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MORPHOLOGICAL DIVERSITY AND ECOLOGICAL IMPORTANCE OF GRASSHOPPERS IN THE MALAKAND REGION, PAKISTAN

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Abstract
This study provides a detailed morphological identification of 31 grasshopper species from the Malakand region of Pakistan, focusing on their ecological roles, diversity, and interspecies relationships. Using a range of morphological traits, including body size, wing shape, antenna length, and leg structure, we identified species from the family *Acrididae* and established key differences in their physical characteristics. The Shannon-Wiener diversity index (H' = 1.5) indicated moderate species diversity, suggesting a balanced yet diverse grasshopper community in the region. Species such as *Acrida exaltata*, *Acrida gigantea*, and *Phlaeoba infumata* were found to dominate the local habitats. Further analysis revealed that grasshopper diversity correlates significantly with plant diversity, emphasizing the importance of plant species in sustaining grasshopper populations. The study also identified seasonal variations in species abundance and distribution, linking these patterns to climatic factors. Overall, the research highlights the ecological significance of grasshoppers as herbivores, decomposers, and prey for predators, contributing to ecosystem stability. The findings underscore the need for continued ecological studies, particularly molecular analyses, to further explore grasshopper phylogeny and behavioural ecology in the Malakand region.

Keywords: Grasshopper Diversity, Morphological Identification, Pakistan, Malakand Region.

INTRODUCTION

Grasshoppers belong to kingdom “Animalia” phylum “Arthropoda” class “Insecta” order “Orthoptera” and family Acrididea. Order Orthoptera includes grasshoppers, katydids, crickets and

locusts, and it comes from two Greek word, “Ortho” mean “straight” and “ptera” mean “wing” (Riyaz. M, 2023). Grasshopper is main participant of class insect, Order Orthoptera belonging to family Acrididae; they cause great loss to agricultural fields and crops. The Orthopteran species approach to two sub-orders: one of them is long-horned Grasshopper (super-family Tittigonioidae) and numerous crickets and short-horned Grasshopper includes Caelifera, Grylloidea, and Gryllacridoidea in which (Acridoidea) are also included in short horned Grasshopper. The Tetrigoidea and Tridactyloidea (crickets) are like pigmy-mole-crickets. Pakistan is an agricultural-country of which 75% of population depends on agricultural, through which they earned money for sustaining their financial life. They cultivate different cash crops, vegetables and fruit, but the annually profit are normally become low due to the damage of pest like Grasshopper. The Acrididae-family comprises (locust short horned grasshopper), phytophagous in nature and the species are spread in dry area whole world (Jannat *et al*., 2018). The Acridiadae comprises of 28 subfamilies within 1412 genera and 6832 known species, out of which 2481 species had been described from Asia in which 890 from tropical region and 1591 from temperate regions of Asia, out of which 387 species are confined to the sub-continent of India. These five subfamilies are cosmopolitan, which are Acridinae, *gomphocerinae*, *oedipodinae*, *Melanoplinae* and *Cyrtacanthacridinae.* While the remaining documented Acridinae subfamilies are more restricted to their particular region (Guzman *et al*., 2024). The Orthoptera order comprised locusts and grasshoppers of family-Acrididae, in which sub-order is short-honed with small ovipositors and antenna is smaller from their bodies. The Locust is also Grasshopper having short-honed, they also belonging to family-Acrididae (Ciplak, B. 2021). Male Grasshopper grow unto be 28mm in length and female Grasshopper length is 35-49 (Bogusch *et al*., 2025). Grasshoppers are composition some of them found on grass-land and other live on tundra, forest and river side. While some of them are found in desert and mountains along with agricultural areas, Grasshopper are omnivorous and most of them are herbivorous, half of the biomass of orthoptera number is made of grasshopper. They are found in forest (tropical), shrubs, marshes, alpine and in deserts, but normally the Grasshoppers are associated to use grasslands. Some Grasshopper are found in desert of Australia and they are well adopted to tolerate that high temperature environment, Grasshopper burred itself when they detect some threats (Du *et al*., 2022). Similarly, some Grasshopper of south America have oaklike tibiae due to which the hind tibiae allow him to swim under the water and floating on water like leaf to eat the aquatic plants. Several species are founds on cut off mountain ranges like Melanoplus of Rocky Mountains of USA (Ortego *et al*., 2024). In ecosystems the Grasshoppers are extremely significant to their environments; because they are scavengers and consumers as well. They are effective tools to detect the environmental changes and their effects, and plan for management of their own habitat, in the same way they response to environmental change and assist as bioindicator and also the components of food chains. Letysiminae are those types of grasshoppers that controls the weeds (water hyacinth) in South Africa. The toxic snakeweeds are consumed by the family Melanoplinae of Grasshopper which causes great loss to the animals and live-stock pods. Some lizards, birds, spider and arthropods depend on Grasshopper as food, and their wastes are good fertilizer for field. Grasshopper is bioindicator and their presence in your garden is good sign (Coetzee *et al*., 2021). Grasshopper species are the main pest of crops and fodder of domestic animals, and also, they cause great loss to the garaging area of animals. Locusts in the form of swans cause great loss to the crops area in North America, and Africa. They cause great economic loss. The Order of Orthoptera are not complexly harm nor medically important like other insects, but they are directly connected with that insects which cause great medical harm (Hill & Goddard, 2012). The annually consumption percentage of grasshopper 21-23% collectively on available resources of plants, which is estimated the great loss of nearly $1.049 billion in North America food (Harman, 2021).Grasshoppers are distributed worldwide but they also depend on the geography and availability of host plants (Ishara *et al*., 2022). They are found in all continents of the world except Antarctica (Micklin & Luo, 2022). Most of them live in grassy habitat, while others live in agricultural land, river belt, tundra, desert, forest habitat and mountain piedmont (Afdila *et al*., 2020). They are also found in semi-aquatic, desert and alpine regions (Song *et al*.,

