GENERAL CONCLUSIONS
AND SCOPE FOR
FURTHER RESEARCH
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It is well known that earlier taxonomists used to depend on few attributes for describing various taxa. Due to recent advances made on systematics, many new techniques have evolved and taxonomists are relying on more and new characteristics. Due to this reason taxonomic revisions of various groups of insects are going on throughout the Globe. The most significant and outstanding contribution on the taxonomy of Indian Geometridae was made by Hampson from 1895 to 1912. The studies conducted by him were based on few external morphological characters in general and wing venation in particular. After him, very few publications can be listed on this economically important group of moths. The present study was undertaken to fulfill the objectives laid down for an entomological and taxonomic research problem entitled, “Taxonomic studies on family Geometridae (Lepidoptera) from North-east India”. During the present course of work, as many as 8 major collection cum survey tours were conducted to seven different North-Eastern states covering more than 52 remote and far-flung localities of this mega-biodiverse country for collection of adult moths belonging to seven subfamilies i.e. Ennominae, Geometrinae, Sterrhinae, Larentiinae, Desmobathrinae, Oenochrominae and Orthostixinae of family Geometridae. Intensive and extensive collection-cum-surveys yielded a rich harvest of 2,645 representatives of 100 species referable to 74 genera of above said subfamilies under family Geometridae. All these species were treated taxonomically and studied in detail with the help of latest and pertinent literature in order to reach final conclusions.

During the present study, it has been seen that most of the species belong to subfamily Ennominae. This group of moths can be characterized by the absence of vein M2 in the hindwing. Subfamily Ennominae is known by 9,710 global species with 1,846 species from Oriental region (Holloway, 1997). As many as 67 species referable to 50 genera of this group were procured and studied here in detail. Various morphological
structures including external male and female genitalic attributes have been studied in considerable details.

Two genera i.e. Neolassaba gen. nov. and Pseudohypochrosis gen. nov. while 18 species viz. Neolassaba prouti sp. nov., Hypochrosis walkeri sp. nov., Pseudohypochrosis unicornuta sp. nov., Luxiaria dirangensis sp. nov., Corymica neopryeri sp. nov., Dalima termeneata sp. nov., Fascellina longipennis sp. nov., Fascellina perchromataria sp. nov., Zamarada valvata sp. nov., Cleora ochreata sp. nov., Cleora pajni sp. nov., Satoblephara satoi sp. nov., Tasta lengpaiensis sp. nov., Metapercnia juxtaria sp. nov., Plutodes digitata sp. nov., Ourapteryx furcata sp. nov., Ruttellerona fuscaria sp. nov. and Psilalcis pseudoinceptaria sp. nov. have been proposed as new to science in the present manuscript.

To begin with, labial palpi are found to be upturned in seven genera Crypsicometa Warren, Ophthalmitis Fletcher, Hypochrosis Guenée, Callocasta (Moore), Psyra Walker, Petelia (Herrich-Schaffer) and Xerodes Guenée whereas porrect or obliquely porrect in rest of the 60 genera. Bipectinate type of antennae upto 2/3rd of length in males and simple in females were observed in majority of the genera but with some variations like simple types in Ourapteryx Leach, Heterostegane Hampson, Entomopteryx (Guenée), Sirinopteryx Butler, Crypsicometa Warren, Callocasta (Moore), Tasta Walker and Obeidia Walker; serrate type of antennae found in Antipercnia Inoue and Opisthogramatopsis (Hübner); ciliated in Luxiaria Walker, Corymica Walker, Satoblephara Holloway, Dalima Moore, Fascellina Walker, Psyra Walker and Psilalcis Warren; Borbacha Moore with pectinate and Peratostega Warren with filiform types of antennae. A prominent character of hind tibia dilated with a fold containing a tuft of hairs has been observed in Lassaba (Moore), Antipercnia Inoue, Luxiaria Walker, Orthocabera (Butler), Chorodna Walker, Vindusara (Moore), Ephemero philia Warren, Parapercnia Wehrli, Xenoplia Warren, Arichanna Moore and Abraxas Leach. All the species have two pairs of tibial spurs except Tyloptera (Christoph) which have single pair of tibial spurs.
General Conclusions and Scope for Further Research

Abdomen has been found with least modifications and variations except in genus Vindusara (Moore) which possess lateral pair of tuft of hairs on fourth, fifth and sixth segments; Corymica Walker have a dorsal patch of small scales on the 5th segment the abdomen of male; Satoblephara Holloway have a strong coremata between segments 4 and 5 and smaller ones between 6, 7 and 8; genus Obeidia Walker possess prominent rounded tympanal organs on its first abdominal segment. External male and female genitalia shows high degree of variations among subfamily Ennominae. In general, uncus is well developed, curved with a pointed tip in 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, Crypsicometa 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 this structure is wanting. Tegumen well developed and simple in all species of subfamily Ennominae studied here. Vinculum well sclerotized, either V or U-shaped and saccus weakly developed. Besides all these features, subfamily Ennominae is also characterized by highly variable and complex valva. 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 membranous in Thinopteryx Butler, Vindusara moorei Thierry-Mieg, Parapercnia Wehrli, Orthocabera (Butler). The shape of cornuti varies from species to species in this subfamily.

