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Research Article

TAXONOMIC AND ECOLOGICAL OBSERVATIONS ON KATYDIDS (CONOCEPHALINE: TETTIGONIOIDEA) IN THE ARID ZONES OF BAHAWALPUR DIVISION, PUNJAB, PAKISTAN

^aMuhammad Irfan, ^aSantosh Kumar, ^bRiffat Sultana, ^aMuhammad Tariq Mahmood, ^cKamal Niaz

^a Department of Zoology, Cholistan University of Veterinary and Animal Sciences, Bahawalpur, Pakistan.

^bDepartment of Zoology, University of Sindh, Jamshoro, Pakistan.

^c Department of Pharmacology and Toxicology, Cholistan University of Veterinary and Animal Sciences, Bahawalpur, Pakistan.

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ABSTRACT

Conocephalinae (Orthoptera: Tettigoniidae: Tettigoniioidea: Ensifera) are primarily phytophagous insects, some of which are known to cause substantial damage to commercial crops. In addition to their agricultural importance, many conocephaline species exhibit ecological associations with forest biosensors and display diverse behavioral adaptations, including predation, mimicry, and camouflage. The Cholistan desert, located within the Bahawalpur division, is characterized by its distinct xeric insect fauna adapted to arid environments. Despite its ecological significance, the Conocephalinae of this region have remained largely unstudied. The objective of the present survey was to assess the diversity and seasonal abundance of Conocephaline katydids in the Bahawalpur division. Over a 12-month collection period (2022-2023), a total of 697 specimens were recorded and identified, belonging to six species: *Euconocephalus incertus* Walker, 1869; *E. pallidus* (Redtenbacher, 1891); *E. mucro* de Haan, 1842; *E. nasutus* Thunberg, 1815; *E. indicus* (Redtenbacher, 1891); and one species of *Conocephalus* (Anisoptera) *maculatus* Le Guillou, 1841. This investigation represents the first systematic documentation of Conocephaline katydids from the arid zones of the Bahawalpur division.

Corresponding Author: Santosh Kumar

Email: santoshkumar@cvas.edu.pk

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INTRODUCTION

Ensifera is a suborder of orthopteran insects, including grasshoppers and crickets. These insects inhabit a wide range of environments across the globe, from tropical rainforests to arid desert dunes. The group is characterized by distinct morphological features, such as long, threadlike antennae that move actively to detect changes in surrounding air pressure. The cerci are modified sensory appendages, typically used immediately

after copulation. Ensifera is a diverse group, comprising 16,317 known species worldwide (Cigliano et al., 2025). These insects are particularly noted for their complex acoustic behavior. Males of many species produce species-specific sounds through stridulation, rubbing their wings together (Hall and Robinson, 2021). These sounds play a key role in mate attraction, as females are drawn to them (Sultana and Wagan, 2007; Sultana and Panhwar, 2012; Sultana et al., 2013). In areas where

acoustic signals may be obscured by the presence of closely related species, Ensifera also rely on vibrational signals for species recognition and communication (Sultana and Wagan, 2008; Sanam et al., 2021).

The large front tibiae of these insects contain tympanal membranes that detect ground-transmitted sound waves. In most Ensifera, these membranes are protected at rest by a backward-facing flap. They also possess functional hind wings (Lomas et al., 2012).

To survive in harsh, arid environments, Ensifera have evolved a variety of behavioral and physiological adaptations. Many species are nocturnal, thereby avoiding the intense heat of the day. They also exhibit effective water conservation strategies, allowing them to persist despite minimal moisture availability. The desert's heterogeneous landscape, with its scattered vegetation and microhabitats, offers essential resources such as food and shelter. Their ecological role is significant, contributing to the stability of fragile desert ecosystems.

The Cholistan Desert, locally known as Rohi, spans approximately 26,300 square kilometers in southeastern Pakistan, primarily within Punjab province. It forms part of the greater Thar Desert, which stretches across the India-Pakistan border. The Indus River lies to its west, and the agricultural fields of Punjab to the north, while the desert merges into the adjacent Thar Desert along its eastern and southern boundaries (Ali et al., 2009; Sultana et al., 2017).

Geographically, the Cholistan desert features expansive sandy mounds reaching up to 150 meters (492 feet), salt flats known as thals, and sparse vegetation composed mainly of drought-tolerant shrubs and grasses (Arshad et al., 2008; Bozdar et al., 2024). The climate is extreme, with summer temperatures soaring to 50°C and winter temperatures occasionally dropping to 0°C. Annual rainfall is less than 200 mm (8 inches), with most precipitation occurring during the monsoon season; the rest of the year is typically marked by drought (Malik et al., 2017; Sultana et al., 2024).

Numerous researchers, including Sultana et al. (2009), Sultana and Wagan (2010), Sultana and Khosru (2011), Sultana et al. (2014), Sultana et al. (2015a, b, c), Panhwar et al. (2016), Sultana et al. (2021a, b, c), Ashfaq et al. (2022), Kumar et al. (2022), Dayo and Sultana (2024), and Sultana and Song (2024) have investigated various aspects of long- and short-horned grasshoppers. However, despite these valuable contributions, there remains a lack of authentic and comprehensive information on this group.

Therefore, the present study aims to document and explore the diversity, ecological adaptations, and acoustic behavior of Ensifera in the Cholistan desert of Pakistan. It seeks to fill existing gaps in comprehensive knowledge on this suborder within arid environments.

MATERIALS AND METHODS

Sampling, killing, and preservation

The study was conducted from October 2022 to September 2023, with sample collection carried out in various localities across the Bahawalpur division, Punjab, Pakistan. Specimens were collected from the districts of Bahawalpur, Bahawalnagar, and Rahim Yar Khan. All samples were transported to the laboratory following standard insect-handling protocols; some specimens were collected alive, while others were already dead. They were sorted by species and sex, with males and females separated and pinned on a stretching board. After a few hours, identification was initiated based on detailed morphological characteristics. The specimens were then preserved and labeled in the Entomological Laboratory for future reference, display, and study (Table 1, Figure 1).

