Biological Forum – An International Journal **7**(2): 591-598(2015)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

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

***Manoj Kumar Arya*[*], *Prakash Chandra Joshi*[**] *and Vinod Prasad Badoni*[**]**

[*]*Insect Biodiversity Laboratory, Department of Zoology,*
D.S.B. Campus, Kumaun University, Nainital, (Uttarakhand), India
[**]*Insect Biodiversity Laboratory, Department of Zoology and Environmental Science,*
Gurukul Kangri University, Haridwar, (Uttarakhand), India

(Corresponding author: Manoj Kumar Arya)
(Received 28 June, 2015, Accepted 01 August, 2015)
(Published by Research Trend, Website: www.researchtrend.net)

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

Orthopterans 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; Olfert 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 Virktamath (1991a), 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 Acididae. 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; Willemse, 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), Lehmannn 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 ($CH_2COOC_2H_5$) 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^oC 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.

Diagnostic Features: Body cylindrical and elongated. Head moderately shorter than pronotum. Mouth parts directed downwards (Hypoganathous head). Antennae filliform reaching up to the end of pronotum. Prozona slightly shorter than metazona. Female larger than male and more elongated. Anterior ovipositor valves short. Subgenital plate elongated. Body colour dark brown, head and pronotum pale brown. Yellow strip behind eye, crossing the pronotal lateral Iobe. Hind femur yellowish with two black bands. Hind tibia red.

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.

Distribution: In the present study *Xenocatantops karnyi* Kirby was collected from western part of Nanda Devi Bioshere Reserve, India. The genus has also been reported from Assam, West Bengal, Kerala, Tamil Nadu, Madhya Pradesh, Arunachal Pradesh and Uttarakhand in India and Burma, Thailand, Malaysia, Vietnam, Philipines and Indonasia in the world (Kirby, 1914a & 1914b, Dirsh, 1956, Willemse, 1957, Tandon, 1972).

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 dectylon* L. and tender leaves of different crops and shrubs.

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

Diagnostic feature: Body cylindrical. Antennae filliform. Head shorter than pronotum. Tegmena and wing absent. Body colour black but pronotum slightly brownish. Front and middle legs short, hind legs long. The cerci usually form claspers but not flat and leaf like.

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 (Shishodia, 1997).

Ecology and Behaviour: It occurs in high altitude area upto 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. Tegmena 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 mutica* 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 sub family 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. Tegmena long and narrow. The inner margin of tegmena green, the rest of tegmena brown. Hind wing, shorter than tegmina. Hind femur long and cylinderical, 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 dectylon* (L.) Pers and *Apluda mutica* 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.

Diagnostic features: Small and brown in colour. Vertex triangular and pointed, antennae filiform. A pale medium band running from fastigium to pronotum and long closed tegmina. A dark area below head and pronotum. Hind femora above distinctly spotted. Hind tibia red. Cerci short, conical valves of the ovipositor short projecting. Male size smaller than female.

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; Willemse, 1951; Usman and Puttarudraiah, 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. *Spathosternum 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 famales, anterior ovipostitor 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: *Spathosternum pr. prasinferum* (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, Kahmir, 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; Willemse, 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 Pheneropterinae 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 post femur. Hind wings projecting and just surpassing hind knees. Cerci long, surpassing apex of subgenital plate, cylindrical and strongly curved at base. Body colour generally yellowish brown.

Morphometry (length in cm.):

Male: Body 2.1, Tegmena 1.4, Hind wing 1.6, Hind femur 1.7.

Female: Body 1.5, Tegmena 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 upto 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 short than hind wing. Medium size and brown in colour.

Morphometry (length in cm.):

Male: Body 1.4, Tegmena 1.8, Hind wing 1.9, Hind femur 1.8 and Tibia 2.1.

Female: Body 1.9, Tegmena 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 Noth-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* Bur.: 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.

