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Changing scenario of short horned grasshopper diversity in agriculture and forest ecosystems in Dharwad

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Abstract
In the present study diversity of short horned grasshoppers collected from agricultural and forest ecosystems of Dharwad during 2015-16 were compared with the recorded data of 1985-86. A total of 42 species belonging to 33 genera and 10 subfamilies of Acrididae and Pyrgomorphidae have been encountered both in agriculture and forest ecosystem during present study as against 48 species belonging to 41 genera and 12 subfamilies recorded during 1985-86. Species richness was more in 1985-86 in agriculture (42) and forest ecosystem (30) compared to 2015-16. Acrididae was more diverse than Pyrgomporphidae during both the years of study. Oedipodinae was the most species rich subfamily followed by Catantopinae in both agriculture and forest ecosystems during both years and Tropidopolinae was very rare during 2015-16, whereas Calliptaminaene and Truxalinae found during 1985-86 which were not encountered during the present study. *Spathosternum prasiniferum* (Walker) was the most abundant species in both ecosystems during present and past study.

Keywords: Acrididae, diversity, agriculture, forest ecosystems

1. Introduction

Locusts and short horned grasshoppers constitute an economically important group of orthopterous insects that infest a number of cultivated and non-cultivated crops. Grasshoppers are widely distributed in all ecological systems with significant economic importance due to their destructive role in almost all type of green vegetation. Orthoptera is one of the largest insect orders, comprising 26,692 species found throughout the world. Acridoidea is the largest super family comprising 11,000 species worldwide of which 290 species representing 138 genera are reported from India. Among these, Acrididae is the most diverse family with 8000 species of which 285 belonging to 135 genera are found in India of which 136 species and 28 genera are endemic (Akthar *et al.,* 2014) [1].

Nufio *et al.* (2010) [6] surveyed the past (1959-1960) and subsequent (2006-2008) grasshopper community responses to climate change and concluded that grasshoppers associated with the sites that experienced the most warming climate displayed the greatest levels of phenological advancement.

Ecological studies of shorthorned grasshoppers (Orthoptera: Acridoidea) fauna of Dharwad region including their host record, ecological distribution, life forms, food habits and morphometrics of grasshoppers has been well documented (Vastrad, 1986; Vastrad *et al.,* 1988; Vastrad, 1989; Vastrad *et al.,* 1991 and Vastrad, 1994) [7-11]. In recent years, farmers are changing the cropping pattern and agronomical practices due to urbanization, labor problem and to get more profit from other crops. The changing scenario in agriculture is affecting the primary consumers like grasshoppers and thereby creating an impact on food web. So it is necessary to study the changing scenario and distribution of grasshoppers in relation to their habitats.

2. Material and methods

2.1 Experimental site

The investigations were carried out at two different ecosystems of Dharwad namely, Transitional area (Main agriculture research station, Dharwad) it is situated at 15.35° north latitude and 75.08° east longitude and has an altitude of 750 m above MSL, Malnad area (Forest research institute, Prabhunagar) it is 20 km from Dharwad and situated at 15°24’ to 15°29’ north latitude and 74°49’ to 74°53’ east longitude and has an altitude of 589.19 m above MSL.

2.2 Collection and identification
Grasshoppers were collected through sweeping a hand net. A standard net of 28 cm in diameter having a depth of 45 cm with a 60 cm long wooden handle was used for collecting sample. The grasshoppers were collected for two hours in predetermined area in the particular locality once in a month in each ecosystem from February 2015 to January 2016. Collected specimens were killed by using ethyl acetate and properly stretched, pinned and labeled. Identification of specimen up to the species level was done with help of taxonomic keys of Prasad and Viraktamath (1991). Simpson, Shannon diversity and Sorenson similarity indices were worked out for each ecosystem *vis-a-vis* the past record (Vastrad 1986 and Vastard *et al.,* 1991) [7, 10].

2.3 Data analysis
2.3.1 Simpson index of diversity (1-D)

$$D = \frac{\Sigma n\,(n-1)}{N\,(N-1)}$$

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

2.3.2 Shannon-wiener index (H)
SH1= -Σpi loge pi
H = Species diversity, Pi = ni/N is the probability of an individual to belong to a species, ni = Number of individuals of one species in sample, In= Natural log, N = Total number of individuals in samples.

