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Diversity and Distribution of True Bugs (Heteroptera) in Ahilyanagar, Maharashtra, India: A Preliminary Study

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Authors' contributions

This work was carried out in collaboration between both authors. Author PGS designed the study, contributed to collection of specimens, identified specimens together with the author INS, carried out the statistical analysis, interpreted the data and drafted the manuscript. Author INS contributed in the collection, preservation, and maintenance of the specimens. Both authors read and approved the final manuscript.

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ABSTRACT

Heteropterans are well-known as true bugs and are notorious crop pests. Ahilyanagar, the largest district of Maharashtra, encompasses diverse habitats conducive to a rich heteropteran fauna. This study presents preliminary insights into the diversity of heteropteran fauna across selected sites within Ahilyanagar. Specimens were collected, preserved, and taxonomically analysed, revealing 61 taxa representing 49 genera and 12 families. Pentatomidae emerged as the most diverse family,

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with 17 taxa, followed by Coreidae, Reduviidae, Dinidoridae, Pyrrhocoridae, Lygaeidae, Miridae, Scutelleridae, and Alydidae. This research constitutes the first comprehensive report on Heteroptera from Ahilyanagar, including new distributional records that enrich Maharashtra's faunal resources and inform pest management strategies.

Keywords: Heteroptera; diversity; true bugs; crop pests, Ahilyanagar, Maharashtra.

1. INTRODUCTION

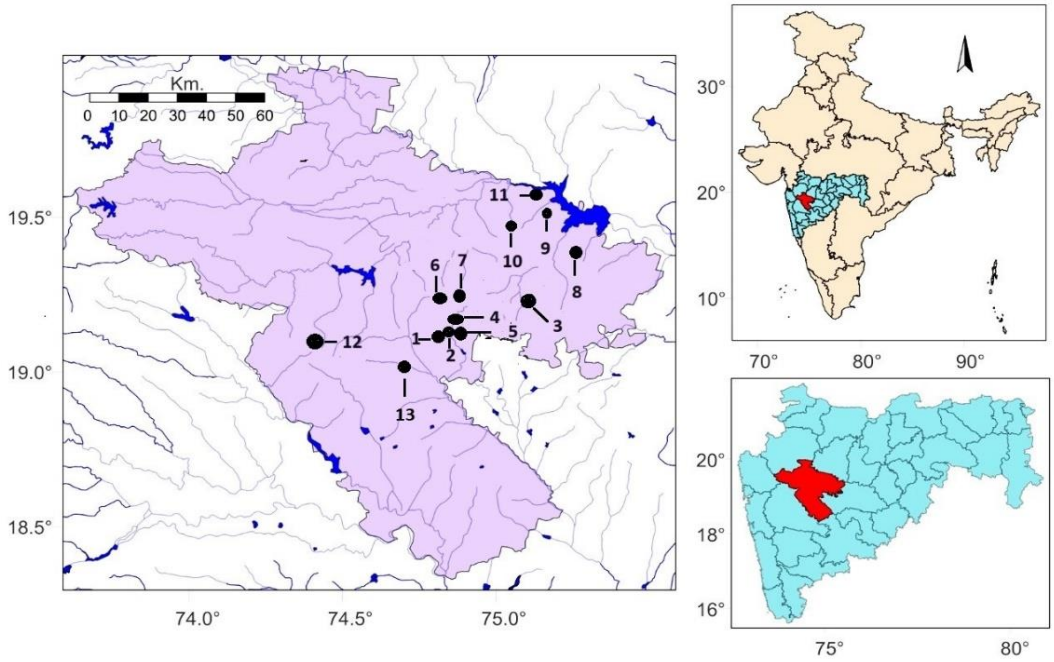
The Heteroptera represents the largest and most diverse group of hemimetabolous insects. They are one of the most widespread and populous insect groups, occupying a variety of environments and climates. The true bugs are particularly common in tropical regions, where a myriad of species thrive in diverse habitats ranging from rainforests to grasslands. Heteroptera presents a vast and varied assemblage, boasting over 42,300 species spread across 89 families and possesses distinctive forewings known as hemelytra [1]. Being the largest group of insects with incomplete metamorphosis, heteropterans have been extensively studied globally, regarding their basic and applied aspects. Heteropterans cause a wide variety of problems for humans; they serve as pests, disease transmitters, and nuisance creators, thereby inflicting damage on crops, forests, and human life [2].

