



Available Online at EScience Press

## Plant Protection

ISSN: 2617-1287 (Online), 2617-1279 (Print)  
<http://esciencepress.net/journals/PP>

### Research Article

## Distribution and Systematics of Leafhoppers (Hemiptera: Cicadellidae) in Tharparkar and Adjacent Areas of Sindh, Pakistan

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### ARTICLE INFO

#### Article history

Received: 2<sup>nd</sup> September, 2025Revised: 20<sup>th</sup> December, 2025Accepted: 25<sup>th</sup> December, 2025

#### Keywords

*Cicadellidae* diversity

Phytophagous insects

Arid agro-ecosystems

Tharparkar

Distributional assessment

Semi-arid ecosystem

Species richness

### ABSTRACT

Leafhoppers (Hemiptera: Cicadellidae) constitute one of the most diverse and economically significant groups of phytophagous insects; however, their diversity and distribution in the arid regions of Pakistan remain poorly documented. The present study provides a comprehensive taxonomic and distributional assessment of Cicadellidae from Tharparkar and adjacent areas of Sindh, Pakistan, based on extensive field surveys conducted during 2023-2024. Specimens were collected using sweep nets, yellow sticky traps, and light traps from four major localities, Umerkot, Nangarparkar, Viravah, and Kaloi, and were identified using detailed morphological characteristics, with particular emphasis on male genitalia. A total of 19 species belonging to 15 genera, 9 tribes, and 3 subfamilies (Deltocephalinae, Megophthalminae, and Cicadellinae) were recorded. Deltocephalinae was the dominant subfamily in terms of both species richness and abundance. Among the recorded species, *Cofana unimaculata* (Cicadellinae) and *Aconurella proluxa* (Deltocephalinae) were the most abundant, indicating strong adaptation to hot, arid conditions and grass-dominated agro-ecosystems. Nangarparkar exhibited the highest overall species abundance, likely due to comparatively better vegetation cover and moisture availability, whereas Kaloi showed the lowest diversity, reflecting poor soil fertility and limited host plant availability. This study represents the first comprehensive checklist of Cicadellidae from Tharparkar and provides baseline data essential for future biodiversity assessments, ecological studies, and the development of pest management strategies in the arid and semi-arid ecosystems of Pakistan.

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### Introduction

Tharparkar district derives its name from two words: Thar and Parkar. The term Thar originates from Thul, a general term for the sand ridges characteristic of the region, while Parkar literally means “to cross over” or “the other side.” The eastern edge of the desert meets the irrigated western areas, hence the notion of “crossing

over” to the Parkar region. Tharparkar forms part of the Great Thar Desert, which spans approximately 446,000 km<sup>2</sup> and acts as a natural boundary between India and Pakistan. Around 85% of the desert lies within India, with the remaining portion in Pakistan. In Pakistan, Tharparkar district is bordered by Mirpurkhas and Umerkot districts to the north, India’s Barmer and

Jaisalmer districts to the east, Badin district to the west, and the Rann of Kutch to the south.

Leafhoppers (family Cicadellidae) are important insect pests reported mainly from Sindh, Punjab, and Khyber Pakhtunkhwa (KPK) in Pakistan. However, insect biodiversity studies in arid to semi-arid regions such as Tharparkar remain scarce, especially for economically significant groups like leafhoppers. The family Cicadellidae comprises more than 22,000 described species worldwide, with approximately 5,000 species in the Neotropical region (Freytag and Sharkey, 2002). It is the largest family within the order Hemiptera and includes 26-40 subfamilies, depending on the classification system (Oman *et al.*, 1990; Dietrich, 2005). Species identification relies on morphological traits such as wing venation, the arrangement of setae on the legs, and the structure of male and female genitalia (Dietrich, 2004).

Leafhoppers are widely distributed across tropical and subtropical regions (Dietrich, 2005). Some species cause direct damage to crops through feeding (Backus *et al.*, 2005; Weintraub and Beanland, 2006), while many others act as vectors of plant pathogens, including viruses and phytoplasmas (Stiller and Michael, 2009). (Edward 1878) first emphasized the taxonomic significance of concealed male genital structures for species differentiation, a method now fundamental in leafhopper taxonomy.

These insects feed on a wide variety of host plants, including vegetables, shrubs, grasses, and trees, and may migrate seasonally to different hosts depending on availability. Young plants are particularly preferred due to their abundant sap supply. Leafhoppers often occupy sheltered parts of plants, such as the abaxial leaf surfaces, whorls, and stems, which provide protection from predators and facilitate access to vascular tissues. Their mouthparts are adapted into a piercing-sucking stylet, allowing them to extract plant fluids efficiently.

Tharparkar district, forming part of the Great Thar Desert, represents an arid to semi-arid ecosystem that remains largely understudied in terms of insect biodiversity. Leafhoppers (family Cicadellidae) are among the most economically significant insect pests due to their ability to cause direct feeding damage and transmit plant pathogens, including viruses and phytoplasmas.

Although leafhopper diversity has been documented in other regions of Pakistan such as Sindh, Punjab, and

Khyber Pakhtunkhwa, there is a significant knowledge gap regarding their occurrence, distribution, and host associations in Tharparkar Sindh. Understanding leafhopper biodiversity in this region is essential for developing effective pest management strategies, preserving ecological balance, and safeguarding agricultural productivity in the desert and adjacent irrigated areas. Moreover, the taxonomic complexity of Cicadellidae, which relies heavily on morphological traits such as genitalia and wing venation, necessitates detailed local studies to document species diversity accurately. The objective of the current study, therefore, was to document the diversity and abundance of leafhopper species in Tharparkar, identify their morphological characteristics for accurate taxonomic classification, investigate their host plant preferences and seasonal distribution, and provide baseline data to support integrated pest management of economically important crops in the region.

## Materials and Methods

### Sampling design and collection methods

Field surveys were conducted using a combination of active and passive sampling techniques to collect leafhoppers. Active sampling was carried out with a standard sweep net (38 cm diameter). At each sampling site, 300 sweeps were performed along linear transects during each visit. Sweeping was conducted during the morning (08:00-11:00 h) and late afternoon (16:00-18:00 h) to coincide with periods of peak leafhopper activity.

Passive sampling employed yellow sticky traps and light traps. Yellow sticky traps were placed at crop canopy height or within adjacent vegetation and were exposed for 48 trap-h per site. Light traps were operated from dusk to dawn for 10-12 h- per night at selected locations to complement sweep net collections and capture nocturnal or less active species.

### Sorting and preservation

Collected specimens were transported to the Entomology and Bio-Control Research Laboratory (EBCRL), Department of Zoology, University of Sindh, Jamshoro, for further processing. Leafhoppers were initially killed using a standard insect killing jar charged with cyanide. Given their small size and morphological similarity to planthoppers and froghoppers, specimens were carefully sorted under a stereomicroscope.

After sorting, specimens were either mounted on

triangular card points or pinned directly, depending on their size. Larger specimens were photographed and pinned directly through the mesothorax, slightly to the right of the midline, following standard entomological procedures. Smaller specimens were temporarily preserved in vials until fully dried and then mounted with appropriate labels. Point-mounted specimens were glued to the right side of the thorax to ensure correct orientation and clear visibility of diagnostic features. All specimens were subsequently stored in insect storage boxes under controlled conditions.

