REVISION OF THE GENUS *HYLES* HüBNER (LEPIDOPTERA: SPHINGIDAE: MACROGLOSSINAE) FROM PAKISTAN AND ITS CLADISTIC RELATIONSHIP

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Abstract

Three species of the genus *Hyles* Hübner are described with emphasis to their head components, venations of fore and hind wings along with genital complexes and the cladistic relationship is also briefly discussed with the help of their apomorphies.

Introduction

The representatives of the genus *Hyles* Hübner are distributed throughout the World. Mostly are recorded from Neotropical and Palaeartic regions. Genus *hyles* includes 42-subspecies and 29-species (Kitching and Cadiou, 2000) in the world. Presently nine species are recorded from different localities including Azad Kashmir and Northern areas of Pakistan. Cotes and Swinhoe (1887) mentioned only three species of the genus *Hyles* as *Deilephila*, viz. *D. livornica, D. lathyrus* and *D. robertsi* from Palaeartic, Oriental and Ethopian regions in their catalogue of moths of India. Hampson (1892) in his fauna of British India including Ceylon and Burma described genus *Hyles* as *Deilephila* with four species with its brief description and colour pattern of larvae.

Rothschild and Jordan (1903) revised the lepidopterous family Sphingidae including thirteen species of the genus *Hyles* as *Celerio.* Bell and Scott (1937) mentioned in their fauna of British India Ceylon and Burma genus *Celerio* which was described by Oken 1815, later synonymized as *Hyles* by Hübner (1819) with four species to its reference of external morphological characters of imago, larvae and pupae. Daniel Franz (1966) presented a notes on collective thirty three species with *Celerio gallii nepalensis* with detail discussion from Nepal. Eichler (1971) described only *Hyles* as *Celerio gallii tibitanica* from Northwest Tibet. Vestergaard (1973) studied the population of *H. gallii* from Eastern Veluwe. Lotzing (1991) were observed twelve species of the family Sphingidae including two species of genus *Hyles* viz. *H. euphorbiae* and *H. gallii*, he also mentioned that species as immigrant for examined district of Stassfurt (Saxony-Anhalt) Germany. Hashmi and Tashfeen (1992) listed only One species of *Hyles* as *Celerio lineata* in their checklist. Meerman (1993) studied 350-adults and 150-Caterpillars of *H. euphorbiae* and described its relationship. He also mentioned that this species is highly variable and widely distributed across the Palaeartic region. Messenger (1997) in his report The sphinx moth of Nebraska included 32-species of 20-geenera including two species of the genus *Hyles* of the family Sphingidae with their description, distribution, biology and food host plant of larvae and adults.

Felipe (2002) described first time only one species of *H. tithymali deserticola* from Canary Island. Yen *et al.* (2003) gave a revised and an annotated checklist of the Tiawanese Sphingidae with a new subspecies of Hawkmoth from Lanyu, Taiwan mentioning only one species of *H. livornica*. Hundsdoerfer *et al.* (2005) analysed the genus *Hyles* with reference to its molecular phylogeny and used DNA sequence. Kamaluddin *et al.* (2007) in their checklist of moths of Pakistan and listed only four species of the family Sphingidae with their distributional range and host plants. Catania (2008) recorded the species of *H. tithymali deserticola* as new record from the Maltese island. Rafi *et al.* (2014) in their report the hawkmoth fauna of Pakistan included sixty species including nine species of the genus *Hyles* of the family Sphingidae with only their distributional ranges.

Materials and Methods

Male and female specimens were collected from Sind, Punjab and Northern Areas of Pakistan and Azad Kashmir on light and identified with the help of literature and also confirmed by Kitching, research entomologist British Museum Natural History, London. The colour photo session were made and prepared the slides wings. The measurement of the body (wing expansion) were taken with the help of a micromillimeter slide and for the study of genital complexes the routine procedure were adopted following Younus and Kamaluddin (2010) and Younus and Kamaluddin (2014).

Results

GENUS: *Hyles* Hübner

Hyles, Hübner, (1819), *Verz. Bekannter Schmett*: 137.
Celerio, Oken, 1815, *Okens Lehrbuch Naturgesch*.3:761.
Celerio, Agassiz,(1846), *Nomencl. Zool.* (*Nom. Syst. Generum Anim.*) *Lepid.*: 14.

Turneria, Tutt, 1903, *Entomologist's Rec. J. Var.* 15 : 76.