Female genitalia of Ennominae 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 Antipercnia Inoue, Zamarada Moore, Orthocabera (Butler), Psyra Walker and Tasta Walker; dot-like in Thinopteryx Butler; long comb-like in Crypsicometa Warren. Ductus bursae either weakly or well sclerotized in various taxa in studied genera. Sterigma highly sclerotized in some of the genera like Metapercnia Wehrli and Zamarada Moore. These taxonomical interpretations have yielded very fruitful and exciting results.

Subfamily Geometrinae can be characterized by the presence of green wing pigment and vein M$_2$ arising much nearer to M$_1$ than M$_3$ in hind wing. These are as many as 2,296 species from the Globe and 584 species from Oriental region. A total number of 11 species have been studied in the present research work. Two species i.e. Lophophelma hunliensis sp. nov. and Dindicodes hanae sp. nov. have been proposed here as new in this manuscript.

Labial palpi are porrect in all the studied species of subfamily Geometrinae. Antennae are simple in Chloroglyphica Warren, Paramaxates Warren and Herochroma (Swinhoe) while bipectinated in all other studied genera. Hind tibiae dilated in Lophophelma Prout, Pingasa Moore and Herochroma (Swinhoe).

8$^{th}$ segment of the abdomen is modified into variable shapes in Berta Walker and Paramaxates Warren. Uncus 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. Socii well-developed in genus Herochroma Swinhoe. Gnathos present in all genera studied in the present work. Tegumen and vinculum simple, either weakly or highly sclerotized and saccus poorly defined. Valva highly developed and variable in size and shape. 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 sacculus are highly

Female genitalia shows a number of variations in the subfamily under reference. Corpus bursae varies in shape and is triangular in *Pingasa* Moore and *Chloroglyphica* Warren; globular in *Pelagodes* Prout and peach shaped in *Neohipparchus* Inoue. Signum is present in only two genera i.e. *Berta* (Walker) and *Paramaxates* Warren.

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 in all the genera studied here. Tegumen highly sclerotized in all genera studied here except *Polynesia* Swinhoe, where it is weakly sclerotized. Vinculum and saccus well developed in different species included in the present work. Signum is very well developed in female genitalia of this group.

One of the species i.e. *Asthena scobili* sp. nov. has been proposed as new to science in the present manuscript.

Subfamily Sterrhinae is represented by 2,763 species from the Globe and 543 species from Oriental region. A total number of 9 species have been studied in the present work. The subfamily is mainly characterized by spurs absent in genus *Antitrygodes* Warren; uncus 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 *Zythos* Fletcher.
General Conclusions and Scope for Further Research

Female genitalia with corpus bursae ornamented with signum of various shapes i.e. globular and elongated in the species studied in the present work.

Two species viz., Organopoda bilobata sp. nov. and O. hampsoni sp. nov. have been described as new to science in the present thesis.

Subfamily Oenochrominae is represented by only single genus i.e. Sarcinodes Guenée in this manuscript. The genus under reference is characterized by a well-developed and variable uncus, socii absent; gnathos well developed in this group. Tegumen simple and highly sclerotized and vinculum well developed and W-shaped but saccus poorly defined. Valva highly developed and variable in this group. Cornuti highly sclerotized in the present genus.

Subfamily Desmobathrinae is characterized by well-developed uncus, tegumen, vinculum, juxta, valvae and aedeagus. Socii absent in this group. Females with comb shaped signum.

Subfamily Orthostixinae is characterized by well-developed uncus and tegumen. Juxta long and bifid towards tip. Valvae simple.

It is worth to mention here that the taxonomical interpretations have yielded very fruitful and healthy results. As many as two new genera and 24 species have been proposed as new to science in this study. A total number of 20 type species have been examined and studied in considerable details. 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.

Scope for Further Research

Research is a continuous process and there is always enough scope for further improvement. One has to cope up with the progressive changes happening in a particular field because a lot of knowledge accumulates along with technological advancements with the passage of time. It has already been stressed in the review of literature that taxonomic studies on family Geometridae were conducted and compiled by only few world renowned taxonomists like Hampson about 119 years ago. There are notable contributions by Hampson (1895-1912) and Prout (1906-1939) in the field of taxonomy.
General Conclusions and Scope for Further Research

on family Geometridae in this mega diverse country. And after this, taxonomy of the family Geometridae was neglected for 70-80 years. A lot of deforestation and environment degradation has taken place during this long gap. Thus, environmentally induced adaptations, behavioural, physiological and ecological variations among individuals of a population resulting in phenotypic plasticity needs seriously to be looked and cannot be ignored. The spread of modern agriculture has also resulted in considerable changes in the biodiversity of specific areas which also affected animal fauna including insects in a drastic manner. Fresh surveys and thorough revision of this economically important group of moths is immediately warranted and need of the hour because of altogether changed environment scenario.

The present research work deals with taxonomy of family Geometridae from North-east India and it yielded very fruitful and satisfied results. So, it has been emphasized 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 Central India, plains of North and South India, Andaman and Nicobar Islands, Lakshadweep islands and high altitudes of Himalayas has to emphasized and highlighted. 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 various species complexes on the basis of morphological attributes. Certainly these new attributes can be used as additional taxonomic attributes. It is hoped that the outcome of the present research work will prove a boon and act as a motivation for the future Geometrid workers.