SPECIES DIVERSITY, SEASONAL ABUNDANCE AND MORPHOMETRIC ANALYSIS OF GRASSHOPPER (ORTHOPTERA: CAELIFERA) IN RAJSHAHI CITY, BANGLADESH

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ABSTRACT

A study from July 2016 to June 2017 was carried out to assess the species diversity, seasonal abundance and morphometric characteristics of grasshopper (Orthoptera: Caelifera) at Rajshahi city of Rajshahi District, Bangladesh. A total number of 286 individuals of grasshopper were examined during the study. Eight species of grasshopper were identified under seven genera of 2 families. The numbers of identified species were seven and one, and their percentages were calculated as 90.9% and 9.1% in families Acrididae and Tetrigidae respectively. Based on monthly occurrence, four species of grasshopper were found throughout 12 months, three were 9-11 months and one was 6-8 months. The highest species abundance of grasshoppers was recorded in the month of July to August and lowest in November to January. Among the collected species the status of *Camnula pellucida* was very common (VC) and rest seven species were considered as not rare (NR). The Simpson's diversity index (1-D) for grasshopper species was 0.80. For the study of inter-specific variations, morphometric analysis of nine parameters *viz.* length of body, antenna, foreleg, midleg, hindleg, forewing and hindwing; width of forewing and hindwing was evaluated. The lengths or widths of these parameters were measured by ImageJ software (1.48v) and data were analyzed by GraphPad InStat 3 and MS Excel 2007. Relationship among parameters and different species were determined using repeated measures ANOVA with Tukey post-test. The variation between these species and parameters was considered highly significant ($p< 0.001$) and showed the dynamic speciation. Morphometric analysis of these eight species was done for the first time from this region.

Keywords: Species Diversity, Seasonal Abundance, Morphometric Analysis, Orthoptera, Grasshoppers

ABSTRAK

Kajian pada Julai 2016 hingga Jun 2017 telah dijalankan untuk menilai kepelbagaian spesies, kelimpahan mengikut musim dan ciri morfometrik belalang (Orthoptera: Caelifera) di Bandar Rajshani daerah Rajshani, Bangladesh. Sejumlah 286 belalang telah diperiksa untuk kajian ini. Sejumlah lapan spesies belalang telah dicamkan di bawah tujuh genus dan dua famili. Jumlah spesies yang dicamkan adalah tujuh dan satu iaitu 90.9% dan 9.1%, masing-masing di bawah famili Acrididae and Tetrigidae. Berdasarkan bulan persampelan, empat spesies belalang telah dijumpai di sepanjang 12 bulan, tiga pada 9-11 bulan dan satu pada 6-8 bulan. Kelimpahan

tertinggi belalang telah direkodkan pada bulan Julai ke Ogos dan yang terendah pada bulan November ke Januari. Status spesies *Camnula pellucida* merupakan yang sangat biasa (VC) dan spesies lain-lainnya adalah bukan langka (NR). Indeks kepelbagaian Simpson's (1-D) adalah 0.80. Kajian variasi inter-, analisis morfometrik untuk sembilan parameter iaitu panjang badan, antena, kaki depan, kaki tengah, kaki belakang, sayap depan dan sayap belakang; lebar sayap depan dan sayap belakang telah dinilai. Panjang dan lebar parameter ini telah diukur menggunakan Perisian ImageJ (1.48v) dan data telah dianalisis menggunakan GraphPad InStat 3 dan MS Excel 2007. Hubungan antara parameter dan spesies yang berbeza ditentukan menggunakan ANOVA dengan ujian post-Tukey. Variasi anatara spesies dan parameter telah dikenalpasti sebagai signifikan ($p < 0.001$) dan menunjukkan spesiasi dinamik. Analisis morfometrik ke atas lapan spesies ini telah di jalankan buat pertama kalinya dari kawasan ini.

Kata kunci: Kepelbagaian Spesies, Kelimpahan Musim, Analisis Morfometrik, Orthoptera, Belalang.