#### **Identification of leafhopper of Cicadellidae**

##### **Diagnostic features of Cicadellidae**

Cicadellidae, commonly known as leafhoppers, is the largest family within the suborder Auchenorrhyncha. These small, plant-feeding insects possess piercing-sucking mouthparts adapted for extracting sap from grasses, shrubs, and trees. Key diagnostic characters include three-segmented tarsi, typically uniform-textured forewings, short bristle-like antennae, and a beak originating from the posterior part of the head. The pronotum does not cover the abdomen, and two ocelli may be present or absent. The hind legs are modified for jumping and bear specialized hairs that distribute brochosomes across the body, providing water repellence and aiding in pheromone transport. Leafhoppers exhibit incomplete metamorphosis and display a range of host associations, from generalist to highly specific. The family has a cosmopolitan distribution, occurring primarily in temperate and tropical regions wherever suitable host plants exist. Several species are economically significant, either as direct crop pests or as vectors of plant viruses and phytoplasmas, some of which replicate within the salivary glands. Additionally, leafhoppers serve as hosts for various pathogens, including viruses, bacteria, and fungi, and are frequently parasitized by a range of natural enemies.

##### **Diagnostic features of Deltocephalinae**

Deltocephalinae is the largest subfamily of Cicadellidae, comprising approximately 40 tribes, nearly 925 genera, and over 6,500 species worldwide. Members are common in grassland and forest ecosystems and include important crop pests that cause damage both through sap feeding and the transmission of plant pathogens.

##### **Tribe: Chiasmini Distant, 1908**

Chiasmini is a grassland-associated tribe within Deltocephalinae, encompassing 21 genera and more than

300 species globally. These leafhoppers are small to medium-sized and predominantly feed on grasses. Diagnostic features include a tapering or parallel-sided clypellus, a basally hinged aedeagus, an elongate ovipositor, and distinctive valvula sculpturing (Dietrich and Rakitov, 2002; Zahniser, 2008).

##### **Tribe: Deltocephalini Fieber, 1869**

Deltocephalini is a tribe within the subfamily Deltocephalinae, comprising small to medium-sized leafhoppers. Members are characterized by a tapering or parallel-sided clypellus, a narrow lorum, a linear connective fused to the aedeagus, and imbricate dorsal sculpturing on the first valvula. Globally, the tribe includes 74 genera and over 600 species, with 12 species currently reported from Pakistan (Duan *et al.*, 2020; Naveed *et al.*, 2021; Shah *et al.*, 2021; Zhang *et al.*, 2023).

##### **Tribe: Macrostelini Kirkaldy, 1906**

Macrostelini is a cosmopolitan tribe of Deltocephalinae comprising 37 genera and over 300 species. Members are elongate leafhoppers with an anteriorly rounded head, tapering anteclypeus, pale stramineous forewings extending beyond the abdomen, and diagnostic male genitalia including an elongate subgenital plate and an aedeagus with paired apical appendages.

##### **Tribe: Opsiini Emeljanov, 1962**

Opsiini is a diverse tribe of Deltocephalinae whose members are small leafhoppers, often characterized by paired aedeagal shafts. Many species are economically important as vectors of viruses, bacteria, phytoplasmas, and spiroplasmas affecting crops.

##### **Tribe: Scaphoideini Oman, 1943**

Scaphoideini comprises about 64 genera and over 600 species, although Oman *et al.*, (1990) recognized only 12 genera. The tribe is identified by a combination of characters, including a head narrower than the pronotum, elongate frontoclypeus, long antennae, slender body, patterned head and wings, and distinctive genital features such as setose pygofer and often membranous subgenital plates. Nymphs and adults are commonly found on grasses and herbaceous plants, while many species require woody hosts for oviposition.

##### **Tribe: Stenometopiini Baker, 1923**

Stenometopiini is a grass-associated tribe of Deltocephalinae characterized by a narrow, shagreen-textured crown, a parallel-sided or apically tapering clypellus, often reduced forewings, and distinctive male and female genitalia, including a sloping pygofer and a strongly protruding ovipositor. The tribe comprises 8 genera and 96

species and is most closely related to Chiasmini and other grass-specialist groups (Zahniser, 2008).

#### **Diagnostic features of Megophthalminae**

Megophthalminae is a subfamily of leafhoppers comprising several tribes, of which Agallini is the largest, including about 37 genera and 650 species with a cosmopolitan distribution. Members are phytophagous and commonly occur in grasslands and mixed meadows. They are characterized by a wedge-shaped, robust body; a short, broad head with the crown wider than long; ocelli located on the face; poorly developed or absent forewing appendix; hind wings with four apical cells; and hind femora bearing a 2+1 apical setal pattern. Body size ranges from 2-9 mm.

#### **Tribe: Agalliini Kirkaldy, 1901**

Agalliini is a tribe of Megophthalminae that breeds on shrubs and herbs and is represented in the Indian subcontinent by 6 genera and 28 species (Viraktamath, 2004). Some species are important vectors of plant pathogens (Nielson, 1979). The tribe is distinguished by hind tibial macrosetae of row R3 originating at or beyond midlength, a usually forked male style apex, and the absence of carinae between the antennal pits and ocelli. Prior to the creation of Pakistan, Pruthi (1930, 1936) described two Agalliini species from the Murree region.

#### **Tribe: Adelungiini Baker, 1915**

Adelungiini is a tribe of Megophthalminae similar in appearance to Agalliini and commonly associated with desert shrubs. The tribe is distributed across Africa, southern Europe, the Middle East, and Asia, and comprises about 13 genera and 60 species worldwide (Viraktamath, 1980; Dietrich, 2005). Members are small, cylindrical leafhoppers characterized by facial ocelli distant from the eyes, absence of lateral frontal sutures, distinctly excavated anterior pronotum, incomplete clypeal suture, reticulate forewing venation, and a hind femoral macrosetal formula of 2+1 or 2+0.

#### **Diagnostic features of Cicadellinae Latreille, 1825**

Members of the subfamily Cicadellinae, commonly known as sharpshooters, belong mainly to the tribes Proconiini and Cicadellini. The subfamily includes about 2,400 species in approximately 330 genera and comprises some of the largest and most brightly coloured leafhoppers. Sharpshooters are xylem feeders and several species are important vectors of the bacterium *Xylella fastidiosa*. The group was comprehensively revised by Young (1968, 1977) and

later catalogued by McKamey (2007), making Cicadellinae one of the best-studied leafhopper subfamilies. Sharpshooters are strong jumpers and flyers with powerful hind legs, large eyes, and well-developed vision, and are particularly attracted to yellow hues (Tipping *et al.*, 2004).

#### **Tribe: Cicadellini Latreille, 1825**

These leafhoppers, commonly known as sharp shooters, are generally small to medium-sized, slender, and often brightly coloured or patterned. The head is frequently wider than the pronotum, and the group shows greater diversity in temperate regions.

#### **Results**

During the present survey conducted in 2023-2024, leafhopper specimens collected from diverse habitats of Tharparkar were classified into three subfamilies and nine tribes. The subfamily Deltocephalinae was represented by six tribes, Chiasmini, Deltocephalini, Macrostelini, Opsiini, Scaphoideini, and Stenometopiini, comprising eight genera. Megophthalminae included two tribes, Agalliini and Adelungiini, with three genera, while Cicadellinae was represented by the tribe Cicadellini with a single genus.

In total, 19 species were recorded from the study area. Among these, *Cofana unimaculata* and *Aconurella prolixa* were the most abundant species, occurring across multiple localities. These species are described below.

#### **Systematics**

Family: Cicadellidae

Subfamily: Deltocephalinae

Tribe: Chiasmini

Genus: *Aconurella* Ribaut, 1948

Species: *Aconurella prolixa* (Lethierry, 1885)

#### **Tribe: Chiasmini Distant, 1908**

#### ***Aconurella prolixa* (Lethierry, 1885)**

#### **Description**

The body is generally greenish-brown with variable markings. The face may be entirely black or ochraceous, with two prominent or indistinct markings on the vertex; occasionally, these markings are reduced or absent. Forewings are macropterous. The male pygofer bears small spines and is darkly sclerotized (Figure 1).

