

Research Article

Taxonomic revision of the Genus *Pieris* Schrank (Lepidoptera: Pieridae) from India

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Abstract

The genus *Pieris* Schrank popularly called as garden whites are economically important species of family Pieridae, comprise 35 species world over and in India is represented by nine species. In the present manuscript, six species of genus *Pieris* Schrank *i.e.*, *i.e.* *P. brassicae* (Linnaeus), *P. canidia* (Linnaeus), *P. deota* (de Niceville), *P. extensa* Poujade, *P. melete* Menetries and *P. rapae* (Linnaeus) have been treated taxonomically from India. Besides studying morphological characters, their male and female genitalia have been described in details and illustrated for the first time. The diagnosis of the genus and key to species has been updated using genitalic attributes. In the study of genitalia, it has been observed that in the male genitalia of the genus *Pieris* the uncus is undivided and aedeagus is short and thick, whereas in the female genitalia the signum is bifid and appendix bursae are well developed. In the present work, the male genitalia of scheduled species *P. deota* has been studied and illustrated for the first time. The male and female genitalia of dry season forms and wet season forms of species *P. melete*, and the subspecies and polymorphic forms of species *P. canidia* have been studied and compared. It has been observed that in all forms there were no genitalic variations within the species.

Keywords: Dry season form, Female genitalia, Male genitalia, *Pieris*, Species, Subspecies, Wet season form

INTRODUCTION

The genus *Pieris* was reported by Schrank in 1801 with type species *Papilio brassicae* Linnaeus. It is a cosmopolitan genus with maximum diversity in Palearctic region. Presently genus *Pieris* comprises 35 species globally of which 9 species are reported from India *i.e.* *P. ajaka* Moore, *P. brassicae* (Linnaeus), *P. canidia* (Linnaeus), *P. deota* (de Niceville), *P. dubernardi* Oberthur, *P. extensa* Poujade, *P. krueperi* Staudinger, *P. melete* Menetries and *P. rapae* (Linnaeus). This genus has been studied by various eminent works from time to time such as Bingham (1907), Verity (1919), Antram (1924), Klots

(1931), Talbot (1939), Leech (1819) and Herman (1971). Klots (1931) illustrated the genitalic attributes of *P. brassicae* and *P. rapae* and Talbot (1939) described the genitalic attributes of genus *Pieris*. In the present work, the morphological characters, genitalic attributes and the distribution of six species belonging to this genus have been studied. The genitalic attributes of all the species have been studied, illustrated and compared with each other.

MATERIALS AND METHODS

The adult Pierid butterfly representatives were captured by using the sweeping net from different

localities of India. The localities from where various species of genus *Pieris* have been collected are given in Table 1 and Fig. 1

The collected specimens were killed by putting them straight into the insect-killing bottle containing ethyl acetate vapours. The representatives were then transferred to the butter sheet envelopes and brought to the laboratory. They were stretched on the stretching board by using entomological pins and then taken out after 4-5 days. The dried specimens tagged with the labels of locality, date of collection, altitude, etc. were preserved in the entomological storage boxes duly fumigated with the naphthalene balls. The representatives were identified on the basis of their morphological characters by consulting literature such as Antram (1924), Bingham (1907), Evans (1932) and Talbot (1939). The pictures of adult members were obtained from the dorsal and ventral sides with a Nikon digital camera (18-105mm). Then they were identified by dissecting their genitalia by adopting the method proposed by Robinson (1976). The terminology for the genitalia has been adopted from Klots

(1970). The photography of external genitalia of both the sexes has been accomplished by using Leica microscope equipped with a photographic unit. The Pierid species preserved in the National Museum of Lepidoptera, ZSI, Kolkata have also been studied.

OBSERVATIONS AND DISCUSSION

Genus *Pieris* Schrank, 1801

Common name: Whites

Pieris Schrank, 1801; *Fauna Boica* 2 (1): 152.

Ganoris Dalman, 1816; *K. Vetensk Acad. Handl.* (1): 61.

Tachyptera Berge, 1842; *Schmetterlingsbuch.* 19: 92-105.

Artogeia Verity, 1947; *Le Farfalle diurn. d'Italia* 3: 192.

Talbotia Bernardi, 1958; *Rev. franc. Ent.* 25: 125.

Type species: *Papilio brassicae* Linnaeus, 1758

Papilio brassicae Linnaeus, 1758; *Syst. Nat.* (Edn 10) 1: 467.

Diagnosis: Forewing vein R_3 arises from vein R_5 , and the fork is more close to the apex of the wing instead of the apex of the cell. Juxta cone-shaped

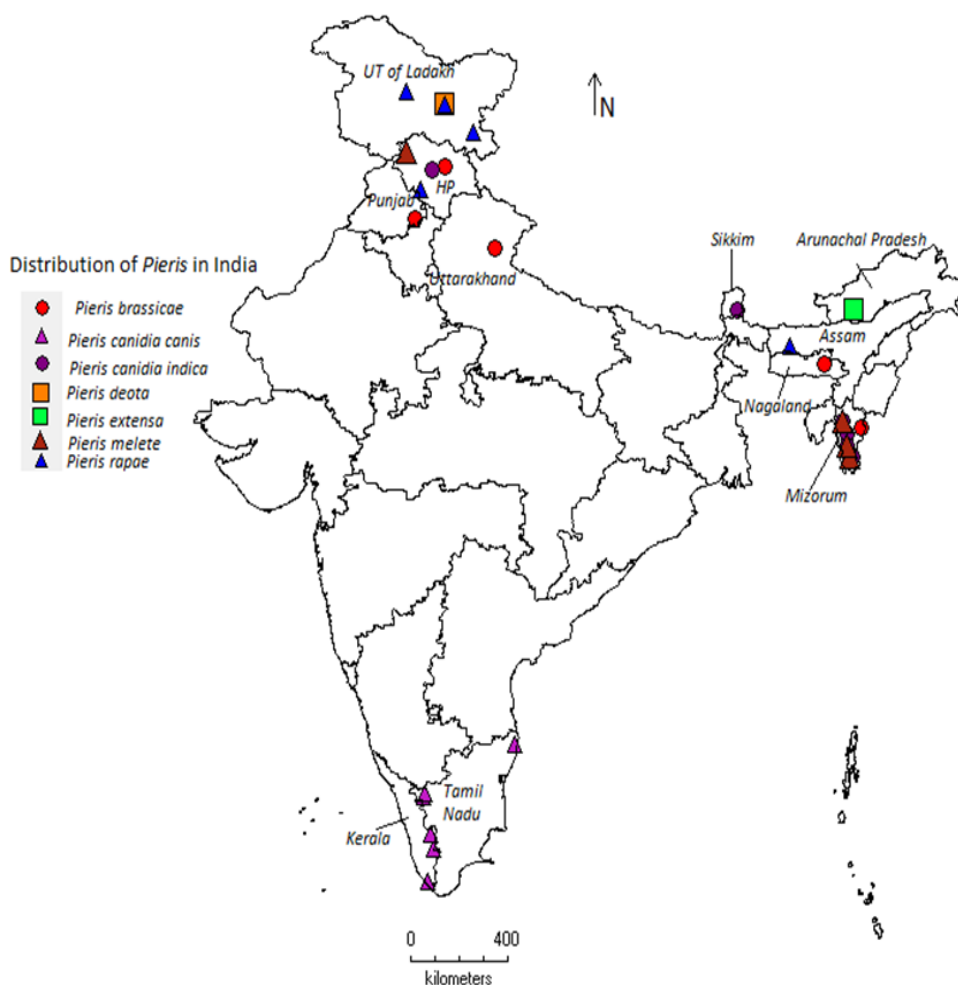


Fig. 1. Distribution of various species of the genus *Pieris* Schrank in India.

Table 1. Collection localities (along with Latitudes and Longitudes) of various species of genus *Pieris* Schrank from India.

S. No.	Species	Locality	Latitude	Longitude
1.	<i>Pieris brassicae</i>	Sukha, Nantial	29.380304	79.46357
2.	<i>Pieris brassicae</i>	Shillong	25.5788	91.8933
3.	<i>Pieris brassicae</i>	Punjabi University Patiala	30.359057	76.449078
4.	<i>Pieris brassicae</i>	Thenzawl, Mizoram	23.2808	92.7741
5.	<i>Pieris brassicae</i>	Lunglei, Mizoram	22.867069	92.765533
6.	<i>Pieris brassicae</i>	Lawngtlai, Mizoram	22.528445	92.892634
7.	<i>Pieris brassicae</i>	Champai, Mizoram	23.4566	93.3282
8.	<i>Pieris brassicae</i>	Reiek, Mizoram	23.6777	92.6037
9.	<i>Pieris brassicae</i>	Taradevi, H.P.	32.084206	77.571167
10.	<i>Pieris deota</i>	Ladakh	34.152588	77.577049
11.	<i>Pieris canidia canis</i>	Coonoor, T.N.	11.350208	76.796104
12.	<i>Pieris canidia canis</i>	Chennai, T.N.	13.067439	80.237617
13.	<i>Pieris canidia canis</i>	Thenmala, Kerala	8.523953	76.960924
14.	<i>Pieris canidia canis</i>	Periyar, Kerala	9.6031	77.1615
15.	<i>Pieris canidia canis</i>	Munnar, Kerala	10.089167	77.059723
16.	<i>Pieris canidia canis</i>	Kotagiri, T.N.	11.4218	76.8617
17.	<i>Pieris canidia indica</i>	Kullu, H.P.	31.957851	77.109459
18.	<i>Pieris canidia indica</i>	Sikkim	27.338936	88.606506
19.	<i>Pieris canidia indica</i>	Thenzawl, Mizoram	23.2808	92.7741
20.	<i>Pieris canidia indica</i>	Lunglei, Mizoram	22.867069	92.765533
21.	<i>Pieris canidia indica</i>	Lawngtlai, Mizoram	22.528445	92.892634
22.	<i>Pieris canidia indica</i>	Reiek, Mizoram	23.6777	92.6037
23.	<i>Pieris canidia indica</i>	Siaha, Mizoram	22.489735	92.979271
24.	<i>Pieris canidia indica</i>	Goorais Valley, Kashmir		
25.	<i>Pieris rapae</i>	Goalpara, Assam	26.17	90.620003
26.	<i>Pieris rapae</i>	Ladakh	34.152588	77.577049
27.	<i>Pieris rapae</i>	Kargil, Ladakh	34.5539	76.1349
28.	<i>Pieris rapae</i>	Leh, Ladakh	34.152588	77.577049
29.	<i>Pieris rapae</i>	Dumka, Ladakh		
30.	<i>Pieris rapae</i>	Nyoma, Ladakh	33.2059	78.6484
31.	<i>Pieris rapae</i>	Bilaspur, H.P.	31.3407	76.6875
32.	<i>Pieris melete</i>	Lawngtlai, Mizoram	22.528445	92.892634
33.	<i>Pieris melete</i>	Reiek, Mizoram	23.6777	92.6037
34.	<i>Pieris melete</i>	Zoltan, Mizoram	22.911099	92.756942
35.	<i>Pieris melete</i>	Ilwas, Chamba, H.P.	32.5553	76.1265
36.	<i>Pieris extensa</i>	Kameng, Arunachal Pradesh	27.361012	93.040095

with two long, thin arms; aedeagus stout, rounded, curved, ductus ejaculatorius entering widely dorsad; female genitalia with signum well sclerotized and bilobed.

