Voyage Journal of Scientific Research and Exploration (VJSRE) *Vol 2. Issue 1*
ISSN (Online): 3007-3898, ISSN (Print): 3007-388X, April to September 2025

OCCURRENCE AND RELATIVE ABUNDANCE OF LEAFHOPPERS (CICADELLIDAE) ACROSS SELECTED LOCALITIES OF THARPARKAR, SINDH

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Abstract

Studies on leafhoppers of Tharparkar located in southeastern Sindh, Pakistan, was conducted during 2023-2024.Leafhoppers are very small but active jumping phytophagous insects, known for their significant impact on agriculture due to their sap-sucking behavior and potential as vectors of plant pathogens. This study aims to document the diversity and distribution of leafhoppers in various localities of Tharparkar. Keeping in viewextreme temperature variations, and water scarcity, provided a unique flora of Tharparkar. Field surveys conducted across various habitats, including agricultural fields, desert vegetation, and rangelands. The study documented 19 species belonging to 12 genera, 9 tribes, and 3 subfamilies (Deltocephalinae, Megophthalminae, Cicadellinae). Significant taxa included: Aconurellaprolixa (Lethierry, 1885), Exitianusindicus (Distant, 1908), Exitianusnanus (Distant, 1908), Maiestaspruthii (Metcalf, 1967), Maiestastareni (Dash and Viraktamath, 1968), Cicadulinabipunctata (Melichar, 1904), Macrostelesindrina (Pruthi, 1930), Neoaliturustenellus (Baker, 1896), Grammacephaluspallidus (Linnavuori, 1978), Grammacephalusindicus (Viraktamathand Murthy, 1999), Stirelluslahorensis (Distant, 1918), Stirellusviridulus (Pruthi, 1930), Austroagalliarobusta (Sawai Singh and Gill, 1973), Austroagalliasarobica (Dlabola, 1964), Agalliarobusta (Pruthi, 1930), Agalliacuspidata (Dlabola, 1957), Platyproctusmaculatus (Pruthi, 1930), Cofana spectra (Distant, 1908) and Cofanaunimaculata (Signoret, 1854). These species were examined in detail, including diagnostic morphological features, ecological notes, illustrations, and material examined. The results revealed that the diversity of Cicadellidae varied significantly with habitat type.

Keywords: Cicadellidae,Phytophagous insects, Desert vegetation, Male genitalia, Stereomicroscope.

Introduction

From Pakistan mostly the leafhoppers have been identified from Sindh, Punjab and KPK but in regions like Tharparkar, an arid to semi-arid district, the study of insect biodiversity, particularly of economically important groups like leafhoppers, remains largely neglected. Leafhoppers, due to their close association with specific host plants and their sensitivity to environmental changes, can serve as useful indicators of ecological variation and habitat quality in this region.Keeping in view the importance of the study area; Tharparkar is regarded as a dry natural resource, primarily rich in native coal, granite, salt mines, livestock, and China clay; however, most of the region is uninhabited, with only 1.5% seen as agricultural land (Nazim *et al*., 2024). Tharparkar district is selected for study because it's a part of Sindh province having natural border between India and Pakistan. About 85% of the Thar Desert issituated in India while rest of 15% is in Pakistan along the eastern border of Sindh province, and extends to the southeastern parts of Punjab, where it joins the Cholistan Desert. District Tharparkar is bounded in the North by Mirpurkhas and Umerkot districts, in the East by India (Barmar and Jaisalmir districts), in the West by Badin district, and in the South by Runn of Kutchh.