Table 1. Geographic coordinates of sampling sites in Bahawalpur division.

Sr. No.	Localities	Coordinates	
		Latitude	Longitude
Bahawalpur district			
1	Karaniwala	28.3086	70.1283
2	Jaunwala	29.4716	70.5283
3	Yazman	29.1242	71.7483
4	Lalohanra	29.4691	71.9782
5	Ahmedpur	29.1532	71.2611
6	Uch	29.2389	71.0614
Bahawalnagar district			
1	Bahawalnagar	29.9935	73.2527
2	Chishtian	29.7945	72.8577
3	Haroonabad	29.6104	73.1388
4	Fortabas	29.1930	72.8574
5	Donga Bonga	29.7472	73.2440
6	Islampur	29.8892	73.1042
Rahimyar Khan district			
1	Liaquatpur	28.9393	70.9456
2	Sadiqabad	28.3086	70.1283
3	Khanpur	28.6477	70.6560
4	Zahirpir	28.6613	70.6381
5	Alanpur	28.4176	70.3036
6	Chandpur	28.4602	70.5283

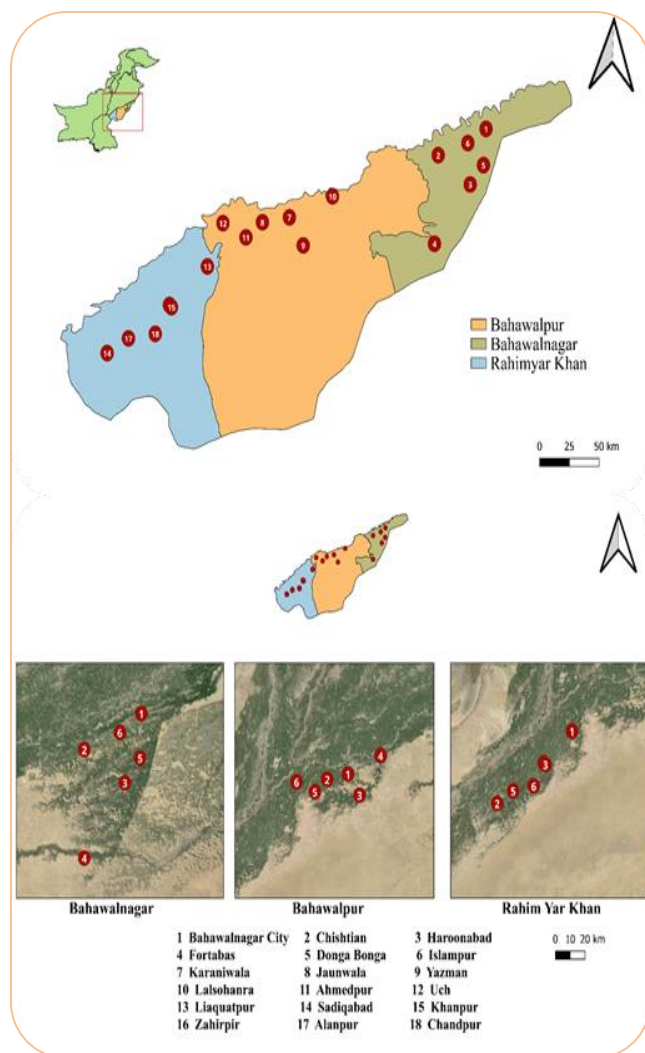


Figure 1. Map of sampling sites in the Bahawalpur division.

Morphological identification

Insect identification was carried out following the methods described by Sultana and Wagan (2015), along with direct observation under a stereoscopic microscope (Model: OM2300S-GS4, Serial No. 4433881) with a zoom range of 3.5×-45×. Species descriptions and available identification keys were used to ensure accurate classification of all insect specimens. A preliminary inventory was prepared for each insect category, which was then grouped into two main categories for presentation. All specimens were sorted and identified based solely on morphological characteristics.

Imaging and morphometry

Photographs of all specimens were taken using a Canon DSLR camera (Model: 1500D) with an 18-55 mm IS lens. Measurements of various body parts were recorded

using a digital vernier caliper.

Key to tribes of Conocephalinae

Following key was used for the identification tribes of Conocephalinae of Bahawalpur division, Pakistan.

1. Larger species (Length without ovipositor > 23.5 mm); vertex on head produced to form a tapering cone between antennal bases, notched below, extending beyond basal antennal segments; fore and middle tibiae with spines beneath; mostly nocturnal and crepuscular..... Copiphorini

2. Smaller species (Length without ovipositor 8.5–9.7 mm); vertex on head not extending beyond the basal antennal segment, produced like a rounded tubercle with concave sides, not notched beneath; fore and middle tibiae without spines beneath; mostly diurnal and repuscular.....Conocephalini

Key to species of Euconocephalus

The species of Euconocephalus of Bahawalpur were identified by following the given below key

1A. Fastigium is separated from frons by notch; pronotum with side keels.....2

1B. Fastigium short; pronotum elongated with or without keels.....3

2A. Cerci in male thick; ovipositor long and straight.....*Euconocephalus incertus*

2B. Cerci slender or elongated, thick in the basal half.....4

3A. Cerci in male thick at the basal half and pointed at apex.....*E. pallidus*

3B. Cerci elongated, tapering towards the tip, and dorsally positioned (on the upper side) of the abdomen...*E. mucro*

4A. Hind femora and fore tibia with numerous ventral spines.....*E. nasutus*

4B. Hind femur with seven-minute external and 14 internal spines; fore tibia with six internal and six external spines.....*E. indicus*

Statistical analysis

Measurements of different body parts of adult insects were analyzed using SPSS version 26. Significant differences among means were determined using the Least Significant Difference (LSD) test.

RESULTS AND DISCUSSION

During the survey, conducted from October 2022 to August 2023 period, a total of 697 specimens of the subfamily *Conocephalinae* were collected from various localities in the Bahawalpur division. Among them, 435 were males and 262 were females (Table 2).

Table 2. Comparative Measurement of different body parts of Conocephalinae.