#### **Material examined**

2♂, 7♀; Sultana R, Naz A; 25-05-2023; Umerkot, 4♂, 5♀; Sultana R, Naz A; 25-05-2023; Kaloi, 18♂, 25♀; Naz A; 05-09-2023; Viravah, 12♂, 34♀; Naz A; 05-09-2023; Nangarparkar, 2♂, 3♀; Sultana R, Naz A; 27-03-2024;

Umerkot, 0♂, 3♀; Sultana R, Naz A; 10-05-2024; Umerkot, 11♂, 29♀; Sultana R, Naz A; 10-05-2024; Kaloi, 11♂, 20♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 16♂, 19♀; Naz A; 17-07-2024; Viravah, 11♂, 15♀; Naz A; 15-09-2024; Umerkot, 11♂, 15♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 3.3, FW 2.5, CLM 0.34, CWE 0.95, IOW at anterior 0.62, ELC 0.38, PW 0.85, PL 0.34, ML 0.14, SL 0.19.

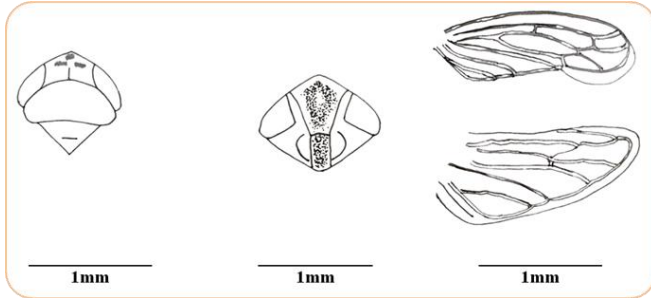


Figure 1. *A. prolixa* (Lethierry 1885): a, head and thorax, dorsal view; b, face; c, hindwing; d, forewing.

#### *Exitianus indicus* (Distant, 1908)

##### Description

This species is brownish in color, with several crosswise brownish stripes across the vertex and a pale median line. The scutellum bears a pair of faint triangular markings. The wings display brown patterns. The pygofer is broad and rounded posteriorly, usually featuring a ventroapical lobe with 2–3 dark brown or black macrosetae.

##### Material examined

1♂, 4♀; Sultana R, Naz A; 25-05-2023; Umerkot, 0♂, 0♀; Sultana R, Naz A; 25-05-2023; Kaloi, 9♂, 18♀; Naz A; 05-09-2023; Viravah, 14♂, 17♀; Naz A; 05-09-2023; Nangarparkar, 2♂, 0♀; Naz A; 27-03-2024; Umerkot, 2♂, 3♀; Sultana R, Naz A; 10-05-2024; Umerkot, 0♂, 0♀; Sultana R, Naz A; 10-05-2024; Kaloi, 7♂, 9♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 5♂, 13♀; Sultana R, Naz A; 17-07-2024; Viravah, 5♂, 8♀; Naz A; 15-09-2024; Umerkot, 1♂, 6♀; Naz A; 16-10-2024; Umerkot.

##### Measurements (mm)

♂ TL 4.4mm, FW 3.5, CLM 0.33, CWE 1.4, IOW at anterior 0.81, ELC 0.52, PW 1.33, PL 0.5, ML 0.27, SL 0.37.

#### *E. nanus* (Distant, 1908; previously *Athysanus*)

##### Description

This is the most widespread species of the genus in the Old World. The body ranges from yellowish-brown to light brown and shows considerable variation compared

with *E. indicus*. The face is pale yellowish with faint light brown spots. The pronotum is broader than the head, and the scutellum is paler than the pronotum. A pair of triangular marks on the mesonotum distinguish this species from closely related taxa. Wings exhibit brown veins. The pygofer has a few long macrosetae along the posterior margin.

##### Material examined

4♂, 3♀; Sultana R, Naz A; 25-05-2023; Umerkot, 0♂, 1♀; Sultana R, Naz A; 25-05-2023; Kaloi, 4♂, 7♀; Naz A; 05-09-2023; Viravah, 5♂, 7♀; Naz A; 05-09-2023; Nangarparkar, 0♂, 1♀; Naz A; 27-03-2024; Umerkot, 2♂, 3♀; Sultana R, Naz A; 10-05-2024; Umerkot, 0♂, 1♀; Sultana R, Naz A; 10-05-2024; Kaloi, 10♂, 12♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 4♂, 13♀; Sultana R, Naz A; 17-07-2024; Viravah, 6♂, 9♀; Naz A; 15-09-2024; Umerkot, 0♂, 1♀; Naz A; 16-10-2024; Umerkot.

##### Measurements (mm)

♂ TL 4.0, FW 3.40, CLM 0.25, CWE 1.17, IOW at anterior 0.72, ELC 0.48, PW 1.11, PL 0.47, ML 0.16, SL 0.25.

#### Tribe: Deltocephalini Fieber, 1869

#### *Maiestas pruthii* (Metcalf, 1967)

##### Description

Small, elongate leafhoppers, slightly flattened dorsoventrally, ranging in color from yellowish to light brown. The head shows variable patterning, with large, deep purple eyes and ocelli reduced to small, colorless marginal spots. The scutellum is pale with darker margins, and dark brown pigmentation is densely concentrated along the forewing veins. The male pygophore is broader than long and bears 12–18 macrosetae.

##### Material Examined

7♂, 5♀; Sultana R, Naz A; 25-05-2023; Umerkot, 4♂, 2♀; Sultana R, Naz A; 25-05-2023; Kaloi, 14♂, 9♀; Naz A; 05-09-2023; Viravah, 15♂, 19♀; Naz A; 05-09-2023; Nangarparkar, 2♂, 1♀; Naz A; 27-03-2024; Umerkot, 8♂, 7♀; Sultana R, Naz A; 10-05-2024; Umerkot, 3♂, 2♀; Sultana R, Naz A; 10-05-2024; Kaloi, 19♂, 23♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 12♂, 6♀; Sultana R, Naz A; 17-07-2024; Viravah, 20♂, 9♀; Naz A; 15-09-2024; Umerkot, 3♂, 3♀; Naz A; 16-10-2024; Umerkot.

##### Measurements (mm)

♂ TL 3.0, FW 2.39, CLM 0.25, CWE 0.72, IOW at anterior 0.47, ELC 0.3, PW 0.7.1, PL 0.36, ML 0.13, SL 0.21.

#### *M. tareni* (Dash and Viraktamath, 1968)

##### Description

These species are characterized by a variable color pattern with black patches on the head and thorax, head

wider than pronotum. Forewings bearing oblong spots. The pygophore is broader than long, with a triangular projection on the posterodorsal margin, with both macro and micro setae.

#### Material examined

4♂, 5♀; Sultana R, Naz A; 25-05-2023; Umerkot, 0♂, 0♀; Sultana R, Naz A; 25-05-2023; Kaloi, 3♂, 8♀; Naz A; 5-09-2023; Viravah, 5♂, 13♀; Naz A; 05-09-2023; Nangarparkar, 0♂, 1♀; Naz A; 27-03-2024; Umerkot, 3♂, 7♀; Sultana R, Naz A; 10-05-2024; Umerkot, 0♂, 0♀; Sultana R, Naz A; 10-05-2024; Kaloi, 2♂, 9♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 4♂, 5♀; Sultana R, Naz A; 17-07-2024; Viravah, 6♂, 8♀; Naz A; 15-09-2024; Umerkot, 0♂, 3♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 3.0, FW 2.46, CLM 0.33, CWE 1.0, IOW at anterior 0.60, ELC 0.43, PW 0.55, PL 0.41, ML 0.10, SL 0.25.