Taxon (Order: Orthoptera)	**Length of Body**		**Length of Antennae**		**No. of Segment**		**Length of Tegmena**		**Length of Hind Wing**		**Length of Hind Femur**		**Length of Tibia**		
	M	F	M	F	M	F	M	F	M	F	M	F	M		F
FAMILY: ACRIDIDAE															
Xenocatantops karnyi Kirbry	2.1	2.8	0.7	0.8	24	26	1.9	2.0	2.0	2.2	1.2	1.4	0.9		1.1
Paraconophyma scabra Walk.	1.9	2.1	0.6	0.8	21	23	----	-----	-----	----	0.8	0.9	0.6		0.8
Oedipoda himalayan Uvarov	1.8	2.3	0.7	0.9	22	23	1.8	2.1	2.0	2.2	1.5	1.7	1.4		1.6
Gastrimargus transversus Thun.	2.2	3.6	1.2	1.4	26	27	2.1	2.2	2.3	2.4	1.5	1.8	1.4		1.5
Aulacobothrus luteips Walk.	1.4	1.8	0.6	0.7	23	24	1.2	1.5	1.6	1.9	0.9	1.1	0.6		0.9
Spathostenum pr. prasiniferum Walk.	1.6	1.9	0.7	0.8	23	24	1.6	1.8	2.0	2.2	1.1	1.3	1.0		1.1
FAMILY: TETTIGONIDAE															
Himertula kinneari Uvarov	2.1	1.5	----	-----	----	----	1.4	1.5	1.6	1.8	1.7	1.9	-----		-----
Letana linearis Walker	1.4	1.9	----	-----	----	----	1.8	1.9	1.9	1.8	1.8	1.6	2.1		1.8
Phaneroptera gracilis Burmeister	1.7	2.2	2.8	3.1	138	142	1.9	2.1	2.9	3.1	2.3	2.4	2.2		2.3
Conocephalus maculatus Le Guillow	1.2	2.3	4.2	4.4	162	167	1.8	1.9	1.9	2.1	1.2	1.4	1.3		1.5

(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. Tegmena shorter than hind wing. Wing extending upto the apex of pronotum. It is of medium size and green in colour.

Morphometry (length in cm.):

Male: Body 1.7, Antenna 2.8, Tegmena 1.9, Hind wing 2.9, Hind femur 2.3 and Tibia 2.2.

Female: Body 2.2, Antenna 3.1, Tegmena 2.1, Hind wing 3.1, Hind femur 2.4 and Tibia 2.3.

Distribution: This species, *Phaneroptera gracilis* Bur. 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 Tettigonidae and subfamily Cononcephalinae 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 upto 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, Tegmena 1.8, Hind wing 1.9, Hind femur 1.2 and Tibia 1.3. **Female:** Body 2.3, Antenna 2.3, Tegmena 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 Indonasia, 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 dectylon* 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).

ACKNOWLEDGEMENTS

The authors would like to thank Ministry of Environment and Forests, Govt. of India for providing financial support for this study. Thanks are due to scientists of Northern Regional Station, Zoological Survey of India and Forest Research Institute, Dehradun for their cooperation in identifying grasshopper species.

REFERENCES

Arya, M. K. and Dayakrishna. (2013). Community dynamics and secondary productivity of Grasshoppers (Insecta: Orthoptera) in a high altitude forest ecosystem in the Kumaun Himalayas, India. *Annals of Forestry*, **21**(2): 237-245.

Bazelet, C.S. (2011). Grasshopper bioindicators of effective large-scale ecological networks, Ph.D. Dissertation, Department of Conservation Ecology and Entomology, Stellenbosch University, South Africa.

Beeson, C.F.C. (1928). The defoliation of teak. *Ind. For*., **54**: 204-205.

Beeson, C.F.C. (1941). The Ecology and control of the forest insects of India and neighboring countries. Vasant Press, Dehradun 1007pp.

Belovsky, G.E. (2000). Do grasshoppers diminish grassland productivity? A new perspective for control based on conservation", in Grasshoppers and Grassland Health. *Managing Grasshopper Outbreaks without Risking Environmental Disaster*, J.A. Lochwood, Latchininsky, A.V. and Sergeev, M.G. Eds., pp. 7-30, Kluwer Academic Publishers, Dordrecht, Netherlands.

Bhowmik H.K. (1990). Indian species of the genus *Aulacobothrus bolivar* (Orthoptera: Acrididae). *Rec. Zool. Surv. India*, **86**(3&4): 413-423.

Bhowmik, H.K. and Rui, K.N. (1982). Note on collection of grasshoppers (Orthoptera: Acrididae) from Shivalik hills. *Ind. Museum Bull.*, **17**: 48-54.