Body Parameter	<i>E. incertus</i>		<i>E. pallidus</i>		<i>E. mucro</i>		<i>E. nasutus</i>		<i>E. indicus</i>		<i>C. maculatus</i>	
	♂ (n=15)	♀ (n=15)	♂ (n=15)	♀ (n=15)	♂ (n=15)	♀ (n=15)	♂ (n=15)	♀ (n=15)	♂ (n=15)	♀ (n=15)	♂ (n=15)	♀ (n=15)
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Length of head	4.012±0.11	4.33±0.18	4.37±0.14	4.51±0.14	4.71±0.24	4.81±0.14	4.03±0.89	5.3±0.88	4.79±0.19	4.31±0.11	3.11±0.09	3.71±0.15
Length of pronotum	7.02±0.08	11.01±0.33	6.07±0.26	7.9±0.27	8.25±0.31	8.45±0.41	7.95±0.19	8.05±0.29	5.94±0.03	9.04±0.18	2.93±0.05	3.24±0.02
Length of tegmina	46.16±0.29	43.12±0.27	45.18±0.31	45.5±4.3	31.95±0.55	33.65±0.65	45±0.37	46±0.31	43.01±0.18	43.04±0.26	14.06±0.17	17.04±0.21
Length of femur	23.09±0.28	26.04±0.33	21.09±0.23	23.04±0.30	22.06±0.21	23.6±0.11	22±0.19	24±0.21	23.08±0.36	23.14±0.31	12.01±0.16	15±0.43
Length of tibia	17.02±0.15	19.3±0.13	21.01±0.06	23.7±0.16	19.06±0.23	21.6±0.13	21.04±0.06	23.4±0.16	17.97±0.29	19.98±0.27	17.91±0.21	19.91±0.28
Length of ovipositor	---	26.16±0.23	---	23.03±0.31	---	23.03±0.31	---	24.2±0.37	---	21.92±0.31	---	8.04±0.19
Total body length	33.05±0.18	34.86±0.27	32.22±0.26	33.06±0.35	29.94±0.26	31.4±0.23	31.2±0.24	32.8±0.14	32.06±0.26	33.2±0.29	13.04±0.14	15.78±0.21

Systematic account

Subfamily Conocephalinae Kirby and Spence, 1826
Tribe Copiphorini Karny, 1912

Genus *Euconocephalus* Karny, 1907

Conocephalinae Kirby & Spence, 1826

Diagnosis

The grass katyids were cone-headed bush crickets. Their bodies were elongated, medium to small in size. The coloration was green or brownish, occasionally with distinct stripes, especially on the pronotum. The head was usually subconical and often darker and pointed. The antennae were longer than the body and inserted at the center of the eyes, with insertions often lightly margined. The prothoracic spiracles were large and elongated, often covered by the pronotum. The prosternum usually bore a pair of spines, though in some cases, these were absent. The anterior tibiae lacked terminal spines, which were rarely present. Hearing organs were usually concealed. The hind tibiae typically bore one or two terminal spines. The first and second tarsal segments were laterally grooved, mostly long and thin, often resembling grass blades, stems, or young leaves. Males

exhibited modified, though not disproportionate, structures. The ovipositor ranged from long to extremely long, upright or slightly bent upwards, located near the basal stridulatory organs.

Tribe Copiphorini Karny, 1912

Diagnosis

The head was elongate and cone-shaped, with the fastigium extending beyond the antennal bases. It had a broader base than the first antennal segment and lacked a median groove. The thorax was typically green or brownish, and the head was generally inclined at an obtuse angle rather than held horizontally.

The hind femora were armed along a single margin, while the fore tibiae bore tympanal slits and were occasionally lined with spines. Both dorsal and ventral surfaces of the hind tibiae were equipped with spines. The forewings were sometimes short. The ovipositor was straight and unspecialized, lacking serrations. The male cerci possessed two sharply pointed, differently shaped denticles and were curved apically. Five species belonging to a single genus were examined and are listed under:

Genus: *Euconocephalus* Karny, 1907

Euconocephalus Karny, 1907, p. 39 (originally described as a subgenus of *Conocephalus*)

Type species: *Locusta acuminata* Fabricius (= *Conocephalus nasutus* Thunberg)

Euconocephalus indicus (Redtenbacher)
Conocephalus indicus Redtenbacher, 1891, p. 408

Diagnosis

The fastigium of the vertex extended over the head, positioned between the antennae, often appearing punctate and occasionally elongated. A small tubercle was present at its base. A distinct notch separated the frons from the fastigium. Most species exhibited a rounded pronotum with deep, rather than long, lateral keels. The eyes were typically oval to sub-spherical, and the head was slightly elongated but not prominently so. The fore tibiae bore ventral spines, and the knees were armed. The wings were long and fully developed (non-brachypterous). Male stridulatory files exhibited species-specific characteristics. The posterior femora also bore ventral spines, and the knees were armed. The ovipositor was long, straight, and sword-shaped (ensiform).

Euconocephalus incertus* (Walker, 1869)Conocephalus incertus* Walker, F. 1869*Ecuconocephalus breviceps* (Redtenbacher, 1891)*Ecuconocephalus chagosensis* (Bolívar, 1912)*Euconocephalus incertus* Uvarov. 1922. J. Bombay Nat. Hist. Soc. 28(3):735*Euconocephalus incertus* Karny. 1926. Treubia 9(1-3):252**Diagnosis**

The body was medium to large and slender in form, with a greenish-brown coloration. The head was cone-shaped with a well-developed fastigium that extended beyond the antennal bases. The eyes were spherical, with a distinct notch separating the fastigium from the frons. The pronotum exhibited lateral keels. The tegmina and fully developed wings were extremely thin, with transparent membranes and greenish veins. The stridulatory organ was present on the left tegmen. The hind femora extended beyond the tip of the abdomen. Ventral spines were observed on both the hind femora and fore tibiae. In males, the cerci had a broad basal portion tapering to a small, pointed tip. In females, the cerci were thick at the base and narrowed towards the apex. The ovipositor was straight and elongated (Figure 2).