INTRODUCTION

Grasshopper is the most important group of insect belonging to order Orthoptera and used to estimate the species diversity, abundance and bionomics (Joern & Gaines 1990; Lockwood 1997; Pfadt 1984). They have caused significant damage to crop of farmers since the beginning of recorded history (Schell & Lockwood 1995; Tappan et al. 1991). These species represent perhaps the most conspicuous of all insect pests and are abundant insects of dry grassland and desert (Gates et al. 2015). Grasshopper damage becomes visible as round to ragged holes in the leaves of vegetation. This damage expands in from the leaf margins and between the veins of the plant.

Grasshoppers are also sensitive bioindicator in assessment of habitat quality and environmental changes (Bazelet & Samways 2011; Fartmann et al. 2012). Grasshoppers are already recognized as a very important source of protein food for several birds (Jiguet 2002; Si Bachir et al. 2001). It is generally established that the diversity and abundance of grasshopper populations are influenced by availability of host plants, weather patterns and location (Gage & Mukerji 1977; Kemp et al. 1990; Whipple et al. 2012). Some grasshopper species can change color, behavior and form swarms at their high population densities and under certain environmental conditions (Forsman et al. 2002).

The order Orthoptera is one of the larger orders of insects, comprising more than 20,000 species worldwide of which about 1200 species in 256 genera could be found in North America (Arnett 2000). The grasshoppers with about 11,000 species are known globally among them 660 found in North America (Bug guide 2017). 35 species under 29 genera of the grasshopper fauna were reported in Kolkata, India which is located near the Bangladesh (Dey & Hazra 2003). A preliminary study identified seven species of grasshopper at Baltistan and Azad Jammu-Kashmir region of Pakistan (Mahmood et al. 2004).

Insects show morphometric differences interrelated with the environment that may be the result of phenotypic and genotypic variation (Adis et al. 2008; Cherril 2005). Previous study shows that the variation in body size is an element of natural populations and has vital implications for the understanding of the population dynamics and stability of ecological systems (Filin & Ovadia 2007; Roonwal 1981). The morphometric characteristics of grasshopper have also been very useful in the study of the evolution of body size, color patterns

and life history (Ahnesjö et al. 2003; Klingenberg & Spence 1997). Most taxonomic works are restricted to the Orthopteran fauna of relatively small regions or to particular taxonomic groups within the order. However, no detailed work on the diversity, abundance and morphometric analysis of grasshoppers in Rajshahi city of Rajshahi district in Bangladesh has been done to date. Keeping in view with this fact, an attempt has been made to study the species diversity, seasonal abundance and morphometric analysis of grasshopper in this area.

MATERIALS AND METHODS

Study Area

Grasshopper specimens were collected from Rajshahi city of Rajshahi District, Bangladesh. Rajshahi city area is 96.68 sq km, located in between 24°20′ north latitudes and 88°36′ east longitudes.

Sampling Method

Sample collections were done during July 2016 to June 2017. In every month, samples were collected randomly for four times between 8am to 3pm in twelve different sites of the study area. For collection of specimens, sweep net and hand picking method were used (Sanjayan 1994). For preservation and identification, collected specimens were narcotized with menthol (naphthalene) crystals and brought into the Crop Protection and Toxicology Laboratory, Department of Zoology, University of Rajshahi and air dried for 24h.

Identification

All collected specimens were identified to the lowest taxonomic level using standard identification key or manual (Bug guide 2017; Kirby 1914). The color of specimens and external features were used for identification. Pictures of grasshopper were taken for morphometric analysis using DSLR camera (Canon 750D). Then, identified specimens were labeled and preserved in insect boxes according to species and tagged with certain number.

Morphometric measurements

For the study of inter-specific variations, nine parameters were measured using by ImageJ software (1.48v). Measurement sites in grasshopper are shown in Figure 1. The parameters studied were body length (BL), antenna length (AL), foreleg length (FLL), midleg length (MLL), hindleg length (HLL), forewing length (FWL), forewing width (FWW), hindwing length (HWL) and hindwing width (HWW).