#### Tribe: Macrostelini Kirkaldy, 1906

#### *Cicadulina bipunctata* (Melichar, 1904)

#### Description

Small wedge-shaped, straw-colored leafhoppers, commonly known as two spotted maize leaf hoppers having two prominent black spots on pronotum and pronotum as wide as head; crown lengthened; face wider than long; ocelli near to eye and marginal; scutellum triangular. Forewing veins darkened, three apical cells present. Pygofer with deep broad dorsal notch, few elongate apical setae with 7-8 dorsal macrosetae are present.

#### Material examined

8♂, 9♀; Sultana R, Naz A; 25-05-2023; Umerkot, 0♂, 1♀; Sultana R, Naz A; 25-05-2023; Kaloi, 18♂, 15♀; Naz A; 5-09-2023; Viravah, 17♂, 28♀; Naz A; 05-09-2023; Nangarparkar, 0♂, 1♀; Naz A; 27-03-2024; Umerkot, 7♂, 9♀; Sultana R, Naz A; 10-05-2024; Umerkot, 2♂, 2♀; Sultana R, Naz A; 10-05-2024; Kaloi, 15♂, 21♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 9♂, 10♀; Sultana R, Naz A; 17-07-2024; Viravah, 9♂, 5♀; Naz A; 15-09-2024; Umerkot, 3♂, 2♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 2.7, FW 1.59, CLM 0.20, CWE 0.65, IOW at anterior 0.45, IOW 0.29, PW 0.61, PL 0.32, ML 0.07, SL 0.15.

#### *Macrosteles indrina* (Pruthi, 1930)

**Description:** Small to medium, often golden-yellow in color. Slender body featuring tiny anteriorly curved crown with bilateral black spots; face length equal to its width. Vertex with distinct markings or spots, sometimes dark brown. Pronotum longer than crown,

mesonotum marked, dark purple eyes with pink ocelli. Pygofer-semi oval with 6 macrosetae and with a membranous cleft at the basolateral margin.

#### Material examined

3♂, 7♀; Sultana R, Naz A; 25-05-2023; Umerkot, 9♂, 4♀; Sultana R, Naz A; 25-05-2023; Kaloi, 19♂, 21♀; Naz A; 5-09-2023; Viravah, 21♂, 32♀; Naz A; 05-09-2023; Nangarparkar, 2♂, 1♀; Naz A; 27-03-2024; Umerkot, 5♂, 9♀; Sultana R, Naz A; 10-05-2024; Umerkot, 6♂, 7♀; Sultana R, Naz A; 10-05-2024; Kaloi, 16♂, 13♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 24♂, 13♀; Sultana R, Naz A; 17-07-2024; Viravah, 12♂, 17♀; Naz A; 15-09-2024; Umerkot, 4♂, 7♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 2.7, FW 2.3, CLM 0.14, CWE 0.66, IOW at anterior 0.45, ELC 0.22, PW 0.63, PL 0.3, ML 0.10, SL 0.17.

#### Tribe: Opsiini Emeljanov, 1962

#### *Neoliturus* (Circulifer) *tenellus* (Baker, 1896)

#### Description

*Neoliturus tenellus*, also known as the beet leafhopper. Pale green with dark round markings on the dorsal side of wings and body. Small leafhoppers with broad head than pronotum along with short crown, elongate frontoclypeus, with distinct eyes and a curved anterior margin. Pygofer has a cleft and differentiated rows of macrosetae.

#### Material examined

2♂, 4♀; Sultana R, Naz A; 25-05-2023; Umerkot, 0♂, 0♀; Sultana R, Naz A; 25-05-2023; Kaloi, 9♂, 12♀; Naz A; 5-09-2023; Viravah, 16♂, 9♀; Azra; 05-09-2023; Nangarparkar, 1♂, 2♀; Naz A; 27-03-2024; Umerkot, 2♂, 5♀; Sultana R, Naz A; 10-05-2024; Umerkot, 0♂, 0♀; Sultana R, Naz A; 10-05-2024; Kaloi, 13♂, 14♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 20♂, 22♀; Sultana R, Naz A; 17-07-2024; Viravah, 5♂, 11♀; Naz A; 15-09-2024; Umerkot, 1♂, 3♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 3.45, FW 2.8, CLM 0.25, CWE 0.10, IOW at anterior 0.54, ELC 0.48, PW 0.95, PL 0.44, ML 0.09, SL 0.24.

#### Tribe: Scaphoideini Oman, 1943

#### *Grammacephalus indicus* (Viraktamath and Murthy, 1999)

#### Description

A pointed head with dorsally visible, expanded genae, these species are brownish in color having patterns (strips and circles) on crown; mesonotum bearing two pairs of markings (inner is smaller than outer); vertex sharply triangular; face get longer; pronotum wider than head. Forewings bearing 4 apical cells with small appendix and

reaching the middle of the second apical cell. Pygofer bearing caudal appendage inwardly bent near the apex.

#### Material examined

1♂, 1♀; Sultana R, Naz A; 25-05-2023; Umerkot, 0♂, 1♀; Sultana R, Naz A; 25-05-2023; Kaloi, 3♂, 5♀; Naz A; 5-09-2023; Viravah, 5♂, 9♀; Naz A; 05-09-2023; Nangarparkar, 0♂, 0♀; Naz A; 27-03-2024; Umerkot, 1♂, 0♀; Sultana R, Naz A; 10-05-2024; Umerkot, 1♂, 3♀; Sultana R, Naz A; 10-05-2024; Kaloi, 8♂, 18♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 6♂, 11♀; Sultana R, Naz A; 17-07-2024; Viravah, 3♂, 1♀; Naz A; 15-09-2024; Umerkot, 1♂, 0♀; Naz A; 16-10-2024; Umerkot.

#### Measurement (mm)

♂ TL 5.46, FW 3.78, CLM 0.90, CWE 1.15, IOW at anterior 0.75, ELC 0.70, PW 1.36, PL 0.60, ML 0.25, SL 0.48.

#### *G. pallidus* (Linnavuori, 1978)

##### Description

Head Pointed with dorsally visible, expanded genae. These are average in size with yellowish-brown; reddish-brown eyes, pink-ringed ocelli; pronotum brown having pale irregular spots; and a triangular marking present on the scutellum; vertex brown with stripes along the midline, lateral margin stripes, and ochraceous coloring; scutellum triangle brown with pale markings. Forewings about four times as long as wide, densely speckled with brown, whitish-yellow costal margin with dark brown edges; membranous caudal region of pygofer bearing 6–8 macrosetae.

#### Material examined

0♂, 0♀; Sultana R, Naz A; 25-05-2023; Umerkot, 0♂, 0♀; Sultana R, Naz A; 25-05-2023; Kaloi, 5♂, 5♀; Azra; 5-09-2023; Viravah, 4♂, 9♀; Naz A; 05-09-2023; Nangarparkar, 0♂, 0♀; Naz A; 27-03-2024; Umerkot, 0♂, 0♀; Sultana R, Naz A; 10-05-2024; Umerkot, 0♂, 0♀; Sultana R, Naz A; 10-05-2024; Kaloi, 7♂, 12♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 7♂, 11♀; Sultana R, Naz A; 17-07-2024; Viravah, 0♂, 0♀; Naz A; 15-09-2024; Umerkot, 0♂, 0♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 4.35, FW 3.10, CLM 0.70, CWE 0.90, IOW at anterior 0.58, ELC 0.50, PW 1.03, PL 0.49, ML 0.22, SL 0.45.