Maharashtra, a state in the western region of India, boasts an extraordinary wealth of biodiversity, spanning diverse ecosystems ranging from lush forests to arid plateaus. From the Western Ghats to the Deccan Plateau, and from coastal regions to inland forests, Maharashtra harbours a plethora of ecosystems that likely support a diverse array of heteropteran species. The state's diverse geography, climatic conditions, and varied habitats offer a conducive environment for a rich heteropteran assemblage. Amidst this ecological tapestry, the heteropteran fauna stands as a fascinating and often overlooked component. There are some important contributions to the heteropteran fauna of Maharashtra [3-11].

Despite its significance, the heteropteran diversity of Maharashtra remains relatively understudied and poorly documented. Ahilyanagar district, area-wise, the largest district in Maharashtra state, harbours a variety of habitats suitable for the growth and development of true bugs. Despite the district's rich potential as a habitat for heteropteran bugs, the literature indicates sparse published records regarding the heteropteran fauna of the Ahilyanagar district. Except for a report of the pomegranate pest *Bathycoelia indica* Dallas, 1851 by Kudnar et al.[12] and a preliminary survey of aquatic bugs by Pande et al. [13], there is no published record of the Heteroptera of Ahilyanagar district. Given the district's agricultural prominence, characterized by a diverse range of crops including sugarcane, cotton, onion, soybeans, wheat, maize, paddy, vegetables, and fruits, effective management of heteropteran pests is paramount to mitigating crop losses. Understanding heteropteran diversity is not only essential for enriching our knowledge of regional biodiversity but also holds practical implications for agriculture, public health, and conservation efforts. Consequently, this study endeavours to shed light on the heteropteran diversity within Ahmednagar, highlighting its ecological significance and implications for agriculture and biodiversity conservation. Through comprehensive documentation and analysis, this research seeks to deepen our understanding of this intriguing group and its impact on local ecosystems.

2. METHODOLOGY

Study area: Bug specimens were collected from several areas within Ahilyanagar and the adjoining regions as shown in the study area map (Map 1). The study area included different sites as follows: (1) Ahmednagar College campus, (2) Mukundnagar-Pipeline Road-Nirmalnagar, (3) Garbhagiri Hills (Sonewadi and Baradari Villages), (4) Kapurwadi Village, (5) Bhingar Camp, (6) Manjarsumba Fort-Nagar Tahesil, (7) Dongargan village-Nagar Tahesil (8) Shevgaon Town, (9) Khamgaon-Newasa Tahesil, (10) Gevrai Village -Newasa Tahesil, (11) Suregaon-Galnib Village -Newasa Tahesil (12) Siddheshwarwadi Village- Parner Tahesil, (13) Ghospuri Village- Nagar Tahesil.



Map 1. **Location of Sampling Sites within the Study Area**
(1) Ahmednagar College campus, (2) Mukundnagar-Pipeline Road-Nirmalnagar, (3) Garbhagiri Hills (Sonewadi and Baradari Villages), (4) Kapurwadi, (5) Bhingar Camp, (6) Manjarsumba Fort, (7) Dongargan, (8) Shevgaon, (9) Khamgaon, (10) Gevrai Village, (11) Suregaon-Galnib, (12) Siddheshwarwadi, (13) Ghospuri.

Collection, Preservation and Maintenance: The insects were collected mostly by handpicking and insect nets; and subsequently transported to the departmental laboratory at the Department of Zoology, Ahmednagar College, Ahilyanagar, for thorough examination and study. The specimens were preserved dry by following standard protocols. The preserved specimens were stored in wooden insect storage boxes with naphthalene balls to deter pests. Each specimen was meticulously labelled with details such as locality, date of collection, and collector's name, using a waterproof marker pen.

Photography: Specimens were photographed either in preserved form or alive in the field**.** Different cell phone cameras were used for photographing specimens. Some specimens were photographed using Nikon D5100 DSLR Camera. Photographs were modified with Microsoft Paint and Photo App.

Identification: The identification was based on the external distinguishing characters. The specimens were identified with the help of taxonomic keys from published literature [3,4,5,14-26]. The online taxonomic resources were also used as identification aids. The first author identified the specimens. Although utmost care is taken for correctly identifying specimens, yet consider this identification as approximate and some misidentifications may come to notice in future. The bug specimens are stored in the museum of the PG Department of Zoology, and once the study is complete the specimens will be deposited in the museum at Zoological Survey of India, WRC, Pune for future reference.

Statistical analysis: The relative species richness of each family was calculated by the following formula: [species richness of the family ÷ species richness of the entire study area]. Species richness is the total number of different species belonging to a family or the study area.