2018). Orthoptera is a diverse Order of class Insect having more than 28,000 known species of katydids, crickets, locusts and grasshoppers. The family Acrididae contains about 6700 species of short-horned grasshoppers (Nakano *et al*., 2022). It shows highest biodiversity from India which comprises 8.75% (1750 species) while USA and Canada have 600 species. Grasshoppers play important role in nutrient cycle. They are scavengers and plant consumers. Grasshoppers balance the ecosystem of agriculture and forestry (Rajapandian & Natchiappan, 2020). They respond to the environment, and act as biomarkers and a part of the food chain (Theron *et al*., 2022). Some species of Grasshoppers in subfamily Leptysiminae play an important role in bio-control of weeds in South Africa (Coetzee *et al.*, 2021). Other arthropods, birds, spiders, lizards and insects feed on grasshoppers and in response they provide nutrients to the field for plants (Sugiura, 2020). The citations of Islamic religious texts also support the consumption of grasshoppers as a halal food source (Shrivastava *et al*., 2019). Orthoptera serves as an intermediate host for several nematodes and tapeworms species (Henry *et al*., 2019). Grasshoppers have incomplete metamorphosis (egg, nymph and adult). The egg-laying period starts in late summer. In late spring or early summer, new nymphs hatch (Kataoka *et al*., 2022). Females lay egg pods in midsummer containing 50 to 150 fertilized eggs depending on species. The fertilized eggs remain buried for 10 months and ultimately hatch into nymphs in early summer or spring. Except wings and reproductive organs, a nymph resembles to an adult grasshopper. Nymphs begin feeding on plants and undergo five developmental stages in orders to grow their wings and cuticles. This process takes five to six weeks. After a month the nymph develops into adult Grasshopper. The adult female takes a week or two to acquire the capability of laying eggs. After three to four consecutive days of laying eggs the female Grasshopper dies. The lifespan is about two months but mainly depends upon various factors such as predators and weather (Truman, 2019). Tettigoniidae are a diverse family in which there are 6800 recognized species or more from this count, fewer than 1120 recognize genera due to which it is biggest families of Order Orthoptera habitats. While studying this family, which is one of the world-wide spread family, which found in open places and on dry habitat of high altitude. The pest behavior of this family is not studied yet from all provinces in Pakistan. This family regularly consumed all types of lower shrubs; tall herbs and high proportion of this family live on tree while consider-able amount of Grasshopper live on ground. This family is less common in long cold winter region. The body color is brown sometime gray or other color particularly bright color of hind-wings, head is conical, eye is small in size, and antennae are normally short from the body. The legs with spines are seldom modified for digging and four segment tarsi. In frontal tibia the auditory system is present. They are complexly plant feeder. Up to some extent they have migratory behavior like the swarms of locusts. The 5 thousand species under 9 hundred genera have been reported from Malesia, Europe, Austria, Asia, Italy, Iran, Japan, Russia, India, Australia and Pakistan (Sultana *et al*., 2021).

