General Conclusions and Scope for Further Research

In his monumental works Distant (1902, 1908, 1910 and 1918) revised the families Coreidae and Lygaeidae in the form of Fauna of British India. However, most of the taxonomic conclusions were based on external morphological characters in general. He did not include even the all important external genitalia for species diagnosis. He gave descriptions of 154 species of family Coreidae and 201 species of Lygaeidae from British India. After him, only scattered works have appeared related to Indian fauna, that too related to economically important groups only. Very little attention has been paid to systematically explore the Heteropteran fauna from north India. Keeping in view this bankruptcy of knowledge, the present work was undertaken to update our knowledge about two families with the hope that similar studies will be started by future workers on other families of this diverse order.

The present study is based upon the examination of approximately 1100 adults of family Coreidae referable to two subfamilies, 12 genera and 38 species and 900 adults belonging to family Lygaeidae referable to 5 subfamilies, 19 genera and 28 species. Collection for this purpose has been made since November, 2008 to October, 2011 from different states of north India viz., Punjab, Haryana, Himachal Pradesh, Uttarakhand, some parts of Jammu and Kashmir, Union territories of Chandigarh and NCR region of Delhi. An extensive and intensive search has been made for the bugs belonging to families Coreidae and Lygaeidae from their natural abodes. A thorough study of literature has also been made to know about their global distribution.

Along with morphological characters, genitalia of species belonging to both the families have also been studied. It has been found that male genitalia as well as female genitalia are highly species specific. Paramere with its stem and blade is highly variable at the interspecific level. Similar is the case of vesica and appendages of the aedeagus. But it is very difficult to inflate aedeagus of these families for proper studies. Shape of the pygophore also differs among the species. In female genitalia spermatheca is species specific though highly variable at the interspecific level. Genital plate differs in shape of 1st gonocoxa and shape of 8th and 9th paratergites. On the basis of genitalia studies morphologically similar species can easily be distinguished.
During the present project, four new species of family Coreidae have been reported belonging to genus *Cletus* Stal. These are *Cletus pathankotensis* sp. nov., *C. pygophorus* sp. nov., *C. pseudotrignus* sp. nov. and *C. tashiae* sp. nov.. 4 species have been recorded for the first time from India. These are *Notobitus affinis* (Dallas), *Cletus feanus* Distant, *Cletus borealis* Blotte, and *Cletus similis* Blotte. Similarly 17 new records from north India have been reported. These are *Homoeocerus prominulus* (Dallas), *H. sigillatus* Stal, *H. macula* Dallas, *H. fasciolatus* Stal, *H. atkinsoni* Distant, *H. serrifer* (Westwood), *C. horrens* Dohnr, *Anoplocnemis phasiana* (Fabricius), *A. binotata* Distant, *Pteleocnemis obscura* Dallas, *Hydara orientalis* Distant, *Ochrochira nigrorufa* (Walker), *Acanthocoris scabrador* (Fabricius), *C. rubidiventris* (Westwood), *C. punctulatus* Westwood, *C. punctiger* (Dallas), *C. trigonus* (Thunberg). A few new localities have also been added.

Among the studied species of family Lygaeidae, 5 species are new records from India i.e. *Pamara punctulata* (Motschulsky), *P. undulata* (Dohrn), *Usilanus burmanicus* Distant, *Oncopeltus rubricatus* (Stal), *Neoletheus extremus* (Walker). 9 species represent new record from north India. These are *Horridipamera nietneri* (Dohrn), *Paraeucosmetus pallicornis* (Dallas), *Pseudopachybrachius vinctus* (Say), *Graptostethus quadrisignatus* Distant, *Aspilocoryphus guttiger* (Dallas), *Lethaeus indicus* (Dallas), *Lachnesthus singalensis* (Dohnr), *Eucosmetus incisis* (Walker). A few new localities have been added e.g. *Rhyparothesus kangricus* (Kirkaldy) from Uttarakhand, *Spilostethus simla* (Distant) from Punjab and *Rhyparothesus dudgeoni* (Distant) from Uttarakhand.