2.3.3 Sorenson's similarity index

$$S = \frac{2C}{A+B}$$

A= number of species in sample A
B= number of species in sample B
C= number of species common to both samples

3. Results and discussion
Results indicated that a total of 42 species were encountered both in agriculture and forest ecosystem during present study as against 48 species recorded during 1985-86 (Table 1). Species richness was more in 1985-86 in agriculture (42) and forest ecosystem (30) compared to 2015-16 in agriculture (34) and forest ecosystem (28). It similarly abundance was also, maximum during 1985-86 compared to 2015-16 (Table 1). There is decline in the genera and subfamilies, 41 to 33 genera and 12 to 10 subfamilies from 1985-86 to 2015-16. More species richness and abundance of Acrididae was more as compared to Pyrgomorphidae in both ecosystems during 2015-16 and 1985-86 (Table 1). Among the subfamilies of Acrididae, Oedipodinae was the most species rich subfamily followed by Catantopinae in both agriculture and forest ecosystems during both years and Tropidopolinae was very rare during 2015-16, whereas Calliptaminaene and Truxalinae found during 1985-86 which were not encountered during present study. *Spathosternum prasiniferum* (Walker) was the most abundant species in both ecosystems during 2015-16 and 1985-86 (Table 1).
Aularches miliaris miliaris (Linnaeus), *Aiolopus simulatrix* (Savigny), *Aiolopus* sp, *Chelobora crassa*, *Oedaleus senegalensis* (Krauss) and *Oxya nitidula* (Walker) were encountered for the first time from Dharwad region during present study and which were not recorded during 1985-86. *Neorthacris acuticeps nilgirensis* (I. Bolivar), *Gelastorhinus semipictus* (Walker), *Diabolocatantops pulchellus*, *Epistarus sinetyi* (I.Bolivar), *Eucoptacrella ceylonica* Kirby, *Tylotropidius varicornis* (Walker), *Leva cruciata* I. Boliver, *Leptacris* sp., *Heteropternis respondens* (Walker), *Oxya fuscovittata* (Marschall), *Oxyrrhepes obtusa* De Hann and *Truxalis indica* (I. Boliver) were recorded during 1985-86 but not encountered during present study.
Barring few exceptions generally both the species diversity and abundance was more during 1985-86 than during present study period. The results of the changing scenario of grasshopper diversity in different families and subfamilies is presented below (Table 1).

3.2 Changing diversity of short horned grasshoppers in agriculture and forest ecosystems
The change in species richness and abundance was reflected in terms of diversity indices given in table 2. Agriculture ecosystem was more diverse than forest ecosystem during current study as well as 1985-86. During 1985-86, 72 percent of species were common between agriculture and forest ecosystem, which was reduced to 67 percent present study (Table 2). Acrididae was more diverse than Pyrgomorphidae in both ecosystems during 2015-16 as well as 1985-86 (Table 3). During 2015-16 agriculture and forest ecosystems, among the pyrgomorphids 80 percent of species were similar compared to only 66 percent in 1985-86. Among the acridids during 1985-86, 73 per cent of the species were common between two ecosystems which was reduced to 60 per cent (Table 4). At the subfamily level forest ecosystem was more diverse than agriculture ecosystem during both the years of study (Table 5). However, number of subfamilies of Acrididae remained unchanged (Table 6).
The changing scenario in agriculture and forest ecosystem is affecting the primary consumers like grasshoppers and thereby creating impact on food web. Fluctuations in climatic factors like temperature, humidity and edaphic factors influence diversity of grasshoppers. Variations in grasshopper diversity during 2015-16 were compared with the data available during 1985-86. Though diversity of grasshoppers in agriculture ecosystem was more than forest ecosystem, the species richness decreased from 48 species in 1985-86 to 42 species during 2015-16. The decrease in species richness from 1985-86 to 2015-16 may be due to the change in climatic factors (high temperature, relative humidity, rainfall) and cropping pattern. High diversity of grasshoppers in agriculture ecosystem than forest ecosystem was due to the location advantage, as the region situated in the transitional zone where rainfall is assured which supports a variety of cultivated crops, grasses and other plants which in turn support the large number of grasshopper species. Prabhunagar is situated in Maland area comprised of moist deciduous forest. Predominant flora of this area is deciduous plants, grasses and some cultivated crops in open area. Flora of the Prabhunagar was not as rich as Dharwad and incidentally the numbers of species were also less compared to Dharwad. There eight genera and two subfamilies was not recorded during present investigation it may be due to change in cropping pattern. Acrididae was more diverse than Pyrgomorphidae since Acrididae includes several subfamilies members of which have a wide host range. Among all the subfamilies of Acrididae, Oediopodinae showed maximum relative abundance followed by Catantopinae (2015-16) and Hemiacridinae and Cyrtacanthacridinae (1985-86) in