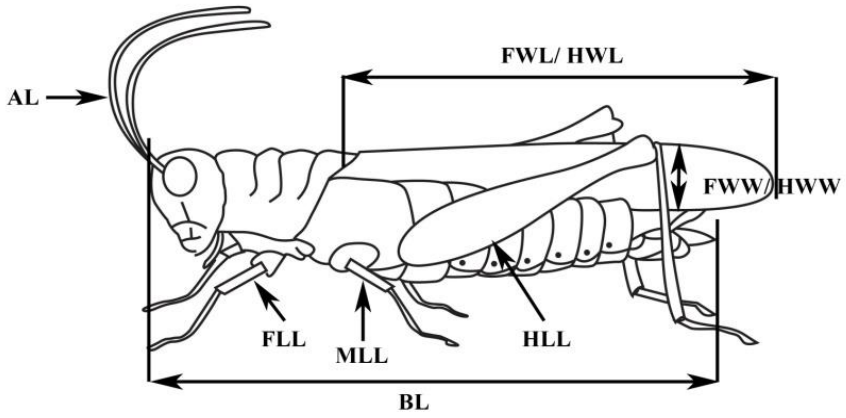

Figure 1 Morphometric measurement sites in grasshopper. BL, body length; AL, antenna length; FLL, foreleg length; MLL, midleg length; HLL, hindleg length; FWL, forewing length; FWW, forewing width; HWL, hindwing length; HWW, hindwing width.

Data analysis

The Simpson's diversity index was used to measure diversity (Simpson 1949).

$$\text{Simpson's Diversity Index} = 1 - D$$

$$\text{Here } D = \frac{\sum n(n-1)}{N(N-1)}$$

Where, n = the total number of organisms of a particular species
N = the total number of organisms of all species

Variation among parameters and different species were determined using repeated measures ANOVA with Tukey post-test by GraphPad InStat 3 and MS Excel 2007.

RESULTS AND DISSCUSSION

Grasshopper species were collected from July 2016 to June 2017 from different sites in Rajshahi city. A total of 286 individuals were found during the study period. The listed specimens were identified as 8 species under 7 genera from 2 families (Table 1). The maximum number of species was recorded in family Acrididae (n= 260) and minimum in Tetrigidae (n= 26) (Figure 2A). The numbers of identified species were 7 and 1 and their percentage were 90.9% and 9.1% in family Acrididae and Tetrigidae respectively (Figure 2B).

The highest species abundance of grasshopper was recorded in the month of July to August and lowest in November to January (Table 1 & Figure 3A). The month wise percentage of identified species shows in Figure 3B. The most abundant grasshopper species recorded was *Camnula pellucid* (n= 108), and second abundant grasshopper species counted was *Acrida conica* (n= 35) (Table 1). Base on monthly occurrence 4 species of grasshopper were found throughout 12 months, 3 were 9-11 months and 1 was 6-8 months (Table 1). Based on number of sightings, Tiple et al. (2006, 2007) categorized butterfly status into VC, very common (> 100 sightings); C, common (50–100 sightings); NR, not rare (15–50 sightings); R, rare (2–15 sightings); VR, very rare (< 2 sightings). Only two categories species were found in the study.

The status of *Camnula pellucida* was very common (VC) and the rest seven species were considered as not rare (NR) (Table. 1). The Simpson's diversity index (1-D) for grasshopper species at Rajshahi city area is 0.80. For the study of inter-specific variations, 10 adults of each species were used for morphometric measurements. Morphometric analysis of nine parameters *viz.* length of body, antenna, foreleg, midleg, hindleg, forewing, hindwing, width of forewing and hindwing was calculated (Figure 1). Average lengths (mm) of different parameters of grasshopper are shown in Table 2. The body length was the maximum (39.51 mm) for *A. exaltata* and the minimum (14.84 mm) for *Tetrix ornata*.