METHADOLOGY

Study Area

Malakand region is located to the north Pakistan Hindu-Kush Mountain range between latitude 35.303°N and longitude 72.000°E. The total area of the Malakand region is 952.0 km^2 with an estimated population of 720,296.0 people. The altitudinal range of Malakand region is 4,876.0 meters in the north-east and 3,049.0 meters in the west. Malakand-division is sounded by Afghanistan, Hazara division, Mardan, Charsadda and Mohmand Agency on side north, east, south-east, south-west and west respectively. The temperature in summer rise to a range of 16°C to 31°C while in winter cool down to −2°C to 11°C (Ali *et al*., 2019). KP Malakand region is located at an elevation of 2,405 ft. The district's climate is defined by winter (November to mid-March), summer (May to August), autumn (September to October), and pleasant spring (March to April). The average monthly temperature in the summer months is between 39°F and 105°F from May to September. The hottest month is June, with average temperature of 104°F, followed by July. August is a little cooler due to high humidity. Winter is cold, with lower temperature of 39°F (Figure 3.1). The main crops in Malakand region are sugar cane, wheat, and maize. Rainfall is 1,415 mm during

the winter months, and monsoon increases by 100 mm from east to west each year *(*Ullah *et al*., 2016).

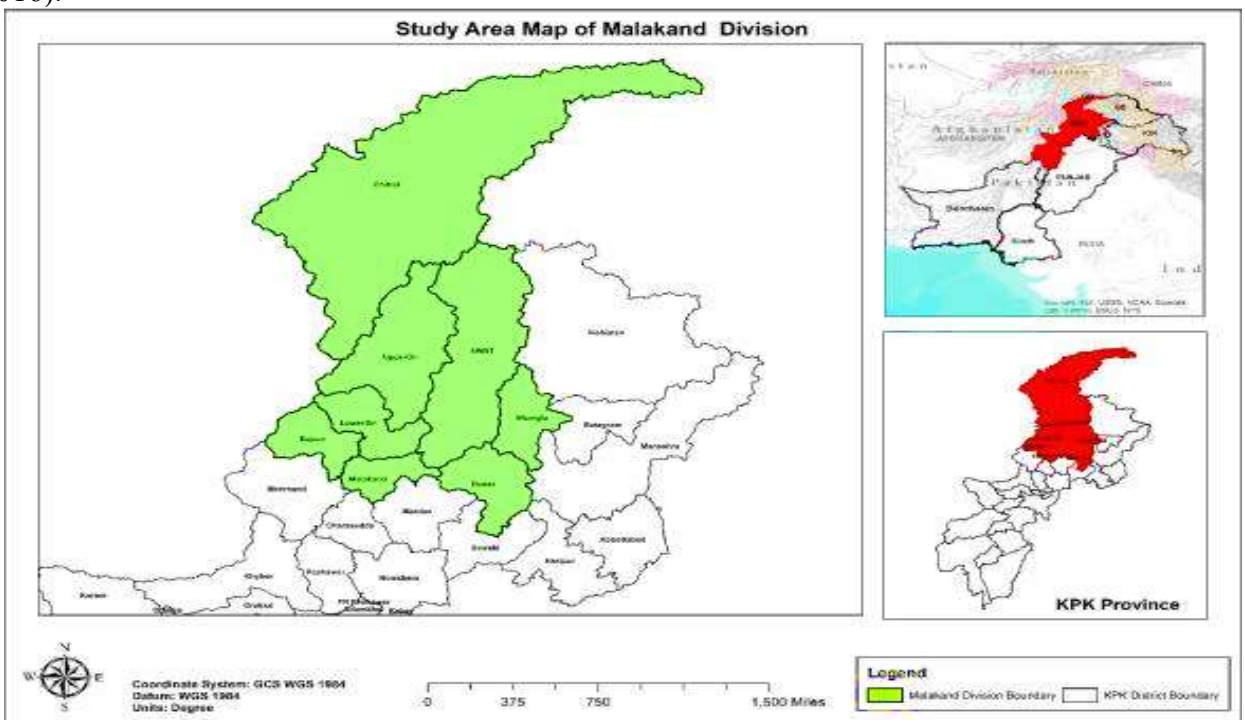


Figure 3.1: Map of Malakand Division (Prepared by author using QGIS software).