Bhowmik, H.K. (1985). Outline distribution with an index catalogue of Indian Grasshoppers (Orthoptera: Acrididae). Part I. Subfamily Acridinae, Truxalinae, Gomphocerinae and Oedipodinae. *Rec. Zool. Surv. India, Occ. Paper*, **78**: 1-47.

Bhowmik, H.K. (1985). Outline of distribution with an index-Catalogue of Indian Grasshoppers (Orthoptera: Acrididae). Part I. Subfamilies – Acridinae, Truxalinae, Gomphocerinae and Oedipodinae. *Records of the Zoological Survey of India Misc Publ.*, 1985; **78**: 1-51.

Bolivar, I. (1902). Les Orthopteres de St Joseph's College a Trichinopoly (Sud de 1' Inde). 3me partie. *Ann Soc Ent Fr* 1902; **70**: 580-635.

Bolivar, I. (1912). Estudios Entomologicos. Trab. Mus. Cenc. Nat Madr, Zool Ser., **4**: 62.

Browne, F.G. (1968). Pests and disease of forest plantation an annotated list of the principal species occurring in the British common wealth. Oxford, Clarendon Press XII+1330pp.

Chopard, L. and Chatterjee, N.C. (1937). Entomological investigstion on the spike disease of sandal: Dermentera and Orthoptera. *Ind. For. Res. (Ent.),* **3**(1): 30pp.

Dirsh, V.M. (1956). Preliminary revision of the genus *Catantops* Schaum and review of the group Catantopini (Orthoptera: Acrididae). *Publcoes Cul. Co. Diam. Angola*., **28**: 11-151.

Dirsh, V.M. (1961). Preliminary revision of the families subfamilies of Acridoidea (Insecta: Orthoptera). *Bull. Br. Mus. Nat. (Ent.),* **9**: 349-419.

Gadagakar, R., Chandrashaekara, K. and Nair, P. (1990). Insect species diversity in the tropics: Sampling method and case study. *Journal of Bombay Natural History Society*, **87**(3): 328-353.

Hazra, A.K., Tandon, S.K., Shishodia, M.S., Dey, A. and Mandal, S.K. (1993). Insecta: Orthoptera: Acridoidea. State Fauna Series, 3: Fauna of West Bengal, Part 4, Zool Surv India, 287-354.

Hewitt, G.B. and Onsager, J.A. (1982). A method for forecasting potential losses from grasshopper feeding on northern mixed prairie forages. *Journal of Range Management*, **35**: 53-57.

Julka, J.M., Tanton, S.K., Haldar, P. and Shishodia, M.S. (1982). Ecological observation on Grasshopper (Orthoptera: Acidoidea) at Solan, Himanchal Pradesh. *Oriental Insects*, **16**(1): 63-75.

Kanuch, P. and Kristin, A. (2009). Somatic and population adaptations of *Polysarcus denticauda* (Orthoptera) in extreme altitudes. *Entomologica Fennica*, **20**: 207-214.

Kirby, W.F. (1914a). The fauna of British India, including Ceylon and Burma Orthoptera (Acrididae) London, Taylor and Francis IX+266pp.

Kirby, W.F. (1914b). The Fauna of British India, including Ceylon and Burma. Orthoptera (Acrididae). Ix +276, London.

Kulkarni, P.P. and Shishodia, M.S. (2004). Insecta: Orthoptera Fauna of Pench National Park. *Conservation Area Series*, **20**: 207-225.

Kulkarni, P.P. and Shishodia, M.S. (2005). Insecta: Orthoptera Fauna of Melaghat Tiger Reserve. *Conservation Area Series*, **24**: 317-340.

Kumar, H. and Usmani, M.K. (2012a). A Checklist of Acrididae (Orthoptera: Acridoidea) of Himachal Pradesh. *Advances in Life Sciences*, **1**(2): 162-163.

Kumar, H. and Usmani, M.K. (2012b). A Checklist of Acridoidea (Orthoptera) of Punjab, India. *J. Ent. Res.*, **36**(2): 173-175.

Kumar, H. and Usmani, M.K. (2014). Taxonomic studies on Acrididae (Orthoptera: Acridoidea) from Rajasthan (India). *Journal of Entomology and Zoology Studies*, **2**(3): 131-146.