In present study various localities of Tharparkar were visited for collection of leafhoppers, most of the collection was done on vegetation, ranging from thorny shrubs to drought-resistant crops, through sweep net.Leafhoppers are presented worldwide from tropical regions and temperate grasslands Morris, (1971); Waloff, (1980), leafhoppers eat vegetables, shrubs, grasses, and trees and they can migrate to specific plants at various times of the season if their preferred food is available. Some leafhoppers species exist worldwide usually feed on a diverse range of plants while many species have a particular host plant (DeLong, 1948; Brown *et al*., 1992; Whitcomb *et al*., 1987; Whitcomb and Hicks, 1988; Nickel and Remane, 2002). They particularly enjoy young plants that provide them with plenty of sap. Leafhoppers prefer sheltered parts of plants, such as aboxial sides of leaves, whorls and stem tissues and this is the greater protection from predators and greater access to vascular tissues.Many predators feed on leafhoppers; hence they are a good food source for small predators (Hammond, 2018). Leafhoppers have their mouth parts arranged into a tube, the stylet, which they insert into a plant leaf or stem and then use to suck plant fluids in order to extract the diluted proteins and nutrients they need. The result is a lot of undigested sugar-water that passes through the insect, which is excreted as waste. This clear, sticky liquid is called Honeydew. The ants receive the sugary fluid called "honeydew" and complement the hoppers by guarding them from insect predators and parasites. The negative impact of honeydew is that when it is in more quantity than to utilize by ants, it causes sooty mold to develop. This is a black coating, powdery in appearance, caused by a fungus growing on the honeydew. Over time, this coating covers more of the plant, stopping the sunlight from reaching the foliage. The plant loses vigor, and over time becomes weakened. It's also unsightly in appearance. While other negative impacts of leafhoppers are that many leafhoppers' species are pests in agriculture (Day and Fletcher, 1994).

Biodiversity assessments in arid zones are crucial as these ecosystems are sensitive to climatic fluctuations, land use changes, and overgrazing, all of which may influence insect population

dynamics. This work is the first attempt of the area and will help future workers to understand the leafhopper fauna of the region. The current study represents the first comprehensive systematics of Cicadellidae from Tharparkar, filling a critical knowledge gap and laying the groundwork for future studies in insect biodiversity and pest management.

Material and Methods

Study site

The material collected from the Tharparkar desert Sindh during the year 2023-2024 from different localities, *i.e.* Umerkot, Chachro, Kantio, Diplo, Chelhar, Nangarparkar, Viravah, Dahli, Kaloi, Islamkot and Mithi. The region is characterized by an arid to semi-arid climate, sandy soils, sparse vegetation, and extreme temperature variations.

Sampling

A standard insect sweep net (38 cm diameter) was used to collect leafhoppers from various vegetation types. Key sampling sites included different trees, herbs, shrubs and grasses agricultural fields (e.g., millet, sorghum), and areas with wild grasses and drought-resistant flora. Sampling was conducted at different timings, particularly early morning and late afternoon to maximize insect activity. Specimens were killed in a bottle containing potassium cyanide.

Sorting and preserving

Material was brought to Entomology and Bio-Control Research Laboratory (EBCRL), Department of zoology, University of Sindh Jamshoro. Leafhoppers present in insect killing jar containing cyanide, sorted out due to their minute structures and resemblance with plant hoppers and frog hoppers then preserved in 80-90% ethanol. All specimens were labeled as per locality, date of collection, name of the collector and the host plant if known. For the confirmation of specimens up to species level, male genitalia was dissected, the method of dissection was followed (knight, 1965). Specimens were observed under dissecting microscope and necessary images were captured.

Observations

A macerated abdomen was placed in glycerin and dissected under a 3D dissecting microscope (Labomed CSM2, 20X–40X). For detailed study the genitalia were observed under a compound microscope (Kyowa Medilux 20) fitted with a USB Camera (350 k pixel).

Identification

Adult specimens were identified in the laboratory using standard procedures, including a low-power stereomicroscope, relevant taxonomic keys, and species descriptions. The maceration process was employed to examine internal genitalia.