Figure 2. *Euconocephalus incertus*.**Materials examined**

Punjab: Bahawalpur, Karaniwala 03.vii.2023 7♂♂ 4♀♀ (Irfan, M., Sultana. R. and Kumar, S.), Januwala 6.vii.2022 9♂♂ 3♀♀ (Irfan, M. and Zain, M.) Yazman 8.vii.2022 6♂♂ 7♀♀ (Irfan, M. and Waseem, M.) Lal sohanra 2.xii.2022 9♂♂ 10♀♀ (Irfan, M., Abdullah, M. and Kumar, S.), Ahmedpur 5.xi.2022 3♀♀ 1♂ (Irfan, M., Kumar, S. and Abdullah, M.), Uch 3.v.2023 10♀♀ 2♂♂ (Irfan, M. and Waseem, M.), Bahawalnagar, 1.x.2022 6♀♀ (Irfan, M., Sanwal, M.), Haroonabad 5.xi.2022 10♀♀ (Irfan, M., Kumar, S., Abdullah, M., Umair, M. and Sanwal, M.), Fortabbas 8.iv.2023 1♂ 2♀♀ (Irfan, M. and Zain, M.), Chishtian 12.vi.2023 4♂♂ 3♀♀ (Irfan, M., Kumar, S. and Abdullah, M.), Domga bonga 3.viii.2023 3♀♀ (Irfan, M. and Waseem, M.), Rahimyar Khan, Sadiqabad 27.ix.2022 9♂♂ 4♀♀ (Irfan, M. and Kumar, S.), Islampur 12.xi.2022

2♂♂ (Irfan, M. and Zain, M.), Liaqatpur 10.viii.2023 8♂♂ 4♀♀ (Irfan, M. and Umair, M.), Khanpur 30.ix.2022 5♂♂ 4♀♀ (Irfan, M. and Kumar, S.), Zahirpir 27.ix.2022 5♂♂ 2♀♀ (Irfan, M. and Zain, M.), Alanpur 6.iii.2023 4♂♂ 4♀♀ (Irfan, M. and Kumar, S.), Chandpur 8.viii.2023 3♂♂ 3♀♀ (Irfan, M. and Umair, M.).

Comments

Euconocephalus pallidus (Redtenbacher, 1891) has been previously recorded from various regions across the country. Historical distribution records also document its occurrence in several other countries, including the Philippines, Java, Calcutta (India), Sri Lanka, Burma, Tonkin, and Penang (Hebard, 1920). The present study provides the first report of this species in association with specific host plants. Specimens were predominantly collected from grassland habitats interspersed with shrubby vegetation and *Acacia nilotica* trees during the course of the current investigation. Field observations revealed that individuals exhibited localized movement behavior through walking, leaping, and short-distance flight. During the nymphal stages (instars I-V), the insects fed aggressively on grasses such as *Desmostachya bipinnata*, *Echinochloa colona*, and *Cynodon dactylon*. Upon reaching adulthood, a dietary shift was observed, with adults feeding preferentially on the young foliage of *Saccharum officinarum* (sugarcane) and *Sorghum vulgare* (sorghum).

Conocephalus pallidus Redtenbacher. 1891. Verh. der Zoologisch-Botanischen Gesellsch. Wien 41, 383, 414

Conocephalus pallidus Brunner von Wattenwyl. 1893. Ann. Mus. Civ. Stor. Nat. Genova 2 13(33):180

Conocephalus pallidus Bolívar, I. 1900[1899]. Ann. Soc. Ent. Fr. 68, 776

Euconocephalus pallidus Karny. 1912. Genera Insectorum 139, 35

Euconocephalus pallidus Karny. 1926. Treubia 9(1-3), 253

Diagnosis

The body was medium to large in size. Antennae were green with brown pigmentation. The fastigium was small, and the pronotum was large, lacking any distinct keels. Wings were fully developed. A small black line was present along the extreme anterior margin of the tegmen. The fore tibiae possessed ventral spinules. On the left tegmen, the stridulatory organ was slender in shape. Cerci were thick at the basal half. The ovipositor was long, slightly straight, and gradually tapering apically (Figure 3).

Figure 3. *Euconocephalus pallidus*.**Materials examined**

Punjab: Bahawalpur, Karaniwala 26.x.2022 2♂♂ 1♀♀ (Irfan, M., Sultana, R. and Kumar, S.), Januwala 6.xi.2022 5♂♂ 3♀♀ (Irfan, M. and Zain, M.) Yazman 8.x.2022 1♂♂ (Irfan, M. and Waseem, M.), Lal Sohanra 12.xii.2022 6♂♂ 3♀♀ (Irfan, M., Abdullah, M. and Kumar, S.), Ahmedpur 16.xi.2022 3♀♀ 2♂♂ (Irfan, M., Kumar, S. and Abdullah, M.), Uch 26.vi.2023 5♀♀ 2♂♂ (Irfan, M. and Waseem, M.), Bahawalnagar, 11.ix.2022 5♀♀ 1♂ (Irfan, M. and Sanwal, M.), Haroonabad 15.xi.2022 2♀♀ (Irfan, M., Kumar, S., Abdullah, M., Umair, M. and Sanwal, M.), Chishtian 19.vii.2023 3♂♂ 2♀♀ (Irfan, M., Kumar, S. and Abdullah, M.), Domga Bonga 23.vii.2023 4♀♀ 3♂ (Irfan, M. and Waseem, M.), Rahimyar Khan, Sadiqabad 20.x.2022 1♂ 2♀♀ (Irfan, M. and Kumar, S.), Islampur 2.xii.2022 2♂♂ (Irfan, M. and Zain, M.), Liaquatpur 13.xii.2023 4♂♂ 2♀♀ (Irfan, M. and Umair, M.), Khanpur 3.i.2023 5♂♂ 2♀♀ (Irfan, M. and Kumar, S.), Zahirpir 7.ii.2023 3♂♂ 2♀♀ (Irfan, M. and Zain, M.), Alan Pur 16.vi.2023 1♂♂ (Irfan, M. and Kumar, S.), Chandpur 28.vii.2023 6♂♂ 3♀♀ (Irfan, M. and Umair, M.).