Kumar, H. and Usmani, M.K. (2015). Taxonomic studies on Acrididae (Orthoptera: Acridoidea) from Punjab (India). *International Journal of Fauna and Biological Studies*, **2**(2): 38-58.

Kumar, P. and Virktamath, C.A. (1991a). Illustrated keys for identification of common species of short horned grasshoppers (Orthoptera: Acridoidea) of Karnataka and notes on their ecology and behaviour. *Hexapoda*, **3**(1&2): 53-70.

Kumar, P. and Virktamath, C.A. (1991b). Taxonomic significance of the male genitalia (Epiphallus) of some species of short horned grasshoppers (Orthoptera: Acridoidea). *J. Bombay Nat. Hist. Soc.*, **88** (2): 200-209.

Latchininsky, A., Sword, G., Sergeev, M., Cigliano, M. M. and Lecoq, M. (2011). Locusts and Grasshoppers: Behavior, *Ecology and Biogeography*. *Psyche*, pp.4. DOI: 10.1155/2011/578327.

Lehmann, G.U.C. and Lehmann, A.W. (2008). Variation in body size among populations of the bushcricket *Poecilimon thessalicus* (Orthoptera: Phaneropteridae): An ecological adaptation? *Journal of Orthoptera Research*, **17**(1): 1-5.

Mani, M.S. (1968). Ecology and Biogeography of high altitude insects. The Huage. Dr. W. Junk B.V. Publishers 1-524pp.

Mondal, S.K., Hazra, A.K. and Tandon, S.K. (1999). Studies on Taxonomy, Biology and Ecology of Grasshoppers Infesting Field Crops and Vegetables with notes on Nymphal Taxonomy of some species in West Bengal. *Records of the Zoological Survey of India, Occasional Paper*, **173**: 1-178.

Muralirangan, M.C., Shrinivasan, C. and Suresh, P. (1992). Studies on short horned grasshoppers (Acridoidea) of Tamil Nadu. Part II. Catantopinae, Cyrtacanthacrinae, Coptacridinae, Eyprepocneminae and Hemiacridinae. *Hexapoda*, **4**(2): 149-166.

Olfert, O.O. and Mukerji, M.K. (1983). Effects of acute simulated and acute grasshopper (Orthoptera: Acrididae) damage on growth rates and yield in pring wheat (*Triticum aestivum*). *The Canadian Entomologist*, **115**(6): 629-639.

Peters, R.H. (1983). The Ecological Implications of Body Size. Cambridge University Press. Cambridge.

Priya, A.V. and Narendran, T.C. (2003). A key and a checklist of the genera of short horned grasshoppers (Orthoptera: Acridoidea) of Kerala. *Entomon*, **28**(3): 223-230.

Ritchie, J.M. (1981). A Taxonomic revision of the genus *Oedaleus* Fieber (Orthoptera: Acrididae). *Bull. Br. Mus. Nat. Hist. (Ent.),* **42**(3): 83-183.

Ritchie, J.M. (1982). A Taxonomic revision of the genus *Gatrimargus* Saussure (Orthoptera: Acrididae). *Bull. Br. Mus. Nat. Hist. (Ent.),* **44**: 239-329.

Roonwal, M.L., Bhasin, G.D. and Misra. S.D. (1951). A systematic catalogue of the main identified entomological collection at the Forest Research Institute, Dehradun. Part 5. Order: Orthoptera (continued) family Acrididae. *Ind. Forester*, **77**: 319-330.

Sandrasagara T.R. (1950). A catalogue of the named Ceylonese Tetrigidae, Eumastacidae and Acrididae (Insecta: Orthoptera) in the collection of the Colombo Museum, with records of distribution. *Rec. Indian Mus.*, **47**: 135-157.

Saussure, H.D.E. (1884). Prodromus Oedipodiorum, insectorum ex ordine Orthopterorum. *Mem. Soc. Phys. Geneve*. **28**: 1-256.

Saussure, H.D.E. (1888). Additamenta ad Prodromum Oedipodiorum. *Mem. Soc. Phys. Geneve*, 30: 1-182.

Sergeev, M.G. (1989). Zonal-landscape distribution of Orthoptera zoomass in Middle Region of the USSR. *Geographia i Prirodnyje Resursy*, **2**: 89-92.

