*Biological Forum – An International Journal* **5**(2): 71-80(2013)

**ISSN No. (Print): 0975-1130**
**ISSN No. (Online): 2249-3239**

# Taxonomic Update and Relative Abundance Studies on some Cutworms (Family: Noctuidae) in Conifer Forests of Himachal Pradesh with brief account of its Wing Venation and Genitalia

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*(Received 05 June, 2013, Accepted 15 July, 2013)*

**ABSTRACT: Subfamily Noctuinae are distributed in Great Plains and Deccan Peninsulas. They can be well examined and identified by their wing venation and genitalia. In the present study, four species *Agrotis ipsilon* Hufnagel, *Agrotis segetum* Denis and Schiffmuller, *Xestia c-nigrum* Linnaeus and *Xestia renalis* Moore were collected from different conifer forests of Himachal Pradesh. An account of genitalia, wing venation and relative abundance of these species are given and key has been furnished for interspecific discrimination by dwelling upon different morphological and genitalic characters.**

**KEY WORDS**: Conifer forest, genitalia, wing venation,

## INTRODUCTION

The species of the subfamily Noctuinae are also known as cutworms, because of their habit to cut young shoots below the surface. They are serious agricultural pest of many crops including winter cereals, cotton, clover, beets, potato and onion. Agriculture is the major section of growth in Indian economy. The exact limits for this clade, which Lafontaine (1993) termed the 'true cutworms', remain unclear but broadly includes a majority of species in the four largest traditional trifine subfamilies, Amphipyrinae, Hadeninae, Cuculliinae and Noctuinae (nomenclature of Franclemont and Todd, 1983). Based on adult morphology, monophyly of this assemblage seems to have been recognized first by Borner (1953) and Kitching (1984). Beck (1992) subsequently excluded the Amphipyrini of Franclemont and Todd (1983), in agreement with Holloway (1989), while including Franclemont and Todd's Cuculliinae: Xylenini. Poole (1995), formalizing the ideas of Lafontaine (1993), expanded Beck's (1992) Noctuinae *s.l.* to include parts of Amphipyrini plus some of the 'unassociated genera' of Amphipyrinae of Franclemont and Todd (1983). Kitching and Rawlins (1999) accepted the monophyly of the Noctuinae *s.l.* as defined by Poole, but preferred a different classification, treating Noctuinae in the narrower traditional sense, Ufeinae, and Hadeninae *s.l.* as separate subfamilies. Their expanded, explicitly paraphyletic concept of Hadeninae encompassed all the pieces of the traditional subfamilies Cuculliinae and Amphipyrinae that Poole (1995) placed instead in Noctuinae *s.l.*, including Callopistria and relatives, which Poole separated as Eriopinae. Apart from these proposals, higher-level relationships with the 'true cutworm' assemblage have been with the remainder of Poole's (1995) Noctuinae *s.l.* During the present study, four species *Agrotis ipsilon* Hufnagel, *A. segetum* Denis and Schiffmuller, *Xestia c-nigrum* Linnaeus, *X. renalis* Moore from the genus *Agrotis* and *Xestia* respectively have been reported from conifer forests and dealt with taxonomic update. Wing venation and genitalic characters of these species have been elaborated and key is furnished for inter-specific discrimination.

## MATERIAL AND METHODS

The moths belonging to the subfamily Noctuinae have mainly been collected by the method designed by Common (1959). The moths were immediately killed with ethyl acetate vapours in insect killing bottles followed by freezing treatment. In order to keep the scales intact on the body of the moths, they were removed from the bottles as soon as they were killed. Each specimen was pinned through the middle line of the thorax. Different types of pins were used for stretching the moths according to the size of specimens. This was preceded by spreading of both the wings on insect stretching boards, followed by their drying, either in the oven (45°C) or in the improvised drying chambers. Followed by the tentative sorting in the field, each specimen was labelled, indicating the locality and date of collection. Resetting is done in the laboratory, by relaxing such specimens in the relaxing chambers (containing carboxylic acid and camphor in the ratio of 3:1), followed by drying in oven.