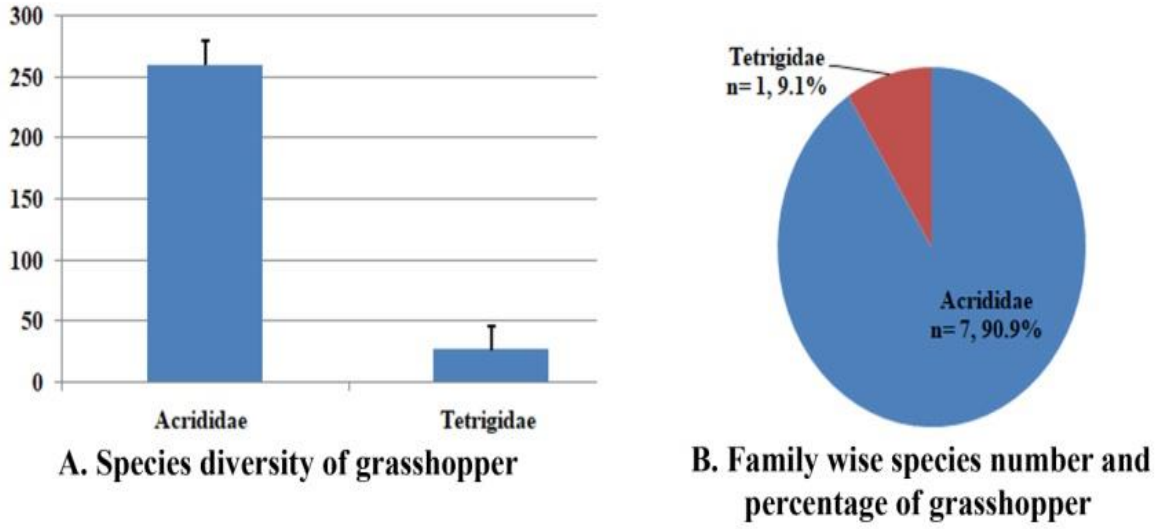

Figure 2 Family wise **A.** Species diversity and **B.** species number (n) and percentage of grasshopper of the study area.