#### Tribe: Stenometopiini Baker, 1923

#### *Stirellus lahorensis* (Distant, 1918)

##### Description

These leafhoppers are moderate in size and yellowish brown in colour; notably angulate and prominent crown is present; ocellus present slightly below the margin; Scutellum with a weak median transverse

ridge. Forewing four-apical-celled; appendix short, extending to second apical cell. Pygofer elongate, apically slightly upturned with sparse caudal macrosetae and fine basal setae.

#### Material examined

3♂, 1♀; Sultana R, Naz A; 25-05-2023; Umerkot, 2♂, 6♀; Sultana R, Naz A; 25-05-2023; Kaloi, 3♂, 11♀; Naz A; 5-09-2023; Viravah, 9♂, 13♀; Naz A; 05-09-2023; Nangarparkar, 1♂, 1♀; Naz A; 27-03-2024; Umerkot, 1♂, 0♀; Sultana R, Naz A; 10-05-2024; Umerkot, 3♂, 12♀; Sultana R, Naz A; 10-05-2024; Kaloi, 12♂, 22♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 4♂, 21♀; Sultana R, Naz A; 17-07-2024; Viravah, 7♂, 3♀; Naz A; 15-09-2024; Umerkot, 4♂, 0♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 4.0, FW 3.05, CLM 0.63, CWE 1.0, IOW at anterior 0.59, ELC 0.46, PW 0.95, PL 0.36, ML 0.19, SL 0.25.

#### *S. viridulus* (Pruthi, 1930)

##### Description

Its head is less angulate and less strongly produced compared to *S. lahorensis*, pronotum about twice as broad as long, large compound eyes; ocelli situated on the lateral crown edges, scutellum length equals its width, medium sized leafhoppers with greenish colour. Forewing having four apical cells; reduced appendix reaching second apical cell. Pygofer extended, with sparse stout and hairlike setae.

#### Material examined

5♂, 7♀; Sultana R, Naz A; 25-05-2023; Umerkot, 4♂, 5♀; Sultana R, Naz A; 25-05-2023; Kaloi, 6♂, 14♀; Naz A; 5-09-2023; Viravah, 6♂, 9♀; Naz A; 05-09-2023; Nangarparkar, 1♂, 4♀; Naz A; 27-03-2024; Umerkot, 3♂, 11♀; Sultana R, Naz A; 10-05-2024; Umerkot, 3♂, 9♀; Sultana R, Naz A; 10-05-2024; Kaloi, 11♂, 23♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 11♂, 23♀; Sultana R, Naz A; 17-07-2024; Viravah, 15♂, 21♀; Naz A; 15-09-2024; Umerkot, 7♂, 4♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 3.5, FW 2.64, CLM 0.46, CWE 0.92, IOW at anterior 0.50, ELC 0.51, PW 0.90, PL 0.35, ML 0.13, SL 0.19.

#### Megophthalminae

#### Tribe: Agalliini Kirkaldy, 1901

#### *Austroagallia robusta* (Sawai Singh and Gill, 1973)

##### Description

This species has a pale-yellow head with ivory white robust body, with single tiny spots on crown/pronotum; scutellum typically has a basal dark brown triangular marking. Wing venation reticulates due to cross veins

divided into subapical cells; pygofer with caudoventral notch and microsetae.

#### Material examined

2♂, 4♀; Sultana R, Naz A; 25-05-2023; Umerkot, 1♂, 3♀; Sultana R, Naz A; 25-05-2023; Kaloi, 8♂, 9♀; Naz A; 5-09-2023; Viravah, 11♂, 8♀; Naz A; 05-09-2023; Nangarparkar, 1♂, 3♀; Naz A; 27-03-2024; Umerkot, 4♂, 7♀; Sultana R, Naz A; 10-05-2024; Umerkot, 4♂, 6♀; Sultana R, Naz A; 10-05-2024; Kaloi, 9♂, 19♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 11♂, 8♀; Sultana R, Naz A; 17-07-2024; Viravah, 7♂, 5♀; Naz A; 15-09-2024; Umerkot, 2♂, 3♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 4.0, FW 3.46, CLM 0.10, CWE 1.25, IOW at anterior 0.90, ELC 0.36, PW 1.10, PL 0.46, ML 0.28, SL 0.27.

#### *A. sarobica* (Dlabola, 1964)

##### Description

Pale yellow head with yellowish white body, distinctive tiny circular dark markings on vertex and pronotal posterior with dark patching and some small speckle-like spots; face and vertex shagreened; pronotum with minute punctures. Caudoventral region of pygofer shows bulbous lobe.

#### Material examined

3♂, 2♀; Sultana R, Naz A; 25-05-2023; Umerkot, 4♂, 3♀; Sultana R, Naz A; 25-05-2023; Kaloi, 10♂, 2♀; Naz A; 5-09-2023; Viravah, 13♂, 17♀; Naz A; 05-09-2023; Nangarparkar, 01♂, 1♀; Naz A; 27-03-2024; Umerkot, 7♂, 5♀; Sultana R, Naz A; 10-05-2024; Umerkot, 3♂, 5♀; Sultana R, Naz A; 10-05-2024; Kaloi, 11♂, 12♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 11♂, 4♀; Sultana R, Naz A; 17-07-2024; Viravah, 11♂, 8♀; Naz A; 15-09-2024; Umerkot, 3♂, 1♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 2.98, FW 2.45, CLM 0.10, CWE 0.94, IOW at anterior 0.72, ELC 0.26, PW 0.88, PL 0.45, ML 0.15, SL 0.23.

#### *Agallia robusta* (Pruthi 1930)

##### Description

They are generally small to medium in size, robust body form, color pale ochre with vertex bearing a pair of small dark brown spots whereas posterior part of pronotum bearing bigger pair of spots; short broad head with facial ocelli, lacking carinae between antennal pits and ocelli. Hind wing venation showing four closed apical cells; forewings appendix vestigial or absent.

#### Material examined

0♂, 2♀; Sultana R, Naz A; 25-05-2023; Umerkot, 0♂, 0♀; Sultana R, Naz A; 25-05-2023; Kaloi, 9♂, 11♀; Naz A; 5-

09-2023; Viravah, 5♂, 7♀; Naz A; 05-09-2023; Nangarparkar, 1♂, 1♀; Naz A; 27-03-2024; Umerkot, 1♂, 3♀; Sultana R, Naz A; 10-05-2024; Umerkot, 0♂, 0♀; Sultana R, Naz A; 10-05-2024; Kaloi, 7♂, 11♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 15♂, 11♀; Sultana R, Naz A; 17-07-2024; Viravah, 6♂, 9♀; Naz A; 15-09-2024; Umerkot, 4♂, 3♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 3.65, FW 2.98, CLM 0.18, CWE 1.28, IOW at anterior 0.90, ELC 0.36, PW 1.10, PL 0.60, ML 0.14, SL 0.30.

#### *A. cuspidata* (Dlabola 1957)

##### Description

The coloration and markings may include ochraceous (yellowish-brown) face with fuscous (dark brown) spots, and potentially black spots on the pronotum. The pronotum often exhibits a shagreened (granular or pebbly) texture rather than smooth or striated. Male Pygofer with distinctive lobes, often dorsally directed and bearing setae.

#### Material examined

3♂, 2♀; Sultana R, Naz A; 25-05-2023; Umerkot, 1♂, 4♀; Sultana R, Naz A; 25-05-2023; Kaloi, 11♂, 14♀; Naz A; 5-09-2023; Viravah, 16♂, 8♀; Naz A; 05-09-2023; Nangarparkar, 1♂, 1♀; Naz A; 27-03-2024; Umerkot, 5♂, 2♀; Sultana R, Naz A; 10-05-2024; Umerkot, 4♂, 7♀; Sultana R, Naz A; 10-05-2024; Kaloi, 21♂, 11♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 15♂, 123♀; Sultana R, Naz A; 17-07-2024; Viravah, 6♂, 4♀; Naz A; 15-09-2024; Umerkot, 1♂, 0♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 4.0, FW 3.25, CLM 0.24, CWE 1.40, IOW at anterior 1.06, ELC 0.47, PW 1.31, PL 0.56, ML 0.26, SL 0.34.