**Wing venation:** Wing preparations were made as per the method of Zimmerman (1978). To begin with, the process of mounting, the wings were detached from the body of insect and were subsequently dipped in 70 % alcohol.

Then they were transferred into sodium hypochlorite solution. Scales got removed in the solution. The bleached and de-scaled wings were then transferred into distilled water and were washed thoroughly. Washed wings were transferred into stain preparation (10 g chloral hydrate, 5 ml acetic acid, 1g acid fuschin, 100ml of 50 % ethyl alcohol) for twenty four hours. In case of overstaining, the stain can be removed by dipping wings into 95 per cent alcohol and then followed by dehydration in different grades of alcohol. After that wings were cleared in clove oil and mounted in DPX. The drawing of wings was drawn with the help of trisimplex projector.

**Genitalia preparation**: For the examination of genitalia, the abdomen of the noctuid moth was detached by applying a little jerk in upward direction. The detached abdomen was then put into 10 per cent KOH solution and the same was put in an oven for 10-12 hours at about 45°C in order to soften the chitin and to dissolve away the muscles. The material was then washed in distilled water. After proper washing, material was dissected in 10 per cent alcohol and genitalia were removed carefully with the help of fine forceps and needles, watching under Zoom binocular microscope. For dissection, different processes were followed for removal of male and female genitalia (Martin, 1996). The material was transferred to 30 per cent alcohol and then transferred to stain (chlorozol black E). After staining, material was dehydrated in different grades of alcohol and thereafter transferred from absolute alcohol to "Euparal essence" (Euparal Solvent). Genitalia and abdomen were put on a drop of Euparal on a slide and coverslip was placed gently on the preparation, care being taken not to allow the genitalia roll on the slide and prevent bubbles to lodge or material to float out. After mounting, the slides were dried in an oven (45°C) for 48 hrs (Robinson, 1976). The sketches of genitalia were made with the help of a square ocular grid under Zoom Binocular Microscope on the graph paper.

## RESULTS AND DISCUSSION

**Key to genera of subfamily Noctuinae**

1. Palpi obliquely porrect……...***Agrotis*** **Ochsenheimer** - Palpi not present…… **(2)**
2. Vein Sc + R, rapidly diverging from the base ……..….....***Xestia*** **Hubner**

**Key to species of the genera *Agrotis* Ochsenheimer**

1. Forewing with area beyond postmedial line somewhat golden, cornuti not restricted in its distribution on the vesica of male genitalia; corpus bursae of female genitalia not bifurcated.……....***ipsilon*** **Hufnagel**
- Forewing with area beyond postmedial line not differentiated; cornuti of male genitalia restricted in its distribution; corpus bursae bifurcated into two portions…….. **(2)**
2. Forewing dark brown, claviform indistinct, antemedial line double distinct, cornuti present in bundle on vesica of male genitalia……..... ***segtum*** **Denis and Schiffmuller**

***Agrotis ipsilon* Hufnagel *Phalaena* 1766: 416**

**Synonyms**: *Noctua segetum* [Denis and Schiffermuller] 1775

*Agrotis frivola* Wallengren 1860

**Venation (Plate 1, Fig. A-B):** Forewing with discal cell more than half length of wing, vein $S_c$ straight upto mid-costal region, vein $R_1$ from more than half the region of discal cell, $R_2$ just beyond $R_1$ , $R_3$+ $_4$ and $R_s$ connate from end of areole. $M_1$ from anterior angle of the cell, $M_2$ and $M_3$ from posterior angle of the cell, $Cu_1$ from little behind the posterior angle of the cell, $Cu_2$ from the one-third region of posterior angle of the discal cell, 1A connate at the base running upto the entire length of wing; Hind wing with discal cell less than half the length of wing, $S_c$ + $R_1$ running upto the apex and approximated with cell at the base, $R_s$ and $M_1$ connate, vein $M_3$ and $Cu_1$ connate from the posterior angle of the discal cell, $Cu_2$ from little behind the posterior angle of the discal cell, 1A and 2A strong running upto the base.

