SUMMARY
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The present research work is related to the basic science i.e. Taxonomy/Systematics. Taxonomic studies on family Geometridae (Lepidoptera) have been carried out from August 2009 to July 2013. The whole thesis is divided into seven chapters viz., Introduction, Review of literature, Materials, methods and procedure of study, Observations, General conclusions and scope for further research, Summary and Literature cited.

INTRODUCTION

- The current status of biodiversity and relevance of taxonomy for the conservation and sustainable utilization of biodiversity is discussed in brief.
- Lepidoptera is the third largest order of class Insecta and family Geometridae known as the second largest family of this order in terms of species richness.
- The diagnostic features of family Geometridae are highlighted in this chapter. Besides this, the classification of this family has also been discussed. The classification followed by eminent Geometrid specialist from the Globe i.e. Scoble (1999), has been adopted in the present study.
- Family Geometridae is of immense economic importance because many of its species are serious pest species of agricultural crops, forest trees and ornamental plants.

REVIEW OF LITERATURE

- An effort has been made to review the entire work taken up on this family by eminent Geometrid workers throughout the world. The perusal of literature reveals that Moore, Butler, Hampson and Prout were eminent taxonomists, who laid the foundation as eminent workers on the taxonomy of this group in eighteen and nineteen centuries. It is crystal clear from the Literature that this group of moths has been better attended to in different parts of the Globe as compared to India. The taxonomic revision of family Geometridae is the need of hour.
MATERIALS, METHODS AND PROCEDURE OF STUDY

- The collection of Adult Geometrid moths was planned in a systematic manner from August 2009 to July 2013. To fulfil the objectives laid down in the original synopsis, as many as eight major collection-cum-survey tours were conducted in the far flung localities of seven different states of North-eastern parts of India. A total number of 3645 representatives of 100 species referable to 74 genera were procured, preserved, identified and described.

- After proper sorting the collections were identified as per techniques adopted by pioneer Lepidopterists. The identification was done with the help of relevant literature and by comparison with reference collections lying in National museums. For Identification, help was also taken from the eminent Geometrid workers like Dr. George Martin (NHM, London), Dr. M.J. Scoble (Rtrd. NHM, London), Dr. J.D. Holloway (NHM, London), Dr. Hongxiang Han (Institute of Zoology, Chinese Academy of Sciences, Beijing, China), Dr. A. Hausmann (Zoological Collection of the Bavarian State, München, Germany) and Dr. S.W. Choi (Mokpo National University, Muan, Korea)

- In order to study wing venation, the permanent slides of fore and hind wings were prepared following the method proposed by Common (1970) and advocated by Zimmerman (1978). The nomenclature given by Comstock and Needham (1898-99), Imms (1957) and slightly modified later on by Miller (1970) was followed in the present studies.

- For study of external genitalic attributes the dissections were performed after removal of whole abdomen of various species belonging to seven subfamilies studied here. For dissection and preparation of permanent slides of genitalia, procedure given by Robinson (1976) has been followed in this research work. The terminology given by Klots (1970) for nomenclature of various genitalic structures has been used in the present study.

- The illustrations of wing venation were drawn by using tri-simpex projector and inking was done by rotring ink pen. Photography of external male and female
Summary

genitalia was completed with the help of an image processing unit in the Entomology laboratory of Department of Zoology & Environmental Sciences, Punjabi University, Patiala. The photographs of adult moths are given in all the plates including wings and genitalic attributes. The plates were compiled by using Adobe Photoshop software.

OBSERVATIONS

- Intensive and extensive collection-cum-survey tours were conducted from September 2009 to October 2012 in the far-flung localities of North-East India. These surveys yielded a good harvest of 100 species of Geometrid moths referable to 74 genera and belonging to seven subfamilies viz. Ennominae, Geometrinae, Sterrhinae, Larentiinae, Desmobathrinae, Oenochrominae and Orthostixinae.