Comments

Euconocephalus pallidus predominantly inhabits green vegetation and natural grasslands within arid and semi-arid desert ecosystems. Occasional specimens were also recorded along roadside vegetation. Historically, this species has been documented from multiple biogeographic regions, including the Philippines, Sri Lanka (formerly Ceylon), Myanmar (Burma), the Tonkin grasslands, Penang, Singapore, Java, and Calcutta, India (Hebard, 1920). Morphometric comparison with smaller specimens reported in earlier literature suggests possible geographic variation or reflects limitations due to sample size in prior collections. Tan et al. (2018) documented seven male specimens from Singapore, whereas the current study yielded a comparatively extensive series from multiple localities within the Bahawalpur region.

Despite the relatively high specimen count, the abundance of *E. pallidus* remains lower than that of the sympatric *E.*

incertus in the surveyed areas. Field observations revealed that *E. pallidus* is commonly associated with habitats dominated by *Sorghum vulgare*, *Helianthus annuus*, *Echinochloa colona*, *Acacia nilotica*, *Acacia parkinsonia*, *Ziziphus mauritiana*, *Sesbania bispinosa*, and *Saccharum officinarum*, typically interspersed with thorny undergrowth. Within these vegetative assemblages, the species demonstrated moderate aerial activity, including characteristic hovering behavior.

***Euconocephalus mucro* (Haan, 1843)**

Conocephalus mucro Haan. 1842

Euconocephalus sobrinus (Bolívar, 1884)

Euconocephalus mucro Karny. 1926. Treubia 9(1-3), 249

Diagnosis

The head was smaller than the pronotum, which appeared ventrally compressed and distally broader. The fastigium exhibited horizontally elongated dark markings on its lateral sides. The body was slender with a silky brown coloration, and the antennae were dark brown. Both the tegmina and hind wings were well developed. The fastigium was elongated and sharply pointed, extending beyond the antennal sockets. The tegmen showed pale margins with a distinct deepening toward the distal end. The left stridulatory file was crescent-shaped and moderately broad. The cerci were slender medially and broadened basally (Figure 4).

Figure 4. *Euconocephalus mucro*.**Materials examined**

Punjab: Bahawalpur, Karaniwala 23.viii.2022 2♂♂ 4♀♀ (Irfan, M., Sultana, R. and Kumar, S.), Januwala 19.xi.2022 2♂♂ (Irfan, M. and Zain, M.) Yazman 14.iv.2023 3♂♂ 2♀♀ (Irfan, M. and Waseem, M.), Lal sohanra 21.ii.2023 2♂♂ 1♀ (Irfan, M., Abdullah, M. and Kumar, S.), Ahmedpur 5.vii.2023 1♀ 1♂ (Irfan, M., Kumar, S. and Abdullah, M.), Uch 21.vi.2023 8♀♀ 3♂♂ (Irfan, M. and Waseem, M.), Bahawalnagar, 20.v.2023 3♂♂ 1♀ (Irfan, M. and Sanwal, M.), Haroonabad 18.i.2023 2♂♂ 1♀ (Irfan, M., Kumar, S. Abdullah, M., Umair, M. and Sanwal, M.), Fortabbas 8.i.2023 5♂♂ 2♀♀ (Irfan, M. and Zain, M.), Chishtian 12.xi.2022 6♂♂ 3♀♀ (Irfan, M., Kumar, S. Abdullah, M.), Domga bonga 3.xii.2022 1♀ (Irfan, M. and

Waseem, M.), Rahimyar Khan, Sadiqabad 17.x.2022 5♂♂ 2♀♀ (Irfan, M. and Kumar, S.), Islampur 2.ii.2023 3♂♂ 2♀♀ (Irfan, M. and Zain, M.), Liaquatpur 10.vii.2023 2♂♂ (Irfan, M. and Umair, M.), Khanpur 3.ii.2023 4♂♂ 2♀♀ (Irfan, M. and Kumar, S.), Zahirpir 7.x.2022 7♂♂ 2♀♀ (Irfan, M. and Zain, M.), Chandpur 18.iii.2023 2♂♂ 1♀ (Irfan, M. and Umair, M.).

Comments

Tan et al. (2018) reported five specimens from various locations in Singapore. In the present study, numerous specimens were collected from multiple sites. *Euconocephalus mucro* is polyphagous in nature, with individuals obtained from cultivated fields bordered by *Acacia nilotica*, *Cynodon dactylon*, *Echinochloa colona*, and *Sesbania bispinosa* (Panhwar et al., 2014a, b). Most specimens were collected from areas with mixed vegetation, including low timber shrubs, tall grasses, and plants that bloom from spring to early summer.

Euconocephalus nasutus (Thunberg, 1815)

Conocephalus nasutus Thunberg. 1815. Mem. Acad. Imp. Sci. St. Petersburg 5, 273.

Conocephaloides nasutus Kirby, W.F. 1906. A Synonymic Catalogue of Orthoptera (Orthoptera Saltatoria, Locustidae vel Acridiidae) 2, 250.

Euconocephalus Hebard. 1922. Proc. Acad. Nat. Sci. Philad. 74, 240.

Euconocephalus nasutus Vickery, D.K.M. Kevan and Stanford English. 1999. Micronesica 32(1), 56 [264].

Diagnosis

The body was calendar-shaped, medium to large in size, with a greenish coloration. The antennae were pale brown. The pronotum was pointed and bore a distinct white lateral band. The fastigium was small, blunt, and extended beyond the base of the antennae. The tegmina were fully developed, with colorless cells and green veins. Ventral spines were present on both the fore and hind tibiae. The female exhibited a pointed cervix and a straight, elongated ovipositor (Figure 5).



Figure 5. *Euconocephalus nasutus*.