**Genitalia (♂) (Plate 1, Fig. C):** Uncus curved, sclerotized; tegument sclerotized; valve uniformly sclerotized, distal end conical; harpe well marked; sacculus demarcated; saccus prominent,well developed. Aedeagus short, stout; vesica everted out with two sets of cornuti.

**Genitalia (♀) (Plate 1, Fig. D):** Ovipositor lobes well developed, sclerotized; posterior apophysis shorter than anterior apophysis; ostium bursae sclerotized, well developed; ductus bursae broad tube like; corpus bursae large, globular, bilobed structure.

**Wing expanse:** ♂: 42- 56 mm ; ♀: 48-60 mm.

**Material examined**

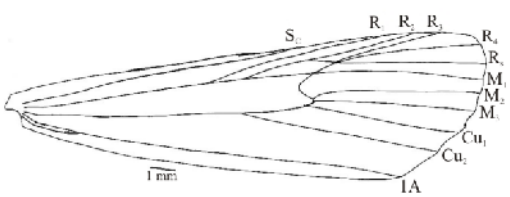
Kinnaur : Akpa, 10 ♂♂-21.4.09 ; 4 ♀♀-21.4.09

Hamirpur: Chakmoh, 7 ♂♂-28.4.09 ; 3♀♀-28.4.09

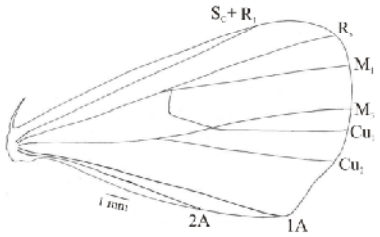
Shimla: Theog, 10 ♂♂-4.5.09 ; 8♀♀-4.5.09;

Collector Name: Pawan Kumar, Shweta, Amit

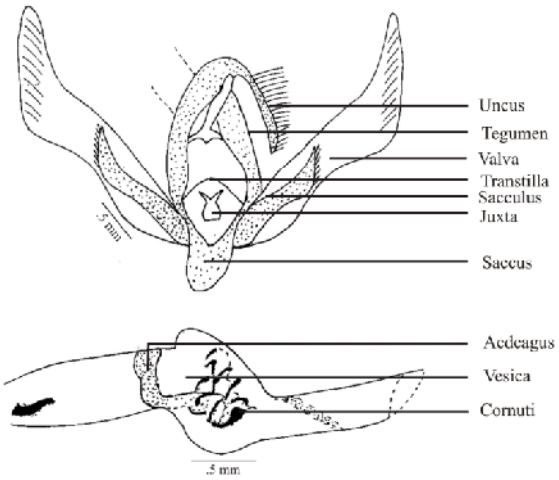
**Plate-1**




**A**



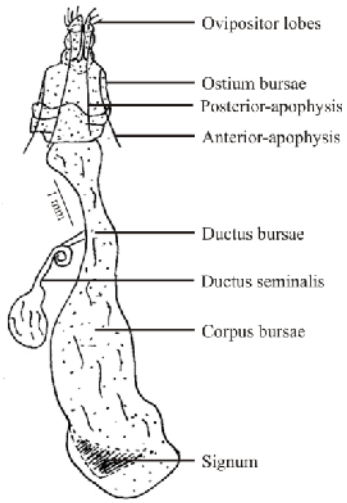

**B**







**C**




**D**

**Fig. A** **Fore wing of *Agrotis ipsilon* Hufnagel**
**Fig. B** **Hind wing of *Agrotis ipsilon* Hufnagel**
**Fig. C** **Male Genitalia of *Agrotis ipsilon* Hufnagel**
**Fig. D** **Female Genitalia of *Agrotis ipsilon* Hufnagel**

***Agrotis segetum* [ Denis and Schiffermuller] *Noctua*, 1775: 81**

**Synonyms**: *Noctua sordida* [Denis and Schiffermuller] 1775 *Agrotis denticulosa* Wallengren 1860 *Agrotis lassa* Swinhoe 1886