3. RESULTS

Faunal diversity of heteroptera: The present study reports 61 species of heteropteran bugs representing 49 genera and 12 families (Table 1). The analysis of results obtained shows that the Pentatomidae is the most diverse family, with 17 species recorded in study area. This result roughly conforms to those obtained by Jadhav and Hegde [8], who reported 18 species of stink bugs representing 16 genera while studying stink bugs of Pune.

Table 1. List of heteropteran taxa recorded from study area

Pentatomoidea	1. *Carbula insocia* (Walker, 1868)
Pentatomidae	2. *Halys serrigera* (Westwood, 1837)
	3. *Eocanthecona furcellata* (Wolff, 1811)
	4. Plautia crossota (Dallas, 1851)
	5. Plautia stali (Scott, 1874)
	6. *Bathycoelia indica* (Dallas, 1851)
	7. Halyomorpha picus (Fabricius, 1794)
	8. Dalpada versicolor (Herrich-Schaeffer, 1853)
	9. Eysarcoris guttiger Thunberg, 1783
	10. Eysarcoris montivagus (Distant, 1902)
	11. Erthesina acuminata (Dallas, 1851)
	12. Erthesina fullo (Thunberg, 1783)
	13. Nezara viridula (Linnaeus, 1758)
	14. Niphe subferruginea (Westwood, 1837)
	15. Bagrada hilaris Burmeister, 1835
	16. Catacanthus incarnatus Druery 177
	17. Amyotea malabarica (Fabricius, 1775)
Dinidoridae	*18. Cyclopelta siccifolia* (Westwood, 1837)
	19. *Coridius janus* (Fabricius, 1775)
	20. *Coridius brunneus* (Thunberg, 1783)
	21. *Coridius chinensis* Dallas, 1851
	22. *Megymenum distanti* Kocorek and Ghate, 2012
Scutelleridae	23. *Solenostethium rubropunctatum* (Guerin-Meneville, 1830)
	24. *Chrysocoris purpureus* (Westwood, 1837)
	25. *Chrysocoris stollii* Wolf, 1801
Tessaratomidae.	*26. Tessaratoma javanica* (Thunberg, 1783)
Pyrrhocoroidea	*27. Dysdercus evanescens* Distant, 1902
Pyrrhocoridae	*28. Dysdercus koenigii* (Fabricius, 1775)
	29. Dysdercus cingulatus (Fabricius, 1775)
	30. *Probergrothius nigricornis* (Stal, 1861)
	31. Antilochus coquebertii (Fabricius, 1803)
Coreoidea	32. *Leptocorisa acuta* (Thunberg, 1783)
Alydidae	33. *Riptortus pedestris* (Fabricius, 1775)
Rhopalidae	34. *Leptocoris augur* (Fabricius, 1781}
Coreidae	35. *Plinachtus acicularis* (Fabricius, 1803)
	36. Cletus rubidiventris (Westwood, 1842)
	37. *Physomerus parvulus* Dallas, 1852
	38. *Physomerus centralis* Mukherjee, Hassan and Biswas, 2016
	39. *Acanthocoris scabrator* (Fabricius, 1803)
	40. Homoeocerus signatus Walker, 1871.
	41. *Anoplocnemis phasianus* (Fabricius, 1781)
	42. *Clavigralla gibbosa* Spinola, 1837
	43. *Petillopsis calcar* (Dallas, 1852)
Lygaeoidea	44. *Metochus uniguttatus* (Thunberg, 1822)
Lygaeidae	*45. Spilostethus pandurus* (Scopoli, 1763)
	46. Graptostethus servus (Fabricius, 1787)
	47. Lygaeus militaris (Fabricius, 1775)
	48. Lygaeus kalmia Stal 1874
Aradoidea	
Aradidae	*49. Mezira granulata* (Say, 1832)
Miroidea	50. *Trigonotylus tenuis* Reuter, 1893
Miridae	51. *Dolichomiris linearis* Reuter, 1882
	52. *Creontiades pallidifer* (Walker,1873)
	53. *Lygus patrius* Distant 1959
Cimicomorpha	54. *Ectrychotes dispar* Reuter 1881
Reduviidae	*55. Scadra annulipes* Reuter, 1881
	56. *Rhynocoris marginatus* (Fabricius)
	57. *Rhynocoris fuscipes* (Fabricius) 1787
	58. Acanthaspis sexguttata (Fabricius, 1775)
	59. Acanthaspis quinquespinosa (Fabricius, 1781)
	60. Catamiarus brevipennis (Serville, 1831)
	61. *Tribelocephala indica* (Walker, 1873)