Morphological characteristics of Cicadellidae

Family Cicadellidae commonly called leafhoppers and sharpshooters (Membracoidae) has more than 22000 described species worldwide (Oman *et al*., 1990; Dietrich, 2005). Cicadellidae is cosmopolitan in distribution Fletcher *et al*., (1991) and members occur everywhere, where plants (their hosts) can survive (Nielson and Knight, 2000) and mostly occur throughout the temperate and tropical regions. They are plant feeders that have sucking mouthparts that suck plant sap from grass, shrubs, or trees, causing various pests by depending on the hosts. Leafhoppers are of various forms, colors and sizes. Most species are less than about ½ inch (13mm), some may reach 1¼ inches (Triplehorn and Johnson, 2005). Many species are grey, brown, tan, black or various shades of green or orcher, even the species with relatively drab coloration frequently possess intricately beautiful markings (Shah and Zhang, 2018). By the presence of two or more rows of spines on the hind tibia (Shins) insects can be distinguished as a member of the Auchenorrhyneca (Bahder *et al*., 2025). Their bodies tend to be parallel sided or taper toward the rear. The bulbous base of each thin bristle like antenna is relatively short (compared to that of planthoppers). There are 2 ocelli (small, simple eyes) atop the head (usually between the two compound eyes. They are also different by not having the pronotum extending back over the abdomen as present in their close relative, the membracidae (viraktamath, 2005).

Results and Discussion

The collected material from various habitats and different localities of Tharparkar region over the survey period 2023-2024 were identified and classified into 3 subfamilies with 9 tribes. **1**. Deltocephalinae with 6 tribes *i.e.* Chiasmini, Deltocephalini, Macrostelini, Opsiini, Scaphytopiini, Stenometopiini including 8 genera. **2**. Megopthalminae with 2 tribes Agalliini and Adelungiini comprising 3 genera and **3**. Cicadellinae with a tribe Cicadellini and 1genus (Table 1).

Table 1. Checklist of Cicadellidae species of Tharparkar, Sindh

Order	Family	Subfamily	Tribe	Genus	Species
Hemiptera	Cicadellidae	Deltocephalinae	Chiasmini	*Aconurella*	*A. prolix*
				Exitianus	*E. indicus*
					E. nanus
			Deltocephalini	*Maiestas*	*M. pruthi*
					M. tareni
			Macrostelini	*Cicadulina*	*C. bipunctata*
				Macrosteles	*M. indrina*
			Opsiini	*Neoaliturus*	*N. tenellus*
			Scaphytopiini	*Grammacephalus*	*G. pallidus*
					G. indicus
			Stenometopiini	*Stirellus*	*S. lahorensis*
					S. viridulus
		Megophthalminae	Agalliini	*Austroagallia*	*A. robusta*
					A. sarobica
				Agallia	*A. robusta*
					A. cuspidate
			Adelungiini	*Platyproctus*	*P.maculatus*
		Cicadellinae	Cicadellini	*Cofana*	*C. spectra*
					C. unimaculata

The highest number of collections from all the 19 species collected was *Cofana unimaculata* from Umerkot with 92 specimens and the second highest number of specimens from the same locality was *Aconurella prolixa* with 79 specimens. From Chhachro the maximum number of *Aconurella prolixa* and *Cofana unimaculata* was collected with 73 and 64 specimens respectively. From kantio 95 and 84 specimens of *Cofana unimaculata* and *Aconurella prolix* with higher ratio respectively. *C. unimaculata* with 51 and *Aconurella prolix* having number of 42 were found from Diplo (Table 2a & Figure 1).

Table 2(a). List of species collected from different localities of Tharparkar Sindh, Pakistan during the year 2023-2024

Species	Umerkot			Chhachro			Koenti road			Diplo		
		M	F		M	F		M	F		M	F
Aconurella prolixa	79	32	47	73	21	52	84	34	48	42	24	18
Exitianus indicus	32	11	21	23	15	08	-	-	-	21	06	15
E. nanus	29	12	17	39	11	28	12	08	04	14	05	09
Maiestus pruthi	57	32	25	24	17	07	21	13	08	27	09	18
M. tareni	37	13	24	14	05	09	23	10	13	11	03	08
Cicadulina bipunctata	53	27	26	31	19	12	38	21	17	26	12	14
Macrosteles indrina	67	26	41	57	36	21	92	37	55	37	15	12