Materials examined

Punjab: Bahawalpur, Karaniwala 03.xi.2022 7♂♂ 2♀♀ (Irfan, M., Riffat, S. and Kumar S.), Januwala 26.i.2023 10♂♂ 3♀♀ (Irfan, M. and Zain, M.) Yazman 18.viii.2022 5♂♂ 2♀♀ (Irfan, M. and Waseem, M.), Lal sohanra 20.ii.2023 8♂♂ 3♀♀ (Irfan, M., Abdullah, M. and Kumar, S.), Ahmedpur 25.vi.2022 2♀♀ 4♂♂ (Irfan, M., Kumar, S. Abdullah, M.), Uch 23.vii.2023 3♀♀ 7♂♂ (Irfan, M. and Waseem, M.), Bahawalnagar, 17.vi.2022 4♂♂ 3♀♀ (Irfan, M. and Sanwal, M.), Haroonabad 23.iii.2023 3♂♂ 1♀ (Irfan, M., Kumar, S., Abdullah, M., Umair, M. and Sanwal, M.), Fortabbas 22.v.2023 3♂♂ 2♀♀ (Irfan, M. and Zain, M.), Chishtian 21.vii.2023 9♂♂ 3♀♀ (Irfan, M., Kumar, S. and Abdullah, M.), Domga bonga 29.ii.2023 2♂♂ 1♀ (Irfan, M., Waseem, M.), Rahimyar Khan, Sadiqabad 7.viii.2023 9♂♂ 4♀♀ (Irfan, M. and Kumar, S.), Islampur 27.vi.2023 5♂♂ 2♀♀ (Irfan, M. and Zain, M.), Liaquatpur 16.vii.2023 2♂♂ 2♀♀ (Irfan, M. and Umair, M.), Khanpur 3.iv.2023 7♂♂ 3♀♀ (Irfan, M. and Kumar, S.), Zahirpir 21.x.2022 9♂♂ 3♀♀ (Irfan, M. and Zain, M.), Alan pur 26.vi.2023 6♂♂ 4♀♀ (Irfan, M. and Kumar, S.), Chandpur 18.iii.2023 4♂♂ 2♀♀ (Irfan, M. and Umair, M.).

Comments

Euconocephalus nasutus (Thunberg, 1815) is a bush cricket predominantly found in sunlit grasslands, particularly in areas where rice is cultivated. It displays green and brown body coloration and can be distinguished from the closely related species *Conocephalus acuminatus* (Thunberg, 1815) by its more pointed wing tips. This species was first recorded in habitats containing crops such as *Oryza sativa*, *Saccharum officinarum*, *Ziziphus mauritiana*, and *Prosopis cineraria*, occurring across sloped, flat, and swampy terrains. *E. nasutus* exhibits moderate activity levels and feeds exclusively on the young leaves of these host plants.

Euconocephalus indicus (Redtenbacher, 1891)

Diagnosis

The ventral tubercle was minute, and the ventral notch was distinctly open. The fastigium was short, broad, and extended beyond the antennal sockets; the fastigial vertex was blunt and rounded. Antennae were intact. The pronotum was deep and moderately elongated, converging dorsally toward the posterior margin. A pair of spines was present on the prosternum. The anterior lobes of the mesosternum and metasternum were rounded, whereas the posterior lobes were angulate. The forewings were long with rounded apices, extending beyond the hind knees. The second radial sector

appeared outside the central area of the wing. The cubito-anal region of the forewing was not distinctly rounded or expanded.

All legs were long and slender, with spines on the ventral side of the femur both internally and externally. The number of spines on the ventral margins of the tibiae and femora were as follows: protibia had six external and six internal spines; mesotibia had six external and six internal spines; post-tibia bore 25 minute external and 25 minute internal spines. The profemur lacked external spines and had two indistinct internal ones; the mesofemur had four external and no internal spines; the postfemur bore seven external and fourteen minute internal spines. Each tibia had a dorsal margin bearing an apical spine, and each post-tibia was equipped with two ventro-apical spurs. The femora were smooth posteriorly. The dorsal borders of the post-tibia had 28 small external and 25 small internal spines.

The ovipositor was straight and exceeded the body in length. The tympana on both sides of the fore tibiae were closed (Figure 6).



Figure 6. *Euconocephalus indicus*.

Materials examined

Punjab: Bahawalpur, Karaniwala 24.vi.2023 5♂♂ 2♀♀ (Irfan, M., Riffat, S. and Kumar, S.), Januwala 2.iv.2023 9♂♂ 3♀♀ (Irfan, M. and Zain, M.) Yazman 12.vii.2023 5♂♂ 4♀♀ (Irfan, M. Waseem, M.), Lal sohanra 29.iii.2023 8♂♂ 2♀♀ (Irfan, M., Abdullah, M. and Kumar, S.), Uch 29.xi.2022 5♀♀ 3♂♂ (Irfan, M. and Waseem, M.), Bahawalnagar, 6.viii.2022 9♂♂ 3♀♀ (Irfan, M. and Sanwal, M.), Haroonabad 19.vii.2023 2♂♂ 1♀ (Irfan, M., Kumar, S., Abdullah, M., Umair, M. and Sanwal, M.), Fortabbas 20.viii.2022 2♂♂ 1♀ (Irfan, M. and Zain, M.), Chishtian 21.vii.2023 9♂♂ 3♀♀ (Irfan, M., Kumar, S. and

Abdullah, M.), Rahimyar Khan, Sadiqabad 19.viii.2022 9♂♂ 4♀♀ (Irfan, M. and Kumar, S.), Islampur 21.v.2023 4♂♂ 2♀♀ (Irfan, M. and Zain, M.), Liaquatpur 1.v.2023 1♂ (Irfan, M. and Umair, M.), Sadiqabad 23.ix.2022 2♂♂ 1♀ (Irfan, M. and Kumar, S.), Zahirpir 2.v.2023 5♂♂ 2♀♀ (Irfan, M. and Zain, M.), Chandpur 19.ii.2023 2♂♂ (Irfan, M. and Umair, M.), Khanpur 23.vii.2023 8♂♂ 1♀ (Irfan, M. and Kumar, S.).

Comments

A few specimens of this species were recorded from the Himalayan Mountains, China, Burma, Penang, Borneo, Sumatra, Java, and Peak Downs, Australia, by Hebard (1920). Similarly, Sultana and Panhwar (2013a, b) reported a single male specimen from the Himalayas. The present study, based on several male and female specimens collected from various regions, confirms the widespread occurrence of this species across the country. It was found in scattered mountain grasslands subjected to grazing, as well as in herbaceous plantations of *Helianthus annuus*, *Echinochloa colona*, *Acacia nilotica*, and *Acacia parkinsonia*.