Key to species:

1. Forewing dorsal side apex and termen black with

smooth inner edge up to vein Cu_2 ; hindwing without marginal border. Valva with distal end concave to form a distally pointed process making the appearance of the apex of valve bifid; aedeagus not arched; suprazone abruptly swollen forming dorsal hump before middle, constricted, then again swollen

tip blunt.....**brassicae**
 - Forewing dorsal side apex and termen with dentate black border up to vein Cu₂; hindwing dorsal side with dentate marginal border. Valva with distal end protrudes to form a short, blunt process; aedeagus short, suprazone with a dorsal hump, tip blunt.....**deota**

2. Forewing dorsal side apex and termen with black dentate border up to vein Cu₁; hindwing dorsal side with black marginal dots. Uncus in dorsal view Y-shaped with a pointed tip, arms broad.....**canidia**

-Forewing dorsal side apex with black border; hindwing dorsal side without black marginal dots. Uncus in dorsal view Y-shaped with blunt tip, arms narrow.....**rapae**

3. Forewing ventral side with a black spot in area Cu₂; ventral side of hindwing base and forewing apex light lemon yellow. Valva broader than longer; aedeagus with arched suprazone.....**melete**

iv). Forewing ventral side without a black spot in area Cu₂; ventral side of hindwing and forewing apex dark yellow. Valva broad and long; aedeagus with tortuous suprazone.....**extensa**

Pieris brassicae (Linnaeus, 1758)

Common name: Large Cabbage White (PLATES-I & II)

Papilio brassicae Linnaeus, 1758; *Syst. Nat.* (Edn 10) 1: 467.

Pontia chariclea Stephens, 1827; *Ill. Br. Ent.* 1 (1): 17.

Pieris brassicae Rober, 1896; *Ent. Nachr.* 22 (6): 81.

Pieris brassicae Krulikovskiy, 1902; *Revue Russe Ent.* 2 (4): 221.

Pieris brassicae Rober, 1907; *Gross-Schmett. Erde* 1: 45.

Adult (Male): Forewing dorsal surface creamish-white; base with dusted black scales; costa black; apex and termen widely black up to vein Cu₁ with smoothly curved inner edge. Ventral surface white; costa and base little dusted with black scales; apex ochraceous-yellow; black quadrate spots in areas Cu₂ and M₃. Hindwing dorsal surface creamish-white; a little dusting of black scales at the base; large black spot at the costa. Ventral surface ochraceous-yellow, little dusted with black scales; costal spot shows through.

Adult (Female): Forewing dorsal surface creamish-white; base heavily dusted with blackish scales; apex and termen black; inner margin of the black area not smoothly curved; two black quadrate spots in areas Cu₂ and M₃. Ventral surface white; costa and base dusted with blackish scales; apex and termen ochraceous-yellow; two quadrate black scales in areas

Cu₂ and M₃. Hindwing dorsal surface creamish-white with little yellow tinge; black costal spot. Ventral surface ochraceous-yellow with black costal spot visible through.

Wing-span: 60-75 mm.

Male genitalia: Uncus in lateral view narrow, slightly curved, in dorsal view V-shaped; tegumen narrow, sclerotized, V-shaped from dorsal view, uncus and tegumen projected upwardly, latero-ventral projections of tegumen narrow; vinculum sinuous; saccus sclerotized, curved upwardly; appendices angulares long, well sclerotized, broad towards valva, gradually narrow towards tegumen; juxta conical, arms sinuous; valva long, tortuous, broad, sparsely setosed, distal end concave to form a distally pointed process

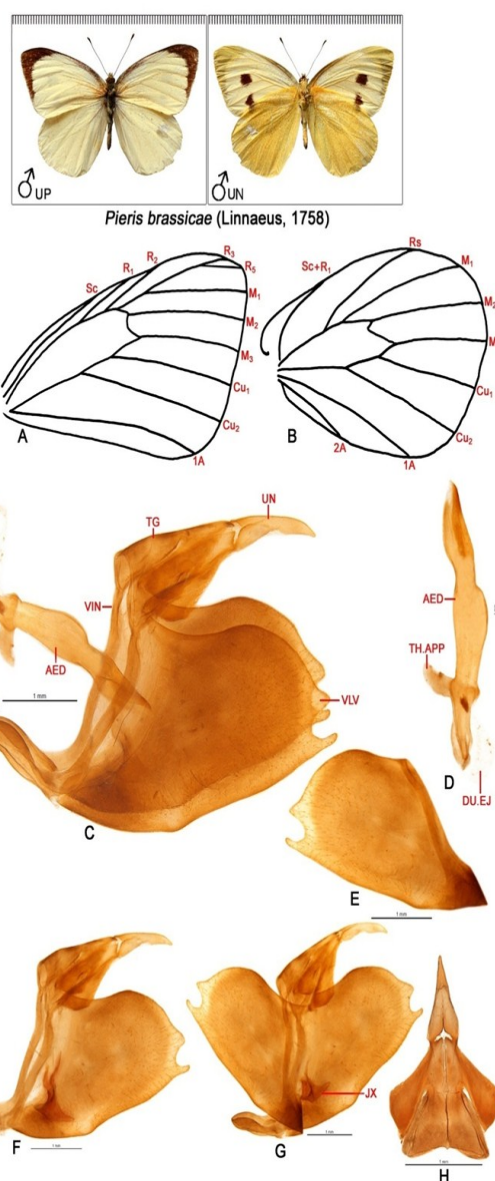


PLATE-I. *Pieris brassicae* (male). A. Forewing, B. Hindwing, C. & F. Male genitalia, (lateral view), D. Aedeagus, E. Valva, G. Male genitalia (after opening), H. Uncus (Dorsal view).

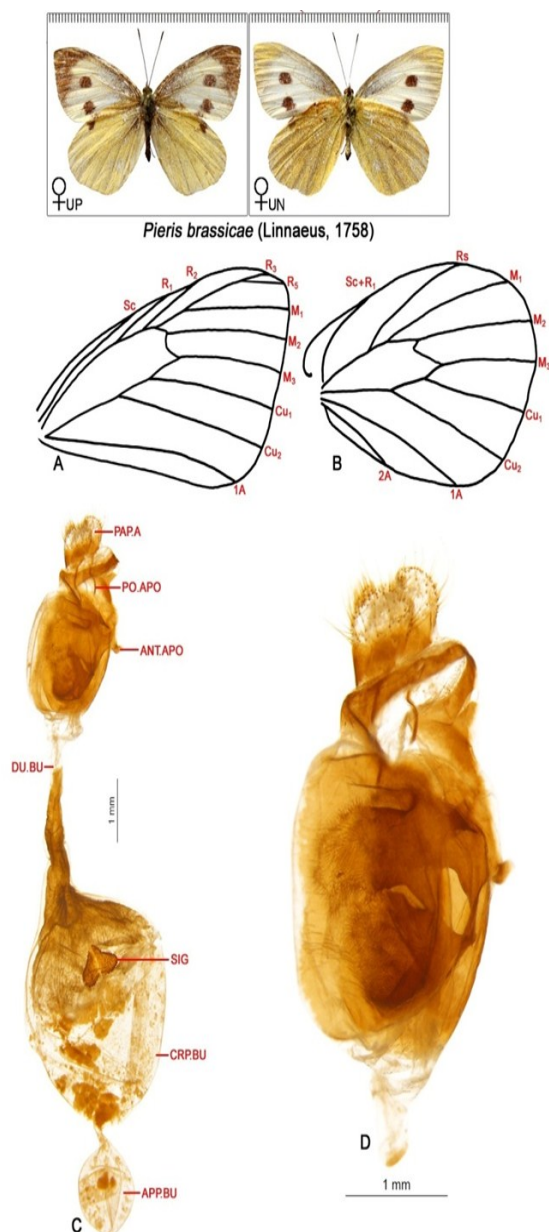


PLATE-II. *Pieris brassicae* (female). A. Forewing, B. Hindwing, C. Female Genitalia, D. Papilla analis.

making the appearance of the apex of valve bifid; aedeagus short, subzone smaller than suprazone, latter abruptly swollen forming dorsal hump before middle, constricted, then again swollen, tip blunt, thecal appendage ventral, moderately broad, ductus ejaculatorious enters dorsally.

Female genitalia: Corpus bursae rounded, gradually narrow towards appendix bursae; signum bifid by shallow suture, outer margins more sclerotized; appendix bursae globular, moderately large, membranous, clearly separated from corpus bursae; ductus bursae long, well sclerotized; papilla analis rounded and setosed; posterior apophysis long, thin, sclerotized, blunt tips; anterior apophysis smaller, broad.