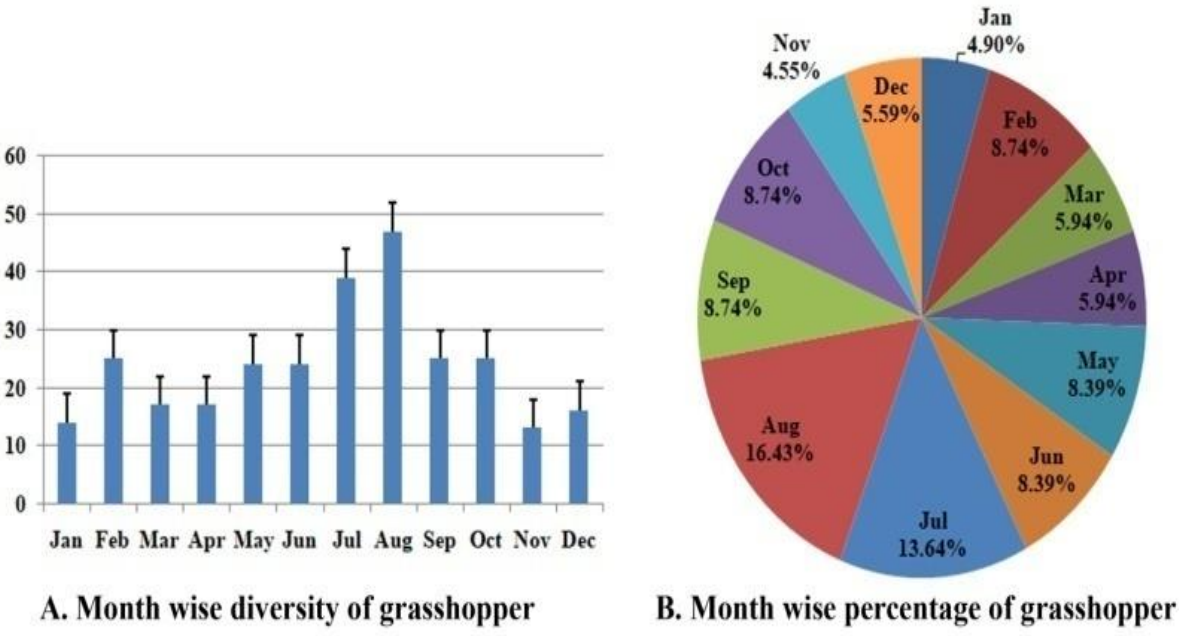

Figure 3 Month wise **A.** species diversity and **B.** percentage of grasshopper of the study area.

The antenna length was the maximum (17.82 mm) for *Melanoplus bivittatus* while the minimum (4.61 mm) for *Tetrix ornata*. The *Melanoplus bivittatus* had a maximum length of foreleg of 14.52 mm while the minimum length of 4.83 mm in *Tetrix ornata*. The highest midleg length was observed 14.91 mm in *Acrida conica* and the lowest (5.23 mm) in *Tetrix ornata*. The longest hindleg length (44.18 mm) was found in *Melanoplus bivittatus* whereas the shortest (12.59 mm) in *Tetrix ornata*.

The maximum forewing length was noted in *A. exaltata* (23.00 mm) and the minimum (6.00 mm) in *Acrida conica* and *Trimerotropis pallidipensis*. The bigger forewing was found in *Melanoplus bivittatus* (5.33 mm) and the narrowest in *Trimerotropis pallidipensis* (1.00 mm). The highest hindwing length and width were showed in *Camnula pellucida* (21.20 and 17.30 mm) and the shortest in *Trimerotropis pallidipensis* (5.00 mm and 2.00 mm). The variations among these species and parameters were considered highly significant ($p < 0.001$) (Table 3).

Table 1 Monthly abundance of collected samples of different species of grasshopper. 1, January; 2, February; 3, March; 4, April; 5, May; 6, June; 7, July; 8, August; 9, September; 10, October; 11, November; 12, December; VC, very common (> 100 sightings); NR, not rare (15–50 sightings).

Family	No.	Species name	Monthly abundance of individual												Total	Status
			1	2	3	4	5	6	7	8	9	10	11	12		
Acrididae	1	*Camnula pellucida*	5	6	6	8	10	12	16	20	9	8	4	4	**108**	**VC**
	2	*Acrida conica*	2	2	3	3	4	4	5	6	2	2	1	1	**35**	**NR**
	3	*A. exaltata*	1	2	0	0	2	2	4	5	1	3	2	2	**24**	**NR**
	4	*Mermiria bivittata*	1	2	1	0	1	1	3	3	1	1	0	4	**18**	**NR**
	5	*Melanoplus bivittatus*	0	4	1	2	2	2	2	2	3	2	1	0	**21**	**NR**
	6	*Trimerotropis pallidipensis*	2	3	0	0	1	0	4	6	1	3	1	0	**21**	**NR**
	7	*Dichromorpha viridis*	2	4	4	1	2	2	4	4	1	3	2	4	**33**	**NR**
Tetrigidae	8	*Tetrix ornata*	1	2	2	3	2	1	1	1	7	3	2	1	**26**	**NR**
Total (monthly)			**14**	**25**	**17**	**17**	**24**	**24**	**39**	**47**	**25**	**25**	**13**	**16**	**286**	

Table 2 Morphometric measurement (mm) of different parameters of 8 species of grasshopper. BL, body length; AL, antenna length; FLL, foreleg length, MLL, midleg length, HLL, hindleg length, FWL, forewing length; FWW, forewing width, HWL, hindwing length; HWW, hindwing width.

