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Summary and Conclusion

The present study entitled "Diversity, Morphometry and Phylogenetic relationship of Orthopterans" has been conducted in Coimbatore District, Tamil Nadu, India. A preliminary study was conducted to assess the geographical and seasonal variation effects on Orthopterans diversity among different host plants and determine the morphology and molecular variation among selected dominant acridids in the study area. The salient findings are summarized under the following phases.

Phase - I

- A total of 45 Orthopterans belonging to 35 genera, 26 tribes and 16 subfamilies under four families viz., Acrididae, Pyrgomorphidae, Tettigoniidae and Gryllidae were collected from the different regions across all the seasons of the study area.
- During the study period, the largest number of species belonging to the family Acrididae followed by Tettigoniidae, Pyrgomorphidae and Gryllidae. Subfamily Oedipodinae has the highest species diversity in all the sites and seasons compared to other subfamilies of Orthopterans.
- Overall, the maximum number of Orthopterans and their Shannon diversity index, Simpson index and Margalef richness were observed in site I (Marudhamalai) during monsoon season. Cluster analysis results showed that the highest similarity of species composition occurred between site I and site III; monsoon and pre-monsoon season, respectively.
- Among the collected Orthopterans, *T. annulata*, *L. indica*, *A. patruelis*, *O. abruptus*, *P. infumata*, *A. luteipes*, *M. fasciata*, *O. fuscovittata* and *D. venusta* from Acrididae family were found in all the season as well as all sites of the study area.

Phase - II

- Totally, 38 host plants of Orthopterans belonging to 37 genera and 16 families were collected from five different regions of the study area. Among the five sites, site I and site III; monsoon and pre-monsoon season comprised the highest plant species composition.

- The overall diversity of Orthopterans and their Shannon diversity index, Simpson index and Margalef richness were recorded maximum in the host plants *C. dactylon* and the minimum species diversity was recorded in *I. tigridis*. PC analysis revealed that family Poaceae comprised the highest number of host plants and also supported the highest number of Orthopterans.
- Among the Orthopterans, *T. annulata* species was found in the maximum number of host plants, whereas *X. humilis*, *H. banian*, *A. insubricus*, *H. kinneari* and *S. rugosa* distribution were observed from only two types of host plants.
- Among the different habitats, higher number of Orthopterans were collected from grasslands followed by agricultural sites and ground surface.
- The present study indicated a strong positive correlation between the plant and Orthopterans diversity. The relationship of plant-grasshopper diversity varied notably between sites.

Phase - III

- Over the study period, 3939 number of acridids belonging to nine species were collected from the five different sites of Coimbatore. Among the nine species of acridids, *T. annulata* was found to be the most dominant species.
- PC analysis revealed that the number of acridids individuals were observed maximum in site I during monsoon season.
- Cluster analysis results revealed that the population dynamics of acridids similarity was highest between site I and site III and monsoon and pre-monsoon.
- Correlation coefficient results indicated that the acridids population positively correlated with rainfall and negatively correlated with maximum temperature, minimum temperature and humidity.

Phase - IV

- The mean±SD values of various morphometric measurements such as body length, head length, pronotum length, antenna length, fore wing length and hind femur length were recorded maximum in *P. infumata* species and minimum in *L. indica* species. The results of one-way Analysis of variance (ANOVA) showed significant differences in the length of all analysed structures of acridids.

- Based on the PCA and boxplot results, fore wing length showed the highest variation among acridids followed by hind femur length and body length, whereas the length of head, pronotum and antenna length showed less variance. Cluster analysis and survivorship curve results revealed the highest similarity between the body length and fore wing length; antenna length and hind femur length; head length and pronotum length of acridids.
- Totally, 19 homologous landmarks were identified in the wing vein of nine acridids species in order to characterize the shape variation. Among the nine acridids species, wing variability was recorded maximum in *T. annulata* population, whereas lesser variation was observed minimum in *A. luteipes* population.
- The first two relative warps showed the highest proportion of variance in all species of acridids. The minimum Procrustes distance and tangent space distance were observed in *D. venusta*, while the maximum distance was observed in *T. annulata*. CV analysis of studied species was statistically different from each other in wing morphological characters.