**RAPD STUDIES:**

The intraspecific variations among the populations of the same species collected from different localities such as one collected from Punjab and other from Himachal Pradesh or Uttarakhand have been studied. Here RAPD has been performed on 19 species collected from different localities. 9 species of family Coreidae and 10 species of family Lygaeidae have been studied from this angle. These all species show a significant amount of intraspecific variations. So we can say that there are variations among the same species collected from different localities.
SCOPE FOR FURTHER RESEARCH

The families Coreidae and Lygaeidae have been extensively studied taxonomically throughout the world and active research is still going on to update our knowledge about these two families having considerable economic importance. However, the scenario is not very encouraging as far as studies on Indian fauna are concerned. After a series of monumental publications by Distant in the pre-independence era, no effort has been made to systematically explore different areas in order to know the latest situation in the country. Though taxonomic studies had taken a back seat as a whole during the half century of independent India, bugs have remained totally ignored at the hands of Indian workers. With growing awareness about the urgent need of mapping our biodiversity, initiatives have recently been taken in this direction. The present work should also be considered as a contribution in this direction and it should be considered as a base model for such future works.

New methods of agriculture involving extensive use of pesticides have resulted in considerable changes in the biodiversity of specific areas and loss of many species of insects. However, we do not even have an idea about the damage that has already been done. So there is an urgent need to explore different regions of the country to enlist the species and to undertake revisionary works of various taxa, particularly belonging to the order Hemiptera.

RAPD studies in the two families under consideration have given encouraging results and this methodology can be further refined for studying intraspecific variations. The trend now a day is towards sequencing specific genes, particularly COI and CO II. It helps in differentiating at specific level as well as for phylogenetic analysis. Such studies on the families Coreidae and Lygaeidae can be quite rewarding keeping in view their economic importance.
SUMMARY

The research work has been carried out on an entomological problem entitled, “Taxonomic studies on families Coreidae and Lygaeidae (Hemiptera: Heteroptera) from North India supplemented with RAPD markers”. The thesis has been compiled under following chapters: introduction, review of literature, materials and methods, observations and discussion, general conclusions and scope for further research, summary and literature cited. It has been considered worthwhile to summarize the work chapter wise in the following text.

INTRODUCTION

1. First of all the importance of biodiversity is discussed. Then role of taxonomy for conservation and maintenance of biodiversity has been stressed upon.
2. Importance of insects for mankind is discussed alongwith relevance of their taxonomic studies in the present context.
3. General characters of order Hemiptera are enumerated. The order is divided into 5 suborders: Heteroptera, Sternorrhyncha, Cicadomorpha, Fulgoromorpha and Coleorrhyncha.
4. General characters and distinguished characters of suborder Heteroptera are given that include shape of head, pronotum, scutellum, male genitalia and female genitalia.
5. General and diagnostic characters of families Coreidae and Lygaeidae are discussed. Classification of family given by Schuh and Slater (1995) has been followed. Economic importance of the families has also been discussed.
6. Area of the present study i.e. North India is discussed. The states covered under this area include Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Uttarakhand, Chandigarh and Delhi
7. Need and importance of RAPD technique is discussed.

REVIEW OF LITERATURE

1. This chapter has been divided in to four subchapters under the headings General Heteroptera, Coreidae, Lygaeidae and RAPD.
2. An exhaustive review has been provided about the suborder Heteroptera in general taking in to consideration several monumental works.

3. The review of literature for the two families under study has been discussed under three headings: national, oriental (excluding India) and international.

4. It is followed by review of literature for molecular techniques in insect taxonomy in general with particular reference to RAPD.

5. It can be concluded that the families Coreidae and Lygaeidae have been extensively studied taxonomically throughout the world. Research is still going on to update our knowledge about these two families having considerable economic importance.

6. However, the scenario is not very encouraging as far as studies on Indian fauna are concerned. After a series of monumental publications by Distant in the pre-independence era, no effort has been made to systematically explore different regions in order to know the latest situation in the country.