**Venation (Plate 2, Fig. A-B):** Forewing with discal cell more than half the length of wing, vein $S_c$ straight upto mid-costal region, vein $R_1$ from the base parallel to $S_c$, $R_2$ from middle of discal cell, $R_s$ from the origin of stalk of $R_3$+ $_4$ connate from end of aerole. $M_1$ from anterior angle of the cell, $M_2$ and $M_3$ closely approximated at base, $Cu_1$ from the posterior angle of the cell, $Cu_2$ from little behind the posterior angle of the discal cell, 1A connate at the base, well developed; Hindwing with discal cell less than half the length of wing, $S_c$ + $R_1$ running upto the apex, $R_s$ and $M_1$ connate from the anterior angle of the discal cell, vein $M_3$ and $Cu_1$ connate from the posterior angle of the discal cell, $Cu_2$ from little behind the posterior angle of the discal cell, 1A and 2A strong running upto the base.

**Genitalia (♂) (Plate 2, Fig. C):** Uncus prominent, sclerotized; tegumen broad, sclerotized; valve simple, uniformly sclerotized; harpe present; sacculus marked; juxta well developed; saccus prominent,well developed. Aedeagus broad, moderately long; vesica everted out , embedded with a bundle of small cornuti.

**Wing expanse:** ♂ : 42- 48mm ; ♀: Not studied.

**Material examined**

Kinnaur : Akpa, 8♂♂- 21.4.09 ;
Hamirpur: Chakmoh, 5 ♂♂- 16.4.09 ;
Shimla: Theog, 10 ♂♂- 4.5.09 ;
Collector Name: Pawan Kumar, Shweta, Amit

**Key to species of the genera *Xestia* Hubner**

1 Forewing has large orbicular and reniform stigmata, the former has triangular and black patches before and after it and latter defined by inner and outer lines……. ***c-nigrum* Linnaeus**

- Forewing has small orbicular and reniform stigmata, a blackish fascia from the former to the outer margin below apex and latter not well defined by inner and outer lines……..... **(2)**

2 Cucullus, valuulla differentiated, harpe long sclerotised forked at tip, juxta dome shaped in male genitalia, corpus bursae of female genitalia sclerotisation on proximal part…….....……***renalis* Moore**

***Xestia c-nigrum* Linnaeus *Phalaena Noctua*, 1758: 516**

**Synonyms**: *Agrotis c-nigrum* subsp. *kurilana* Banghaas 1912 *Amathes c-nigrum* subsp. *ignorat*a Eitschberger 1972.

**Venation (Plate 3, Fig. A-B):** Forewing with discal cell more than half the length of wing, vein $S_c$ straight upto mid-costal region, vein $R_1$ from one-third region of discal cell, $R_2$ from half the length of discal cell, $R_3$ and $R_4$ are stalked running upto the apex, $R_s$ and $M_1$ connate from anterior angle of the cell, $M_2$ and $M_3$ closely approximated at base from the posterior angle of the cell, $Cu_1$ from little behind the posterior angle of the cell, $Cu_2$ from well before the posterior angle of the discal cell, 1A well developed running upto the base; Hindwing with discal cell less than half the length of wing, $S_c$ + $R_1$ running upto two-third of costal region, $R_s$ and $M_1$ connate from the anterior angle of the discal cell, vein $M_3$ and $Cu_1$ connate from the posterior angle of the discal cell, $Cu_2$ from little behind the posterior angle of the discal cell, 1A and 2A strong running upto the base.

**Genitalia (♂) (Plate 3, Fig. C):** Uncus slightly curved, sclerotized; tegumen broad, sclerotized; valve simple, uniformly sclerotized; saccular region well with a small extension; costa marked, ampulla present. Aedeagus sclerotized, moderately long; vesica everted out, simple.