Neoalitrus tenellus	36	11	25	25	09	16	11	06	05	07	03	04
Grammacephalus indicus	07	05	02	12	07	05	16	09	07	07	02	05
G. pallidus	-	-	-	04	01	03	-	-	-	-	-	-
Stirellus lahorensis	21	16	5	27	12	15	18	07	11	15	08	07
S. viridulus	69	31	48	72	32	40	81	35	46	39	18	21
Austrogallia robusta	38	16	22	31	15	16	18	11	06	11	07	04
A. sarobica	42	25	17	35	17	18	07	04	03	02	01	01
Agallia robusta	18	04	14	3	01	02	04	02	02	06	02	04
A. cuspidate	25	16	9	15	06	09	08	05	03	07	05	02
Platyproctus maculatus	61	23	38	32	19	13	44	27	17	17	12	05
Cofana spectra	67	23	44	36	07	29	32	13	19	21	02	19
C. unimaculata	92	33	59	64	28	36	95	42	53	51	27	24

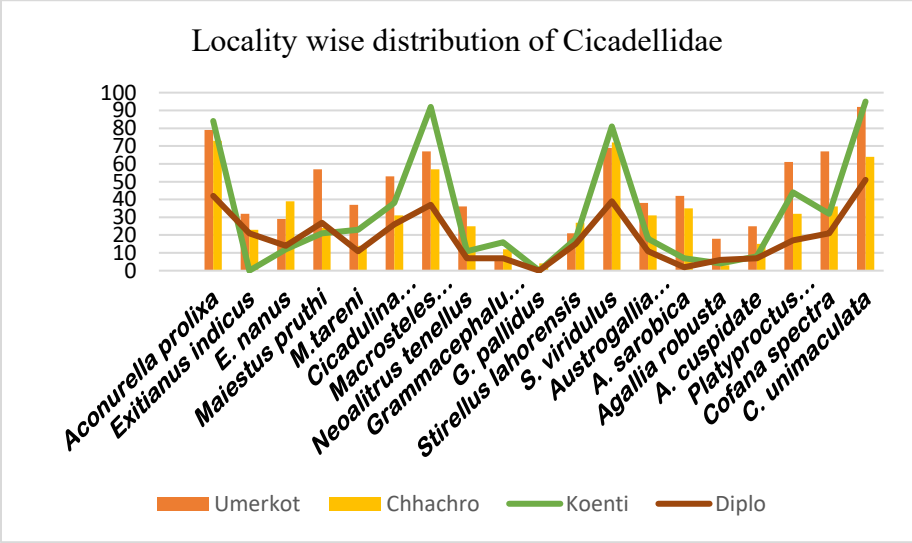

Figure 1. Distribution of collected species from Umerkot, Chhachro, Koenti road and Diplo during the year 2023-2024

From Chelhar *Stirellus viridulus* having maximum number of 28 and *Macrosteles indrina* with a number of 27 individuals. From Nangarparkar *Cofana unimaculata* with a maximum number of 102 and *Aconurella prolixa* having number 96. In Viravah *Platyproctus maculates* found in greater number of 85 and *Macrosteles indrina* with 77 specimens. Dahli *Stirellus lahorensis* has more number than other species *i.e.* 43 and second number is 35 of *Aconurella prolixa* species (Table 2b & Figure 2).

Table 2 (b). List of species collected from different localities of Tharparkar Sindh, Pakistan during the year 2023-2024