Genus *Conocephalus* Thunberg, 1815

Conocephalus Thunberg, 1815, 214.

Anisoptera Bethold, 1827, 409.

Neoxiphidion Karny, 1912, 8.

Palotta Walker, 1869, 249.

Xiphidion Audinet-Serville, 1831, 159.

Xiphidium Burmeister, 1838, 707.

Xiphidium Fieber, 1853, 170.

Type species: *Gryllus* and *Tettigonia* and *Conocephalus* Linnaeus, 1767.

Diagnosis

The body was small in size, with the vertex roughly smooth laterally and rounded at the apex, generally positioned higher than the cranium in lateral view but not exceeding the frontal fastigium. The lateral lobes of the pronotum were triangular and slanted. The hindwings and tegmina were either fully developed or reduced. Ventrally, the fore and mid femora bore spines, while the hind femur possessed two spines at the knees. The tympanal organ on the fore tibiae was closed. Both the fore and mid tibiae had small ventral spurs but lacked dorsal spurs. Males exhibited fangs within their cerci. The ovipositor was sword-shaped, robust, and smooth (Figure 7).

Conocephalus (Anisoptera) maculatus (Le Guillou, 1841)

Xiphidium maculatum Le Guillou, 1841: 294;

Locusta (*Xiphidium*) *lepida* De Haan, 1842: 189;

Locusta (*Xiphidium*) *continuum* Walker, 1869: 271;
Locusta (*Xiphidium*) *maculatum* Walker, 1869: 275;
Xiphidium sinense Walker, 1871: 35;
Anisoptera maculatum Kirby, 1906: 278;
Xiphidium maculatum Karny, 1907: 93;
Xiphidium maculatum Matsumura et Shiraki, 1908: 51;
Xiphidium neglectum Bruner, 1920: 123;
Conocephalus (*Xiphidium*) *maculatus* Karny, 1912: 11;
Conocephalus maculatus Bolivar, 1913: 8;
Conocephalus sinensis Jin et Xia, 1994: 33.

Diagnosis

This species was smaller in size, with dark brown dorsal and ventral bands and light brown antennae. The vertex by the fastigium was wide, and the prosternum was macropterous and bispinose. Dark spots were shaded on the forewings. The costal and precostal areas lacked distinct markings, but the veins were evident in these regions. The male forewing stridulatory file was shaped like that of the left forewing. The hind femora were unarmed ventrally. The tibiae were spotted with a black patch near the base and were typically pale otherwise, with six apical spurs on the hind tibiae. The male cerci bore a single internal spine, while the female cerci lacked an internal spine. The ovipositor was comparatively short and straight (Figure 7).



Figure 7. *Conocephalus maculatus*.

Materials examined

Punjab: Bahawalpur, Karaniwala 4.xi.2022 4♂♂ 3♀♀ (Irfan, M., Riffat, S. and Kumar, S.), Januwala 29.vii.2023 2♂♂ 1♀ (Irfan, M. and Zain, M.) Yazman 22.ii.2023 9♂♂ 3♀♀ (Irfan, M. and Waseem, M.), Lal Sohanra 9.ix.2023 5♂♂ 3♀♀ (Irfan, M., Abdullah, M. and Kumar, S.), Uch 21.viii.2022 9♀♀ 3♂♂ (Irfan, M. and Waseem, M.), Ahmedpue 9.ix.2023 3♂♂ 2♀♀ (Irfan, M., Abdullah, M. Kumar, S.), Bahawalnagar, 26.xii.2022 6♂♂ 3♀♀ (Irfan, M. and Sanwal, M.), Haroonabad 9.ii.2023 6♂♂ 1♀ (Irfan, M., Kumar, S., Abdullah, M.,

Umair, M. and Sanwal, M.), Fortabbas 25.vii.2023 8♂♂ 1♀ (Irfan, M. and Zain, M.), Chishtian 4.xi.2022 2♂♂ 2♀♀ (Irfan, M., Kumar, S. and Abdullah, M.), Rahimyar Khan, Sadiqabad 29.ii.2023 1♂ (Irfan, M. and Kumar, S.), Liaqatpur 21.vi.2023 3♂♂ 1♀ (Irfan, M. and Umair, M.), Sadiqabad 27.ix.2022 2♂♂ 1♀ (Irfan, M. and Kumar, S.), Zahirpir 12.x.2022 7♂♂ 4♀♀ (Irfan, M. and Zain, M.), Chandpur 3.vii.2023 2♂♂ (Irfan, M. and Umair, M.), Khanpur 9.viii.2022 8♂♂ 4♀ (Irfan, M. and Kumar, S.), Alanpur 27.x.2022 10♂♂ 4♀♀ (Irfan, M. and Kumar, S.), Chandpur 12.xii.2022 9♂♂ 3♀♀ (Irfan, M. and Zain, M.).

Comments

This species was reported by Gupta and Shishodia (2009) from Chamba, Sirmour, and Solan in India. Moreover, Garai (2002) recorded three males and one female from northern Pakistan, although the exact location was not specified. In the present study, specimens were collected from various ecological zones, including swampy grasslands, semi-desert areas, and fertile agricultural lands, indicating the adaptability of the species to diverse environmental conditions. The highest collection rates were recorded between April and September, with numbers declining during the winter months.

Seasonal population dynamics of Conocephalinae

Monthly data collected during 2022-2023 revealed clear seasonal fluctuations in the abundance of six baseline species of Conocephalinae (Table 3). Peak population densities occurred during the four-month period spanning late spring to early summer, particularly in June (99 individuals), May (87), and August (81). The lowest population levels were recorded in January (31) and February (26). Among these species, *Euconocephalus indicus* and *Conocephalus maculatus* consistently exhibited high population densities, reflecting their ecological adaptability and widespread occurrence. *E. pallidus* showed a winter peak with complete absence in February, while *E. incertus* and *E. mucro* exhibited population peaks in May. The overall trend demonstrated a population rise from March to June followed by a gradual decline toward December, indicating a strong climate-driven seasonal cycle. These results underscore the ecological significance of mid-year months for monitoring and conservation efforts. Species like *E. indicus* may serve as potential bioindicators of habitat health in arid and semi-arid ecosystems.