7. No specific work has been done in the country as far as RAPD studies on bugs are concerned.

**MATERIALS AND METHODS**

1. The present study is based upon the examination of approximately 1100 adult specimens referable to two subfamilies, 12 genera and 38 species belonging to family Coreidae and 900 adult specimens referable to 5 subfamilies, 19 genera and 28 species under the family Lygaeidae.

2. Collection tours were arranged during November, 2008 to October, 2011 covering different states of North India viz., Punjab, Haryana, Himachal Pradesh, Uttarakhand and some parts of Jammu and Kashmir, union territory of Chandigarh and NCR region of New Delhi.

3. Heteropterans occur in a wide variety of habitats, for example on leaves, under leaf litters, on foliage of small herbaceous plants, on grasses and on trees. Various methods have been used for collection of bugs e. g. by beating vegetation, by sorting leaf litter, sweeping net method, with the help of light trap method etc.

4. Mounting of insects was done in two ways—pin mounting and card mounting.
5. The collection was preserved in air tight boxes which were periodically fumigated.

6. Each specimen was labeled carrying information about the collection locality, date of collection, name of collector and host plant (if known).

7. For dissection of male and female genitalia different methods, have been given by different authors. For male genitalia methodology given by Pruthi (1925), Ashlock (1957) and for female genitalia methodology given by Scudder (1963) is followed.

8. Species were identified mainly on the basis of Fauna of British India given by Distant (1902, 1908, 1910, and 1918). Relevant literature was used for identification of species published afterwards. Genital characters have been employed for correctly differentiating the species which were closely similar.

9. All the descriptions have been written to make these adequate and uniform, as most of the earlier descriptions are incomplete describing coloration only. The descriptions have been based on the most typical specimens selected in each case and considered to have the basic characters of form, color, size, abdominal lines, terminal abdominal sterna, antennae etc. Population variations have been mentioned, wherever observed.

**RAPD STUDIES**

Different techniques for RAPD STUDIES have been discussed and a protocol has been standardized. All the bands and cardiograms for different species and samples of same species from different localities have been provided. Interpretation of RAPD STUDIES has been given, wherever relevant.

**OBSEVATIONS**

1. Intensive and extensive collection cum survey tours were conducted from different localities covering the area of north India. A total of 66 species were studied of which 38 belonged to the family Coreidae and 28 to family Lygaeidae.

2. The species belonging to family Coreidae fall under two subfamilies. 36 species under 11 genera belong to subfamily Coreinae and 2 species under one genus belong to subfamily Pseudophloeinae. Lygaeid species were
included under 5 subfamilies of which 8 species under 4 genera belong to subfamily Lygaeinae, 19 species under 12 genera belong to subfamily Rhyparochrominae, the remaining species belong one each to the subfamilies Oxycareninae, Orsillinae and Blissinae. Diagnostic features of each family as well as each subfamily are discussed. Taxonomic keys have been provided for all the included subfamilies, genera and species.

3. Diagnostic features of each genus are given along with its first reference, synonymy and type species.

4. For each studied species, the original reference, synonymy (if any), detailed description, material examined, old and new distribution and remarks are provided. Photography of all species has been done both for morphological parts (whole insect, head, pronotum, scent gland, ventral view of male and female abdomen) and genitalic parts (both male and female genitalia).

5. Four new species have been proposed under one genus of family Coreidae. These are *Cletus pathankotensis* sp. nov., *C. pseudotrigonus* sp. nov., *C. tashiae* sp. nov., and *C. pygophorus* sp. nov.

**GENERAL CONCLUSIONS AND SCOPE FOR FURTHER RESEARCH**

A little work has been done by Chopra, Rustagi and Singal from Hisar agricultural University. The studies conducted by Distant were based on external morphological characters in general. He gave descriptions of 154 species of family Coreidae and about 201 species of Lygaeidae from British India. After him, very few publications were listed on this economically important group.

During the present study 12 genera and 38 species of family Coreidae have been collected and identified. Four new species have been reported belonging to genus *Cletus* Stal. 19 genera and 28 species belonging to family Lygaeidae have been recorded. Among these 5 species are new records from India.