No.	Species name	BL	AL	FLL	MLL	HLL	FWL	FWW	HWL	HWW
1	*Camnula pellucida*	32.39	7.71	8.08	9.10	25.12	22.00	4.60	21.20	17.30
2	*Acrida conica*	30.15	13.10	11.98	14.91	30.03	6.00	1.50	5.50	2.50
3	*A. exaltata*	39.51	8.40	9.87	11.58	29.60	23.00	3.40	20.40	13.70
4	*Mermiria bivittata*	28.93	8.51	8.37	10.39	30.05	15.70	4.60	14.80	9.50
5	*Melanoplus bivittatus*	32.73	17.82	14.52	14.61	44.18	22.33	5.33	22.00	12.33
6	*Trimerotropis pallidipensis*	31.97	8.78	9.77	11.12	29.89	6.00	1.00	5.00	2.00

7	*Dichromorpha viridis*	31.58	7.33	7.80	10.64	30.38	19.00	3.60	17.56	15.20
8	*Tetrix ornata*	14.84	4.61	4.83	5.23	12.59	11.90	2.90	11.10	10.50

Table 3 ANOVA of morphometric measurement (mm) of different parameters of 8 species of grasshopper.

Source of Variation	SS	df	MS	F	P-value	Significance
Rows (Species)	870.48	7	124.35	6.08	2.67E-05	P < 0.001
Columns (Parameters)	5304.45	8	663.06	32.41	2.48E-18	P < 0.001
Error	1145.82	56	20.46			
Total	7320.75	71				

In the insect's class, grasshopper is one of the largest and diverse groups. They are dominant above ground invertebrates in cultivated and in natural grasslands ecosystems. This is the first report of grasshopper (Orthoptera: Caelifera) in Rajshahi city. In the present study, the maximum diversity was shown by the family Acrididae that is consistent with the results of some previous researchers (Akhtar & Usmani 2014; Mahmood et al 2004; Pfadt 1984). It was reported that thirty-three species of locusts and grasshoppers have been found in Western Uttar Pradesh of India (Usmani et al. 2010). During surveys of paddy fields in Uttar Pradesh, 21 species of grasshopper representing 14 genera of family Acrididae were studied (Akhtar & Usmani 2014). Only one species of grasshopper i.e., *Hieroglyphus banian* out of 23 species of insect pest of rice ecosystem was reported in Maharshtra, India (Jadhao & Khurad 2011). Previous study has shown that seven species of grasshopper belonging to subfamily Oedipodinae, Calliptaminae and Acridinae were found in Baltistan, Azad Jammu & Kashmir, Pakistan (Mahmood et al. 2004).

The maximum grasshopper population observed during July-August was probably associated with the maximum vegetative growth during that period (Dwivedi & Chattoraj 1984; Hazra 1984). The rainfall plays a vital role in vegetative growth because floristic species diversity and richness is rainfall dependent since June to August is rainy season in Bangladesh. The environmental condition that increases plant quality will increase population growth in herbivores insect (Awmack & Leather 2002). The minimum population of grasshopper was recorded during the month of November to January during the winter season in Bangladesh. Grasshopper populations are dependent on a large number of deterministic and random variables (Davis et al. 1992).

Morphometric measurement of the different parts of the body is one of the important elements for taxonomical study. The highly significant difference among the species and the parameters was found ($p < 0.001$). Morphometric analyses of these eight species determine the inter-species variation and show dynamic speciation

CONCLUSION

A total of eight species of grasshopper with 284 individuals were recorded from different sites in Rajshahi city, Bangladesh. Acrididae is the largest contributor to the highest abundance of

very common. Morphometric analyses of different parameters of grasshopper have been calculated. In our knowledge, there is no report on morphometric lengths of different parts of available grasshopper in our country. Hopefully this study will provide latest information about biodiversity and taxonomy of grasshopper in all over Bangladesh. grasshopper species in this study. The highest abundance had been observed in July to August. Four species were found throughout the year, and based on sightings *Camnula pellucid* was

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