Phase - V

- The Mitochondrial DNA of the COI gene was used to differentiate all of the species used in this investigation. In the current study, nine acridids sequenced were analysed in the BLAST to perform a similarity search for matching the sequence to the already existing data in the NCBI database.
- All of the species were correctly identified with the highest possible identification values with reference species in the database. *T. annulata, A. luteipes P. infumata, O. fuscovittata,* O. *abruptus, M. fasciata* and *A. patruelis* showed 100% of similarity; *D. venusta* with 98.66% similarity and *L. indica* with 96.92% similarity.
- The parameters such as nucleotide composition, codon positions, substitution matrix, transition and transversion bias, evolutionary divergence, F84 distance, synonymous and non-synonymous substitution and phylogenetic analysis were checked to understand their evolutionary lineage. Hence, the sequences analysed in the present study exhibited high inter-species variability on the basis of COI nucleotide sequences.

Conclusion

Biodiversity is one of the important cornerstones for maintaining overall environmental health and stability of various kinds of ecosystems. The world is currently facing the greatest biodiversity crisis. The present study emphasized that species are becoming extinct because of overpopulation, habitat loss, land use change, pollution and the threat of global climatic changes. A small change in species composition from a healthy stable state can adversely destroy the many ecological services and thus affect the interaction of the remaining component in an ecosystem. Orthopterans are one of the most dominant invertebrate groups in the terrestrial ecosystem and contribute much to the natural welfare as indicators and a vital role in protecting the ecosystem structure and function. Changing scenarios in an ecosystem have influenced the primary consumers like Orthopterans, thereby creating an effect on the entire food web in an ecosystem. Hence, the promotion of Orthopterans biodiversity conservation as well as management of ecosystem is an important step for a sustainable world. The taxonomy and phylogeny of Orthopterans are used to describe new species and support the global biodiversity profile worldwide.

Scope for future research

- Understanding the relationship between environmental factors and the distribution of Orthopterans is necessary to monitor ecosystem health management in the future. Implementation of continuous monitoring plans and periodic measurement of environmental variables in the region.
- A long-term study is needed to record the species distribution and their interaction with biotic and abiotic factors from this area, in order to get better and comprehensive information about more number Orthopterans species. Further research of Orthopterans diversity can be extended to the district level by adding different criteria.
- Plant diversity to guide the effective and meaningful restoration programs for present and future initiatives for conserving the Orthopterans diversity. Increasing the host plant composition in an ecosystem can be supported a large number of diversity and population of Orthopterans.
- Morphometric measurement of body length and geometric morphometrics in wing veins of acridids will provide the best discriminative characters to taxonomical study.

- The molecular study provided a general framework for taxon sampling in future studies of acridids phylogeny on a global basis. A larger number of acridids species need to be examined to further understand the phylogenetic relationship of acridids.

Recommendation

The present study provides distinctive information of Orthoptera diversity among different host plants, different seasons as well as different regions of the study area and this result would help to assess appropriate and possible strategies for Orthopteran conservation as well as ecosystem management in the future. This study will not only show the species existence in the ecosystem but also explained how different environmental structure affects their composition, morphology and genotype. The study of plant composition among Orthopterans habitats will help to identify the preferable host plant for rearing Orthopteran in the future. Meteorological parameters with grasshopper population can help to understand the correlation between environment and species. This will help to assess the relative success or failure of the reconstruction and the quality of ecosystems. The morphometric and molecular study will provide information about the taxonomy of acridids based on their various morphological features and genetic characteristics. The molecular study proposes novel information among major lineage within selected acridids. Overall, this study added basic knowledge to the diversity, morphometry and molecular evolution of Orthopterans.