Species	Chelhar			Nangarparkar			Viravah			Dahli		
		M	F		M	F		M	F		M	F
Aconurella prolixa	19	06	13	96	23	63	74	29	45	35	07	28
Exitianus indicus	-	-	-	47	21	26	45	14	31	14	02	12
E. nanus	2	0	02	34	15	19	28	08	20	8	03	05
Maiestus pruthi	23	08	15	76	34	42	41	26	15	21	14	07
M. tareni	11	07	04	29	07	22	20	07	13	-	-	-
Cicadulina bipunctata	18	11	07	81	32	49	52	27	25	34	15	19
Macrosteles indrina	27	09	18	82	37	45	77	43	34	31	15	16
Neoalitrus tenellus	15	07	08	52	29	23	63	29	34	-	-	-
Grammacephalus indicus	-	-	-	40	13	27	25	09	16	-	-	-
G. pallidus	-	-	-	32	11	21	28	12	16	-	-	-
Stirellus lahorensis	12	04	08	56	21	35	39	07	32	43	05	38
S. viridulus	28	12	16	59	17	32	56	15	36	32	14	18
Austrogallia robusta	04	01	03	47	14	33	36	19	17	19	11	07
A. sarobica	07	04	03	53	24	29	27	21	06	12	04	08
Agallia robusta	-	-	-	34	12	18	45	24	22	07	03	04
A. cuspidate	18	11	07	56	37	19	63	26	37	05	03	02
Platyproctus maculatus	24	10	14	79	41	38	85	39	46	09	05	04
Cofana spectra	22	09	13	45	13	32	41	28	13	17	11	06
C. unimaculata	21	06	15	102	44	58	59	37	22	23	10	13

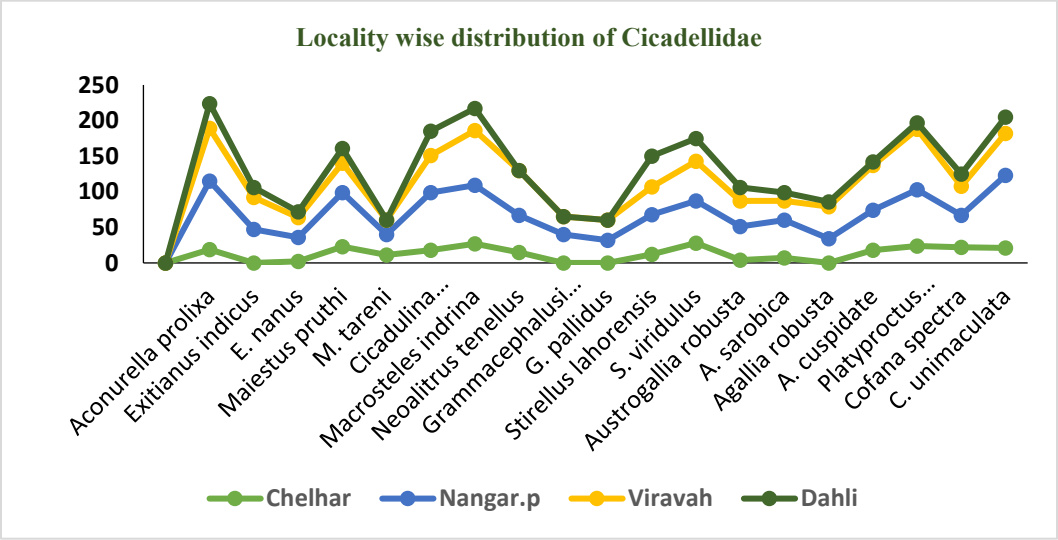

Figure 2. Distribution of collected species from Chelhar, Nangarparkar, Viravah andDahliduring the year 2023-2024

Whereas Kaloi, Islamkot and Mithihavea smaller number of specimens found during 2023-2024 (Table 2c & Figure 3).

Table 2 (c). List of species collected from different localities of Tharparkar Sindh, Pakistan during the year 2023-2024