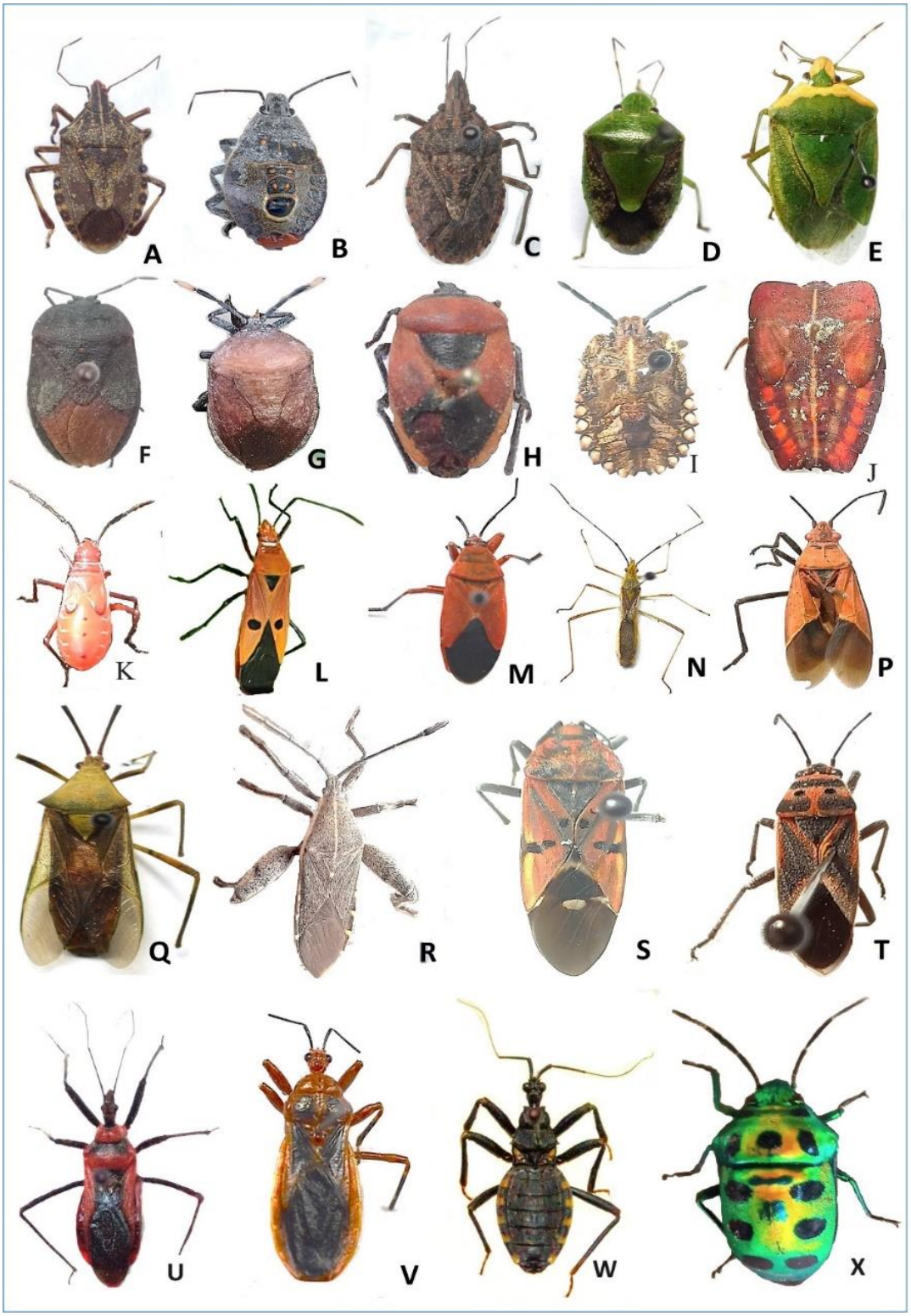
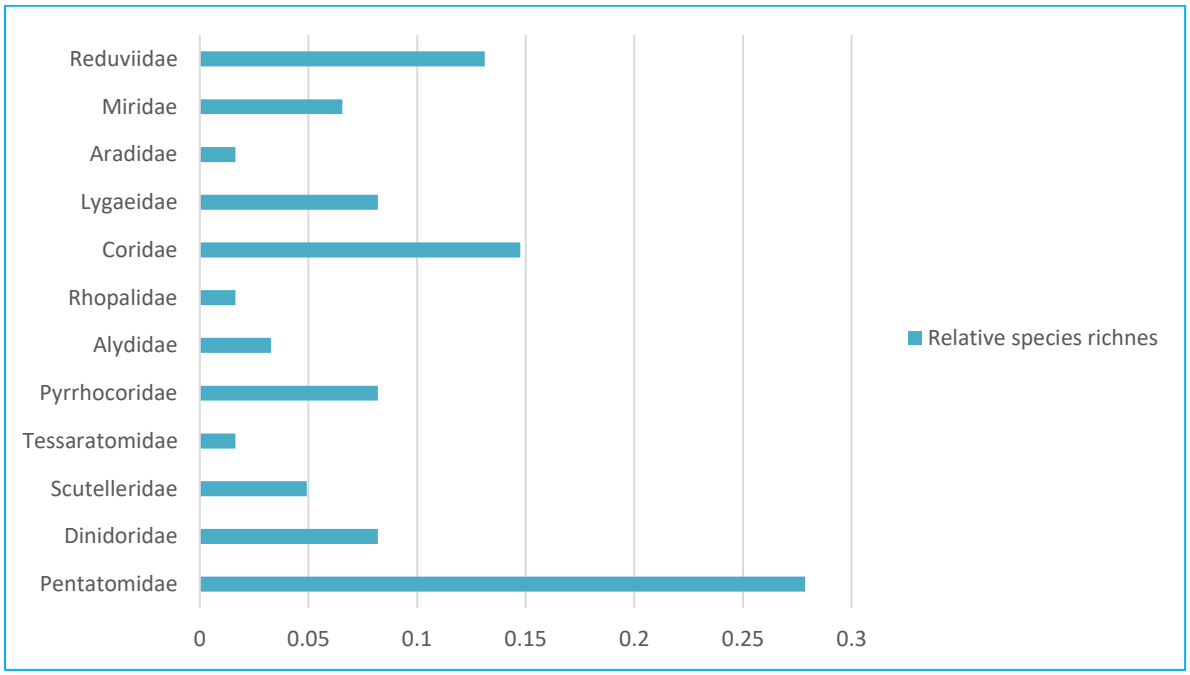