Table 3. Seasonal collection of Conocephaline katydids from the study area during the year 2022-23.

Sr. No.	Month	Species						Total
		<i>E. incertus</i>	<i>E. pallidus</i>	<i>E. mucro</i>	<i>E. nasutus</i>	<i>E. indicus</i>	<i>C. maculatus</i>	
1	January	7	4	1	5	9	5	31
2	February	3	0	3	6	6	8	26
3	March	13	11	12	2	7	4	49
4	April	11	6	14	5	12	12	60
5	May	21	17	19	7	14	9	87
6	June	19	19	12	13	24	12	99
7	July	13	9	11	9	19	7	68
8	August	24	18	9	2	7	21	81
9	September	13	6	13	11	12	6	61
10	October	9	12	4	9	8	3	45
11	November	11	7	6	8	11	9	52
12	December	6	2	7	7	9	7	38
Total		150	111	111	84	138	103	697

Host plants associated with Ensifera

A diversity of agroecosystems and wild flora was recorded as being utilized by Ensifera species for feeding, shelter, and oviposition (Table 4). Major host plants included staple cereal crops such as wheat (*Triticum aestivum*), maize (*Zea mays*), and rice (*Oryza sativa*), which provided substantial foliage and structural refuge. Crop combinations such as sugarcane (*Saccharum officinarum*) and mustard (*Brassica campestris*) offered dense vegetation, favorable for concealment and oviposition. The integration of fodder crops like *Trifolium alexandrinum* indicated associations with livestock-based systems, while wild grasses such as *Cynodon dactylon* reflected adaptability to grasslands and wastelands.

Table 4. Important host plants recorded during the field survey.

Sr. No.	Host Plant	
	Local Name	Scientific Name
1	Wheat	<i>Triticum aestivum</i>
2	Maize	<i>Zea mays</i>
3	Rice	<i>Oryza sativa</i>
4	Sugarcane	<i>Saccharum</i>
5	Mustard	<i>Brassica campestris</i>
6	Fodder crop	<i>Trifolium</i>
7	Wild grass	<i>Cynodon dactylon</i>
8	Cotton	<i>Gossypium hirsutum</i>
9	Sunflower	<i>Helianthus annuus</i>

Economically significant crops, including cotton (*Gossypium hirsutum*) and sunflower (*Helianthus annuus*), demonstrated the potential for Ensifera to colonize high-value crops, raising concerns about pest status. The broad host range confirms the ecological plasticity of Ensifera species in the study area, highlighting the need for environmentally conscious management practices that acknowledge their role in both agricultural and semi-natural ecosystems.

Conservation status of Ensifera

The decline of Ensifera in arid regions poses significant ecological threats, disrupting essential ecosystem services such as pollination, nutrient cycling, and food web stability for insectivorous fauna. Owing to their sensitivity to environmental change, Ensifera are effective bioindicators in dryland habitats. Declines in orthopteran populations may signal broader ecosystem degradation in arid and semi-arid zones (Ingrisch and Köhler, 1998; Samways, 2005). To counteract these effects, conservation strategies should prioritize habitat restoration through reforestation, soil stabilization, and re-establishment of native plant communities that support insect life cycles. Maintaining habitat heterogeneity and enhancing insect diversity can be achieved through sustainable land-use practices, such as rotational grazing and minimized pesticide use, as evidenced by success in other insect groups (Bazelet and Samways, 2011).

Enhanced research and monitoring are critical, given that Ensifera remain poorly documented in many arid regions.

Emerging tools like acoustic monitoring, GIS-based habitat modeling, and DNA barcoding can improve understanding of their distribution, population dynamics, and ecological interactions (Montealegre-Z et al., 2011). Moreover, insights into their physiological and behavioral adaptations to abiotic factors (e.g., temperature, moisture, and vegetation structure) are essential for predicting responses to climate change.

Community participation is equally vital. Local engagement, citizen science initiatives, and participatory habitat restoration can increase public awareness and foster stewardship, leading to more effective conservation outcomes. Raising awareness about the ecological importance of insect biodiversity reinforces the relevance of Ensifera in maintaining ecosystem integrity. A multidisciplinary and ecosystem-based strategy, integrating ecological science with responsible land management, policy frameworks, and stakeholder involvement, is imperative to arrest the decline of Ensifera and to sustain the resilience of arid landscapes. Such an approach aligns with global conservation agendas, including the Convention on Biological Diversity (CBD) and the United Nations Sustainable Development Goal 15 (Life on Land).

CONCLUSION

This study presents the first comprehensive account of Conocephalinae diversity in the Bahawalpur division, documenting 697 specimens across six species through detailed morphological analysis. The findings offer baseline taxonomic and ecological insights, with species composition and abundance closely linked to environmental parameters such as temperature, humidity, and soil characteristics. These results advance our understanding of Conocephalinae diversity in arid zones of Pakistan and reinforce the broader ecological relevance of Ensifera.

Given their critical roles as pollinators, nutrient recyclers, and prey species within trophic networks, the observed patterns emphasize the urgent need for conservation interventions. These should include habitat restoration, ecologically sound land-use practices, robust monitoring systems, and community engagement. A cross-disciplinary, ecosystem-based approach is essential to curb the ongoing decline in Ensifera populations and to safeguard the ecological stability of arid ecosystems, where these insects serve as keystone contributors.

AUTHORS' CONTRIBUTIONS

MI carried out the field survey and analyses; SK and RS designed and supervised the study and helped in the identification of insects; MTM and KN carried out the laboratory analyses; All the authors proofread and approved the final manuscript.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUSTAINABLE DEVELOPMENT GOALS TARGETED

SDG 12: Responsible Consumption and Production

SDG 13: Climate Action

SDG 15: Life on Land

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