- A total number of 67 species referable to 50 genera belong to Subfamily Ennominae. Besides this, subfamily Geometrinae is represented by 11 species under 10 genera, subfamily Desmobathrinae by 2 species under genus Ozola Walker, subfamily Orthostixinae includes single species Naxa textilis Walker, subfamily Oenochrominae has 3 species under Sarcinodes Guenée, Subfamily Sterrhinae includes 9 species under 5 genera and 7 species under 6 genera belong to subfamily Larentiinae. All these species have been studied in detail.

- First reference, distribution, diagnosis, and suitable remarks are included under each genus. Likewise, the original reference, synonymy, detailed descriptive account, material examined, old distribution and remarks (wherever necessary) have been provided for all the species included in the present manuscript.

- Two genera i.e. Neolassaba gen. nov., Pseudohypochrosis gen. nov. have been proposed as new to science in the present work.

- A total number of 24 species (i.e. 18 species in Ennominae; 2 species in Geometrinae; 1 species in Desmobathrinae; 2 species in Sterrhinae and 1 species in Larentiinae) have been described here as new to science.
• As many as 8 species have been reported for the first time from India as new records whereas 7 species are new records from North-East India.

GENERAL CONCLUSIONS AND SCOPE FOR FURTHER RESEARCH

• The conclusions drawn on the basis of study of external morphological attributes along with the external male and female genitalic structures are highlighted in this chapter.

• The uncus is highly variable in subfamily Ennominae. It is well developed, curved with a pointed tip in some genera like Cleora Curtis, Borbacha Moore, Luxiaria Walker, Vindusara Moore, Arichanna Moore, Chorodna Walker, Sirinopteryx Butler, Tasta Walker; sickle shaped in Heterostegane Hampson, Entomopteryx (Guenée), Opisthograptis (Hübner), Tanaoctenia Warren, Achrosis Guenée; beak like in Psyra Walker, Crypsicoma Warren; fan like in Hypochrosis Guenée; spatulated in Celenna (Walker) and Mimomiza (Moore). However, shape of uncus varies from species to species in genus Fascellina Walker. Gnathos is a well developed structure in almost all genera of this subfamily except Abraxas Leach, Heterostegane Hampson, Tanaoctenia Warren and Neolassaba gen. nov. where the attribute is absent. Tegumen well developed and simple in all species of subfamily Ennominae studied here. Vinculum well sclerotized, either V-shaped or U-shaped and saccus weakly developed. The subfamily Ennominae is also characterized by highly variable and complex valva. It is divided into six parts i.e., costa, sacculus, harpe, ampulla, cucullus and valvula in genus Abraxas Leach. Otherwise, valva differentiated into costa and sacculus in most of other genera. However, it is simple, foot like without any differentiation into parts in some genera like Ourapteryx Leach and Fascellina Walker. Juxta well developed with variable structures in different genera. Aedeagus strongly built with vesica either scobinated or membraneous in Thinopteryx Butler, Vindusara moorei Thierry-Mieg, Parapercnia Wehrli, Orthocabera (Butler). The shape of cornuti varies in species different species.
• Subfamily Geometrinae is characterized by a well developed and variable uncus. It is strongly bifid in *Pingasa* Moore, *Lophophelma* Prout and *Dindicodes* Prout and apically bifurcated in genus *Neohipparchus* Inoue. However, uncus weakly developed in *Paramaxates* Warren. Acrotergite absent in all the species studied here. Socii highly developed in genus *Herochroma* Swinhoe. Gnathos present in various genera of this subfamily. Tegumen and vinculum simple, either weakly or highly sclerotized and saccus poorly defined. Valva highly developed and variable in this subfamily. It is simple in *Berta* (Walker), *Paramaxates* Warren, *Neohipparchus* Inoue and *Pelagodes* Holloway as there is no differentiation of its constituent parts. However, costa and saccus are highly differentiated in *Lophophelma* Prout, *Dindicodes* Prout, *Herochroma* Swinhoe and *Pingasa* Moore.

• Subfamily Sterrhinae is mainly characterized by reduced uncus in various genera. It is reduced and almost absent in genus *Zythos* Fletcher, weakly developed in *Antitrygodes* Warren and very long in *Organopoda* Hampson. However, supra uncus is present in genus *Problepsis* Lederer. Acrotergite and Gnathos are wanting in this subfamily. Socii well developed in *Synegiodes* Swinhoe and *Zythos* Fletcher. Tegumen highly sclerotized and spinose in genus *Problepsis* Lederer and weakly sclerotized in other genera. Vinculum V-shaped in *Organopoda* Hampson, however, broad U-shaped in other genera. Saccus altogether absent in different species studied here.

