Studies on Taxonomy, Distribution, Ecology and Behaviour of Grasshoppers (Insecta: Orthoptera) in Nanda Devi Biosphere Reserve, Western Himalayas, India

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ABSTRACT: Present investigations were undertaken to know taxonomy, ecology and behaviour of Grasshoppers in the Nanda Devi Biosphere Reserve (NDBR), Western Himalayas, India. 1,269 specimens were collected from different locations of NDBR and a total of ten species of Grasshoppers (Insecta: Orthoptera) belonging to two families under six sub-families were recorded during the study period. Acrididae was the dominant family with six species and Tettigonidae with four species. The present study provides information on diagnostic features, morphometry, distribution, ecology and behaviour of Grasshoppers which identified up to species level in the Nanda Devi Biosphere Reserve.

Keywords: Acrididae, Behaviour, Distribution, Ecology, Family, Grasshoppers, Orthopteran, Species.

INTRODUCTION

Orthoptera are common in terrestrial ecosystem and they are found in different diverse ecosystem from sea level to high altitude of Himalayan hills (Bhowmik and Rui, 1982). Grasshoppers are an essential components of both, healthy, and disturbed grassland ecosystems. These insects are abundant in natural and anthropogenic habitats (Latchininsky et al., 2011). They stimulate plant growth, participate in nutrient cycling and play important role in food chains (Stebaev, 1972; Hewitt and Onsager, 1982; Olforth and Mukerji, 1983; Sergeev, 1989 and Belovsky, 2000). Some grasshoppers are proposed as ecological indicators of ecosystem qualities and efficacy of ecological networks (Bazelet, 2011). Ecological observations on grasshoppers at Solan, Himachal Pradesh, India have carried out by Julka et al. (1982). A considerable amount of work on Indian grasshoppers has been carried out by different scientists in detail (Uvarov, 1921a & 1921b; 1924; 1927 & 1942; Stal, 1860; 1873a & 1873b; Walker, 1870 &1871; Saussure, 1884 & 1888 and Bolivar, 1902 & 1912). Similarly, in past few decades Bhowmik (1985), Shishodia (1987; 1997 & 1999), Tandon and Shishodia (1976a; 1976b; 1976c & 1977), Usmani and Shafee (1983; 1984 & 1990), Bhowmik (1990), Kumar and Viraktamath (1991), Muralirangan et al. (1992), Hazara et al. (1993), Priya and Narendran (2003), Kulkarni and Shishodia (2004 & 2005) and Usmani (2005) have contributed works on the taxonomy of this group. In a more recent study, Usmani et al. (2010), Usmani et al. (2011), Usmani and Nayeem (2012), Kumar and Usmani (2012a & 2012b), Kumar and Usmani (2014) and Kumar and Usmani (2015) studied the Indian Acrididae. Similarly, Tandon and Shishodia (1995), Shishodia (1997) and Arya and Dayakrishna (2014) worked on orthopteran fauna of Western Himalayas, India. Studies on the distribution of Orthopteran insects in different parts of the world have been carried out by (Kirby, 1914a & 1914b; Uvarov, 1921, 1929 & 1941; Tinkham, 1935 & 1940; Chopard and Chatterjee, 1937; Sansdrasagara, 1950; Roonwal et al., 1951; Willems, 1951; 1956 & 1957; Usman and Puttarudraiah, 1955; Dirsh, 1956; Browne, 1968; Tandon, 1972; Ritchie, 1982; Shishodia, 1991; Tandon and Shishodia, 1995; Shishodia, 1997; Sigfrid and Shishodia, 1998 and Mondal et al., 1999).