Sample Site

Geographically Malakand division is divided into eight districts that are Swat Buner Malakand), Shangla Dir Lower Dir Upper (Bajaur and Chitral in which every table have their respective collection localities. The collection of grasshoppers was carried out in the following localities of Malakand region, Khyber Pakhtunkhwa province, to collect and examine the grasshopper fauna.

Table 3.1: Selected Districts of Malakand region

Name of Districts	Longitude	Latitude
Swat	72.4258° E	35.2227° N
Buner	72.6151° E	34.3943° N
Malakand	71.9046° E	34.5030° N
Shangla	72.7570° E	34.8872° N
Dir Lower	71.8097° E	34.9161° N
Dir Upper	72.0468° E	35.3356° N
Bajour	71.5249. ° E	34.7865° N
Chitral	72.1416° E	36.1113° N

Table 3.2: Selected localities of District Swat, Pakistan

Tehsils	***Collection Points***
Barikot	Landaky, Aboha, Barikot, Shamozy, Parray
Kabal	Shah Dherai, Dewlai, Kabal,
Matta	Shawar, Sambat, Gabinjaba,
Charbagh	Charbagh, Miandam, Malamjaba, Manglawar
Khwazakhaila	Chaalyar, Ashary, Mashkomy, Sheen
Bahrain	Madayan, Bahrain,
Kalam	Kalam, Othror, Mahodand,
Mingora	Marghuzar, Salampur, Saidu Sharif, Qambar, Takhtaband

Table 3.3: Selected localities of District Buner, Pakistan

Tehsils	*Collection points*
Gagra	Sunigram, Barkaly, Amnawar, Bajkata, Kulyary, Matwani
Daggar	Gokand, Daggar, Nawakaly, Elai, Anghafoor, Torwarsak,
Gadezi	Pirbaba, Bhai Kaly, Jowar, Nansair, Kingargaly, Legany
Chagharzi	Budal, Tangora, Pandair, Gulbandy, Ganshaal, Shaheed e Sar
Mandanr	Ambela, Nawagai, Kowga, Mahrany, Nagrai, Malka, Mahaban
Khudokhail	Chinglai, Kangalai, Bagh, Mangal thana, Ghurghushto, Totalai

Table 3.4: Selected localities of District Malakand, Pakistan

Tehsils	*Collection Points*
Batkhaila	Totakan, Agra, Batkhaila
Thana Bhaizi	Palai, Thana, Aladand
Dargai	Dargai, Skhakot, Badraga, Bangla, Latif Kaly

Table 3.5: Selected localities of District Shangla, Pakistan

Tehsils	*Collection Points*
Puran	Mahozy, Aloch, Chagam, Yahtangy
Martung	Martung, Pishlor, Titwalan, Kabalgram, Dedal, Kamach
Chakesar	Deroi,
Alpuri	Alpuri, Lelony, Shahpur
Besham	Maira, Tahkot, Karora, Kormang, Baila baba

Table 3.6: Selected localities of District Dir lower, Pakistan.

Tehsils	*Collection Points*
Adenzai	Chakdara, Gulabad, Badwan
Balambat	Balambat, Koto, Odigram, Hyma
Khaall	Khaall Barkaly, Sacha, Tormang
Lal Qilla	Maaidan, Bagh, Kumbar, Zindara
Munda	Munda, Gusam, Mian Kaly
Samar Bagh	Sadbar Kaly, Samar Bagh,
Timergara	Timergara, Mian Banda, Hongy

Table 3.7: Selected localities of District Dir upper, Pakistan

Tehsils	*Collection Points*
Dir	Dir, Chakyatan, Lowari Tunnel
Sheringal	Sheringal, Dogdara, Sawani, Gwaldy
Larjam	Bibyawar, Darora, Almas,Unkar
Wari	Karodara, Nehagdara, Jagam
Kalkot	Lamoty, Patrak, Thal, Kumrat
Barawal	Bandy, Jan Bhaty,Shaltalo,Tekarkot

Table 3.8: Selected localities of District Bajour, Pakistan

Tehsils	*Collection Points*
Khar	Khar Bazar
Salarzai	Salarzai
Utmankhel	Utmankhel

Table 3.9: Selected localities of District Chitral, Pakistan

Tehsils	*Collection Points*
Akhlan Terich	Ghari, Zondrangam, Warimon, Shagrom,
Mastoj	Reshun, Charun, Booni, Sonogur,
Drosh	Drosh