• Subfamily Larentiinae is characterized by a reduced or weakly developed uncus in various genera of this group included in the present study. It is almost membranous in genus *Polynesia* Swinhoe, weakly developed in *Asthena* Hübner and *Physetobasis* Hampson, well developed in *Photoscotosia* Warren and *Tyloptera* Christoph. Socii absent. Tegumen highly sclerotized in all genera studied here except *Polynesia* Swinhoe, where it is weakly sclerotized. Vinculum and sccus well developed in different species included in the present work.
Summary

- Subfamily Oenochrominae is characterized by a well-developed and variable uncus. Socii absent and gnathos well developed in this subfamily. Tegumen simple and highly sclerotized. Vinculum well developed and W-shaped but saccus poorly defined. Valva highly developed and variable in this group. Cornuti highly sclerotized in the present genera.
- Subfamily Desmobathrinae is characterized by well-developed uncus, tegumen, vinculum, juxta, valvae and aedeagus. Socii absent in this group.
- Subfamily Orthostixinae is characterized by well-developed uncus and tegumen. Juxta long and bifid towards tip. Valvae simple.
- 8th sternite well developed or modified in Paramaxates Warren, Physetobasis Hampson, Zythos Fletcher and Antitrygodes Warren.
- Female genitalia of family Geometridae show varied degree of variations. Corpus bursae varies in shape i.e. elongated or triangular with or without signa. Shape and size of signum differs in various species. This structure is completely covered with star like markings in Genus Antiperenia Inoue, Zamarada Moore, Orthocabera (Butler), Psyra Walker and Tasta Walker; dot-like in Paramaxates Warren, Thinopteryx Butler; long comb-like in Crypsicometa Warren and Ozola Walker; signum expanded to full length of corpus bursae in Antitrygodes Warren and Problepsis Lederer. Ductus bursae either weakly or well sclerotized in various taxa in studied genera. Sterigma highly sclerotized in some of the genera like Metaperenia Wehrli and Zamarada Moore.
- As far as the scope for further taxonomic research on this group of moths is concerned, it is tremendous and the family needs immediate taxonomic revision. So, it has been emphasized in this chapter that taxonomic revision of family Geometridae is of utmost importance in order to revise this economically important group of moths from India, the need for fresh surveys to collect adult Geometrid moths from different unexplored pockets of India like Andamans, Nicobars and Lakshadweep is the immediate need of hour. These areas are still unexplored and needs to be surveyed. It has also been pointed out that for sorting
and solving of the species complexes, the help of new trends in taxonomy like molecular systematics has to be explored. Sometimes it becomes difficult to resolve these species complexes on the basis of morphological characters. Certainly these new attributes can be used as additional taxonomic attributes.

SUMMARY

All important inferences of various chapters have been highlighted in the summary.

LITERATURE CITED

A complete list of references cited in the present study has been provided in this chapter.

A List of presently studied species under family Geometridae is given below:
SUBFAMILY ENNOMINAE