Material examined: ZSI, Kolkata, National Museum Collections: 1♂, 12.iv.1916, Sukha, Nainital, Uttarakhand; 1♀, 23.vi.1959, Shillong, Meghalaya. 3♂, 19.iv.2016, Punjabi University, Patiala, Punjab, (Coll. Manpreet Kaur); 3♂, 2♀, 14.vi.2016, Thalyara, (Coll. Manpreet Kaur); 6♂, 3♀, 6.iv.2017, Thenzawl, Mizoram, (Coll. Manpreet Kaur); 4♂, 2♀, 10.iv.2017, Lunglei, Mizoram, (Coll. Manpreet Kaur); 2♂, 3♀, 14.iv.2017, Lawngtlai, (Coll. Manpreet Kaur); 2♂, 18.iv.2017, Champai, Mizoram, (Coll. Manpreet Kaur); 2♂, 19.iv.2017, Reiek, Mizoram, (Coll. Manpreet Kaur); 3♂, 2♀, 3.iii.2018, Taradevi, Himachal Pradesh, (Coll. Manpreet Kaur).

Distribution India: Sikkim, Uttarakhand, Himachal Pradesh, Nagaland, Jammu and Kashmir, Manipur, Arunachal Pradesh, Meghalaya, Punjab, Delhi, Uttar Pradesh.

Elsewhere: Nepal, West Siberia, South Siberia, Mongolia, China, Japan, Amur, Ussuri, Thailand, Vietnam, Yunnan, Cyprus.

Remarks: *Pieris brassicae* (Linnaeus) is a common species distributed in the Oriental and Palearctic regions. Bingham (1907), Antram (1924) and Talbot (1939) described the male and female external characters and distribution of this concerned species. Verity (1919) studied the seasonal variations in *P. brassicae* by comparing the features of three broods of this species and concluded that the third brood possesses intermediate features between first brood and second brood. In this present work, the morphological characters and genitalic characters of both the sexes have been described and compared with other Indian species of the genus. The genitalia is also compared with the illustrations given by Klots (1931). Its valve, aedeagus and uncus show remarkable differences from other species of the genus. The valve is long, tortuous, slightly concave at the base of costa. The distal tip invaginates to form a smaller, narrow and blunt ended process. These processes are absent in other Indian species of this genus. Aedeagus with proximal part of suprazone abruptly swollen forming dorsal hump. Saccus is longer as compared to other species of this group. In females, the signum is inverted heart-shaped in *P. brassicae*.

***Pieris deota* (de Niceville, 1884)**

Common name: Dusky White (PLATE-III)
Mancipium deota de Niceville, 1884; *J. Asiat. Soc. Bengal* 52: 82.

Pieris roborowskii Alpheraky, 1887; *Mem. Lep.* 3: 404.

Pieris roborowskii Grun- Grshimailo, 1890; *Mem. Lep.* 3: 214.

Pieris deota Korb & Bolshakov, 2011; *Eversmannia Suppl.* 2:26.

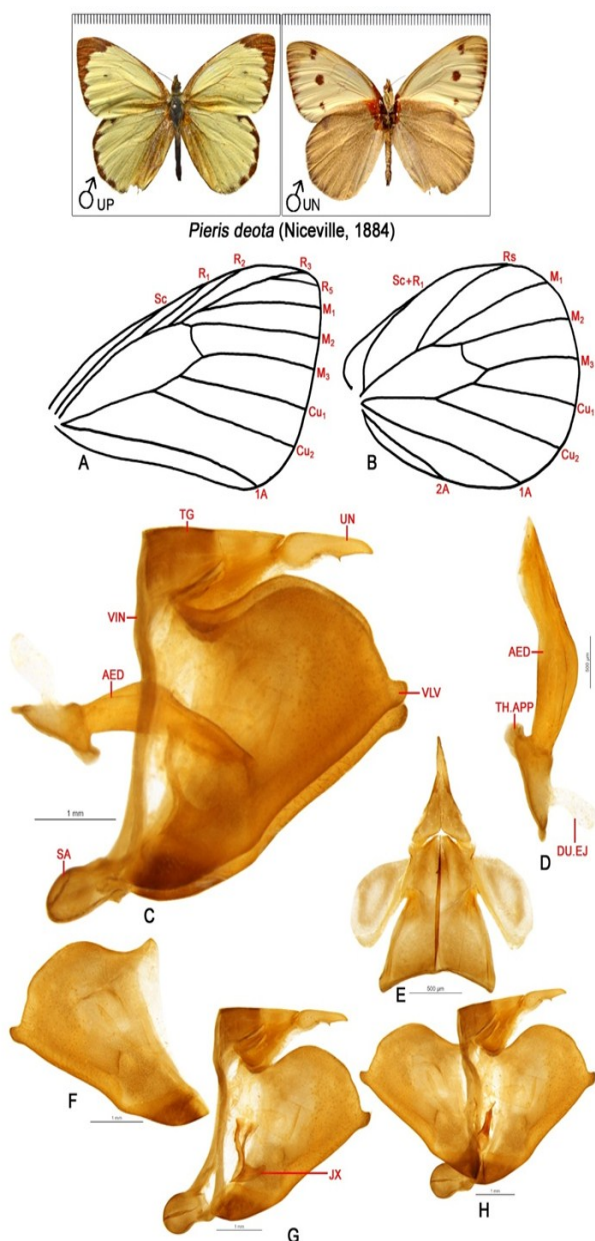


PLATE-III. *Pieris deota* (male). A. Forewing, B. Hindwing, C.&G. Male Genitalia, (lateral view), D. Aedeagus, E. Uncus (Dorsal view), F. Valva, H. Male genitalia (after opening).

Adult (Male): Forewing dorsal surface creamish-white; costa thin black; apex and termen black with denticulate inner margin; black thin spot in area M_3 . Ventral surface white with light brownish apex and termen; dark brownish spots in areas Cu_2 , M_3 and R_5 . Hindwing white with base and inner margin dusted with black scales; outer margin with denticulate black border. Ventral surface light brownish little dusted with black scales; black dot in the subcostal area.

Wing-Span: 56-65 mm.

Male genitalia: Uncus narrow, straight, blunt tip, in dorsal view V-shaped, shorter and narrower than tegumen; tegumen sclerotized, anteriorly broad; vin-

culum slightly curved, sclerotized, saccus short, flattened, distal end strongly rounded; juxta large, upper part with long, slender, curved arms, lower part forms conical structure caudad; valva obliquely oriented, costa strongly convex, distal end protrudes to form a short, blunt process; aedeagus short, robust, subzone smaller than suprazone, suprazone with dorsal hump, blunt apically, thecal appendage short, distal end blunt, ductus ejaculatorius enters dorsally.

Material examined: ZSI, Kolkata, National Museum Collections.

1♂, 4.vii.1887, 1♀, viii.1914, Ladakh.

Distribution India: Kashmir

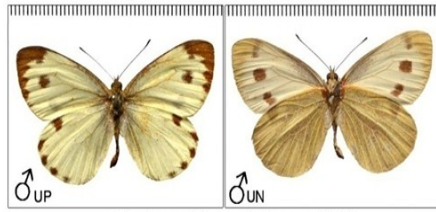
Elsewhere: Hunza, Baluchistan, Pakistan.

Remarks: *Pieris deota* (de Niceville) is protected under Schedule II of the Indian Wildlife (Protection) Act, 1972. It is distributed between the altitude of 3600m to 4400m and has been recorded from India, Central Asia, Pakistan and Tibet. Bingham (1907), Antram (1924) and Talbot (1939) compared the morphological attributes of *P. deota* with *P. brassicae* and reported them as closely resembling species. In the present work, the morphological as well as genitalic attributes of *P. deota* have been studied and illustrated for the first time, and compared with *P. brassicae* & other Indian species of this group. It has been observed that both the species are morphologically somewhat similar with slight differences. Both the species are white dorsally with a black border on the dorsal side of forewing apex and termen and on the ventral surface of forewing with a black spot in areas M_3 and Cu_2 . In *Pieris deota*, the black border on dorsal side of forewing apex and termen and on the dorsal side of hindwing margin is macular whereas in *P. brassicae*, the black margin on the dorsal side of forewing apex and termen is smooth and on the dorsal side of hindwing this border is absent. The black spots in areas M_3 and Cu_2 are large in *Pieris deota* with additional submarginal spot whereas these spots are small in *P. brassicae*. In *P. deota*, the valva is obliquely oriented with costal margin strongly convex, and the distal end protrudes to form a small, blunt ended process. The aedeagus is highly robust with dorsal margin strongly convex and ventral margin almost linear. In *P. brassicae*, the valve is long, tortuous, slightly concave at the base of costa, and the distal tip invaginates to form a smaller, narrow and blunt ended process. Aedeagus with proximal part of suprazone abruptly swollen forming dorsal hump.

***Pieris canidia* (Linnaeus, 1768)**

Common name: Indian Cabbage White (PLATES-IV to VIII)

Papilio canidia Linnaeus, 1768; *Amoenitates Acad.* 7: 504.