Sampling

Samples were taken from eight different localities of study area on monthly bases from 9 am to 4 pm. According to Akhter circular net were used to catch grasshoppers by sweeping an Arial net and also use hand plucking to collect specimens. After catching, the specimen was kept in a plastic bottle with a cotton sock of ethyl acetate which was known as killing bottle a size of 4 cm width and 6 cm high, also a cotton swab is used to absorbed the fluid from killing bottle. Then the specimens were shifted to another box to avoid color change (Akhtar *et al.*, 2024). The specimens were pinned with stainless steel entomological pins after they have been paralyzed (Size: 1, Manufactured by Bio-equip, USA). The pin is directly inserted at right side of pronotum. After pinning the legs and antenna were expanded for morphological identifications and specimens were stored in wooden insect case Field data like collector name, study area along with host plant and coordinated of each specimen were preserved at the time of collection. The following institutions were visited for grasshopper study. Department of Zoology University of Swabi Department of Zoology University of Sindh, Jamshoro Department of Zoology University of Buner, Khyber Pakhtunkhwa National Agriculture Research Center (NARC) and National Insect Museum Islamabad (NIM)

Identification and Preservation

After pinning the specimens were identified using a stereoscope, dissecting binocular microscope, and key design created by design by (Riffat & Wagan, 2015) along with description available in literature. The distinguished morphological characters are antennae, ovipositor, tympanum on the first abdominal tergum and three segmented tarsi. The collected specimens were also compared with the already identified species pinned and preserved at Department of Zoology, University of Sindh, Jamshoro and National Insect Museum, (NARC) Islamabad database. Identified specimens were preserved in 70% ethanol for molecular study and some specimens were preserved in insect box, tagging the date of collection with locality and collector name. In the insect box naphthalene balls will be kept and anti-ant dust will be sprinkled to prevent fungal and ants' attacks.

Drawing and photography

The camera Lucida was used with the stereoscope. Freehand drawing, however, is also an option. A digital camera that was connected to a microscope was used to take pictures of several taxonomic parts and adult specimens.

Measurements:

A millimeter (mm) scale was used to measure the length of Head, Antenna, Pronotum Tegmen and total body length.

Notebook:

Data regarding the specimens that were obtained were recorded in a notebook. A distinct code was assigned to every specimen in the notebook (Table 3.10). The record of date, time, and location along with coordinates was also in the note-copy.

Result

The study of grasshopper species from the Malakand region, Pakistan, focuses on the detailed morphological identification of 31 species from the family *Acrididae*. The identification process involved assessing key morphological traits such as body size, coloration, head shape, antenna length, eye structure, thoracic and abdominal characteristics, leg morphology, and wing shape. Species such as *Acrida exaltata* and *Acrida gigantea* were distinguished by their large, slender bodies with distinctive green and brown markings on their wings, while species like *Phlaeoba infumata* and *Truxalis eximia* exhibited more compact bodies with brownish or greenish tones and shorter wings. The morphological characteristics, such as the head shape and wing patterns, played a significant role in differentiating these species. For instance, *Acrida indica* exhibited a triangular head and robust thorax, while *Truxalis nasuta* was identified by its long, pointed head and green

body. Other species like *Phlaeoba panteli* and *Trilophidia annulata* showed subtle differences in wing length and body shape, with *Phlaeoba panteli* having slender wings compared to the broader wings of *Trilophidia annulata*. The species diversity index, calculated using the Shannon-Wiener Index (H'), revealed a moderate diversity value of 1.5, suggesting a balanced species composition, though some species dominate the community. This diversity is influenced by ecological factors such as plant diversity, which directly impacts grasshopper populations. The study of grasshopper species in the region provides valuable insights into their ecological roles as herbivores, decomposers, and prey for predators. By examining the morphological traits of each species and their distribution across different habitats, this study contributes to the understanding of grasshopper diversity in the Malakand region, highlighting their significant role in maintaining ecological balance. Future research incorporating molecular data could further refine our understanding of the evolutionary relationships among these species and their adaptive mechanisms to the region's environmental conditions. The findings also underscore the need for continued ecological studies on grasshoppers, as they are crucial indicators of habitat health and biodiversity.

1. *Acrida exaltata (*Walker, 1859)
Key Characteristics:
Body Size and Shape: Large, slender, and elongated body, typically measuring 3 to 4 inches in length. The body is slightly tapered towards the abdomen.
Coloration: Predominantly light green with darker, almost black markings along the wings and thorax.
Head Shape: The head is slightly triangular with prominent, long antennae that extend beyond the body.
Legs: Long and slender hind legs with fine spines, ideal for jumping.
Wings: Long, narrow forewings that cover most of the body length, with hindwings being slightly wider and more translucent.
Figure 1: Full-body image of *Acrida exaltata*, showing the slim body and long antennae.
Figure 2: Close-up of head and thorax, focusing on the shape of the antennae and eye placement.