1. Heterostegane bilineata (Butler)
2. Heterostegane urbica (Swinhoe)
3. Heterostegane tritocampsis (Prout)
4. Heterostegane subtessellata (Walker)
5. Lassaba contaminata Moore
6. Neolassaba prouti sp. nov.
7. Hypochrosis baenzigeri Inoue
8. Hypochrosis walkeri sp. nov.
9. Hypochrosis hyadaria Guenée
10. Pseudohypochrosis unicornuta sp. nov.
11. Luxiaria dirangensis sp. nov.
12. Luxiaria amasa Butler
13. Petelia delostigma Prout
14. Corymica neopryeri sp. nov.
15. Hyposidra talaca (Walker)
16. Dalima termeneata sp. nov.
17. Fascellina longipennis sp. nov.
18. Fascellina perchromataria sp. nov.
19. Fascellina inconspicua Warren
20. Fascellina plagiata (Walker)
21. Achrosis pallida (Moore)
22. Achrosis incitata (Walker)
23. Ephemerothila pallescens Inoue
24. Ephemerothila subterminalis (Prout)
25. Borbacha punctipardaria Holloway
26. Obeidia lucifera semifumosa Prout
27. Callocasta similis (Moore)
28. Zamarada valvata sp. nov.
29. Cleora ochreata sp.nov.
30. Cleora pajnii sp.nov.
31. Antiperenia belluaria (Guenée)
32. Satoblephara satoi sp. nov.
33. Tasta lengpaiensis sp. nov.
34. Metaperenia ductaria (Walker)
35. Metaperenia juxtaria sp. nov.
36. Plutodes subcaudata Butler
37. Plutodes digitata sp. nov.
38. Ophthalmitis cordularia Swinhoe
40. Xerodes ypsaria Guenée
41. Crypsicoma homoema Prout
42. Alcis variegata Moore
43. Myrioblephara duplexa (Moore)
44. Tanaoctenia haliaria (Walker)
45. Ourapteryx primularis (Butler)
46. Ourapteryx furcata sp.nov.
47. Ourapteryx pluristrigata Warren
48. Sirinopteryx rufivinctata (Walker)
49. Chorodna metaphaearia (Walker)
50. Opisthograptis moelleri Warren
51. Mimomiza cruentaria (Moore)
52. Arichanna lapsariata (Walker)
53. Arichanna consocia (Butler)
54. Orthocabera sericea Butler
55. Ruttellerona fuscaria sp. nov.
56. Entomopteryx obliquilinea (Moore)
57. Paraperenia chinopepla Inoue
58. *Erebabraxas metachromata* (Walker)
59. *Vindusara moorei* Thierry-Mieg
60. *Abraxas martaria* Guenée
61. *Thinopteryx crocaptera* (Kollar)
62. *Celenna festivaria* (Fabricius)
63. *Peratostega deletaria* (Moore)
64. *Psilalcis pseudoinceptaria* sp. nov.
65. *Omiza herois* (Prout)
66. *Xenoplia maculata* (Moore)
67. *Psyra angulifera* (Walker)

**SUBFAMILY GEOMETRINAE**
1. *Pingasa rubicunda* Warren
2. *Pingasa venusta* Warren
3. *Neohippoarchus maculata* (Warren)
4. *Lophophelma hunliensis* sp. nov.
5. *Dindicodes hanae* sp. nov.
6. *Paramaxates taiwana* Yazaki
7. *Chloroglyphica variegata* (Butler)
8. *Comostola quantula* (Swinhoe)
9. *Herochroma viridaria* (Moore)
10. *Pelagodes veraria* (Geunée)
11. *Berta apopemta* Prout

**SUBFAMILY DESMOBATHRINAE**
1. *Ozola hmuifangensis* sp. nov.
2. *Ozola extersaria* (Walker)

**SUBFAMILY ORHOSTIXINAE**
1. *Naxa textilis* Walker

**SUBFAMILY OENOCHROMINAE**
1. *Sarcinodes debitaria* (Walker)
2. *Sarcinodes lilacina* Moore
3. *Sarcinodes aequilinearia* (Walker)

**SUBFAMILY STERRHINAE**
1. *Organopoda bilobata* sp.nov.
2. *Organopoda hampsoni* sp. nov.
3. *Syngiodes hyriaria* (Walker)
4. *Syngiodes histrionaria* Swinhoe
5. *Syngiodes sanguinaria* (Moore)
6. *Antitrygodes vicina* Thierry-Mieg
7. *Antitrygodes divisaria* (Walker)
8. *Zythos avellanea* (Prout)
9. *Problepsis albidor* Warren

**SUBFAMILY LARENTIINAE**
1. *Polynesia sunandava* (Walker)
2. *Polynesia truncapex* Swinhoe
3. *Asthena scobli* sp. nov.
4. *Tyloptera bella* (Butler)
5. *Laciniodes plurilinearia* (Moore)
6. *Physetobasis griseipennis* (Moore)
7. *Photoscotosia miniosata* (Walker)