Pieris canidia canis Evans, 1912

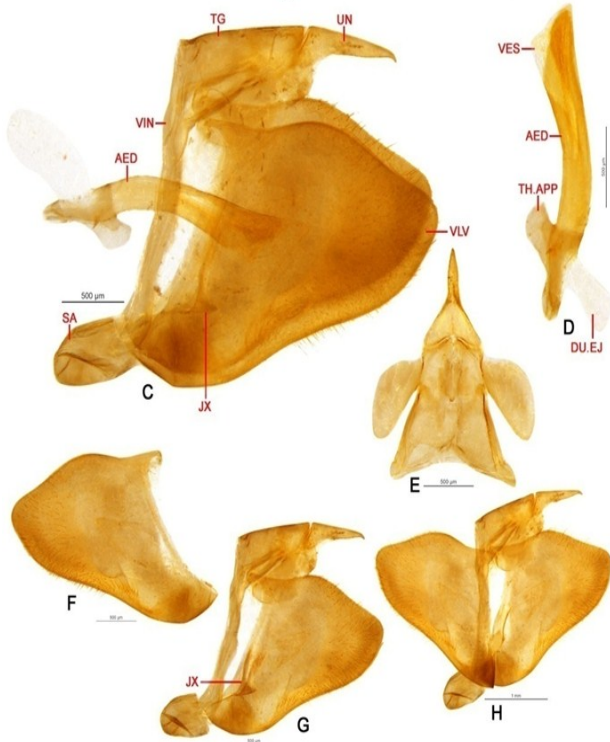
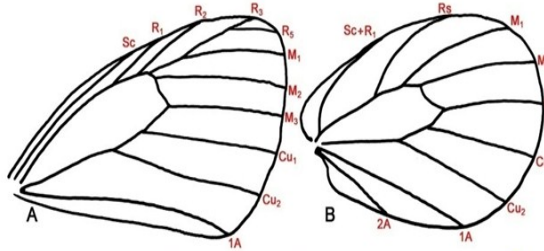
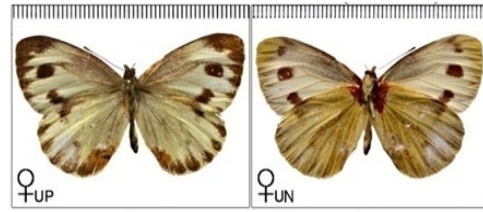


PLATE-IV. *Pieris canidia canis* (male). A. Forewing, B. Hindwing, C.&G. Male Genitalia (lateral view), D. Aedeagus, E. Uncus (Dorsal view), F. Valva, H. Male genitalia (after opening) .

Papilio gliciria Cramer, 1777; *Uitl. Kapellen* 2: 115.
Pieris canidia Korb & Bolshakov, 2011; *Eversmannia Suppl.* 2: 27.

Diagnosis: Forewing dorsal side apex black; termen with black denticulate margin upto vein Cu₁; a black spot in area M₃. Ventral side with black spots in areas M₃ and Cu₂. Hindwing dorsal side with a black costal spot in area Rs.

Male genitalia: Uncus narrow, slightly sinuous, distal tip pointed and downcurved, in dorsal view Y-shaped; tegumen slightly broad, somewhat rectangular in dorsal view, longer than uncus; vinculum thin, heavily sclerotized, ; saccus broad, distal end



Pieris canidia canis Evans, 1912

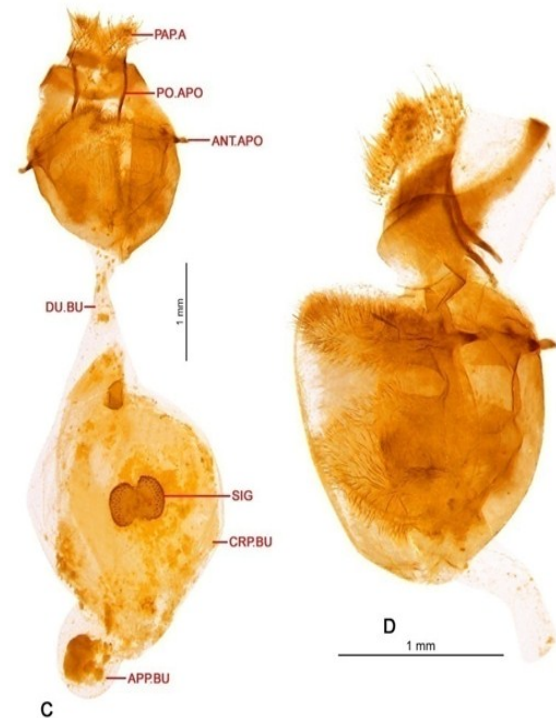
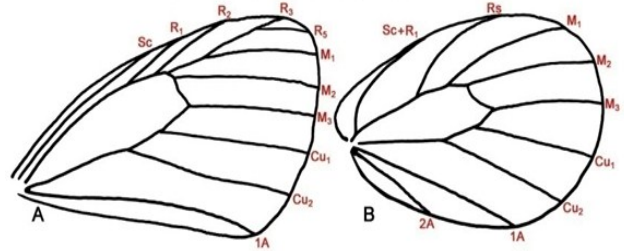
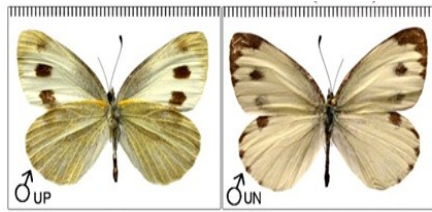


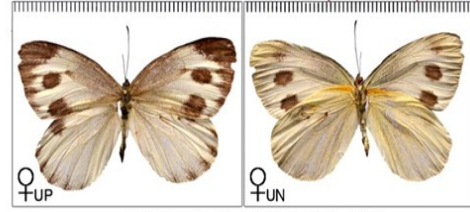
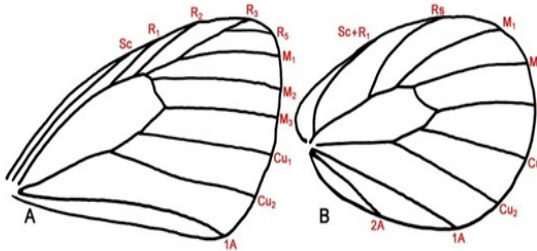
PLATE-V. *Pieris canidia canis* (female). A. Forewing, B. Hindwing, C. Female Genitalia, D. Papilla analis.

rounded; juxta reduced cone-shaped with thin, sclerotized, long arms; valva broad proximally, marginal areas sclerotized and setosed, apex narrow and blunt; costa and lateral margin sinuous; aedeagus robust, slightly curved, subzone smaller and sclerotized than suprazone, thecal appendage ventral, moderately broad, ductus ejaculatorious enters dorsally.

Female Genitalia: Corpus bursae spherical, large; signum double, broad, outer margins more sclerotized, spinuous and invaginated in the center; appendix bursae oval, membranuous; ductus bursae robust; papilla analis sclerotized and setosed; posterior



Pieris canidia indica Evans, 1926



Pieris canidia indica Evans, 1926

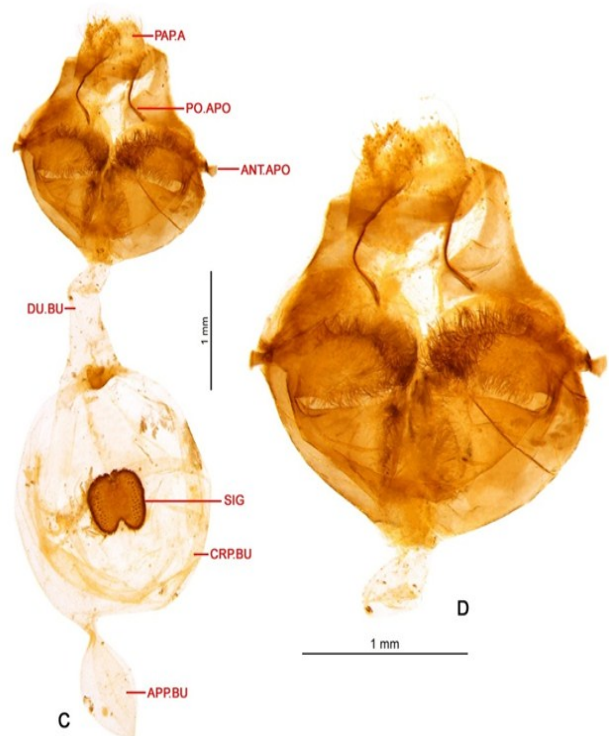
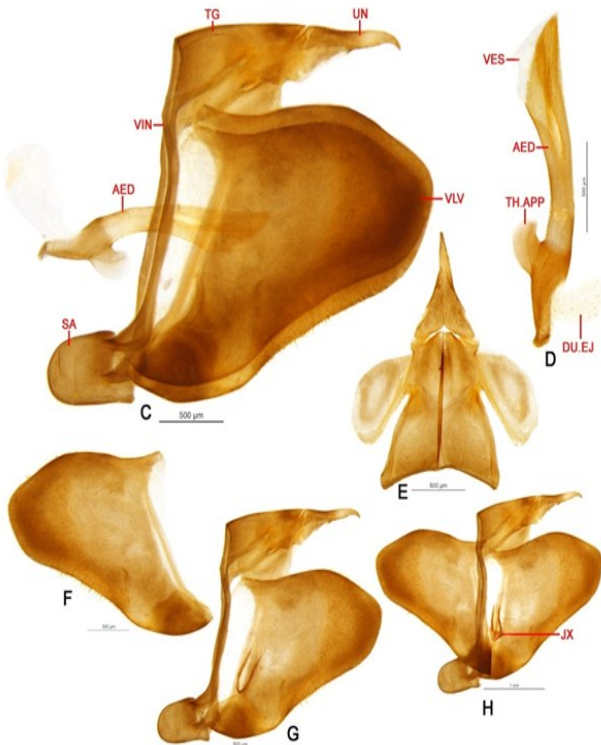
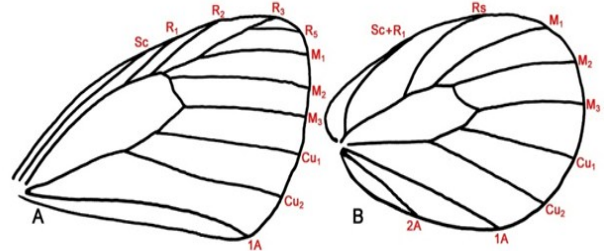


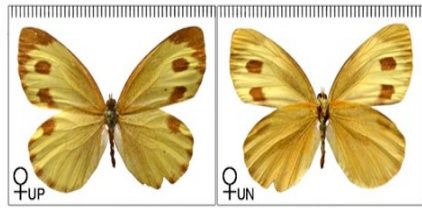
PLATE-VI. *Pieris canidia indica* (male). A. Forewing, B. Hindwing, C.&G. Male Genitalia (lateral view), D. Aedeagus, E. Uncus (Dorsal view), F. Valva, H. Male genitalia (after opening) .