Body size is an important feature of organisms because it strongly correlates with numerous ecological, physiological and life history traits and influence fecundity, fitness and speciation (Peters, 1983). Morphometric characters of orthopterans has been studied on few occasions by Bhowmik (1990), Lehmann and Lehmann (2008), Kanuch and Kristin (2009) and Usmani and Nayeem (2012). Similarly, morphological characters of grasshoppers has been studied on few occasions by Dirsh (1961), Mani (1968), Tandon (1976), Ritchie (1981), Bhowmik (1985 & 1990), Shishodia (1993), Sigfrid and Shishodia (1998) and Mondal et al. (1999).
However, not so much attempts have so far been carried out to study the morphometric characters, ecology and behaviour of Grasshoppers in the Nanda Devi Biosphere Reserve, Western Himalayas. Therefore, keeping in view, the morphometry, diagnostic features, distribution, ecology and behaviour of grasshoppers was carried out in the present investigation.

MATERIAL AND METHODS

Study area: About 1,269 specimens of grasshoppers were collected from various locations of buffer zone of Nanda Devi Biosphere Reserve (NDBR). NDBR is located in the northern part of west Himalaya and spread in three districts of the newly carved state of Uttarakhand, namely Chamoli district in Garhwal Himalayas, Bageshwar and Pithoragarh districts in Kumaun Himalayas.

Grasshopper sampling: The insects were collected by “Sweep Sampling Method”, as per Gadagkar et al. (1990). The net sweeps were carried to collect the insects. The net used in systematic sweeping were made of thick cotton cloth with a diameter of 30 cm at mouth and a beg length of 60 cm. The collected Orthopteran insects were transferred into jars containing Ethyl Acetate (CH₃COOCH₃) soaked cotton. These jars were brought to the laboratory and the insects were stretched and pinned. The entomological pin number 1to 20 were used according to the size of the specimen. These were oven dried at 60°C for 72 hours to preserve them and then set in to wooden boxes and labelled according to their systematic position.

Preparations for morphological studies: Dry mount were also prepared for better understanding of certain characters like body size, colour, texture etc. For this purpose, the specimens were first relaxed, stretched and later they were pinned and labelled properly. Permanent collections of pinned specimens were kept in boxes and cabinets for further studies on their morphological structures.

Preparations for genitalia studies: For a detailed study of the various components of genitalia, permanent slides were prepared and examined under a microscope in order to conduct a detailed study of genitalic structures. Drawings were initially made with the help of camera lucida. Detailed were filled in by conventional microscope examination.

Measurement of morphometric characters of grasshoppers: Different morphometric characters of Orthopteran insects were measured by adopting the methods of Kanuch and Kristin (2009).

RESULTS

The diagnostic features, morphometry, distribution, ecology and behaviour of Grasshoppers species which identified up to species level during the present study have been given below:

1. **Xenocatontops karnyi** Kirby: This species belong to family Acrididae and subfamily Catantopinae of order Orthoptera.


   **Morphometry (length in cm.):**
   - **Male:** Body 2.1, Antenna 0.7, Tegmena 1.9, Hind wing 2.0, Hind femur 1.2 and Tibia 0.9.
   - **Female:** Body 2.8, Antenna 0.8, Tegmena 2.0, Hind wing 2.2, Hind femur 1.4 and Tibia 1.1.

2. **Paraconophyma scabra** Walker: This species belongs to family Acrididae and subfamily Catantopinae of order Orthoptera.


   **Morphometry (length in cm.):**
   - **Male:** Body 1.9, Antenna 0.6, Hind femur 0.8 and Tibia 0.6.
   - **Female:** Body 2.1, Antenna 0.8, Hind femur 0.9 and Tibia 0.8.

   **Distribution:** During the study period, Paraconophyma scabra Walker was collected from Western part of Nanda Devi Biosphere Reserve, India. The species has also been reported from Himachal Pradesh, Karnataka, Maharastra, Rajasthan, Tamil Nadu, Uttarakhand (Nainital, Mussoorie) and West Bengal (Shishodhia, 1997).

**Ecology and Behaviour:** It occurs in mountainous areas up to 3000m in India. It is found in Alpine meadows, croplands and feeds upon grasses Apluda mutica L., Cynodon dactylon L. and tender leaves of different crops and shrubs.