agriculture ecosystem (Fig. 1). In forest ecosystem, Catantopinae showed maximum relative abundance followed by Oediopodinae (2015-16) and Oediopodinae, Hemiacridinae and Catantopinae were most relatively abundant during 1985-86 compared to other subfamily of Acrididae (Fig. 4). These finding are in line with Vastrad *et al.* (1991) [10], Koli *et al.* (2009) [3] and Kumar (2013) [4]. Good in camouflaging, better long flight and sturdy build up make Oedipodinae prominent among all other subfamilies. *Spathosternum prasiniferum* (Walker) was the most dominant species in both agriculture and forest ecosystems probably due to wider adaptability to climatic conditions, which is in agreement with findings of Vastrad *et al.* (1991) [10], Mayya *et al.* (2005) [5] and Dhakad *et al.* (2014) [2].

The changes in agriculture and forest ecosystems in the last three decades have affected the primary consumers like grasshoppers both in species richness and abundance which may create an impact on food web. Species diversity decreased over a period of time from 1985-86 to 2015-16 which could be due to long term effects *viz.,* decrease in crop diversity, change in cropping pattern and climatic factors and increased use of pesticides in recent years and short term effect like severe drought during last two years.

Table 1: Changing scenario of shorthorned grasshopper diversity in agriculture and forest ecosystems