Shishodia, M.S. (1987). Orthoptera Fauna of Assam. *State Fauna Series*, **1**: 91-102.

Shishodia, M.S. (1991). Taxonomy and Zoogeography of the Tetrigidae (Orthoptera: Tetrigidae) of North-Eastern India. *Rec. Zoological Survey of India, Occr. Paper*, **140**: VI+203pp.

Shishodia, M.S. (1993). Insecta: Orthoptera: Tettigonidae: State fauna series 3: Fauna of West Bengal, Part **4**: 179-226.

Shishodia, M.S. (1997). Orthoptera: Fauna of Conservation areas. *Fauna of Nanda Devi Biosphere Reserve*, Zoological Survey of India **9**: 49-53.

Shishodia, M.S. (1997). Orthoptera: Fauna of Delhi. Zool Surv India. *State Fauna Series*, **6**: 173-196.

Shishodia, M.S. (1999). Orthoptera: Fauna of Patalkot, Chhindwara, Madhya Pradesh, India. *Rec. Zool. Surv. India.*, **97**(4): 33-43.

Sigfrid I. and Shishodia M.S. (1998). New species and records of Tettigonidae from India (Ensifera). *Bulletin De La Societe Enromologique Suisse*, **71**: 355-371.

Stal, C. (1860). Orthoptera species, novas descripsit. Kongliga Svenska Fregatten Eugenies Resa omkring Jorden, **2**(1): 299-350.

Stal, C. (1873a). Orthoptera novas descripsit. Kongliga Vetenskaps-akademiens Forhandlingar, Stockholm, **30**(4): 39-53.

Stal, C. (1873b). Recensio Orthopterorum. Revue critique des Orthopteres decrits par Linne, De Geer et Thunber. Norstedt and Soner, Stockholm, **1**: 154.

Stebaev, I.V. (1972). "Periodic changes in the ecological distribution of grasshoppers in the temperate and the extreme continental steppe regions, and their importance for the local ecosystems". *Proceedings of the International Study Conference on the Current and Future Problems of Acridology*, pp. 207-213, Centre for Overseas Pest Research, London, UK.

Tandon, S.K. (1972). On the genus *Xenocatatops* Dirs and Uvarov (Orthoptera: Acridoidea). *Records of Zoological Survey India*, **67**: 59-64

Tandon, S.K. (1976). A check-list of the Acididae (Orthoptera) of india Part I Acrididae. *Records of Zoological Survey of India*, **3**: 1-49

Tandon, S.K. (1976). A Checklist of the Acridoidea (Orthoptera) of India. Part I Acrididae. *Rec. Zool. Surv. India, Occ.*, **3**:1-48.

Tandon, S.K. and Shishodia, M.S. (1969). On a collection of Acridoidea (Orthoptera) from Nagarjuna Sagar Dam Area. *Oriental Insects*, **3**(3): 265-267.

Tandon, S.K. and Shishodia, M.S. (1976a). On a collection of Acridoidea (Orthoptera) from Rajasthan, India. *Newsl. Zool. Surv. India*, **2**(1): 7-11.

Tandon, S.K. and Shishodia, M.S. (1976b). Acridoidea (Insecta: Orthoptera) collected on the bank of river Tawi (J& K), India. *Newsl. Zool. Surv. India*, **2**(2): 58-61.

Tandon, S.K. and Shishodia, M.S. (1976c). On a collection of Orthoptera (Insecta) from the Kanha National Park, Madhya Pradesh, India. *Newsl Zool. Surv. India*, **2**(6): 269-271.

Tandon, S.K. and Shishodia, M.S. (1977). The Acridoidea (Insecta: Orthoptera) of Goa. *Rec. Zool. Surv. India*, **72**: 295-307.

Tandon, S.K. and Shishodia, M.S. (1995). Orthoptera: Fauna of Western Himalaya, Zoological Survey of India, *Him. Ecos. Ser.*, **1**: 44-52.

Tinkham, E.R. (1935). Distribution and Ecological notes on Acrididae from Southeastern Kwangsi with a key to genus *Hieroglyphus. Lingon Sci. J.*, **14**: 477-498.