#### Tribe: Adelungiini Baker, 1915

#### *Platyproctus maculatus* (Pruthi, 1930)

**Description:** It is characterized by cylindrical body shape, colour is pale ochraceous. Forewing with darkly maculated, featuring four apical cells and brief appendix up to fourth. Forefemora bearing anteroventral stouter rows of setae than anterodorsal rows of setae. Pygofer is elongated laterally with marginal anal hook.

#### Material examined

5♂, 8♀; Sultana R, Naz A; 25-05-2023; Umerkot, 1♂, 0♀; Sultana R, Naz A; 25-05-2023; Kaloi, 17♂, 29♀; Naz A; 5-09-2023; Viravah, 18♂, 13♀; Naz A; 05-09-2023; Nangarparkar, 2♂, 7♀; Naz A; 27-03-2024; Umerkot, 6♂, 9♀; Sultana R, Naz A; 10-05-2024; Umerkot, 3♂, 1♀; Sultana R, Naz A; 10-05-2024; Kaloi, 23♂, 25♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 22♂, 17♀; Sultana

R, Naz A; 17-07-2024; Viravah, 9♂, 14♀; Naz A; 15-09-2024; Umerkot, 1♂, 0♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 4.7, FW 3.1, CLM 0.9, CWE 1.66, IOW at anterior 1.10, ELC 0.55, PW 1.43, PL 0.72ML 0.23, SL 0.37.

#### Diagnostic features of Cicadellinae Latreille, 1825

**Tribe: Cicadellini Latreille, 1825**

***Cofana spectra* (Distant, 1908)**

#### Description

*Cofana spectra*, commonly known as the white leafhopper, pale yellow in colour; crown featuring conspicuous muscular patterns, it has four black spots on the vertex including a prominent dark spot at the posterior edge. A faint brownish median stripe runs along the pronotum that is discontinuous and fails to reach the scutellum. The clypeus and clypellus are swollen. Forewings look off-white. Pygofer is nearly oval shaped bearing macrosetae but lacks spines on the pygofer.

#### Material examined

2♂, 11♀; Sultana R, Naz A; 25-05-2023; Umerkot, 2♂, 3♀; Sultana R, Naz A; 25-05-2023; Kaloi, 11♂, 5♀; Naz A; 5-09-2023; Viravah, 4♂, 17♀; Naz A; 05-09-2023; Nangarparkar, 5♂, 9♀; Naz A; 27-03-2024; Umerkot, 7♂, 12♀; Sultana R, Naz A; 10-05-2024; Umerkot, 2♂, 7♀; Sultana R, Naz A; 10-05-2024; Kaloi, 9♂, 15♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 17♂, 8♀; Sultana R, Naz A; 17-07-2024; Viravah, 9♂, 10♀; Naz A; 15-09-2024; Umerkot, 0♂, 2♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 7.3, FW 6.02, CLM 0.55, CWE 1.8, IOW at anterior 1.35, ELC 0.65, PW 1.73, PL 0.10, ML 0.22, SL 0.57.

***C. unimaculata* (Signoret, 1854)**

#### Description

*C. unimaculata* have pale green body with a light green vertex and pronotum. Head pointed and flattened, with an un-swollen clypeus and clypellus; clypeus and genae unmarked. The vertex features three black spots in a transverse row, where the central is comparatively enlarged. Forewings are greyish white with faint veins. Pygofer is equipped with robust apical macrosetae and covered with slender setae over most of its surface except the tip (Figure 2).

#### Material examined

7♂, 14♀; Sultana R, Naz A; 25-05-2023; Umerkot, 2♂, 6♀; Sultana R, Naz A; 25-05-2023; Kaloi, 9♂, ♀; 23 Naz A; 5-09-2023; Nangarparkar, 16♂, 9♀; Naz A; 05-09-2023; Viravah, 5♂, 26♀; Naz A; 27-03-2024; Umerkot, 9♂, 13♀; Sultana R, Naz A; 10-05-2024; Umerkot, 5♂, 8♀;

Sultana R, Naz A; 10-05-2024; Kaloi, 25♂, 35♀; Sultana R, Naz A; 17-07-2024; Nangarparkar, 21♂, 13♀; Sultana R, Naz A; 17-07-2024; Viravah, 8♂, 11♀; Naz A; 15-09-2024; Umerkot, 4♂, 5♀; Naz A; 16-10-2024; Umerkot.

#### Measurements (mm)

♂ TL 6.0, FW 4.7, CLM 0.55, CWE 1.42, IOW at anterior 1.03, ELC 0.50, PW 1.44, PL 0.90, ML 0.16, SL 0.44.

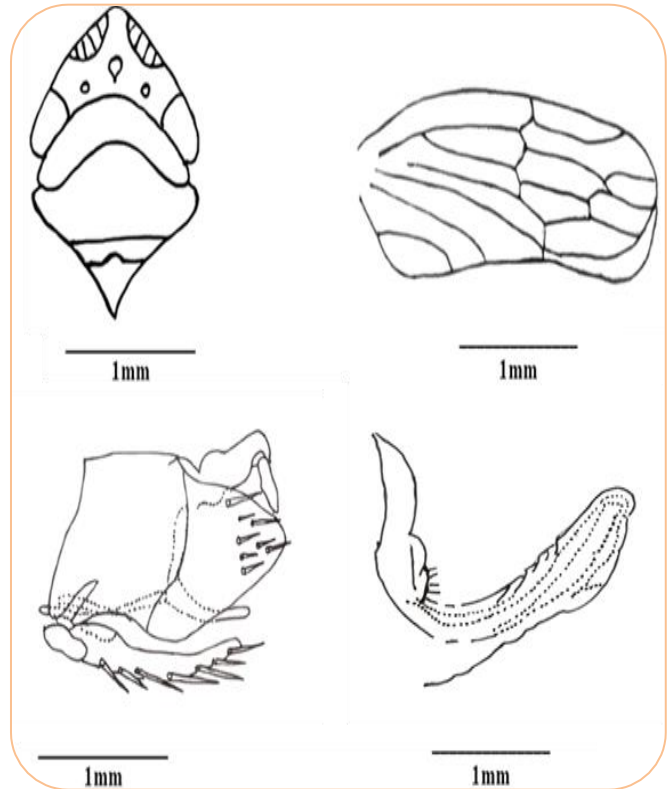


Figure 2. *C. unimaculata* (Signoret 1854): a, head and thorax, dorsal view; b, forewing; c, pygofer, lateral view; d, aedeagus, lateral view.

Table 1 shows that *C. unimaculata* (Cicadellinae) and *A. prolixa* (Deltocephalinae) were the most abundant species, with 274 and 261 specimens recorded, respectively (Figure 3). Deltocephalinae was the most species-rich subfamily. The highest population densities of both species occurred in Nangarparkar and Umerkot, the relatively more irrigated localities of Tharparkar (Table 2; Figure 4), where Poaceae-dominated crops and natural grasslands are prevalent. In contrast, leafhopper abundance was lowest in Kaloi (Table 3; Figure 5), likely due to limited vegetation. Overall, the dominance of *C. unimaculata* and *A. prolixa* across sites (Table 3; Figure 5) highlights the importance of host plant availability and irrigated habitats in shaping leafhopper distribution

and population dynamics.