PLATE-VII. *Pieris canidia indica* (female). A. Forewing, B. Hindwing, C. Female Genitalia, D. Papilla analis.

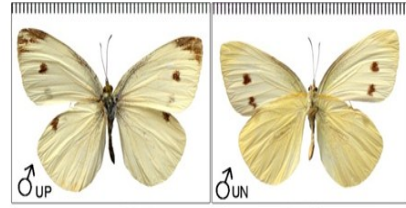
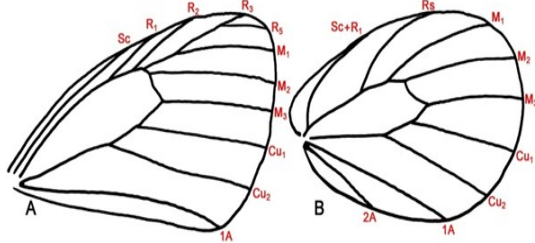
apophysis long, thin, curved, sclerotized, blunt tips; anterior apophysis smaller, blunt tips.

Remarks: *Pieris canidia* (Linnaeus) is a common species widely distributed throughout India at the altitude of 600m to 3400m. There are two subspecies, i.e. *P. c. canis* Evans from South India, North Maharashtra, Madhya Pradesh and Chhattishgarh and *P. c. indica* Evans from Arunachal Pradesh, Mizoram, Manipur, Sikkim, Jammu and Kashmir, Delhi, Punjab and Uttar Pradesh. In the present work, the morphological characters, genitalic attributes and distribution of both the subspecies have

been studied, illustrated and compared. The genitalic attributes of *P. canidia* have been also compared with *P. rapae*. In *P. canidia*, the uncus is prominently Y-shaped from dorsal view with pointed tip whereas in *P. rapae*, the uncus is with a blunt tip. In *P. canidia*, the valve is sinuous with the slightly narrowly rounded and tortuous distal end as compared to *P. rapae* and another species of the genus. In females, the signum is somewhat bilobed in case of *canidia* whereas in case of *P. rapae* the signum is almost rounded with well-sclerotized boundaries.



Pieris canidia (Linnaeus, 1768)



Pieris rapae (Linnaeus, 1758)

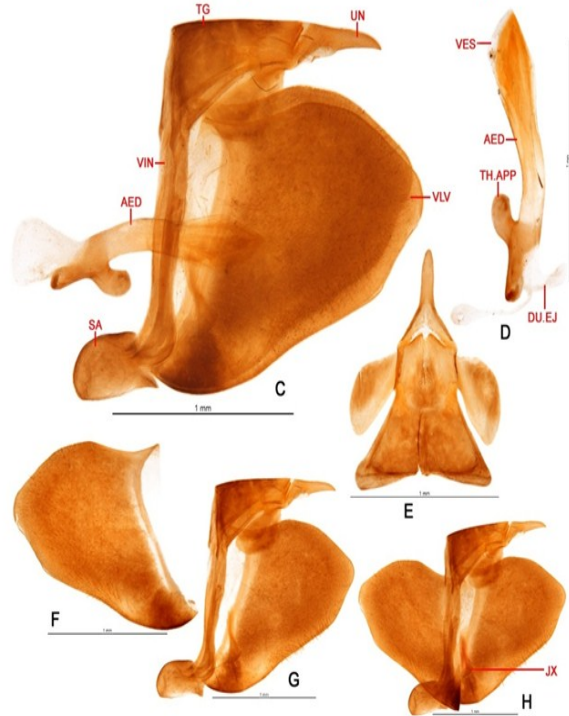
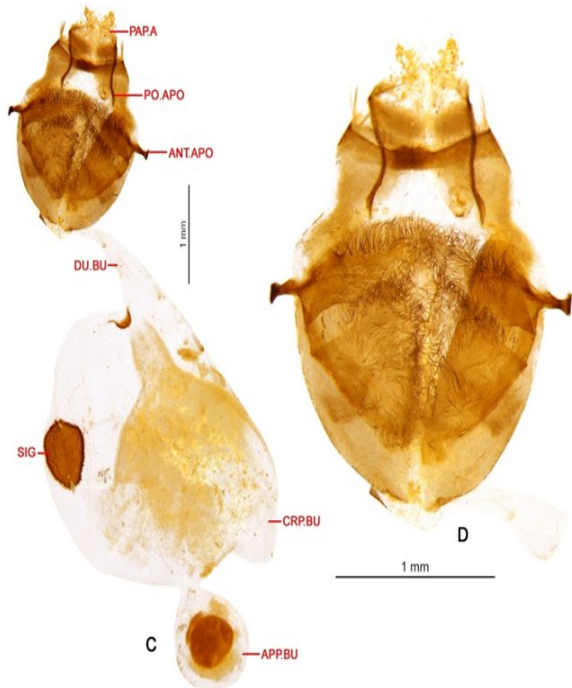
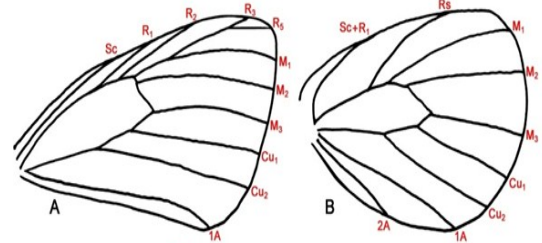


PLATE-VIII. *Pieris canidia indica* (female, yellow form). A. Forewing, B. Hindwing, C. Female Genitalia, D. Papilla analis.

PLATE-IX. *Pieris rapae* (male). A. Forewing, B. Hindwing, C.&G. Male Genitalia (lateral view), D. Aedeagus, E. Uncus (Dorsal view), F. Valva, H. Male genitalia (after opening).

Key to subspecies:

1. Markings dark; forewing dorsal side with small spur produced in area R₅ from black apical portion.....***canidia canis***
5. Markings less dark; forewing dorsal side without spur from black apical portion.....***canidia indica***

***Pieris canidia canis* Evans, 1912**

Common name: Sahyadri Cabbage White
Pieris canidia canis Evans, 1912; *J. Bombay nat. Hist. Soc.* 21 (2): 559.

Adult (Male): Wing maculation dark; forewing dorsal side with apex and termen black with small spur produced in area R₅ from black apical portion; ventral surface white with lemon-yellowish apex.

Hindwing with slightly large black marginal spots; ventral side ochraceous-brownish.

Adult (Female): Wing maculation same as in male but extremely dark and broad. The base of dorsal surface of both the wings and base of ventral surface of forewing dusted with blackish scales.

Wing-Span: 45-60 mm.

Male genitalia: Uncus inclined distally, distal tip pointed and downcurved, in dorsal view Y-shaped; tegumen slightly broad, somewhat rectangular in dorsal view, longer than uncus; vinculum broad; saccus broad, distal end rounded; juxta reduced cone-shaped with thin, long, broad and flattened arms; valva broad proximally, marginal area setosed, apex

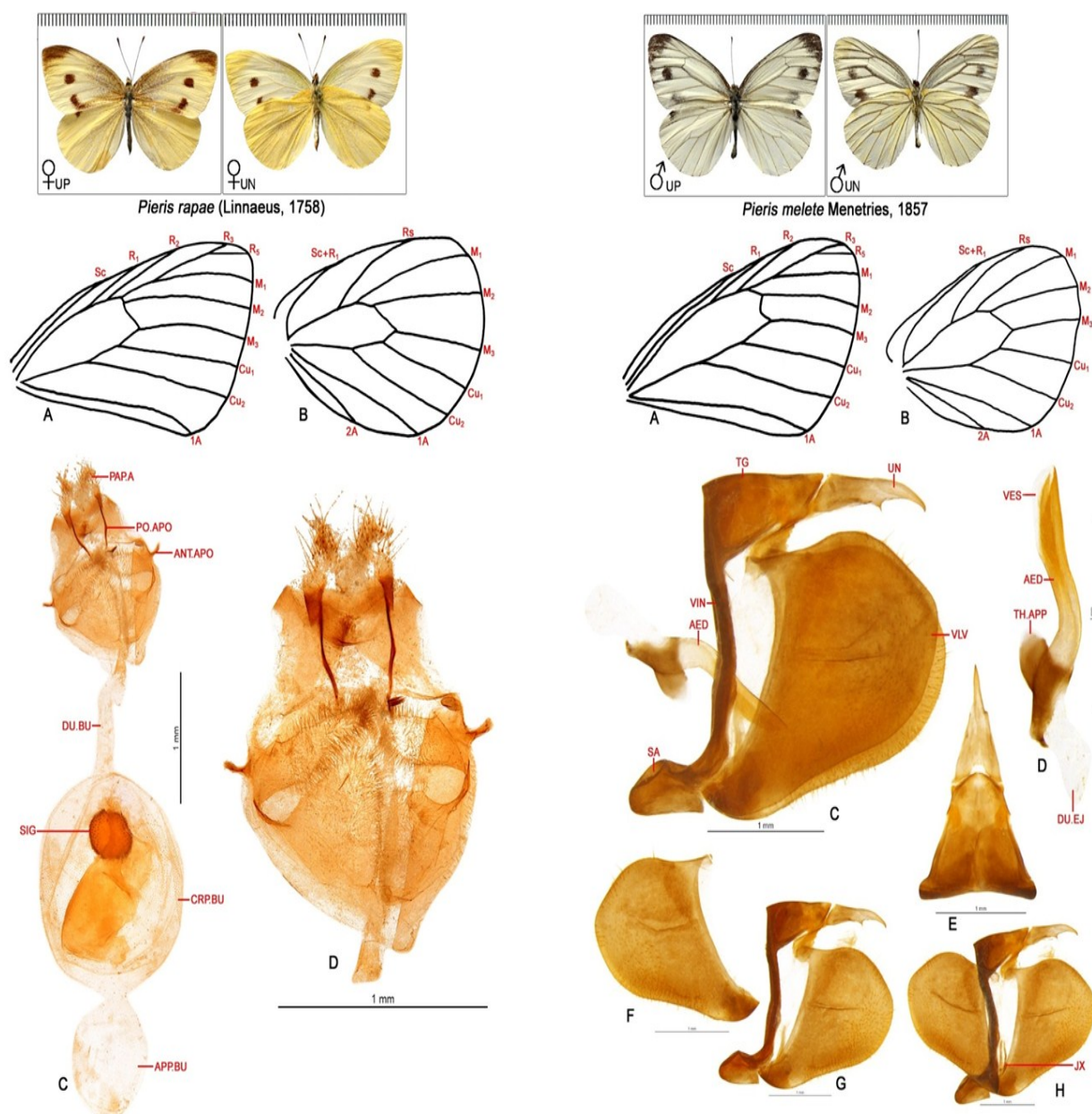


PLATE-X. *Pieris rapae* (female). A. Forewing, B. Hindwing, C. Female Genitalia, D. Papilla analis.