**Wing expanse:** ♂ : 44mm ; ♀: Not studied.

**Material examined**

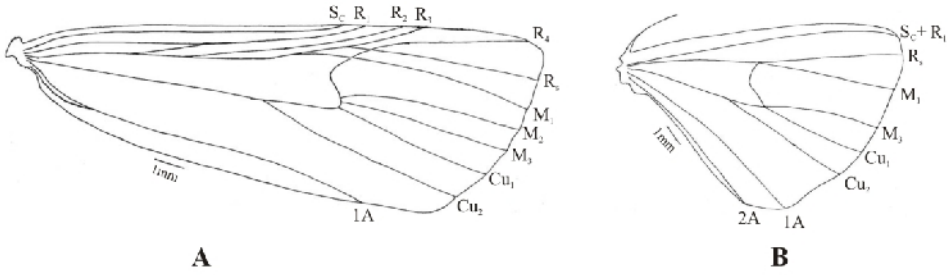
Kinnaur : Akpa, 3 ♂♂-21.4.09;
Hamirpur: Chakmoh, 4 ♂♂-8.10.08;
Shimla: Theog, 7 ♂♂-4.5.09;
Collector Name: Pawan Kumar, Shweta, Amit

***Xestia renalis* Moore *Axylia*, 1881: 341.**

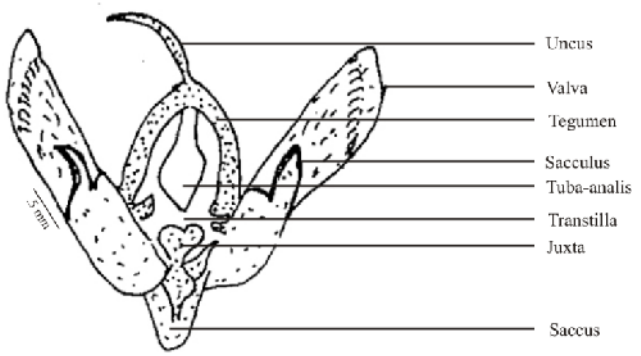
**Synonym**: *Ochropleura subpurpurea* Leech 1900

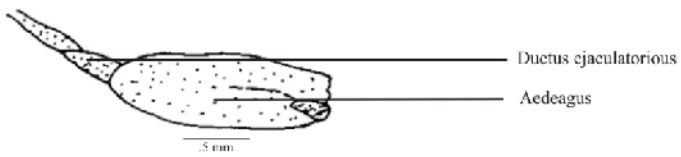
**Venation (Plate 4, Fig. A-B):** Forewing with discal cell more than half the length of wing, vein $S_c$ straight upto mid-costal region, vein $R_1$ from behind the anterior angle of the discal cell, $R_2$ and $R_3$ stalked, parallel to $R_1$, $R_4$ and $R_s$ are stalked from anterior angle of the cell, $M_1$ from anterior angle of the cell, $M_2$ and $M_3$ closely approximated at base from the posterior angle of the cell, $Cu_1$ from the posterior angle of the cell, $Cu_2$ from well before the posterior angle of the discal cell, 1A well developed running upto the base; Hindwing with discal cell half the length of wing, $S_c$ + $R_1$ arising from the base running upto apex, $R_s$ and $M_1$ connate from the anterior angle of the discal cell, vein $M_3$ and $Cu_1$ from the posterior angle of the discal cell, $Cu_2$ from little behind the posterior angle of the discal cell, 1A and 2A strong ,well developed.