Hawaiina, Tutt, 1903, *Entomologist's Rec. J. Var.* 15 : 76. Roths. and Jord., 1903, *Revision of Sphingidae*: 713; 1907, *Gen. Ins. 57*: 127; Jordan, 1911, *Macrolep. Faun. Pal. 2*: 254; Bell and Scott, 1937, *Faun. Brit. Ind. Moths 5*: 400.

Diagnostic features: Body medium sized, thick and stout, generally dark brown with a black and white bands, head with frons broadly rounded, slightly produced, palpi with 2nd segment shorter than basal and much longer than 3rd, proboscis large, antennae incrassate, fore wings large with apical angle sub-rounded, anterior and posterior margin sinuated, apical veins 11- in margin distinctly sinuated, hind wings much shorter than fore wings, veins Rs and M_1 usually originating from upper angle of cell, two anal veins (1A and 2A) present.

Genitalia: Males with tegumen oblongate, saccus cup-shaped, uncus large slightly longer than gnathos, paramere large flipper-like with a spine at inner lateral margin, aedeagus with theca tubular, thecal appendage serrated, membranous conjunctival lobe very large without cornuti. In females papillae anales bean-shaped, apophyses posteriors longer than apophyses anteriors, ductus bursae large tubular, corpus bursae ballon-like with elongated cornuti.

Comparative notes: This genus is most closely related to genus *Deilephila* Laspeyres in having uncus uniobed, paramere without frictional scales but it can easily be separated from the same in having fore wings with apical angle sub-rounded, hind wings with sub-apical margin black, veins Sc+R_1 unite with Rs direct or by cross vein and by the other characters as noted in the description.
Type species: *Hyles gallii* (Von Rottemburg)
Distribution: Cosmopoliton.

Hyles gallii **(Von Rottemburg)**
(Figs.1-8)

Sphinx gallii, von Rottemburg,1775, *Naturf., 7*:107 .

Hyles gallii, Hübner,1819, Verz. Bekannter Schmett.: 137; Pittaway, 1983, *Entomologist's Gaz.34*: 82; Danner, Eitschberger & Surholt,1998, *Herbipoliana, 4* (2): 201.

Deilephila gallii, Buckler, 1887, *Larvae Brit. Butt. & Moths*: 36; Hampson, 1892, *Faun. Brit. Ind. Moths 1*: 98; Dudgeon, 1898, *Journ. Bomb. Nat. Hist. Soc. 9*: 415.

Celerio gallii, Roths. & Jord.,1903, *Revision of Sphingidae,*: 723; Jordan, 1911, *In Seitz's Macrolep. Faun. Pal. 2*: 256; Mell, 1922, *Biol. u. System. der Sudchin. Sphing.*: 278; Sietz, 1928, *In Seitz's Macrolep.10*: 563; Bell and Scott, 1937, *Faun. Brit. Ind. Moths, 5*: 407; Zhu & Wang, *Faun. Sinica Insecta 11* : 342.

Colouration: Body generally brown except dark brown sub-anterior and sub-posterior bands and abdomen, white lateral margins of head and pronotum, lateral margins of 3rd and 4th terga.

Head (Fig. 2): Head with frons sub-rounded, vertex raised, proboscis large, palpi with basal segment about 1.25X longer than second, 3rd segment short about 1/3rd of the second segment.

Fore wings (Fig. 3): Fore wings large about 1.25X the length of hind wings, apical margin sinuated with apical angle sub-acute, veins R_3 and R_4 largely stalked anastomosing with R_5 and originating from upper angle of cell, M_2 originates from lower angle of cell, only one anal vein (1A) present.

Hind wings (Fig. 4): Anterior margin of hind wings sinuated, posterior marign convex, apical margin sinuated with apical angle sub-acute, Sc + R_1 fused with Rs at base, Rs originates from upper angle of cell, M_3 originates from lower angle of cell, two anal veins (1A and 2A) present.

Male genitalia: (Figs. 5-7) Tegumen (Figs. 5-6) oblongate, saccus cup – shaped without saccular process, uncus large apex truncated, gnathos slightly shorter than uncus incurved with blunt apex, paramere large flipper-like, anterior 1/3rd half besets with small scales, a thorn-like inwardly curved process at basal ventro-outer margin, aedeagus (Fig. 7) with theca tubular, with a pair of sclerotized thecal appendage having three or four toothed, membranous conjunctival lobe very large without cornuti.