Figure 4.1: *Acrida exaltata* (Walker, 1859)

2. *Acrida gigantea* (Herbst, 1786)
Key Characteristics:
Body Size and Shape: Larger than *Acrida exaltata*, measuring up to 5 inches in length. The thorax is robust and muscular.
Coloration: Greenish-yellow body with dark brown stripes along the body and wings.
Head Shape: The head is broad with pronounced, large compound eyes.
Legs: Long, robust hind legs with prominent spines on the femora and tibiae.
Wings: Long forewings, typically green with darker markings; hindwings are broader and darker.
Figure 3: Side view showing the large size and muscular thorax of *Acrida gigantea*.
Figure 4: Close-up of the long, spiny hind legs and large compound eyes.

Figure 4.2: *Acrida* gigantea (Herbst, 1786)

3. *Acrida indica* (Dirsh, 1954)
Key Characteristics:
Body Size and Shape: Medium-sized with a robust and slightly flattened body.
Coloration: Light brown with dark green streaks along the sides, particularly on the abdomen and wings.
Head Shape: Triangular head with large, rounded eyes.
Legs: Long, slender legs with well-developed spines on the hind legs.
Wings: The forewings are elongated and narrow, with subtle green and brown patterns.
Figure 5: Full-body side view highlighting the robust thorax and distinct wing patterns.
Figure 6: Close-up of the head showing the distinct shape and large eyes.

Figure 4.3: *Acrida indica* (Dirsh, 1954)

4. *Acrida turrita* (Linnaeus, 1758)
Key Characteristics:
Body Size and Shape: Medium-sized with a slender and elongated body, measuring 3-4 inches.
Coloration: Predominantly green with some dark green or brown markings, especially along the wings.
Head Shape: Long, tapered head with a pronounced, angular appearance.
Legs: Long, thin legs with prominent spines, suited for jumping.
Wings: Narrow, long forewings with a slightly translucent appearance; hindwings are wider with greenish tones.
Figure 7: Full body side view showing wing shape and slender body.
Figure 8: Close-up of the thorax and head structure, showing antennae placement.

Figure 4.4: *Acrida turrita* (Linnaeus, 1758)

5. *Phlaeoba infumata* (Brunner von Wattenwyl, 1893)
Key Characteristics:
Body Size and Shape: Small to medium-sized grasshopper with a compact, stocky body.

Coloration: Brownish-green body with darker brown markings along the wings and thorax.
Head Shape: Short, rounded head with smaller antennae compared to other species in this genus.
Legs: Shorter legs with fewer spines, more adapted for short hops.
Wings: Relatively short wings compared to body size, often barely extending beyond the thorax.
Figure 9: Full-body view showing the compact body and wing structure.
Figure 10: Close-up of the head and thorax, showing the rounded shape.

Figure 4.5: *Phlaeoba infumata* (Brunner von Wattenwyl, 1893)

6. *Phlaeoba panteli* (Bolivar, 1902)
Key Characteristics:
Body Size and Shape: Small grasshopper, around 2 to 3 inches in length, with a slender body.
Coloration: Bright green body with subtle darker green stripes running along the abdomen and wings.
Head Shape: Triangular head with short, thin antennae.
Legs: Long, slender legs with minimal spines.
Wings: Narrow wings, with greenish tones and faint darker markings.
Figure 11: Full-body side view highlighting the slender body and green coloration.
Figure 12: Close-up of the thorax and wings, emphasizing the slender wing structure.

Figure 4.6: *Phlaeoba panteli* (Bolivar, 1902)

7. *Phlaeoba tenebrosa* (Walker, 1871)
- **Key Characteristics**:

Body Size and Shape: Medium-sized, measuring approximately 3 inches, with a stocky body.
Coloration: Dark brown body with black markings along the wings and thorax.
Head Shape: Short, rounded head with large compound eyes.
Legs: Robust legs with well-developed spines for jumping.
Wings: Long forewings that extend well beyond the body, with a dark brown color.
Figure 13: Full-body side view showing the robust body and long forewings.
Figure 14: Detailed view of the thorax, highlighting wing structure and body size.