3. **Paraconophyma gracilis** A. L. & Badoni: This species occurs in high altitude area up to 3500m. The species feeds upon ground vegetation such as Thalictrum pauciflorum Royle, Urtica dioica L. and Apluda mutica L.
3. *Oedipoda himalayana* Uvarov: This species belongs to family Acrididae and subfamily Oedipodinae of order Orthoptera.

**Diagnostic features:** Head large, pronotum short. Face bent downwards. Tegmina long, and mottled grey, black and white in colour. Hind wing bright red. Hind tibia bright red or orange yellow. Male smaller than female.

**Morphometry (length in cm.):**

**Male:** Body 1.8, Antenna 0.7, Tegmena 1.8, Hind wing 2.0, Hind femur 1.5 and Tibia 1.4. **Female:** Body 2.1, Antenna 0.9, Tegmena 2.1, Hind wing 2.2, Hind femur 1.7 and Tibia 1.6.

**Distribution:** *Oedipoda himalayana* Uvarov was collected from Western part of Nanda Devi Biosphere Reserve, India during the study period. The genus has also been reported from Kashmir and Gujarat in India and Pakistan, Sudan, Ethiopia and Somalia in the world. Although the distribution covers such a wide area, it is very discontinuous and consists really of several more or less isolated areas coinciding with system of old eroded mountains fringing the deserts of the Eremian zone (Uvarov, 1941).

**Ecology and Behaviour:** It occurs on stony ground and was mainly found on lichen covered rocks. When it takes short flight it is conspicuous because of its bright red hind wings and loud crepitating, but on landing it suddenly disappears. It lives among short grasses, *Artimisia* sp., *Apluda matica* L. and dry stony or rocky places. It has been found up to 3000m in Western Himalaya. In India it damages young *Pinus longifolia* seedlings, eating the needles and biting through the stem (Beeson, 1941).

4. *Gastrimargus transversus* Thun.: This species belongs to family Acrididae and subfamily Oedipodinae of order Orthoptera.

**Diagnostic features:** Green in colour, antennae reddish. Behind eye a pale spot runs to the back of the head. Abdomen greenish. Tegmina long and narrow. The inner margin of tegmena green, the rest of tegmena brown. Hind wing, shorter than tegmina. Hind femur long and cylindrical, out portion green and inner portion yellowish and spotted. Hind tibia red. Male size smaller than female.

**Morphometry (length in cm.):**

**Male:** Body 2.2, Antenna 1.2, Tegmena 2.1, Hind wing 2.2, Hind femur 1.5 and Tibia 1.4. **Female:** Body 2.6, Antenna 1.6, Tegmena 2.2, Hind wing 2.3, Hind femur 1.8 and Tibia 1.5.

**Distribution:** *Gastrimargus transversus* Thun. was collected from Western part of Nanda Devi Biosphere Reserve, India. The species has also been reported from Assam in India and Burama, Hongkong, Korea, Japan, Taiwan, Thailand, Vietnam, Malaysia, Singapore, Sumatra, Java and West Iran in the world (Ritchie, 1982).

**Ecology and Behaviour:** In the forest, it was found on tall grasses. This species is also found in agricultural land on mountain slopes. *Cynodon dactylon* (L.) Pers and *Apluda matica* L. are favoured grasses of both hoppers and adults.

5. *Aulacobothrus luteipes* Walker: This species belongs to family Acrididae and subfamily Gomphocerinae of order Orthoptera.


**Morphometry (length in cm.):**

**Male:** Body 1.4, Antenna 0.6, Tegmena 1.2, Hind wing 1.6, Hind femur 0.9 and Tibia 0.6. **Female:** Body 1.8, Antenna 0.7, Tegmena 1.5, Hind wing 1.9, Hind femur 1.1 and Tibia 0.9.

