thirteen species from *Theretra* to *Daphnis* falls into further two groups. The first group comprises 8-species viz. *Theretra oldenlandiae, T. alecto, Hippotion celerio, H. rosetta, Hyles gallii, H. livornica, Deilephila rivularis* and *D. elpenor*. Among these *Theretra oldenlandiae* and *T. alecto* plays sister group relationships to each other by hteir synapomorphies like hind wings with anal angles distinctly lobed (zb_2) and saccus V-shaped and proximally narrowed (zv_3) and outgroup relationships with rest of six species by their synapomorphic condition like hind wings with anal angle rounded (zb_1), paramere with 2 or 3-frictional scales at inner apical margin (zm_1) and saccus U-shaped proximally dilated (zv_2). Among rest of the six species the *Hippotion celerio* and *H. rosetta* plays sister group relationship with each other by their synapomorphies like fore wings with two anal veins (y_1) and outgroup relationship with *Deilephila rivularis* and *D. elpenor, Hyles gallii,* and *H. livornica* by their synapomorphies like the fore wings with single anal vein(y_2), hind wings with two anal veins (zd_2) and uncus unilobed (zp_1). In these species the *Deilephila rivularis* and *D. elpenor* plays sister group relationship to each other by hteir synapomorphies like apical angle of fore wings sub-acute (u_2), hind wings with sub-apical margin brown (z_3) and hind wings with $Sc+R_1$ parallel to Rs (zf_2) and outgroup relationship with *Hyles gallii* and *H. livornica* shows their synapomorphies like apical angle of fore wings sub-rounded (u_1), hind wings with sub-apical margin black (z_4) and hind wings $Sc+R_1$ unite with Rs directly or by cross vein (zf_3).

The second group comprises five species viz. *Acosmeryx anceus, A. sericeus, Pergesa acteus, nephele hespera* and *Daphnis nerii* and later three species plays sister group relationships with each other by their sunapomorphies like hind wings with apical margin convex (za_1) and paramere with thorn-like or dentated process at inner margin (zn_1) and out group relationships with *Acosmeryx anceus* and *A. sericeus* shows their synapomorphies like the apical margin of fore wings distinctly sinuated (t_3) and paramere with an Axe-shaped process at base (zn_3). Among the rest of the three species the *Nephele hespera* and *Daphnis nerii* plays sister group relationships by their synapomorphies like frons well developed produced anteriad (g_2), the basal segment of palpi equal to the 2nd segment (h_1) and corpus bursae moderate, proximally straight (zzb_3) and outgroup relationship with *Pergesa acteus* by its autapomorphies like frons is reduced (f_3), basal segment of palpi much shorter than 2nd segment (h_2), apex of apophysis anteriors moderate, club-shaped and corpus bursae large, proximally hook-shaped (zzb_6).

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