Species	Kaloi			Islamkot			Mithi		
		M	F		M	F		M	F
Aconurella prolixa	12	04	08	22	13	09	21	05	16
Exitianus indicus	-	-	-	4	02	02	07	03	04
E. nanus	2	0	02	-	-	-	13	04	09
Maiestus pruthi	11	07	04	14	08	06	16	07	09
M. tareni	-	-	-	09	02	07	11	03	08
Cicadulina bipunctata	5	02	03	07	03	04	19	07	12
Macrosteles indrina	26	15	11	23	12	11	17	12	05
Neoalitrus tenellus	-	-	-	15	06	09	12	07	05
Grammacephalus indicus	05	01	04	03	01	02	12	08	04
G. pallidus	-	-	-	04	02	02	09	05	04
Stirellus lahorensis	13	05	18	19	06	13	12	04	08
S. viridulus	21	07	14	18	07	11	15	03	12
Austrogallia robusta	14	05	09	08	02	06	09	02	07
A. sarobica	15	07	08	11	04	07	14	05	09
Agallia robusta	-	-	-	12	06	06	08	05	03
A. cuspidate	16	05	11	10	03	07	11	07	04
Platyproctus maculatus	05	04	01	17	09	08	13	06	07
Cofana spectra	14	04	10	13	04	09	09	02	07
C. unimaculata	21	07	14	15	05	10	24	09	15

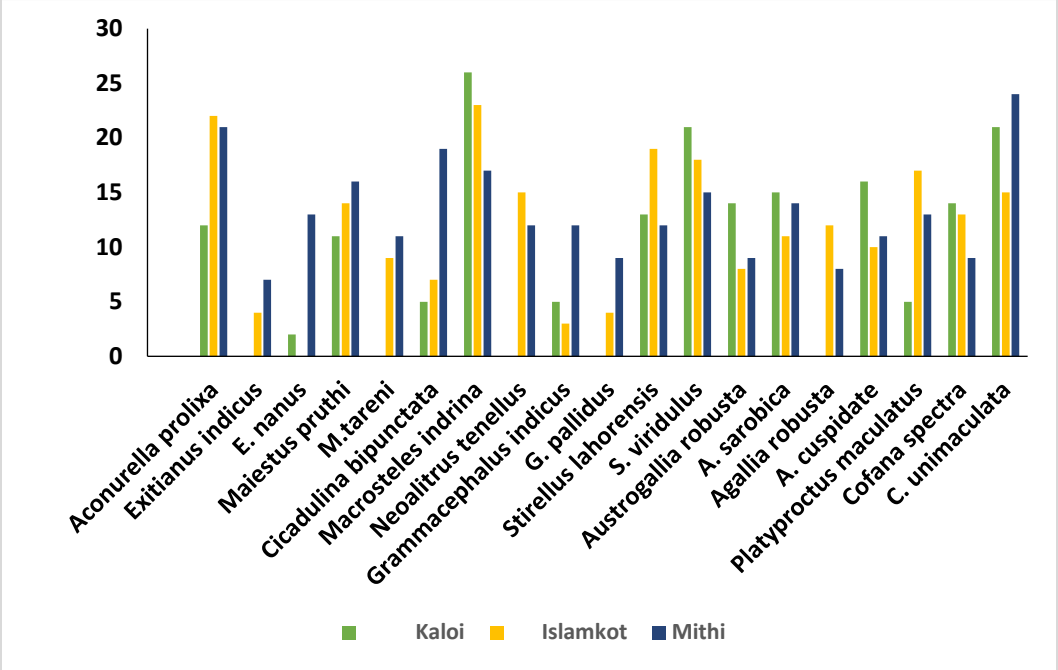

Figure 3. Distribution of collected species from Kaloi, Islamkot and Mithi during the year 2023-2024

The field survey showed the higher population densities of *Aconurella prolixa* and *Cofana unimaculata* in areas such as Umerkot and Diplo (most irrigated part of Tharparkar) due to the presence of host plants in high quantity *e.g.* Poaceae rich crops *i.e.* Millets, Sorghum and Legumes. Both species are known to prefer habitats having cereal crops and grasses belong to Poaceae family (Nielson, 1968 and Young, 1979). As for as Chhachro and Kantio is concerned the host plants are also found in these arid areasbutdue to theoften use of pesticides the quantity leads to lower disturbance and therefore there is lesser chance of survival and protection of all the stages from egg to adult (Table 2a).