1 *Hyles galli*

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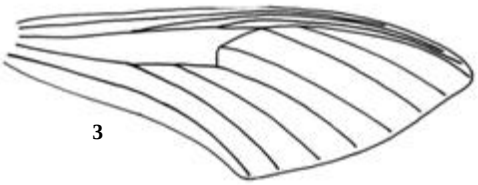

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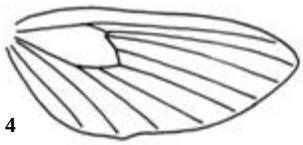

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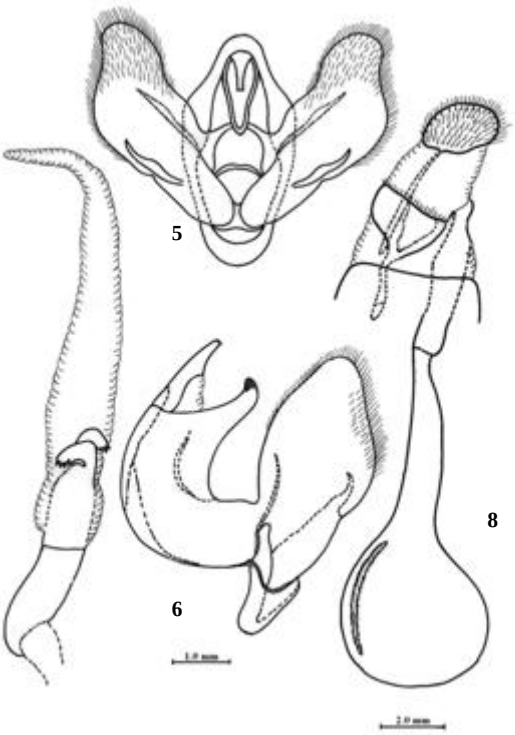

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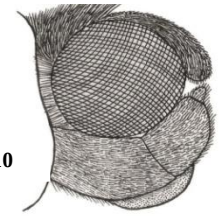

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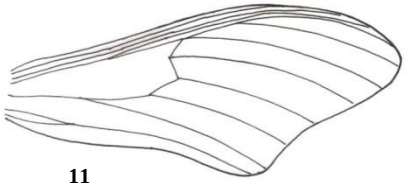

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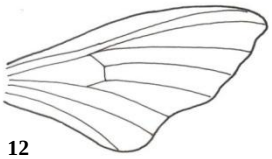

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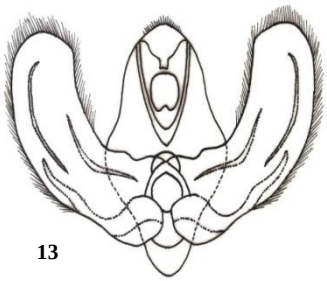

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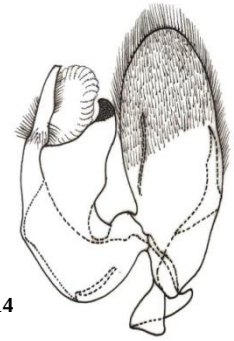

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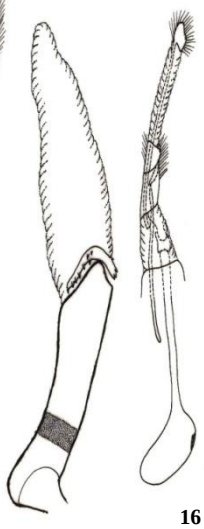

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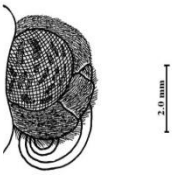
Hyles livornica



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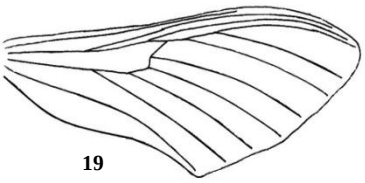

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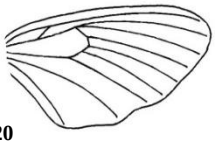