**Distribution:** The species *Aulacobothrus luteipes* Walker, was collected from Western Part of Nanda Devi Biosphere Reserve, India. The species has also been reported from Tamil Nadu, Karnataka, Maharashtra, Kashmir, Himachal Pradesh and Assam in India and Pakistan, Nepal, Sri Lanka, Burma, Thailand and South China in the world (Uvarov, 1921a, 1921b and 1929; Tinkham, 1935; Sansdrasagara, 1950; Roonwal et al., 1951; Willemsse, 1951; Usman and Putturudraiah, 1955 and Browne, 1968).

**Ecology and Behaviour:** The species was found on grasses in Western Part of Nanda Devi Biosphere Reserve, India at an altitude of 2000 to 3500m. Species feeds upon mixed grasses. It has recorded as a minor pest on the foliage of Teak in India (Beeson, 1928).

6. *Spastosternum pr. prasiniferum* (Walker): This species belongs to family Acrididae and subfamily Hemiacridinae of order Orthoptera.

**Diagnostic features:** Body cylindrical, head shorter than pronotum. Mouth parts projecting downwards. Antennae filiform shorter than pronotum. Prozona longer than metazona. A dark brown band behind eye, running along pronotum and tegmena. Cerici short and conical. In females, anterior ovipositor valves long hook like. Body colour green. Tegmena brown or green. The middle areas of tegmena are with black and brown patches. Hind femur and tibia green. Males are smaller than females.

**Morphometry (length in cm.):**

**Male:** Body 1.6, Antenna 0.7, Tegmena 1.6, Hind wing 1.6, Hind femur 1.1 and Tibia 1.0. **Female:** Body 1.9, Antenna 0.8, Tegmena 1.8, Hind wing 1.8, Hind femur 1.3 and Tibia 1.1.

**Distribution:** *Spastosternum pr. prasiniferum* (Walker) was collected from Western Part of Nanda Devi Biosphere Reserve, India at an altitude of 2000 to 2500 m. The species has also been reported from other parts of Uttarakhand, Assam, Bihar, Goa, Karnataka, Kamir, Manipur, Orissa, Rajasthan, Tamil Nadu, West Bengal and Uttar Pradesh in India and Bangladesh, Sri Lanka, Burma, Thailand, Vietnam, China and West Malaysia in the world (Chopard and Chatterjee, 1937; Tinkham, 1940; Willemsse, 1956 and Mondal et al., 1999).
Ecology and Behaviour: It was found on short grasses. Its normal food plants are various succulent grass weeds specially grass, *Cynodon dactylon* L. It was also found in crop lands. The species feeds upon broad leaved plants when grasses are not available. In India it was also observed that the species feeds upon teak leaves and shoots and seedlings of *Pinus roxburghii* (Beeson, 1928 and 1941).

7. *Himertula kinneari* Uvarov: This species belongs to family Tettigonidae and subfamily Phaneropterinae of order Orthoptera.

**Diagnostic features:** Pronotum long narrow. Mouth parts directed backwards. Antennae located below the middle of eyes. Tegmen narrow, reaching apical part of subgenital plate, cylindrical and strongly curved at base. Body colour generally yellowish brown.

**Morphometry (length in cm.):**
- **Male:** Body 2.1, Tegmen 1.4, Hind wing 1.6, Hind femur 1.7.
- **Female:** Body 1.5, Tegmen 1.5, Hind wing 1.8, Hind femur 1.9.

**Distribution:** This species, *Himertula kinneari* Uvarov was collected from Western part of Nanda Devi Biosphere Reserve, India. It has also been reported from North India and the Himalaya (Shishodia, 1991 and Tandon and Shishodia, 1995).

**Ecology and Behaviour:** It occurs in high altitude area up to 2500m in India. It was found on tall grasses and feeds upon *Apluda mutica* L. and tender leaves of herbs and shrubs.

8. *Letana linearis* Walker: This species belongs to family Tettigonidae and subfamily Pnaneropteriane of order Orthoptera.

**Diagnostic features:** Antennae located below the eyes. Paired ocelli placed below the middle of eyes. Biting and chewing mouth parts directed backwards. Pronotum extended beyond the apex of hind femora. Tegmina longer than hind wing. Medium size and brown in colour.