It can be concluded from the foregoing discussion that the families Coreidae and Lygaeidae have been extensively studied taxonomically throughout the world. Research is still going on to update our knowledge about these two families having considerable economic importance. However the scenario is not very encouraging as
far as studies on Indian fauna are concerned. After a series of monumental publications by Distant in the pre-independence era, no effort has been made to systematically explore different areas in order to know the latest situation in the country. Though taxonomy had taken a back seat as a whole, bugs have remained totally ignored at the hands of Indian workers. With growing concept about mapping our biodiversity, initiatives have recently been taken in this direction. The present work should also be considered as a contribution in this direction.

SUMMARY

A summary has been given in which all the important points of various chapters have been highlighted.

LITERATURE CITED

A complete list of all the references cited in the thesis has been given in a uniform pattern.

LIST OF SPECIES

FAMILY COREIDAE:

SUBFAMILY COREINAE:

- Ochrochira nigrorufa (Walker)
- Anoplocnemis phasiana (Fabricius)
- Anoplocnemis compressa (Dallas)
- Anoplocnemis binotata Distant
- Notobitus affinis (Dallas)
- Ptelocnemis obscura Dallas
- Acanthocoris scabrator (Fabricius)
- Dalader acuticosta Amyot and Serville
- Anhomoeus nepalensis (Distant)
- Anhomoeus sulcatus (Distant)
- Homoeocerus borealis Distant
- Homoeocerus prominulus (Dallas)
Homoeocerus signatus Walker
Homoeocerus sigillatus Stal
Homoeocerus serrifer (Westwood)
Homoeocerus atkinsoni Distant
Homoeocerus lacertosus Distant
Homoeocerus macula Dallas
Homoeocerus fasciolatus Stal
Homoeocerus striicornis Scott
Hydara orientalis Distant
Cletus bipunctatus (Westwood)
Cletus feanus Distant
Cletus rubidiventris (Westwood)
Cletus punctulatus Westwood
Cletus bovillus Distant
Cletus punctiger (Dallas)
Cletus pathankotensis sp. nov.
Cletus borealis Blotte
Cletus tashiae sp. nov.
Cletus pseudotrigonus sp. nov.
Cletus trigonus (Thunberg)
Cletus pygophorus sp. nov.
Cletus similis Blotte
Cletomorpha hastata (Fabricius)
Cletomorpha raja Distant

SUBFAMILY PSEUDOPHLOEINAE

Clavigralla scutellaris (Westwood)
Clavigralla horrens Dohn

FAMILY LYGAEIDAE:

SUBFAMILY RHYPAROCHROMINAE:

Lachnesthus singalensis (Dohn)
Eucosmetus incicus (Walker)
- *Lethaeus indicus* (Dallas)
- *Neolethaeus extremus* (Walker)
- *Usilanus burmanicus* Distant
- *Dieuches uniguttatus* (Thunberg)
- *Dieuches coloratus* (Distant)
- *Dieuches leucoceras* (Walker)
- *Elasmolomus sordidus* (Fabricius)
- *Elasmolomus lineosus* (Distant)
- *Rhyparothesus Kangricus* (Kirkaldy)
- *Rhyparothesus dudgeoni* (Distant)
- *Pamera undulata* (Dohrn)
- *Pamera punctulata* (Motschulsky)
- *Horridipamera nietneri* (Dohrn)
- *Paraecosmetus pallicornis* (Dallas)
- *Pseudopachybrachius vinctus* (Say)

**SUBFAMILY LYGAEINAE**

- *Oncopeltus rubricatus* (Stal)
- *Spilostethus pandurus* (Scopoli)
- *Spilostethus hospes* (Fabricius)
- *Spilostethus simla* (Distant)
- *Spilostethus eous* (Distant)
- *Graptostethus nigriceps* Stal
- *Graptostethus quadrisignatus* Distant
- *Aspilocoryphus guttiger* (Dallas)

**SUBFAMILY ORSILLINAE**

- *Nysius inconspicuus* Distant

**SUBFAMILY BLISSINAE**

- *Macropes excavatus* Distant

**SUBFAMILY OXYCARENINAE**

- *Oxycarenus laetus* Kirby
LIST OF ABBREVIATIONS USED

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