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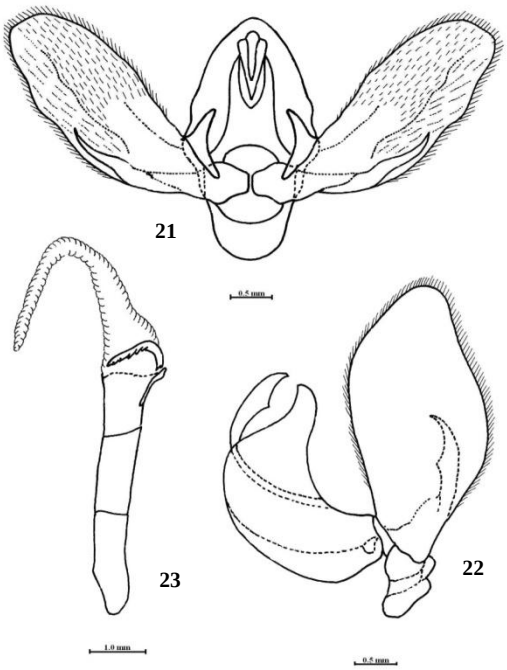

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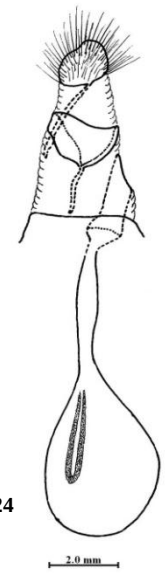

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Illustration of Figures: Figs. 1-8; *Hyles gallii* (Von Rottemburg)., 1. Adult, entire dorsal view; 2. Head, lateral view; 3. Fore wing, dorsal view; 4. Hind wing, dorsal view; 5. Tegumen, male genitalia ventral view; 6. Same, lateral view; 7. Aedeagus, lateral view; 8. Female genitalia, lateral view. Figs. 9-16; *Hyles hippophaes* (Staudinger)., 9. Adult, entire dorsal view; 10. Head, lateral view; 11. Fore wing, dorsal view; 12. Hind wing, dorsal view; 13. Tegumen, male genitalia ventral view; 14. Same, lateral view; 15. Aedeagus, lateral view; 16. Female genitalia, lateral view. Figs. 17-24; *Hyles livornica* (Staudinger)., 17. Adult, entire dorsal view; 18. Head, lateral view; 19. Fore wing, dorsal view; 20. Hind wing, dorsal view; 21. Tegumen, male genitalia ventral view; 22. Same, lateral view; 23. Aedeagus, lateral view; 24. Female genitalia, lateral view.

Female genitalia (Fig. 8): Papillae anales moderate, bean-shaped besets with small thick scales, apophyses posteriors much longer than apophyses anteriors later apically dilated, lobus vaginalis plate-like, ductus bursae large, tubular, corpus bursae ballon-shaped with curved elongated cornuti.

Total length: Wing expansion 74 mm.

Material examined: Five males, Three females; Pakistan: Sind, Karachi, Punjab; Muree, Changla gali, Azad Kashmir; Pirchanasi, on light 24-07-2007, 17-06-2008, 17-10-2010, leg. M. Faheem younus and S. Kamaluddin, lodged at author's collection.

Comparative note: This species is most closely related to *Hyles hippophaes* (Staudinger) in having fore wings with veins R_3 and R_4 largely stalked and anastomosing with R_5 and originating from upper angle of cell, in male uncus truncated at apex but it can be separated from the same in having frons slaunting at apex, hind wings with veins Rs and M_1 not anastomosing, in male inner margin of gnathos concave and by the other characters as noted in the description.

***Hyles hippophaes bienerti* (Staudinger)**

(Figs: 9-16)

Deilephila bienerti, Staudinger, 1874, *Stettin. ent. Ztg 35*: 91.
Deilephila bienerti, Staudinger, 1874.
Deilephila insidiosa, Erschoff, 1874.
Hyles hippophaes caucasica, Denso, 1913.
Celerio hippophaes caucasica, Clark, 1922.
Celerio hippophaes ornatus, Gehlen, 1930.
Hyles hippophaes transcaucasica, Gehlen, 1932.
Celerio hippophaes anatolica, Rebel, 1933.
Celerio hippophaes bucharana, Sheljuzhko, 1933.
Celerio hippophaes shugnana, Sheljuzhko, 1933.
Celerio hippophaes malatiatus Gehlen, 1934.
Celerio hippophaes baltistana O. Bang-Haas, 1939.
Hyles hippophaes miatleuskii, Eitschberger & Saldaitis, 2000, *Atalanta 31*: 213.

Colouration: Body generally brown except black markings at base of fore wings, large basal area and sub-apical band on hind wings and lateral spots on two anterior abdominal segments, reddish median band of hind wings, fuscus lateral margin of head and prothorax.