Tinkham, E.R. (1940). Taxonomic and Biological studies on the Cyrtacanthacrinae of South China. *Lingon Sci. J.*, **19**: 269-382.

Usman, S. and Puttarudraiah, M. (1955). A list of insects of Mysore including the mites. *Bull. Dep. Agri. Mysore (Ent.)*, **16**: 194pp.

Usmani, M.K. (2005). Taxonomic significance of female subgenital plate in some Indian grasshoppers (Orthoptera: Acridoidea). *J. Sebha Univ.*, **4**(1): 51-66.

Usmani, M.K. and Nayeem, M.R. (2012). Studies on taxonomy and distribution of Acridoidea (Orthoptera) of Bihar, India. *Journal of Threatened Taxa*, **4**(13): 3190-3204.

Usmani, M.K. and Shafee, S.A. (1983). A new genus and two new species of the subfamily Acridinae (Orthoptera: Acrididae) from India. *Bull. Soc. Ent. Suisse.*, **56**: 401-403.

Usmani, M.K. and Shafee, S.A. (1984). A new tribe of Oxyinae (Orthoptera: Acrididae). Bull. *Soc. Ent. Suisse.*, **57**: 295-296.

Usmani, M.K. and Shafee, S.A. (1990). Classification of Indian Acrididae (Orthoptera: Acridoidea). *Indian J. Syst. Ent.*, **7**(2): 89-102.

Usmani, M.K., Khan, M.I. and Kumar, H. (2010). Studies on Acridoidea (Orthoptera) of Western Uttar Pradesh. *Biosystematica*, **4**(1): 39-58.

Usmani, M.K., Kumar, K. and Naiko, S.M. (2011). Taxonomic significance of Phallic Complex in some Indian species of Acridoidea (Orthoptera). *Biosystematica*, **5**(1): 55-63.

Uvarov, B.P. (1921a). On records and descriptions of Indian Acididae. *Ann. Mag. Nat. Hist.*, **7**(9): 480-509.

Uvarov, B.P. (1921b). Three New Alpine Orthoptera from Central Asia. *J. Bombay Nat. His. Soc.*, **28**: 71-75.

Uvarov, B.P. (1924). A revision of the old world Cyrtacanthacrini. *Ann. Mag. Nat. Hist.*, **13**(9): 1-19.

Uvarov, B.P. (1927). Distributional records of Indian Acrididae. *Rec. Indian Mus.*, **29**: 233-239.

Uvarov, B.P. (1929). Composition and origin of the palaearctic fauna of Orthoptera. *Proc. of X international Congress of Zoology, Budapest, Sect.*, **8**: 1526-1524.

Uvarov, B.P. (1941). Geographical variation in *Scintharista notabilis* (Walker 1870) (Orthoptera: Acrididae). *Proc. R. Ent. Eco.* (B) **10**: 91-97.

Uvarov, B.P. (1942). Differentiating characters of Oedipodinae and Acridinae. *Trans. Am. Ent. Soc.*, **67**: 303-361.

Walker, F. (1870). Catalogue of the specimens of Dermaptera Saltatoria in the collection of the British Museum, Part I. Locustidae (Concluded) and Acrididae (part) pp. 1-117; Part II. Pp. 154-224; Part III. Pp. 425-604; Part IV. Acrididae (Concluded), 605-801.

Walker, F. (1871). Catalogue of the specimens of Dermaptera Saltatoria in the collection of the British Museum, Supplement, Part V, 49-89.

Willemse, C. (1951). Synopsis of Acridoidea of the Indo-Malayan and adjacent region (Insecta: Orthoptera) Part I. Family Acrididae subfamily Acridinae. *Publties Natuurh. Genoot. Limburg*, **8** (1955): 1-227.

Willemse, C. (1956). Synopsis of Acridoidea of the Indo-Malayan and adjacent region (Insecta: Orthoptera) Part II. Family Acrididae. Subfamily Catantopinae Part I. *Publties Natuurh. Genoot. Limburg*, **8**(1955): 1-225.

Willemse, C. (1957). Synopsis of Acridoidea of the Indo-Malayan and adjacent region (Insecta: Orthoptera) Part II. Family Acrididae, subfamily Catantopinae Part II. *Publties Natuurh. Genoot. Limburg*, **10** (1955): 1-225.