Chelhar is located 30 km north of Mithi. It is a relatively small village having limited cultivation with sparse vegetation, so the number of specimens decline in this area. Nangarparkar and Viravah due to the karoonjhar hills trap monsoon clouds leading to higher rainfall. The monsoon rain provides enough water for the annual herbs and grasses to flourish in the study area. The herbs abundantly grow around Karoonjhar hills of the Nagarparkar (Ahmed *et al*., 2013, Vedantu 2025). Due to the presence of water temporarily absorbed in the topsoil layer and additionally supported with the moisture present in the subsurface soil and sandstone laying beneath the soil along with ancient wells and tanks are present around Karoonjhar leads to fertile soil and make more chance to survive leafhopper species. Particularly the number of *Aconurella prolixa, Stirellus viridulus and Cofana unimaculata* increased due to grass feeding and Poaceae family crops habitat. Dahli Tehsil is a high population, having major dependence upon livestock and due to overgrazing and destruction of key host plants the number of specimens found in low quantity (Table 2b). Kaloi is characterized by sandy-to-sandy loam-soils that are not fertile and suffer from high salinity in the subsoil for that reason number of leafhoppers decreased due to

less availability of plants for their survival. Islamkot and Mithiare flat sandy deserts with sparse thorny vegetation and have high agricultural practices; chemicals used to save crops and neemtrees along the roadsides of Mithi to Islamkot decline the number of leafhoppers (Table 2c). Pakistan is located at the crossroads of three zoogeographic regions (Oriental, Palaearctic and Ethiopian) with great altitudinal variation and diversity of ecological zones. *A. prolixa* is cosmopolitan in distribution but primarily found in Europe, China and Pakistan. The southern part of the Palearctic from the Canary Islands and North Africa to China and Japan, India (Khatri and Webb, 2010), Ethiopia (Heller and Linnavuori, 1968), Sudan (Lindberg, 1927) in South Africa the specimens investigated by (Theron, 1970). In addition, *A. prolixa* was found outside Palearctic in India and in the Northern part of the Tropical Africa, so the finding of such a widespread species in the Southern part of this continent seems quite natural.

Cofana unimaculata is primarily found in Asia, particularly in Bangladesh and India. Now, geographically distributed in Pakistan, Thailand, Malaysia and the U.S.A. It indicates their presence in different climatic zones of both the species. A group of leafhoppers that has been relatively well studied are Nearctic leafhoppers, The Nearctic region, spanning from Mexico to the Arctic, stands out as a leafhopper hotspot, with nearly 3000 described species showcasing a high level of endemism and diversity (Bartlett, *et al*., 2017; Nielson and Knight, 2000; Chandler and Hamilton, 2017; Hamilton, 1997 and 1998; Pinedo and Escatel *et al*., 2021). Climate change significantly contributes to alterations in species distributions, prompting shifts in their geographic ranges (Pecl *et al*., 2017 and Kharouba *et al*., 2019).

Table 3 suggests that *Cofana unimaculata* belonging to the subfamily Cicadellinae and *Aconurella prolixa* of the subfamily Deltocephalinae were found in greater numbers, with 577 specimens (10.25%) and 557 specimens (9.90%) respectively. In contrast, fewer specimens were recorded from the genus *Grammacephalus* including *Grammacephalus pallidus* and *G. indicus*, belonging to the subfamily Megophthalminae, with 77 specimens (1.36%) and 109 specimens (1.93%) respectively (Table 3 & Figure 4). It might be habitat of different insects. It was also observed that *Cofana unimaculata* and *Aconurella prolixa* are better adapted to hot and dry conditions and are typically associated with hardy grass and drought-tolerant vegetation commonly found in Tharparkar. Local agricultural zones that support crops like millet, sorghum, and grasses provide favorable conditions for *Cofana* and *Aconurella*, which are often associated with cultivated ecosystems. This suggests that host plant availability plays an important role in distribution and population of leafhoppers(Wilson *et al*., 1994). *Grammacephalus* spp., however, tends to prefer more humid environments with richer vegetation and may be less tolerant to extreme heat and desiccation. Species of the genus *Grammacephalus* are known to associate primarily with specific plants as well as woody shrubs like Ziziphus and Capparis, which are sparsely distributed in the arid zones of Tharparkar. This makes them less successful in arid zones, resulting in their reduced numbers. The lower abundance of *Grammacephalus* species reflects their narrower habitat requirements and lesser tolerance to arid environments.