Head (Fig. 10): Head with frons rounded, apically lobed, proboscis large, palpi with basal segment about 1.4X longer than second segment, 3rd segment very short 1/5th of the second segment.

Fore wings (Fig. 11): Fore wings large about 1.5X the length of hind wings, apical margin distinctly sinuated with apical angle sub-rounded, Veins R_3 and R_4 largely stalked anastomosing with R_5 and originating from upper angle of the cell, M_2 originates from lower angle of cell, only One anal Vein 1A present.

Hind wings (Fig. 12): Anterior margin of hind wings convex, posterior margin concave, apical margin distinctly sinuated with apical angle sub-rounded, Veins $Sc+R_1$ medially close to Rs but not meeting, Rs and M_1 anastomosing at base and originating from upper angle of cell, M_3 originates from lower angle of cell, two anal veins (1A and 2A) present.

Male genitalia (Figs. 13-15): Tegumen (Figs. 13-14) oblongate, saccus somewhat V-shaped without saccular process, uncus large with apex truncated, gnathos shorter than uncus with sub-acute apex, paramere large, flipper-like, anterior half besets with small scales, a thorn-like large process at basal ventro-outer margin, aedeagus (Fig. 15) with theca tubular with an inverted V-shaped thecal appendage having seven teeth and apex toothed, membranous conjunctival lobe broad and very large without cornuti.

Female genitalia (Fig. 16): Papillae anales trapezoid-shaped, besets with small scales, apophyses posteriors slightly longer than apophyses anteriors, both with blunt end, lobus vaginalis rectangular-shaped, ductus bursae large narrowed, tubular, corpus bursae ballon-shaped with a small triangular cornuti.

Total length: Wing expansion 65-80 mm.

Material examined: Two males and Three females; Azad Kashmir; Pirchanasi and Bagh District, 2009, 2011, leg. M. Faheem Younus, lodged at author's collection.

Comparative note: This species is most closely related to *H. gallii* (Rottemburg) in having hind wings with veins Sc+R_1 separated not unite with Rs by cross vein and in male apex of uncus truncated but it can easily be separated from the same in having frons lobed at apex, maxillary palpus with 3rd segment very short about 1/5th of the 2nd segment, in male inner margin of gnathos sinuated and by the other characters as noted in the description..

Hyles livornica **(Esper)**

(Figs. 17-23)

Sphinx livornica, Esper, 1780, *Schmett., 2*: 88.

Deilephila livornica, Swinhoe, 1884, *Proc. Zool. Soc. Lond.*: 513; 1885A, *Proc. Zool. Soc. Lond*.: 287; 1885B, *Trans. Ent. Soc. Lond.*: 346; Butler, 1886, *Proc. Zool. Soc. Lond.*: 379; Swinhoe, 1886, *Proc. Zool. Soc. Lond.*: 435; Warren, 1888, *Proc. Zool. Soc. Lond.*: 293; Swinhoe,1888, *Journ. Bomb. Nat. Hist. Soc. 3*: 118; Buckler,1887, *Larvae Brit. Butt. & Moths.*; Hampson, 1892, *Faun. Brit. Ind., Moths, 1*: 97.

Celerio lineata livornica, Roths. & Jord., 1903, *Revision of Sphingidae*: 732; Jordan, 1912, *In Seitz's Macrolep. Faun. Pal., 2*: 257; Seitz, 1929, *In Seitz's Macrolep., 10*: 563; Bell and Scott,1937, *Faun. Brit. Ind. Moths, 5*: 408; Eitschberger & Steiniger, 1976, *Atlanta, Munnerstadt 7*:71.

Hyles lineata, Pittaway, 1983, *Entomologist's Gaz. 34*:28; Bridges, 1993, *Cat. Fam. Gen. Spec*. *Sphingidae of the World 8*: 11; Haxaire, 1993, *Lambillionea 93*: 160.

Celerio lineata, Haruta, 1994, *Tinea 14(suppl.1)* 157; Vives Moreneo, 1994, *Cat. Sist. Sinon. Lepid . Penin. Iberica y baleares 2*: 421; Zhu & wang, 1997 *Faun. Sinica Insecta 11*: 342.

Colouration: Body generally olive brown with reddish tinge except black sub-anterior and sub-posterior broad bands on fore wings and basal sub-apical black bands on hind wings, abdomen pale-olive brown with black and white side-patches.