The high abundance of these species suggests that the study area provides suitable habitats for a diverse insect fauna. It was also observed that *C. unimaculata* and *A. prolixa* are well adapted to hot and arid conditions and are commonly associated with hardy grasses and drought-tolerant vegetation characteristic of the Tharparkar region. Local agricultural zones dominated by crops such as millet and sorghum, along with natural grasslands, offer favorable conditions for both species, which are frequently linked to cultivated ecosystems. These findings indicate that host plant availability plays a crucial role in shaping the distribution and population dynamics of leafhoppers (Wilson et al., 1994).

**Discussion**

Despite reports of leafhopper diversity from other regions of Pakistan, information on their distribution, host associations, and abundance in Tharparkar, Sindh, remains limited. This study documents leafhopper diversity, morphological traits, host preferences, and seasonal occurrence to provide baseline data for accurate taxonomy and integrated pest management in the region.

Table 1. Species-wise abundance of Cicadellidae collected during the 2024-2025.

Species	No of specimens
<i>Aconurella prolixa</i>	261
<i>Exitianus indicus</i>	124
<i>E. nanus</i>	89
<i>Maiestus pruthi</i>	185
<i>M. tareni</i>	86
<i>Cicadulina bipunctata</i>	191
<i>Macrosteles indrina</i>	252
<i>Neoliturus tenellus</i>	151
<i>Grammacephalus indicus</i>	77
<i>G. pallidus</i>	60
<i>Stirellus lahorensis</i>	129
<i>S. viridulus</i>	205
<i>Austrogallia robusta</i>	135
<i>A. sarobica</i>	137
<i>Agallia robusta</i>	97
<i>A. cuspidate</i>	160
<i>Platyproctus maculatus</i>	230
<i>Cofana spectra</i>	167
<i>C. unimaculata</i>	274

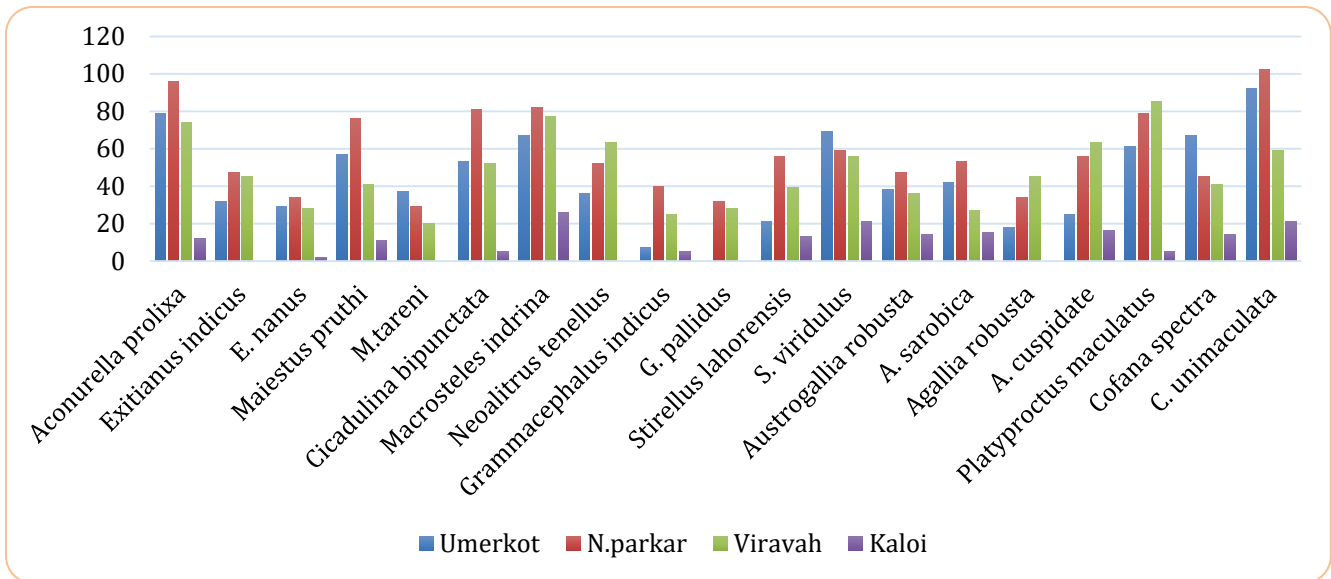


Figure 3. No. of specimens collected from different localities of Tharparkar

The family Cicadellidae comprises more than 22,000 described species worldwide, with over 200 species reported from Pakistan (Khatri and Webb, 2010). Among its subfamilies, Deltocephalinae is the largest and most widely distributed, representing one of the most diverse groups of phytophagous insects globally. Earlier studies documented 31 genera and 57 species of Deltocephalinae

from Pakistan (Khatri and Webb, 2010), and Khatri and Rustamani (2011) subsequently developed identification keys for the tribes and genera known at that time. Later taxonomic revisions, particularly those by Zahniser and Dietrich (2013), resulted in the reassignment of several genera among tribes and expanded the subfamily to more than 38 tribes and approximately 923 genera worldwide.

Such taxonomic efforts are crucial not only for documenting insect biodiversity but also for understanding pest dynamics, as leafhoppers are among

the most important vectors of plant pathogens in agricultural and forest ecosystems (Claridge and Wilson, 1991; Wilson and Turner, 2010).

Table 2. Distribution and abundance of Cicadellidae across selected localities of Tharparkar

Species	Umerkot		Nangarparkar		Viravah		Kalo					
	M	F	M	F	M	F	M	F				
<i>A. prolixa</i>	79	32	47	96	23	63	74	29	45	12	04	08
<i>E. indicus</i>	32	11	21	47	21	26	45	14	31	-	-	-
<i>E. nanus</i>	29	12	17	30	11	19	28	08	20	2	0	02
<i>M.s pruthi</i>	57	32	25	76	34	42	41	26	15	11	07	04
<i>M. tareni</i>	37	13	24	29	07	22	20	07	13	-	-	-
<i>C. bipunctata</i>	53	27	26	81	32	49	52	27	25	5	02	03
<i>M. indrina</i>	67	26	41	82	37	45	77	43	34	26	15	11
<i>N. tenellus</i>	36	11	25	52	29	23	63	29	34	-	-	-
<i>G. indicus</i>	07	05	02	40	13	27	25	09	16	05	01	04
<i>G. pallidus</i>	-	-	-	32	11	21	28	12	16	-	-	-
<i>S. lahorensis</i>	21	16	5	56	21	35	39	07	32	13	05	08
<i>S. viridulus</i>	69	31	48	59	17	32	56	15	36	21	07	14
<i>A. robusta</i>	38	16	22	47	14	33	36	19	17	14	05	09
<i>A. sarobica</i>	42	25	17	53	24	29	27	21	06	15	07	08
<i>A. robusta</i>	18	04	14	34	12	18	45	24	22	-	-	-
<i>A. cuspidate</i>	25	16	9	56	37	19	63	26	37	16	05	11
<i>P. maculatus</i>	61	23	38	79	41	38	85	39	46	05	04	01
<i>C. spectra</i>	67	23	44	45	13	32	41	28	13	14	04	10
<i>C. unimaculata</i>	92	33	59	102	44	58	59	37	22	21	07	14