Table 3. Specimens collected from each species during the year 2023-2024

Species	No of specimens	Percentage
Aconurella prolixa	557	**9.90%**
Exitianus indicus	193	**3.43%**
E. nanus	181	**3.21%**
Maiestus pruthi	331	**5.88%**
M. tareni	165	**2.93%**
Cicadulina bipunctata	364	**6.47%**
Macrosteles indrina	536	**9.52%**
Neoalitrus tenellus	236	**4.19%**
Grammacephalus indicus	109	**1.93%**
G. pallidus	77	**1.36%**
Stirellus lahorensis	275	**4.88%**
S. viridulus	490	**8.71%**
Austrogallia robusta	235	**4.17%**
A. sarobica	225	**4%**
Agallia robusta	137	**2.43%**
A. cuspidate	234	**4.16%**
Platyproctus maculatus	386	**6.86%**
Cofana spectra	317	**5.63%**
C. unimaculata	577	**10.25%**

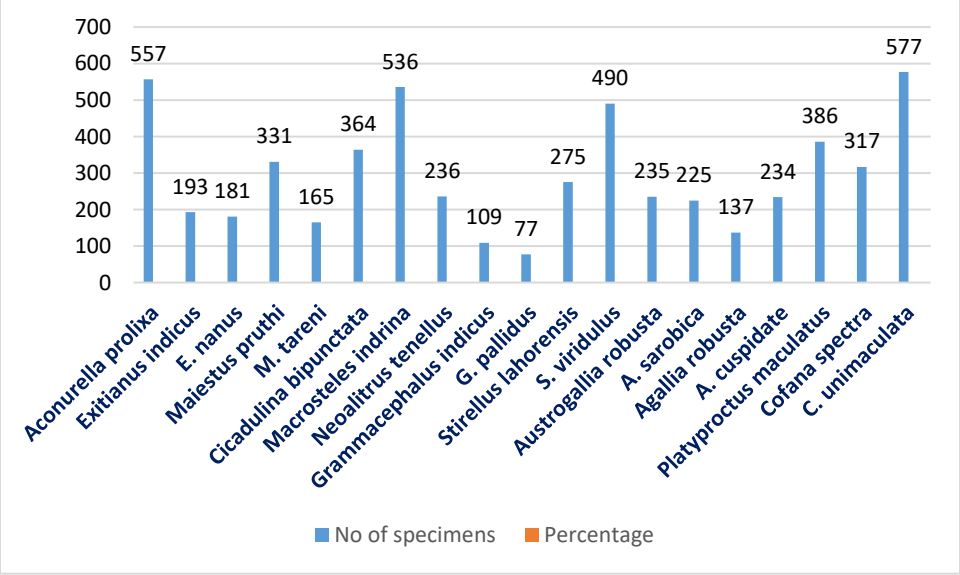

Figure 4.Prevalence of Cicadellidae in Tharparkar (2023-2024)

Conclusion

The present study was conducted from the year 2023 to 2024 to analyze the biodiversity of the order Hemiptera, specifically the family Cicadellidae, in the desert region of Tharparkar, Sindh, Pakistan. Field surveys were carried out across various localities including Umerkot, Chhachro, Koenti Road, Diplo, Chelhar, Nangarparkar, Viravah, Dahli, Kaloi, Islamkot and Mithi. A total of 19 species were collected, representing 9 tribes and 3 subfamilies. Among all collected specimens, *Cofana unimaculata* of Cicadellinae and *Aconurella prolixa* of Deltocephalinae) were found to be the most abundant species across the surveyed localities.

Conflict of interest

Authors declared that there is no conflict of interest.

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