Fig. 1. Images of heteropteran taxa from study area*:* A: *E. acuminata,* B: *E. fullo,* C: *H. serrigera,* D: *P. crossota,* E: *N. viridula,* F: *C. siccifolia,* G: *C. chinensis,* H: *C. janus,* I: *M. distanti* (nymph), J: *T. javanica,* K: *D. koenigii,* L: *D. cingulatus,* M: *A. coquebertii,* N: *L.acuta,* P: *L. augur,* Q: *C. rubidiventris,* R: *P. centralis,* S: *S. pandurus,* T: *G. servus,* U: *R. fuscipes,*V: *S. annulipes,*W: *A. quinquespinosa,* X: *C. purpureus*. [Note: Images not to the scale]



Graph 1. Relative species richness of heteropteran families of study area

Relative species richness: Statistical analysis shows that Pentatomidae shows highest prevalence among all heteropteran families with species richness value of 17 and relative species richness of 0.278. It is followed by Coridae, Reduviidae, Dinidoridae, Pyrrhocoridae, Lygaeidae with relative species richness values of 0.15, 0.13,0.81, 0.081, and 0.081 respectively. The lowest value of relative species richness (0.16) is recorded for each of the Aradidae, Tessaratomidae, and Rhopalidae (Graph 1).

New distributional records: This study provides the first comprehensive report of Heteroptera from Ahilyanagar and includes new distributional records for many bugs. For most of the species reported from the study area, it is the first report about their distribution in the study area. For example, the study adds a new distributional record for a dinidorid species *M. distanti* which was recently described from its type locality Pune [27]. This species was recorded s from Ganpati Temple, in the Mukund Nagar area of Ahilyanagar city.

A. malabarica (Fabricius, 1775) was earlier recorded from various states of India [28] Mumbai [2] and Pune. The *A. malabarica* is recorded for the first time from Ahilyanagar. *P. centralis, a* recently described new [29] is also recorded for the first time from Ahilyanagar.