**Plate-2**




**A** **B**

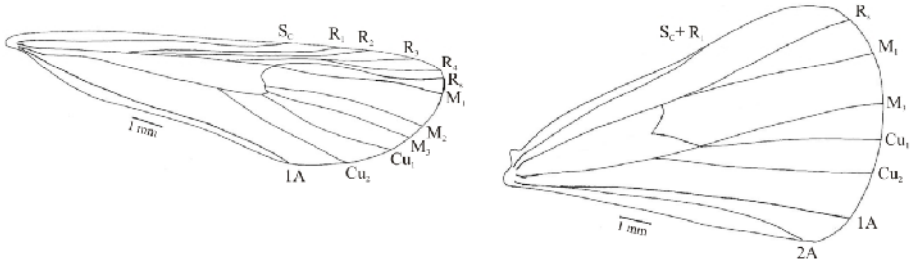


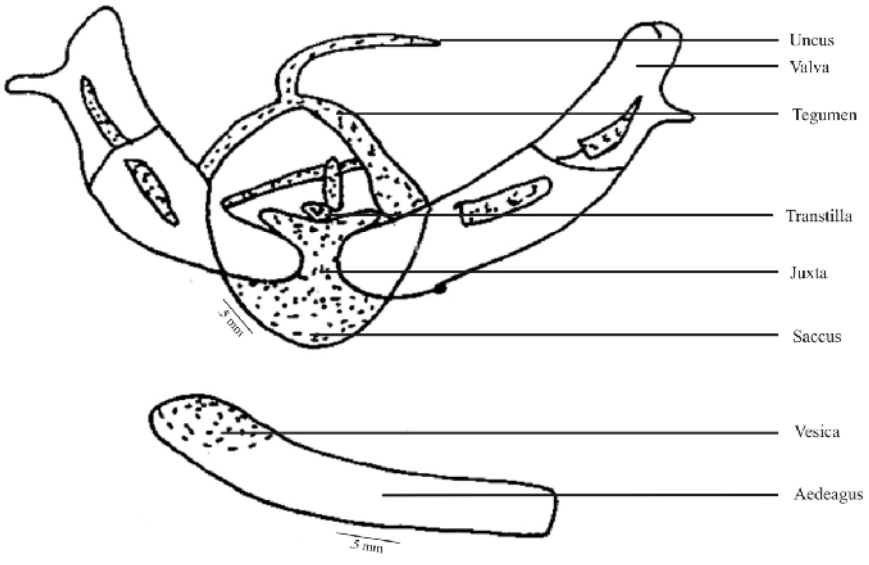

**C**

**Fig. A** **Fore wing of *Agrotis segetum* Denis & Schiffermuller**
**Fig. B** **Hind wing of *Agrotis segetum* Denis & Schiffermuller**
**Fig. C** **Male Genitalia of *Agrotis segetum* Denis & Schiffermuller**

**Plate-3**



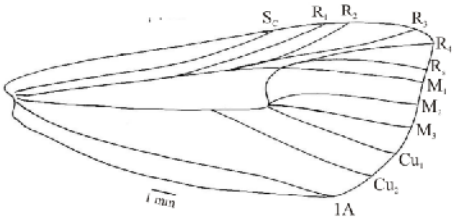

**A** **B**



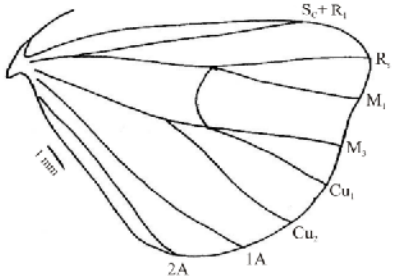

**C**

**Fig. A** **Fore wing of *Xestia c-nigrum* Linnaeus**
**Fig. B** **Hind wing of *Xestia c-nigrum* Linnaeus**
**Fig. C** **Male Genitalia of *Xestia c-nigrum* Linnaeus**