**Morphometry (length in cm.):**
- **Male:** Body 1.4, Tegmen 1.8, Hind wing 1.9, Hind femur 1.6 and Tibia 2.1.
- **Female:** Body 1.9, Tegmen 1.9, Hind wing 1.8, Hind femur 1.6 and Tibia 1.8.

**Distribution:** This species, *Letana linearis* Walker was collected from Western part of Nanda Devi Biosphere Reserve, India during the study period. The species has also been reported from North-East India (Tandon and Shishodia, 1995).

**Ecology and Behaviour:** *Letana linearis* Walker was found in Western part of Nanda Devi Biosphere Reserve, India at an altitude of 2000 to 2400m. It feeds grasses *Artemisia* sp. and *Apluda mutica* L.

9. *Phaneroptera gracilis* Burmeister: This species belongs to family Tettigonidae and subfamily Phaneropterinae of order Orthoptera.

### Table 1: Measurement (Cm.) of Different Species of Grasshopper Recorded from Study Area During The Study Period.

<table>
<thead>
<tr>
<th>Taxon (Order: Orthoptera)</th>
<th>Length of Body</th>
<th>Length of Antenna</th>
<th>No. of Segment</th>
<th>Length of Tegmen</th>
<th>Length of Hind Wing</th>
<th>Length of Hind Femur</th>
<th>Length of Tibia</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAMILY: ACRIDIDAE</td>
<td>M  F</td>
<td>M  F</td>
<td>M  F</td>
<td>M  F</td>
<td>M  F</td>
<td>M  F</td>
<td>M  F</td>
</tr>
<tr>
<td>Xenocatantops karnyi</td>
<td>2.1 2.8</td>
<td>0.7 0.8</td>
<td>24 26</td>
<td>1.9 2.0</td>
<td>2.0 2.2</td>
<td>1.2 1.4</td>
<td>0.9 1.1</td>
</tr>
<tr>
<td>Paraconophylma scabra</td>
<td>1.9 2.1</td>
<td>0.6 0.8</td>
<td>21 23</td>
<td>---</td>
<td>------</td>
<td>---</td>
<td>----</td>
</tr>
<tr>
<td>Oedipoda himalayan</td>
<td>1.8 2.3</td>
<td>0.7 0.9</td>
<td>22 23</td>
<td>1.8 2.1</td>
<td>2.0 2.2</td>
<td>1.5 1.7</td>
<td>1.4 1.6</td>
</tr>
<tr>
<td>Gastrimargus transversus</td>
<td>2.2 3.6</td>
<td>1.2 1.4</td>
<td>26 27</td>
<td>2.1 2.2</td>
<td>2.3 2.4</td>
<td>1.5 1.8</td>
<td>1.4 1.5</td>
</tr>
<tr>
<td>Aulacobothrus luteipennis</td>
<td>1.4 1.8</td>
<td>0.6 0.7</td>
<td>23 24</td>
<td>1.2 1.5</td>
<td>1.6 1.9</td>
<td>0.9 1.1</td>
<td>1.0 0.9</td>
</tr>
<tr>
<td>Spathostenum prasiniferum</td>
<td>1.6 1.9</td>
<td>0.7 0.8</td>
<td>23 24</td>
<td>1.6 1.8</td>
<td>2.0 2.2</td>
<td>1.1 1.3</td>
<td>1.0 1.1</td>
</tr>
<tr>
<td>FAMILY: TETTIGONIDAE</td>
<td>M  F</td>
<td>M  F</td>
<td>M  F</td>
<td>M  F</td>
<td>M  F</td>
<td>M  F</td>
<td>M  F</td>
</tr>
<tr>
<td>Himertula kinneari</td>
<td>2.1 1.5</td>
<td>---</td>
<td>---</td>
<td>1.4</td>
<td>1.5 1.6</td>
<td>1.8 1.7</td>
<td>1.9 1.9</td>
</tr>
<tr>
<td>Letana linearis Walker</td>
<td>1.4 1.9</td>
<td>---</td>
<td>---</td>
<td>1.8</td>
<td>1.9 1.8</td>
<td>1.8 1.6</td>
<td>2.1 1.8</td>
</tr>
<tr>
<td>Phaneroptera gracilis</td>
<td>1.7 2.2</td>
<td>2.8 3.1</td>
<td>138 142</td>
<td>1.9 2.1</td>
<td>2.9 3.1</td>
<td>2.3 2.4</td>
<td>2.2 2.3</td>
</tr>
<tr>
<td>Conocephalus maculatus</td>
<td>1.2 2.3</td>
<td>4.2 4.4</td>
<td>162 167</td>
<td>1.8</td>
<td>1.9 2.1</td>
<td>1.2 1.4</td>
<td>1.3 1.5</td>
</tr>
</tbody>
</table>