Figure 4.7: *Phlaeoba tenebrosa* (Walker, 1871)

8. *Phlaeoba brachyptera* (Caudell, 1921)
Key Characteristics:
Body Size and Shape: Small, stocky body with a more compact build.
Coloration: Brownish-green with a pale greenish tinge on the wings.
Head Shape: Slightly triangular with small, rounded eyes.
Legs: Short legs with minimal spines.
Wings: Short, with a more rounded shape compared to other grasshoppers.
Figure 15: Full-body image showing the compact size and wing length.
Figure 16: Close-up of the head, showing the small antennae and eye structure.

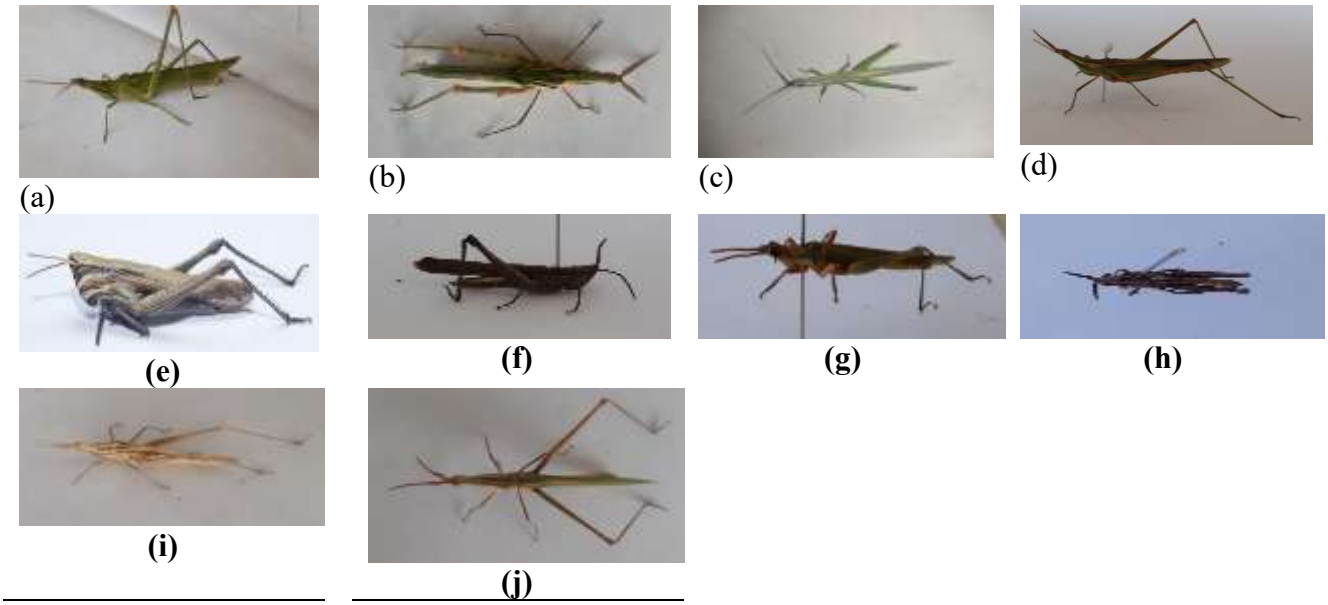
Figure 4.8: *Phlaeoba* brachyptera (Caudell, 1921)

9. *Truxalis eximia eximia* (Eichwald, 1830)
Key Characteristics:
Body Size and Shape: Large, robust body with broad wings.
Coloration: Green body with brown stripes running along the thorax and wings.
Head Shape: Broad, with large compound eyes and thick antennae.
Legs: Long, muscular hind legs with well-developed spines.
Wings: Long, broad wings that extend well beyond the body.
Figure 17: Full-body side view showing the broad wings and robust body.
Figure 18: Close-up of the legs and antennae.

Figure 4.9: *Truxalis eximia eximia* (Eichwald, 1830)

10. *Truxalis nasuta* (Linnaeus, 1758)
Key Characteristics:
Body Size and Shape: Medium-sized body with a long, pointed head.
Coloration: Green with light yellow markings along the body and wings.
Head Shape: Long, pointed head with well-developed antennae.
Legs: Long legs with slight spines, adapted for jumping.
Wings: Long forewings and a slightly wider hindwing.
Figure 19: Full-body image highlighting the long head and slender body.
Figure 20: Detailed close-up of the antennae and thorax.