Head (Fig. 18): Head with frons rounded anteriorly slightly produced, proboscis large, highly coiled, palpi with basal segment about 2X longer than second, 3rd segment short about 1/3rd of the second segment.

Fore wings (Fig. 19): Fore wings large about 1.75X the length of hind wings, apical margin distinctly sinuated with apical angle sub-rounded, veins R_3 and R_4 largely stalked, further largely stalked with R_5 and originating from upper angle of cell, M_2 originates from lower angle of cell, only one anal vein (1A) present.

Hind wings (Fig. 20): Hind wings with anterior margin slightly convex, posterior margin concave, apical margin distinctly sinuated with apical angle sub-rounded, veins Sc + R_1 connect with Rs by a cross vein, Rs and M_1 shortly stalked and originating from upper angle of cell, M_3 originates from lower angle of cell, two anal veins (1A and 2A) present.

Male geintalia(Fig. 21-23): Tegumen (Figs. 21-22) oblongate, saccus cup-shaped without saccular process, uncus narrow, inner median surface acutely produced apex incurved pointed, slightly longer than broad gnathos, later incurved with pointed apex, paramere large, flipper shape, about anterior ½ besets with small hairs, a thorn-like inwardly curved process at basal ventro-outer margin, aedeagus (Fig. 23) with theca large, tubular, divided into two equal part, with a pair of sclerotized thecal appendage having 5–6 dentition on one other simple, membranous conjunctival lobe very large without cornuti.

Female genitalia (Fig. 24): Papillae anales moderate, bean-shaped besets with large thick hairs, apophyses posteriors much longer than apophyses anteriors apically narrowed, lobus vaginalis plate-like, ductus bursae large, tubular, corpus bursae ballon shaped with U-shaped elongated cornuti.

Total length: 52 – 90 mm.

Material examined: Ten males, Five females, Pakistan: Sindh, Malir, Karachi, Punjab; Alipur, on light, 15-07-92, 15-08-92, 16-10-98, 07-09-2004, 29-06-2007, 15-08-2007, 02-09-2010, leg; M. Faheem Younus and S. Kamaluddin, lodged at author's collection.

Comparative note: This species is most closely related to *Hyles gallii* (Von Rottemburg) in having general colour patern, maxillary palpi with 2nd segment about 2.5X of the 3rd but it can easily be separated from the same in having hind wing with vein $Sc+R_1$ unite with Rs by cross vein, in male uncus with apex sharply inturned, in female apophyses anteriors narrowed and by the other characters as noted in the description.

Discussion

The representatives of the genus *Hyles* Hübner are distributed throughout the World. Presently the work is attempted specially with reference to their male and female genitalia of three species viz. *galli* (Rottemburg), *hipophaes* (Staudinger) and *livornica* (Esper.

Among three species the *hypophaes* and *gallii* plays sistergroup relationship by their apomorphies like fore wings with veins R_3 and R_4 largely stalked and anastomosing with R_5 and originating from upper angle of cell and apex of uncus truncated with outgroup relationship with *livornica* by their apomorphies like hind wings with veins $Sc+R_1$ unite with Rs by cross vein and fore wings with veins R_3 and R_4 stalked and further stalked with R_5 and originate from upper angle of cell. The *hipophaes* is separated from *gallii* by its autapomorphies like maxillary palpus with 3rd segment very short and about 1/5th the 2nd, in female papillae anales short, rectangular shape as compare to *gallii* by its autapomorphies like frons slaunting at apex, in female papillae anales large semispherical shortly stalked.

Key to the letterings: e. (eye), fr. (frons), mx. p. (maxillary palpi), prb. (proboscis), Rs. (radio-suctorial vein), Sc. (sub-costal vein), $Sc + R_1$ (sub-costal and radius vein), Cu_1 and Cu_2 (cubital vein 1 and 2), A_1 and A_2 (anal vein 1 and 2), R_1-R_5 (radius vein 1 to 5), M_1-M_3(median vein 1 to 3), un. (uncus), gn. (gnathos), tg. (tegumen), pr. (paramere), Sac. (saccus), th. (theca), mc. l. (membranous conjuctival lobe), p. an. (papillae anales), ap. post. (apophysis posterior), ap. ant. (apophysis anterior), lvg. (lobus vaginalis), d. br. (ductus bursae), c. br. (corpus bursae).

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