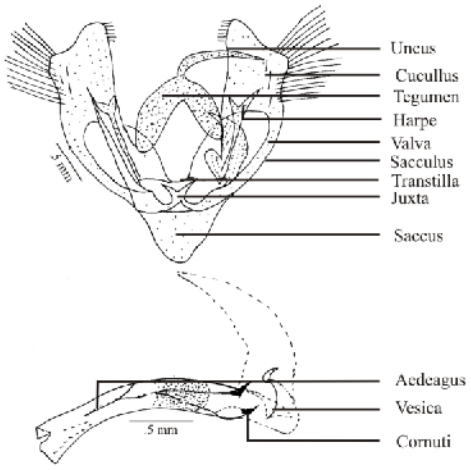
**Plate-4**



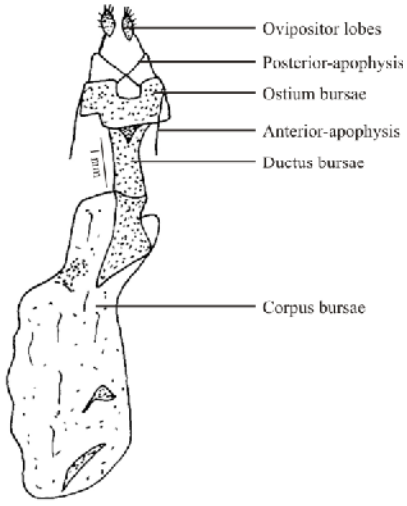

**A**




**B**




**C**




**D**

**Fig. A Fore wing of *Xestia renalis* Moore**
**Fig. B Hind wing of *Xestia renalis* Moore**
**Fig. C Male Genitalia of *Xestia renalis* Moore**
**Fig. D Female Genitalia of *Xestia renalis* Moore**

**Genitalia (♂) (Plate 4, Fig. C):** Uncus moderately developed, bent, tip pointed; valve simple; costa marked sclerotized, cucullus, valvula differentiated outer margin of apex oblique finely decorated with setae, setae thick outer margin weakly rounded then slightly narrower towards sacculus; harpe long, sclerotized with forked tip; juxta dome shaped. Aedeagus moderately long, broad, slender; vesica membranous cornuti, small, anteriorly present to vesica.

**Genitalia (♀) (Plate 4, Fig. D):** Ovipositor lobes well developed, sclerotized; posterior apophysis shorter than anterior apophysis; ostium bursae sclerotized, well developed; ductus bursae broad, well sclerotized, flat tube like; corpus bursae large, with sclerotization on proximal part.

**Wing expanse**: ♂ : 36 mm; ♀: 40 mm.

**Material examined**

Kinnaur : Akpa, 1♂♂- 11.6.08

Hamirpur: Chakmoh, 1♀♀- 18.6.08

Shimla: Theog, 3 ♂♂- 14.6.09 ; 2♀♀- 14.6.09;

Collector Name: Pawan Kumar, Shweta, Amit

**Remarks:** This species was again described as new in Moore, 1882: 103 New combination

**RELATIVE ABUNDANCE**

Noctuinae was represented by 04 species namely *Agrotis ipsilon* Hufnagel, *A. segetum* (Denis and Schiffermuller), *Xestia c-nigrum* Linnaeus and *X. renalis* Moore which were collected from different conifer forests of Himachal Pradesh. Kail forest, Chir pine forest and Chilgoza forest were studied during June 2008- July 2009. Relative abundance of Kail forest was reported to have the greatest diversity and eveness. As, diversity and eveness is highest, the species are equally abundant in Kail (*Pinus wallichiana*) forest.

The subfamily Noctuinae is one of the largest subfamily of the family Noctuidae with about 1600 species known worldwide (Speidel *et al.,* 1996). A number of researchers have reported different number of species from different parts of the world. 415 (Soviet Union); 54 (Iraq); 93 (Balkan countries); 23 (Saudi Arabia); 262 (Europe); 96 (Central Europe).

Detailed investigations on taxonomy and biodiversity of Noctuinae in Israel from 1986-2004 by various investigators have resulted into 36 species of which 27 were earlier published in various checklists (Kravchenko *et al.,* 2001; Hacker, 2001; Hacker *et al.,* 2001). 9 new species were: *Euxoa conspicua, E. hering, Agrotis psammocharis, A. (Powellinia) boetica, Pachyagrotis tischendorfi, Dichagyris melanuroides, D. amoena, Noctua tertia, Noctua interjecta*.