PLATE-XI. *Pieris melete* (male, WSF). A. Forewing, B. Hindwing, C.&G. Male Genitalia (lateral view), D. Aedeagus, E. Uncus (Dorsal view), F. Valva, H. Male genitalia (after opening).

narrow and blunt; costa and lateral margin sinuous; aedeagus robust, slightly curved, subzone smaller than suprazone, thecal appendage ventral, moderately broad, ductus ejaculatorius enters dorsally.

Female genitalia: Corpus bursae somewhat spherical, gradually narrow towards ductus bursae; signum broad, outer margins more sclerotized, spinuous and invaginated in the center; appendix bursae oval, membranuous; ductus bursae small; papilla analis sclerotized and setosed; posterior apophysis long, thin, sclerotized, blunt tips; anterior apophysis smaller, blunt tips, genital plate bilobed, each lobe oval shaped, densely hairy.

Material examined: ZSI, Kolkata, National Museum Collections.

1♀, 16.vii.1880, 1♀, 17.vii.1880, 1♂, 20.vii.1880, Coonoor, Tamil Nadu; 1♂, ii.1962, 1♀, 3♂, v.1926, 3♂, x.1962, Kolagiri; 3♂, 12.iii.1962, 1♂, 29.iii.1962, 1♂, 31.iii.1962, Madras, Tamil Nadu, (Coll. K.V.L Narayana); 4♂, 7.viii.2017, Thenmala, Kerala, (Coll. Manpreet Kaur); 2♂, 3♀, 12.viii.2017, Periyar, Kerala, (Coll. Manpreet Kaur); 2♂, 14.viii.2017, Munnar, Kerala, (Coll. Manpreet Kaur).

Distributin India: South India, North Maharashtra, Madhya Pradesh, Chhattishgarh.

Elsewhere:-

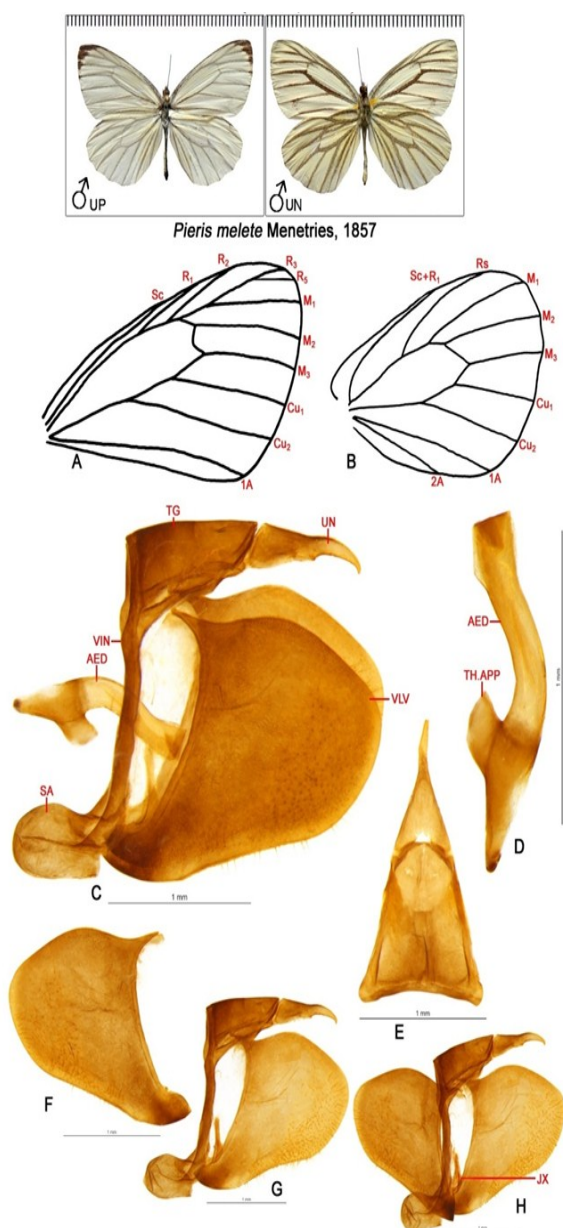


PLATE-XII. *Pieris melete* (male, DSF). A. Forewing, B. Hindwing, C.&G. Male Genitalia (lateral view), D. Aedeagus, E. Uncus (Dorsal view), F. Valva, H. Male genitalia (after opening).

Remarks: *P. canidia canis* is a common species distributed in South India. Evans (1927) recorded *P. canidia canis* as very common from Travancore to Nilgiris. Evans (1932) devised a key for this subspecies on the basis of their morphology including its distribution. Talbot (1939) reported *P. canidia canis* as common subspecies in Nilgiri hills and compared its external morphology subspecies *P. canidia indica*. Gasse (2013) and Varshney Smetacek (2015) recorded its distributional range. In this present research work, the morphological characters, genital attributes and distribution of *P. canidia canis* have

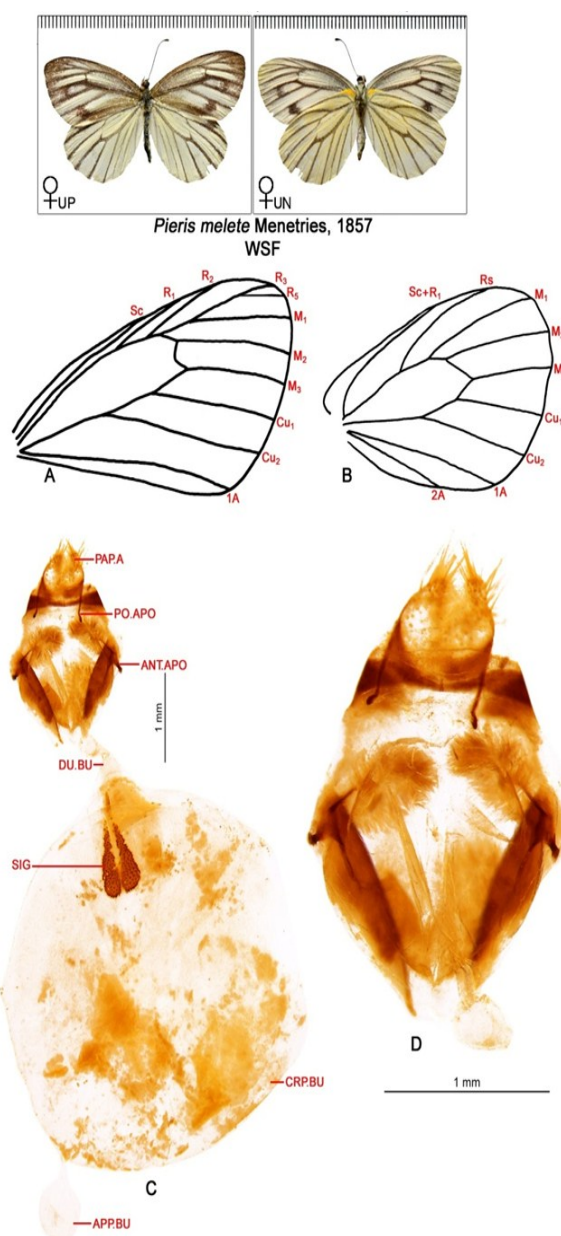


PLATE-XIII. *Pieris melete* (female, WSF). A. Forewing, B. Hindwing, C. Female Genitalia, D. Papilla analis.

been studied and illustrated. The valve of *P. canidia canis* is more sinuous and with the slightly narrowly rounded distal end as compared to other Indian species of the genus.

***Pieris canidia indica* Evans, 1926**

Common name: Himalayan Cabbage White
Pieris canidia indica Evans, 1926; *J. Bombay nat. Hist. Soc.* 31 (3): 712.