4. DISCUSSION

The analysis of results shows that the Pentatomidae is the most diverse family within the study area with 17 taxa. Pentatomidae of Maharashtra includes 58 species representing 42 genera under two subfamilies [6]. Approximately 382 species belonging to 150 genera of Pentatomidae have been reported from India [28]. A species H. *halys* appears phenotypically similar to *H. picus*, however, it is not found in India and its occurrence in India is reported due to misidentification [30].

The reduviids, often known as assassin bugs, are ferocious terrestrial predators with over 7,000 identified species in over 900 genera and 25 subfamilies; they are considered one of the three most abundant groups of Heteroptera [1,15].

The reduviid bugs of the study area are represented by 8 taxa representing 6 genera. Indian reduviid fauna includes 465 species under 144 genera spread over 14 subfamilies [31]. The present study recorded 8 species of reduviid bugs from the study area against 33 species under 7 subfamilies recorded from entire Maharashtra [32]. This number is far less from expected, hence, further research in future will reveal many more species. Notably, *Physomerus centralis* is recorded for the first time after it was described recently [29]. Miridae is by far the most

diverse and speciose family in the Heteroptera, with around 1,300 genera and over 11,000 known species worldwide [33]. Mirids, also known as plant bugs or capsids, are small to medium-sized, elongated to ovoid bugs with triangular heads. This study reports 4 species of Miridae under 4 genera from the study area.

The family Lygaeidae includes so-called "seed bugs". They range in length from 1.2 to 12 mm, are amorphous, brown or black, and show aposematic colouration usually red or yellow. The present study recorded 5 species of Lygaeidae that represent 4 genera. The members of Pyrrhocoridae are commonly known as Cotton stainers. The present study recorded 5 species of cotton stainers representing 3 genera. They are medium-sized bugs that are typically red, yellow, or black. Approximately 30 genera and 300 species are known globally [34]. The members of the family Alydidae are known as Broad-Headed bugs. They are characterized by triangular heads and a small to medium-sized, slender body. The Leaf-Footed Bugs (Coreidae), are also known as squash bugs. These bugs are medium to very large, strong robust bugs with distinct striking coloration. They are characterized by expansion of femora, tibiae, humeral angles, or antennae. The least diverse heteropteran families of the study area include Tessaratomidae, Rhopalidae, and Aradidae each represented by 1 taxon.

The perusal of published literature shows that there exists a remarkable absence of published records regarding the heteropteran fauna of Ahilyanagar. In light of this gap, the current investigation provides the first comprehensive study of its kind and sets the foundational framework for future research into the heteropteran fauna of the region. This study will help to update the data on faunal resources of Maharashtra. It will help to formulate effective strategies for the management of heteropteran pests in the study area. The study on the heteropteran fauna of Ahilyanagar provides a preliminary account of the diversity of true bugs in the study area. However, there are some limitations of the study that should be considered here. Firstly, the study only looked at a small number of sites within the study area, the sample size may limit how broadly findings may be applied. This could lead to failure to observe the heteropteran species present in other habitats or during different seasons of the year. Secondly, the reported diversity aspects might have been impacted by difficulties in the taxonomic identification of specimens. Because of morphological similarities and identification challenges in taxonomy, certain taxa may have been misdiagnosed or ignored despite taxonomic attempts. Taxonomic identifications of bug specimens, especially in diverse groups like Heteroptera, could lead to potential misclassifications or underestimations of faunal diversity. Additionally, a single sample effort may not fully explore the seasonal fluctuations in the abundance and diversity of the fauna being studied. For that reason, a detailed understanding of Ahilyanagar's heteropteran diversity may be possible from future research with larger sample sizes and broader spatial coverage.

5. CONCLUSIONS

This study provides the first systematic report on the diversity and distribution of Heteroptera in Ahilyanagar, Maharashtra. By employing standard collection and preservation protocols, we uncovered a significant diversity of heteropteran species, encompassing 61 taxa spread across 49 genera and 12 families. provides the family Pentatomidae emerged as the most diverse, with 17 taxa and the highest species richness. Other notable families with a significant number of species include Coreidae, Reduviidae, Dinidoridae, Pyrrhocoridae, Lygaeidae, Miridae, Scutelleridae, and Alydidae. Our findings contribute new distributional records for numerous species, highlighting the rich heteropteran biodiversity of Ahilyanagar and underscoring the importance of continued taxonomic and ecological studies in the region.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models and text-to-image generators have been used during the writing or editing of the manuscript. However, sites such as https://app.grammarly.com/ are used for grammatical corrections, and the Quillbot extension in MS Word is used for paraphrasing some sentences.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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