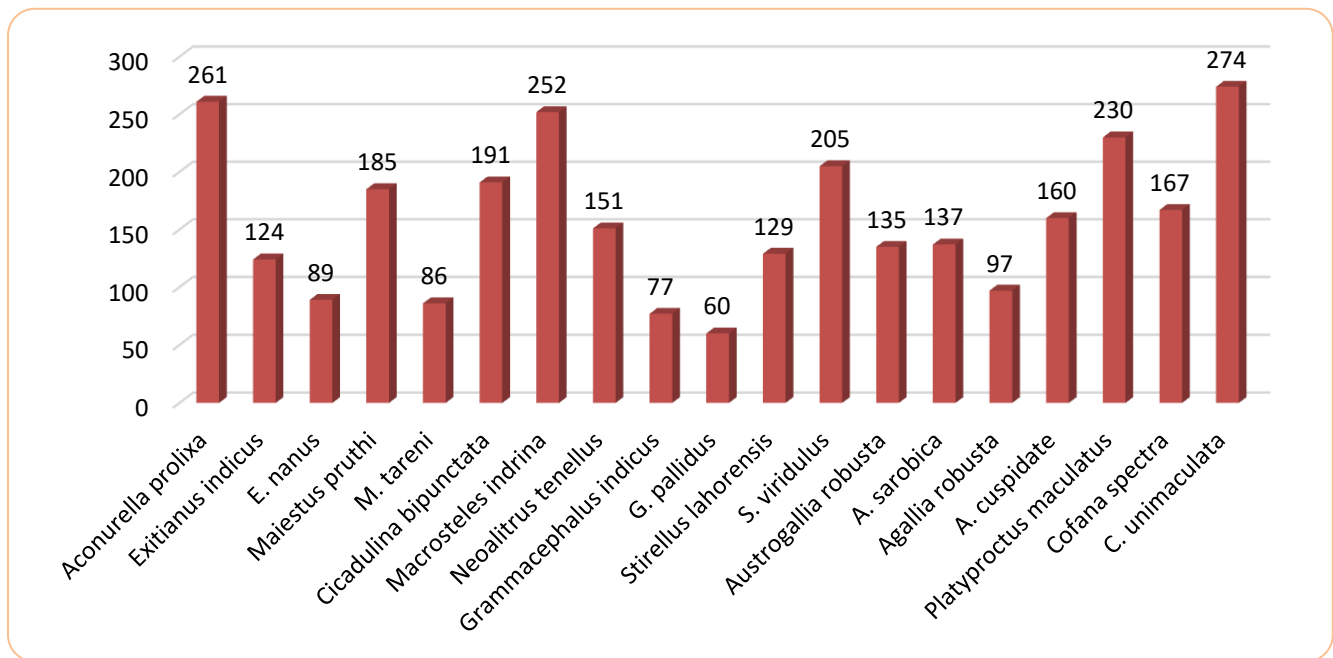


Figure 4. Specimens collected from each species during 2024-2025

Table 3. Overall abundance of Cicadellidae across surveyed localities.

Localities	Total number of specimens
Umerkot	830
Nangarparkar	1096
Viravah	904
Kaloi	190

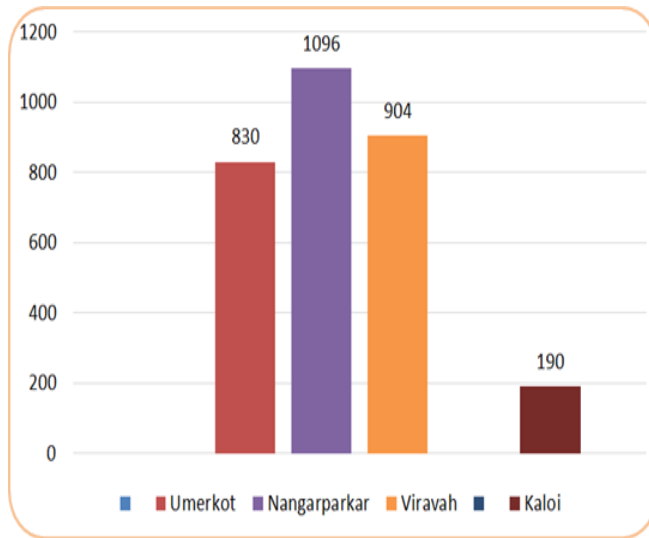


Figure 5. Total specimens collected from each sampling locality.

Leafhoppers occur across a wide range of habitats, from tropical and temperate grasslands to forest ecosystems and high-altitude regions (Morris, 1971; Waloff, 1980). Ongoing climate change is expected to influence host plant physiology, vegetation structure, and species composition, thereby altering plant-insect interactions. Although predicting these responses remains challenging, existing evidence suggests that populations of Cicadellidae may increase under changing climatic conditions, irrespective of vegetation responses. However, the regulatory roles of natural enemies such as predators and parasitoids remain insufficiently understood and warrant further investigation.

During the present survey (2023-2024), leafhopper specimens collected from diverse habitats of Tharparkar were classified into three subfamilies and nine tribes. The subfamily Deltocephalinae was represented by six tribes, Chiasmini, Deltocephalini, Macrostelini, Opsini, Scaphoideini, and Stenometopiini, comprising eight genera. Megophthalminae included two tribes, Agalliini and Adelungiini, with three genera, while Cicadellinae was represented by the tribe Cicadellini with a single genus. In total, 19 species were recorded from the study

area. Among these, *C. unimaculata* and *A. prolixa* were the most abundant species across multiple localities.

The highest population densities of *C. unimaculata* and *A. prolixa* were observed in Nangarparkar and Umerkot, the relatively more irrigated regions of Tharparkar (Table 1, Figure 3). This abundance is likely linked to the availability of suitable host plants, particularly Poaceae-rich crops such as millets and sorghum, as well as legumes. Both species are known to prefer cereal crops and grasses belonging to the family Poaceae (Nielson, 1968; Young, 1979). In Nangarparkar and Viravah, the presence of the Karoonjhar Hills enhances monsoon rainfall by trapping moisture-laden clouds, resulting in vigorous growth of annual herbs and grasses (Ahmed *et al.*, 2013; Soomro *et al.*, 2025; Vedantu, 2025). Temporary water retention in the topsoil, subsurface moisture, underlying sandstone formations, and the presence of ancient wells and water tanks collectively improve soil fertility, creating favorable conditions for leafhopper survival and population growth.

In contrast, leafhopper abundance in Kaloi was comparatively low (Table 2, Figure 4). This area is characterized by sandy to sandy-loam soils with poor fertility and high subsoil salinity, conditions that restrict vegetation growth and limit the availability of suitable host plants. Consequently, these edaphic factors likely contribute to the reduced leafhopper diversity and population density observed in Kaloi.

## Conclusion

The present study, conducted during 2023–2024, assessed the biodiversity of leafhoppers (Hemiptera: Cicadellidae) in the desert region of Tharparkar, Sindh, Pakistan. Field surveys carried out in Umerkot, Nangarparkar, Viravah, and Kaloi resulted in the documentation of 19 species representing three subfamilies and nine tribes. The subfamily Deltocephalinae was the most dominant in terms of species richness. Among the recorded taxa, *C. unimaculata* (Cicadellinae) and *A. prolixa* (Deltocephalinae) were the most abundant species across the surveyed localities, a pattern likely associated with the greater availability of suitable host plants in irrigated and vegetation-rich areas. This study provides baseline information on leafhopper diversity in an understudied arid region and contributes to a better understanding of species distribution in relation to habitat characteristics.

### Acknowledgement

The authors express their sincere gratitude to Prof. Dr. Imran Khatri for his valuable guidance during field surveys and for his assistance in the identification of leafhopper specimens.

### Author Contributions

AN conducted field surveys, collected the samples, compiled the data, and prepared the initial draft of the manuscript. RS conceptualized the study, supervised the research, and performed data analysis. SK proofread the manuscript. All authors read and approved the final version of the manuscript.

### Research Funding

This research did not receive any grant from funding agencies.

### Conflict of Interest

The authors declare no conflict of interest.

### Sustainable Development Goals Targeted

SDG 2: Zero Hunger

SDG 13: Climate Action

SDG 15: Life on Land

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