Adult (Male): All the markings similar to *Pieris canidia canis* but little smaller and less heavily dark in *Pieris canidia indica*. The small spur produced in ar-
ea R₅ from the black apical portion absent, the black

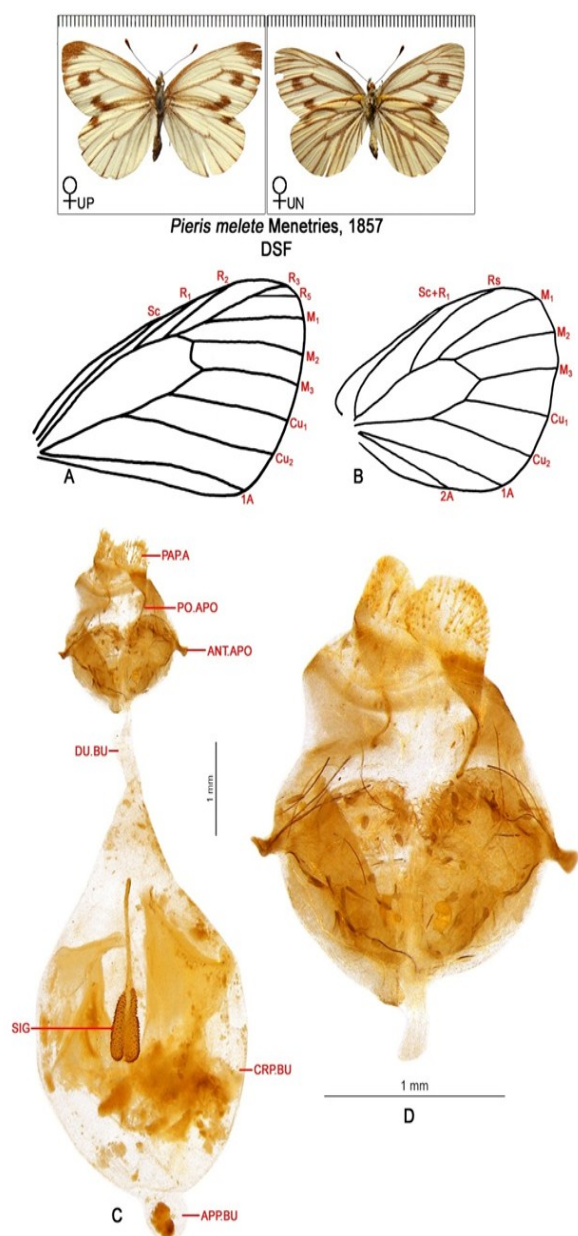


PLATE-XIV. *Pieris melete* (female, DSF). A. Forewing, B. Hindwing, C. Female Genitalia, D. Papilla analis.

marginal spots are smaller and forewing ventral side apex and hindwing ventral side yellowish-green in *Pieris canidia indica*.

Adult (Female): Markings similar to as in male but slightly dark and broad. Forewing ventral side apex and hindwing ventral side light yellowish-green.

Wing-Span: 45-60 mm.

Male genitalia: Similar to as in *P. canidia canis* with slight difference in the uncus. The uncus is almost straight with the dorsal margin of the uncus slightly concave and distal tip arched and downcurved in case of *P. canidia indica*.

Female Genitalia: Similar to as in *P. canidia canis*.

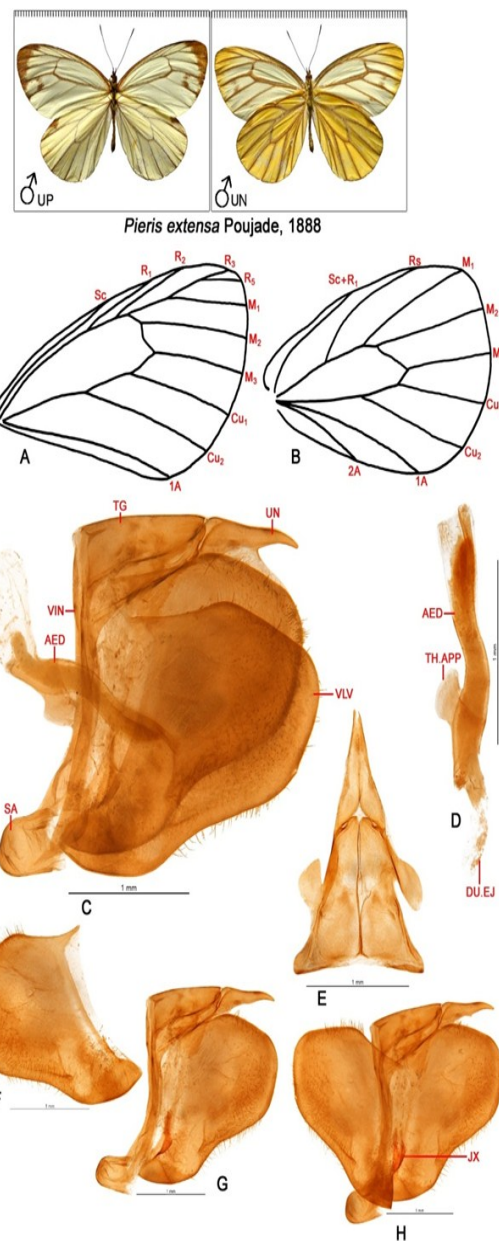


PLATE-XV. *Pieris extensa* (male). A. Forewing, B. Hindwing, C.&G. Male Genitalia (lateral view), D. Aedeagus, E. Uncus (Dorsal view), F. Valva, H. Male genitalia (after opening).

Material examined: ZSI, Kolkata, National Museum Collections: 1♂, 2♀, 5.iv.1880, Kulu; 1♀, 23.vi.1887, Sind valley, Kashmir; 1♂, 23.viii.1887, Goorais valley, Kashmir; 1♂, vi.1890, Sikkim; 1♂, 6.viii.1959, Sikkim (Coll. A.G.K Manon). 5♂, 2♀, 6.iv.2017, Thenzawl, Mizoram, (Coll. Manpreet Kaur); 6♂, 4♀, 10.iv.2017, Lunglei, Mizoram, (Coll. Manpreet Kaur); 5♂, 12.iv.2017, Siaha, Mizoram, (Coll. Manpreet Kaur); 3♂, 2♀, 14.iv.2017, Lawngtlai, (Coll. Manpreet Kaur); 4♂, 2♀, 19.iv.2017, Reiek, Mizoram, (Coll. Manpreet Kaur).

Distribution India: Arunachal Pradesh, Mizoram, Manipur, Sikkim, Jammu and Kashmir, Delhi,

Punjab, Uttar Pradesh.

Elsewhere: West China, Burma, Hainan, Taiwan, Singapore, Turkestan, Japan, Yunnan.

Remarks: *P. canidia indica* is a common species distributed in North-East India. Evans (1927) reported *P. canidia indica* as very variable subspecies. Evans (1932) devised a key for this subspecies on the basis of their morphology including its distribution. Talbot (1939) compared its external morphology subspecies *P. canidia canis*. Gasse (2013) and Varshney and Smetacek (2015) recorded its distributional range. In this present research work, the male and female genitalic attributes of *P. canidia indica* have been compared with *P. canidia canis* for the first time. The genitalia of both the subspecies are similar with a slight difference in their uncus. In *P. canidia indica*, the uncus in lateral perspective is almost straight with the dorsal margin of the uncus slightly concave and distal tip arched and down-curved whereas, in *P. canidia canis*, the uncus is inclined downwardly with distal tip downcurved.

***Pieris rapae* (Linnaeus, 1758)**

Common name: Small Cabbage White (PLATES-IX & X)

Papilio rapae Linnaeus, 1758; *Syst. Nat.* (Edn 10) 1:468.

Pieris rapae Rolfe, 1876; *Entomologist* 9:199.

Pieris rapae Krulikovsky, 1890; *Bull. Soc. Imp. Nat. Moscou* 4 (2): 210.

Pontia rapae Grum-Grshimailo, 1890; *Mem. Lep.* 4: 218.

Pieris rapae Holloway & Peters, 1976; *J. Nat. Hist.* 10: 295.

Pieris rapae Korb & Bolshakov, 2011, *Eversmannia Suppl.* 2: 27.

Adult (Male): Smaller in size. Forewing dorsal surface white; costa lightly dusted with blackish scales; apex wide blackish; black circular spot in the centre of area M_3 . Ventral surface white; costa and anterior half of the cell dusted with blackish scales; moderate blackish spots in areas M_3 and Cu_2 . Hindwing dorsal surface white; subapical black small spot in area Rs . Ventral surface creamish-white without maculation.

Adult (Female): Forewing dorsal surface creamish-white; base, cell and costa dusted with blackish scales; apex thick brownish-black; moderate dark brownish-black spots in areas Cu_2 and M_3 . Ventral surface white; costa and anterior part of the cell dusted with blackish scales; apex yellowish-white; dark brownish-black spots in areas Cu_2 and M_3 . Hindwing dorsal surface creamish-white with a dark black subapical spot. Ventral surface yellowish-white; little dusted with blackish scales.

Wing-Span: 40-55 mm.

Male Genitalia: Uncus straight, slender, distal point-

ed tip, in dorsal view Y-shaped; tegumen sclerotized, somewhat triangular in lateral view, longer than uncus; vinculum sclerotized, broad; saccus broad, distal end rounded; appendices angulares broad; juxta cone-shaped; valva broad, sparsely setosed, distal tip blunt; aedeagus short, broad, subzone smaller than suprazone, thecal appendage ventral, rounded, ductus ejaculatorius enters dorsally.

Female Genitalia: Corpus bursae large, spherical with minute spicules; signum quadrate in shape, outer margin more sclerotized and spinuous; appendix bursae moderately large, membranuous, attached to corpus bursae in close proximity; ductus bursae broad; papilla analis pilosed; posterior apophysis much longer, slender, heavily sclerotized, pointed tips; anterior apophysis small with blunt ends; genital plate bilobed, each lobe hirsuate.

Material examined: ZSI, Kolkata, National Museum Collections.

1♂, 8.viii.1902, Nyome; 1♂, 29.iii.1957, Goalpara, Assam; 1♂, 2♀, 15.viii.1997, Ladakh; 1♂, 18.viii.1997, Dumkhal, Ladakh; 3♂, 25.vii.1998, Kargil road, Ladakh; 1♂, 18.v.2012, Bilaspur, Himachal Pradesh; 5♂, 2♀, 20.viii.2019, Leh, Ladakh, (Coll. Gupta).

Distribution India: Kashmir, Ladakh.

Elsewhere: Pakistan, Europe, America, North Africa, Australia.

Remarks: *Pieris rapae* is a common species distributed widely from Europe to North America. It is also found in Afrotropical and Australian regions. Bingham (1907) and Antram (1924) described the external morphological characters of this species along with its distribution. Herman (1971) compared the female genitalia of *P. rapae* with European *Pieris manni*. Both possess differently shaped signum. In this present work, the external morphological and genitalic characters have been studied in detail, and it has been observed that the male genitalic attributes resembles with the genitalic attributes of male of *P. canidia* with slight differences. Both possess sinuous valve with different shape of the distal end. The aedeagus is broad and arched, and saccus is equally small and broad in both the species. In *P. rapae*, the uncus is with blunt tip whereas in *P. canidia*, it is prominently Y-shaped from dorsal view with a pointed tip. In *P. rapae* the costa of the valve is the strongly convex and distal end is slightly broad whereas in *P. canidia*, the valve is sinuous with slightly narrowly rounded and tortuous distal end as compared to *P. rapae* and another species of the genus. In females, the signum is almost rounded with well sclerotized boundaries in *P. rapae* whereas in case of *canidia* it is somewhat bilobed.