Although, Amsel (1933) have also reported 40 species of noctuid moth belonging to this subfamily from different zones of Israel. Recently, Kravchenko *et al.* (2006) studied the distribution, phenology and ecology of the 76 Noctuinae moths from different parts of Israel. Four species *Agrotis ipsilon* Hufnagel, *A. segetum* Denis and Schiffmuller, *Xestia c-nigrum* Linnaeus, *X. renalis* Moore are morphologically similar as far as colour pattern of their mouth parts, but can be differentiated on the basis of wings colour pattern. There is a slight difference in the wing expanse of these species. These four species were identified, by critically examining and comparing the specimens with those of National collection stored at the Entomological Museum of Forest Research Institute, Dehradun. To update the taxonomic characters of these species wing venation and genitalia have been studied in detail. Study of these characters has helped in identifying these species in an accurate manner. Relative abundance of subfamily Noctuinae is calculated by Shannon-Weaver Information Function (D) and Species Evenness (E) to maintain redundancy and resilience in the ecosystem.

| **Species structure in Chilgoza pine (*Pinus gerardiana*) forest** | | | | | |
|---|---|---|---|---|---|
| Species | *Agrotis ipsilon* | *Agrotis segetum* | *Xestia c-nigrum* | *Xestia renalis* | Total N |
| $n_i$ | 14 | 8 | 3 | 1 | 26=N |
| $p_i( n_i/ N)$ | 0.54 | 0.31 | 0.12 | 0.04 | |
| $\ln p_i$ | -0.63 | -1.17 | -2.12 | -3.22 | |
| $p_i \ln p_i$ | -0.334 | -0.363 | -0.254 | -0.129 | -1.08= Σ |

S = 4 species; N = 26 individuals

**D** = $-\Sigma p_i \ln p_i$ =-1 x -1.08 = **1.08; E**= $2.7^{1.08}/4$ = **0.73**

| **Species structure in Chir pine (*Pinus roxburghii*) forest** | | | | | |
|---|---|---|---|---|---|
| Species | *Agrotis ipsilon* | *Agrotis segetum* | *Xestia c-nigrum* | *Xestia renalis* | Total N |
| $n_i$ | 10 | 5 | 4 | 1 | 20=N |
| $p_i( n_i/ N)$ | 0.5 | 0.25 | 0.2 | 0.05 | |
| $\ln p_i$ | -0.69 | -1.39 | -1.61 | -2.99 | |
| $p_i \ln p_i$ | -0.345 | -0.347 | -0.322 | -0.149 | -1.163= Σ |

S = 4 species; N = 20 individuals

**D =** $-\Sigma p_i \ln p_i$ =-1 x -1.163= **1.163; E=** $2.7^{1.163}/4$ = **0.79**

| **Species structure in Kail (*Pinus wallichiana*) forest** | | | | | |
|---|---|---|---|---|---|
| Species | *Agrotis ipsilon* | *Agrotis segetum* | *Xestia c-nigrum* | *Xestia renalis* | Total N |
| $n_i$ | 18 | 10 | 7 | 5 | 30=N |
| $p_i( n_i/ N)$ | 0.6 | 0.3 | 0.23 | 0.16 | |
| $\ln p_i$ | -0.51 | -1.20 | -1.47 | -1.83 | |
| $p_i \ln p_i$ | -0.306 | -0.36 | -0.338 | -0.293 | -1.297= Σ |

S = 4 species; N = 30 individuals

**D =** $-\Sigma p_i \ln p_i$ =-1 x -1.297 = **1.297; E=** $2.7^{1.297}/4$ **= 0.91**


## ACKNOWLEDGEMENTS

We are grateful to the Head, Himalayan Forest Research Institute, Shimla for providing necessary laboratory facilities. My supervisor Prof. Vinod K.Mattu was the one who introduced me to the more scientific questions concerning the genital evolution of insects. Throughout the entire research, his support and keenness has been a driving force. I have enjoyed belonging to his group and feel that working with him has deepened my scientific thinking. Taxonomic study and relative abundance have played an important role in my research. We are also thankful to the Head, Forest Research Institute, Dehradun for extending help in identification of moths. Working in this field has been challenging.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