(Abbreviation: F= Female, M= Male)
Diagnostic features: Head not exerted above the pronotal surface. Antennae situated below the eyes. Pronotum extending beyond the apex of posterior femora. Tegmina shorter than hind wing. Wing extending up to the apex of pronotum. It is of medium size and green in colour.

Morphometry (length in cm.):
Male: Body 1.7, Antenna 2.8, Tegmina 1.9, Hind wing 2.9, Hind femur 2.3 and Tibia 2.2.
Female: Body 2.2, Antenna 3.1, Tegmina 2.1, Hind wing 3.1, Hind femur 2.4 and Tibia 2.3.

Distribution: This species, Conocephalus maculatus, was collected from Western part of Nanda Devi Biosphere Reserve, India during the study period. It has also been reported from Kashmir and Sikkim in India and Burma (Sigfrid and Shishodia, 1998).

Ecology and Behaviour: It occurs in high altitude area of Western part of Nand Devi Biosphere Reserve, India at an altitude of 2000 to 2500m. Species feeds upon mixed grasses Apluda mutica L., Artemisia sp. and herbs.

10. Conocephalus maculatus Le Guillou: This species belongs to family Tettigoniidae and subfamily Conocephalinae of order Orthoptera.

Diagnostic features: Vertex very little wider than an eye. Antennae situated below the middle of eyes. Frontal costa bifurcates behind the paired ocelli. Wing extended up to the apex of pronotum. Upper margin of hind femora brown and lower margin whitish in colour. Grasshopper is of medium size and light brown in colour.

Morphometry (length in cm.):
Male: Body 1.2, Antenna 4.2, Tegmina 1.8, Hind wing 1.9, Hind femur 1.2 and Tibia 1.3. Female: Body 2.3, Antenna 2.3, Tegmina 1.9, Hind wing 2.1, Hind femur 1.4 and Tibia 1.5.

Distribution: Conocephalus maculatus Le Guillou was collected from Western part of Nanda Devi Biosphere Reserve, India during the study period. The species has also been reported from other parts of Uttarakhand, Orissa, Tripura, West Bengal in India and Indonesia, Moluccas, China (Hong Kong), Philippines Island, Malaya and Singapore in the world (Shishodia, 1991; 1997 and Sigfrid and Shishodia, 1998).

Ecology and Behaviour: It occurs at an altitude of 2000 to 2400m in Western part of Nanda Devi Biosphere Reserve, India. It was found on grasses, its normal food plants are Cynodon dactylon L., Apluda mutica L. and tender leaves of herbs.

Measurement of morphometric characters i.e. body length, antennae, tegmena, hind wing, hind femur and tibia of male and female species of Grasshoppers reported from Nanda Devi Biosphere Reserve are presented in Table 1. The morphological characters of different species of grasshoppers recorded during the present study, showed no marked variation from the descriptions of earlier workers, Dirsh (1961), Mani (1968), Tandon (1976), Ritchie (1981), Bhowmik (1985), Shishodia (1993), Sigfrid and Shishodia (1998) and Mondal et al. (1999).

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