***Pieris melete* Menetries, 1857**

Common name: Green-veined White

(PLATE-XI to XIV)

Pieris melete Menetries, 1857; *Cat. Lep. Petersb.* 2: 113.

Pieris aglaope Motschulsky, 1860; *Etud. Ent.* 9:28.

Synchloe megamera Butler, 1873; *Cist. Ent.* 1 (7): 173.

Pieris melete Winhard, 2000; *Butterflies of the World* 10: 29.

Artogeia melete Korb & Bolshakov, 2011; *Eversmannia Suppl.* 2:27.

Adult (Male WSF): Forewing dorsal surface white; costa thin but dark black; apex broadly black; large circular dark black spot in area M_3 and less dark spot in area Cu_2 ; veins well marked with black. Ventral surface whitish with base and costa little dusted with blackish scales; apex light creamy-yellow; dark black dots in area Cu_2 and M_3 . Hindwing dorsal surface white; dark black spot at the apex; veins well marked with black. Ventral surface yellowish-white with veins darker with black.

Adult (Male DSF): Forewing dorsal surface white; costa little blackish; apex black; spots in areas Cu_2 and M_3 absent. Ventral surface white with dark black veins. Hindwing dorsal surface white; without maculation. Ventral surface yellowish-white with darker veins.

Adult (Female DSF): Forewing dorsal surface creamish-white with wider and brownish-black markings; costa and base of the cell brownish-black; apex and termen up to vein Cu_1 blackish; dorsum dusted with brownish-black scales and joins the brownish-black spot in area Cu_2 ; the dark brownish-black dot in area M_3 . Ventral surface as in male. Hindwing dorsal surface creamish-white with dark blackish veins; dark blackish spot in area Rs. Ventral surface as in male.

Adult (Female WSF): Both the wings with dorsal side white. Markings are similar as in the female of DSF but less dark and dusted with black scales. Forewing dorsal side base and half of the cell dusted with blackish scales.

Wing-span: 55-60 mm.

Male Genitalia (WSF): Uncus broad proximally, slightly arched from middle to a distal end, distal tip pointed, downcurved, V-shaped from dorsal view; tegumen well sclerotized, U-shaped from dorsal view; vinculum sclerotized, sinuous; saccus broad, distal end broadly rounded; juxta reduced cone, upper part U-shaped; valva broad, distal tip rounded marginal area sparsely setosed; aedeagus small, broad, robust, suprazone slightly longer than subzone, subzone much sclerotized, thecal appendage broad, ventral, square-shaped, ductus ejaculatorius

dorsad.

Male Genitalia (DSF): Similar as in the male of WSF but the distal part of the uncus is slightly humped in DSF.

Female Genitalia (DSF): Corpus bursae large, balloon-shaped, narrow towards ductus bursae; signum very long, bilobed, inverted heart-shaped with extremely long tail, outer margins bear spines and more sclerotized; appendix bursae very small, rounded; ductus bursae small; papilla analis setosed; posterior apophysis thin, curved, sclerotized, blunt and slightly swollen ends; anterior apophysis smaller than posterior apophysis, broad, much sclerotized, blunt ends, genital plate bilobed.

Female Genitalia (WSF): Similar to as in the female of DSF with slight differences. Corpus bursae spherical; signum long, bilobed, inverted heart-shaped with a small tail; posterior apophysis straight with blunt distal ends.

Material examined:

5♂ (DSF), 14.iv.2017, Lawngtlai, Mizoram, (Coll. Manpreet Kaur); 3♀, 16.iv.2017, Zotlang, Mizoram, (Coll. Manpreet Kaur); 4♂ (WSF), 19.iv.2017, Reiek, Mizoram; 1♀ (DSF), Ilwas, Chamba.

Distribution India: Uttarakhand, Manipur, Meghalaya, Arunachal Pradesh, Assam, Nagaland, Mizoram and Sikkim.

Elsewhere: China, Korea, Manchuria, Japan.

Remarks: *P. melete* Menetries is a common species distributed in North-East India. Evans (1932) and Talbot (1939) described it as *P. napi* Linnaeus commonly called as European Green veined. Menetries (1857), Gasse (2013) and Varshney (2015) discussed it as *P. melete* including its morphological attributes and distributional range. Lamas (2008) and Kunte et.al. (2020) described it as *P. melete* and stated that *P. napi* is distributed in the Europe, North and West Asia excluding India and the Oriental region. In this present work, the morphological characters, genitalic attributes and distribution of *P. melete* is studied. The morphological and genitalic characters of both the sexes of DSF and WSF have been studied, illustrated and compared for the first time in this work. Morphologically, both forms are different. In WSF, the apical black border is slightly broad, forewing dorsal side with a black spot in area M_3 , hindwing dorsal side with black costal spot and forewing ventral side with black spot in area M_3 and Cu_2 whereas in DSF, the apical black border is narrow and there is no black spot on both the sides of both the wings. The genitalic attributes of both the forms are almost similar with a slight difference in their uncus. In DSF, the distal part of the uncus is slightly humped. In the female genitalia, signum is longer than broad, inverted heart-shaped with a long tail

and the appendix bursae is very small as compared to other Indian species of the genus. In females, the corpus bursae is balloon-like, signum very long with the extremely long tail and posterior apophysis curved in DSF whereas in WSF, the corpus bursae are spherical, signum long with a small tail and posterior apophysis almost straight. The *Pieris melete* has been recorded for the first time from Ilwas, Chamba. There is no previous record of this species from Chamba, Himachal Pradesh.

***Pieris extensa* Poujade, 1888**

Common name: Extended White (PLATE-XV)

Pieris erutae Poujade, 1888; *Bull. Soc. Ent. Fr.* (6) 8: 19.

Pieris eurydice Leech, 1891; *Entomologist* 24: 5.

Pieris extensa Winhard, 2000; *Butterflies of the World* 10: 29.

Adult (Male): Forewing dorsal surface white; well-marked brownish-black veins; costa thin black; apex and termen black up to vein Cu₁; the inner margin of black area uneven; whitish quadrate spot in area M₃. Ventral surface white; costa brownish dusted with light mustard yellow; apex and termen light mustard yellow up to vein Cu₁; veins thick brownish. Hindwing dorsal surface white; black subapical dot; veins strongly black. Ventral surface ochraceous yellow with dark brown veins; veins broader near the cell.

Wing-Span: 75-80 mm.

Male Genitalia: Uncus slender, slightly pointed tip, V-shaped from dorsal view; tegumen sclerotized, longer than uncus, broader anteriorly, gradually narrows towards uncus, somewhat U-shaped from dorsal view; vinculum broad, sclerotized, slightly incurved; saccus short, broad, dorso-ventrally flattened; juxta reduced cone; valva tortuous, distal end broadly rounded, marginal area hirsute with small to medium-sized setae; aedeagus extremely short, sinuous, subzone smaller than suprazone, blunt apically, thecal appendage ventral, short, distal end broadly rounded, ductus ejaculatorious dorso-caudad.

Material examined: ZSI, Kolkata, National Museum Collections.

1♂, 12.v.1961, 5♂, 13.v.1961, Kameng, Arunachal Pradesh.

Distribution India: Arunachal Pradesh.

Elsewhere: West China, Fukien.

Remarks: *Pieris extensa* Poujade is a rare butterfly distributed in India, West China and Fukien. Leech (1819) described this species as *Pieris eurydice* and compared its external morphological characters with *Pieris melete* Menetries. Talbot (1939) reported *P. eurydice* as a darker form of *P. extensa* and also included its nominotypical form, which is comparatively smaller and with reduced black markings. In this present research, the male external morphological char-

acters and male genitalia have been studied, illustrated and compared with *P. melete* and other members of the group for the first time and it has been observed that it morphologically closely resembles with the DSF of *P. melete* with slight differences. Both the species possess dark veins and black apex. The species *P. extensa* is large in size with a black spot in area M₃ and the forewing apex of the ventral side and hindwing ventral side yellow whereas the *P. melete* is smaller in size and forewing apex of the ventral side and hindwing ventral side whitish-yellow. In both the species the valve is with a broadly rounded distal end but in *P. extensa* slightly long and sinuous. The saccus is extremely small, and aedeagus is narrow in both the species as compared to other Indian species of this genus. The aedeagus is more sinuous and narrow in *P. extensa* whereas in *P. melete* it is slightly broad and strongly arched. Uncus slightly resembles the uncus of *Pieris brassicae*. From the study of male genitalia, it is clear that *P. extensa* and *P. melete* are quite distinct species, though morphologically resemble with each other as advocated by Leech (1819) and Talbot (1939)

Conclusion

In the present studies, six species of the genus *Pieris* Schrank have been studied taxonomically from India. The male genitalia of all the species has been studied whereas the female genitalia of four species has been studied. Further, the variable forms, i.e. dry and wet season forms of species *Pieris melete* has been studied morphologically and dissected for comparing their genitalia. Similarly, the subspecies of *P. canidia* have also been studied morphologically and their genially compared. The comparison of the genitalia of various forms reveals that the structure of male and female genitalia within species is quite stable, showing no variations and considerably distinct from other species. On the basis of male genitalia, it can be concluded that in the genus *Pieris* in the male genitalia the uncus is undivided and aedeagus is short and thick, whereas in the female genitalia the signum is bifid and appendix bursae are well developed. On comparison of the male genitalia, it has been found that species *P. brassicae* and *P. deota* form a distinct group where the valva bears apical projection and the aedeagus bears middle hump, in all the remaining species the valva is entire and aedeagus is without hump.

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