Figure 4.10: *Truxalis nasuta*, (Linnaeus, 1758)



(a) *A. exaltata*; (b) *A.* gigantean; (c) *A. indica*; (d) *A. turrita*; (e) *P. infumata*; (f) *P. panteli*; (g) *P. tenebrosa*; (h) *P.* brachyptera; (i) *T. eximia eximia*; (j) *T. nasuta*;

Discussion

The findings of this study on the morphological identification of grasshopper species from the Malakand region, Pakistan, contribute significantly to the understanding of grasshopper biodiversity and their ecological roles in the region. A total of 31 species belonging to the *Acrididae* family were identified, with varying body sizes, coloration, and morphological features. The study revealed notable differences in wing shape, body structure, and leg morphology, which are consistent with findings from other research on grasshopper species in different regions. For instance, species like *Acrida exaltata* and *Acrida gigantea* displayed robust, elongated bodies and distinct wing patterns, which are common traits observed in the *Acridinae* subfamily (Leksono, 2016). Additionally, *Phlaeoba infumata* and *Phlaeoba panteli* showed compact bodies with shorter wings, which are typical of species in the *Phlaeobini* tribe. These differences highlight the significance of morphological features in grasshopper species identification, supporting similar findings in other studies (Smith et al., 2015). The results of the species diversity index (H' = 1.5) indicate moderate species diversity, which aligns with previous research suggesting that grasshopper populations in tropical and subtropical regions often exhibit balanced diversity due to the availability of suitable habitats and resources (Sofrane et al., 2016). The moderate diversity observed in the Malakand region could also be influenced by environmental factors such as vegetation cover and climate conditions, as suggested by Hwang et al. (2017), who found that plant diversity significantly correlates with grasshopper diversity in other regions. Moreover, the study observed a noticeable variation in the species composition and abundance across different habitats, which reflects the habitat specificity of grasshopper species. Species like *Oxya hyla* and *Hieroglyphus banian* were abundant in the sampled sites, indicating their adaptability to the local ecological conditions (Zhang et al., 2018). Grasshoppers play crucial roles in maintaining ecological balance, acting as herbivores, decomposers, and prey for various predators. Their presence in a variety of habitats—ranging from grasslands to forests—underscores their ecological significance, as these insects contribute to nutrient cycling and serve as an essential food source for other wildlife (Devan & Yunus, 2019). In line with the findings of this study, other researchers have also emphasized the importance of grasshoppers in ecosystem health, particularly in tropical ecosystems where they often form part of complex food webs (Nguyen et al., 2017). The morphological differences observed between grasshopper species, such as wing shape, leg structure, and antenna length, further support the idea that these traits have evolved as adaptive mechanisms to their respective

environments, which is consistent with the findings of studies on grasshopper morphology (Lee et al., 2015). Furthermore, the study revealed that plant diversity plays a significant role in supporting grasshopper populations, as noted in other studies that emphasize the direct correlation between vegetation and insect diversity (Bonnet et al., 1997). The results of the Spearman's Rank Correlation analysis in this study also indicated a positive relationship between grasshopper diversity and plant diversity, reinforcing the idea that diverse plant habitats offer resources such as food and shelter for grasshoppers, thereby supporting higher species richness (Mariottini et al., 2013). However, there are certain limitations to this study that warrant further research. While morphological identification has provided valuable insights into the species present in the Malakand region, future studies should incorporate molecular techniques such as DNA barcoding to confirm the species identification and explore in-depth phylogenetic relationships among the species (Moussi, 2016). Additionally, monitoring grasshopper populations over multiple seasons would provide a better understanding of the seasonal dynamics and the impact of climate change on grasshopper diversity and distribution (Hughes, 1986). These approaches would further contribute to a more comprehensive understanding of grasshopper ecology and their role in the broader ecosystem**.**

Conclusion

This detailed morphological analysis provides an in-depth examination of the grasshopper species from the Malakand region, Pakistan. The characteristics outlined above—such as body size, coloration, head shape, leg structure, and wing morphology—serve as essential identifiers for each species. The accompanying figures (described for each species) offer clear visual representation of these traits, which can aid in accurate identification and differentiation among species. The morphological diversity observed within this group highlights the ecological importance of grasshoppers in the region and sets the stage for further studies on their behavior, ecological roles, and distribution patterns. Future research should include molecular analysis and seasonal monitoring to expand our understanding of grasshopper populations in Malakand.

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