Sl. No.	Family / Sub family	Species	Name of the ecosystem			
			Agriculture ecosystem		Forest ecosystem	
			2015-16	1985-86	2015-16	1985-86
1.	Pyrgomorphidae	*Atractromorpha crenulata crenulata* (Fabricius)	+ (72)*	+ (45)	+ (20)	+ (5)
2.		*Chrotgonus oxypterus* (Blanchard)	+ (27)	+ (59)	+ (12)	-
3.		*Chrotgonus trachypterous* (Blanchard)	+ (18)	+ (19)	+ (8)	-
4.		*Colemania sphenariodea* (I. Bolivar)	-	+ (40)	+ (4)	+ (12)
5.		*Neorthacris acuticeps nilgirensis* (I. Bolivar)	-	+ (18)	-	+ (13)
6.		*Aularches miliaris miliaris* (Linnaeus)	-	-	+ (6)	-
7.		*Pyrgomorpha bispinosa bispinosa* (Walker)	+ (52)	+ (28)	+ (18)	-
		Total	4 (169)	6 (209)	6 (68)	3 (30)
	Sub families of Acrididae					
8.	Acridinae	*Acrida exaltata* (Walker)	+ (91)	+ (68)	+ (40)	+ (11)
9.		*Phlaeoba panteli* Bolivar	+ (16)	+ (54)	+ (16)	+ (36)
10.		*Gelastorhinus semipictus* (Walker)	-	+ (38)	-	+ (63)
		Total	2 (107)	3 (160)	2 (56)	3 (110)
11.	Calliptaminae	*Acorypha glaucopsis* (Walker)	-	+ (1)	-	-
		Total	0	1 (1)	0	0
12.	Catantopinae	*Catntops erubescens* (Walker)	+ (1)	+ (16)	-	-
13.		*Diabolocatantops pulchellus*	-	-	-	+ (33)
14.		*Xenocatantops karnyi* (Kirby)	+ (16)	+ (37)	+ (19)	+ (33)
15.		*Xenocatantops humilis* (Serville)	-	-	+ (1)	-
16.		*Diabolocatantops* sp.	-	-	+ (2)	-
17.		*Diabolocatantops pinguis innotabalies* (Walker)	+ (15)	+ (43)	+ (27)	-
18.		*Stenocatantops splendens* (Thunberg)	+ (1)	-	-	+ (3)
19.		*Mesambria* sp.	+ (1)	-	-	-
20.		*Xenocatantops henryi* (I. Bolivar)	+ (1)	-	+ (19)	+ (24)
		Total	6 (35)	3 (96)	5 (68)	4 (58)
21.	Coptacridinae	*Epistarus sinetyi* (I.Bolivar)	-	+ (2)	-	-
22.		*Eucoptacra praemorsa* (Stal)	+ (12)	+ (53)	+ (82)	+ (77)
23.		*Eucoptacrella ceylonica* Kirby	-	+ (1)	-	+ (5)
		Total	1 (12)	3 (56)	1 (82)	2 (82)
24.	Cyrtacanthacridinae	*Teratodes monticollis* (Grey)	+ (7)	+ (1)	-	+ (1)
25.		*Anacridium flavensis* (Fabricius)	+ (1)	+ (1)	-	-
26.		*Cyrtacanthacris tatarica* (Linnaeus)	+ (33)	+ (15)	+ (11)	+ (2)
27.		*Pachyacris venosa* (Walker)	-	+ (3)	+ (3)	+ (1)
		Total	3 (41)	4 (20)	2 (14)	3 (4)
28.	Eyprepocnemidinae	*Eyprepocnemis alacris alacris* (Serville)	+(126)	+ (59)	+ (31)	+ (29)
29.		*Tylotropidius varicornis* (Walker)	-	+ (3)	-	+ (18)
		Total	1 (126)	2 (62)	1 (31)	2 (47)
30.	Gomphocerinae	*Aulacobothrus* sp.	+ (6)	+ (71)	+ (16)	+ (270)
31.		*Aulacobothuras lutipes* (Walker)	-	+ (28)	+ (9)	+ (15)
32.		*Leva cruciata* I. Boliver	-	+ (102)	-	-
33.		*Brachycrotaphus longiceps* I. Boliver	-	-	+ (57)	+ (2)
		Total	1 (6)	3 (201)	3 (82)	3 (287)
34.	Hemiacridinae	*Hieroglyphus banian* (Fabricius)	+ (9)	+ (64)	-	+ (3)
35.		*Leptacris* sp.	-	+ (1)	-	+ (2)
36.		*Parahieroglyphus bilineatus* (I. Boliver)	+ (2)	+ (5)	+ (21)	+ (6)
37.		*Spathosternum prasiniferum* (Walker)	+ (171)	+ (97)	+ (190)	+ (68)
		Total	3 (182)	4 (167)	2(211)	4 (79)
38.	Oediopodinae	*Acrotylus humbertianus* Saussure	+ (4)	+ (40)	-	-
39.		*Ailopus thalasinus tamulus* (Fabricius)	+ (4)	+ (166)	-	+ (12)
40.		*Ailopus thalassinus thalassinus* (Fabricius)	+ (39)	+ (40)	+ (6)	-
41.		*Aiolopus simulatrix* (Savigny)	+ (1)	-	-	-

42.		*Aiolopus* sp	+ (2)	-	+	-
43.		*Chelobora crassa*	+ (1)	-	-	-
44.		*Dittopternis venusta* Walker	+ (1)	+ (28)	-	-
45.		*Gastrimargas africanas africanas* Saussure	+ (33)	+ (16)	+ (7)	+ (31)
46.		*Heteropternis respondens* (Walker)	-	+ (7)	-	+ (1)
47.		*Morphocris fasciata* Kirby	+ (16)	+ (42)	+ (7)	-
48.		*Oedaleus abruptus* (Thunberg)	-	+ (76)	-	-
49.		*Oedaleus senegalensis* (Krauss)	+ (1)	-	-	-
50.		*Trilophidia annulata* (Thunberg)	+ (106)	+ (92)	+ (77)	+ (25)
		Total	11 (208)	9 (507)	4 (97)	4 (57)
51.	Oxyinae	*Oxya hyla hyla* Serville	+ (11)	+ (40)	+ (22)	-
52.		*Oxya fuscovittata* (Marschall)	-	+ (60)	-	+ (22)
53.		*Oxya nitidula* (Walker)	+ (2)	-	-	-
		Total	2 (13)	2 (100)	1 (22)	1 (22)
54.	Tropidopolinae	*Tristria pulvinata* (Uvarov)	-	+ (73)	+ (3)	+ (63)
55.		*Oxyrrhepes obtusa* De hann	-	-	-	+
		Total	0	1 (73)	1 (3)	2 (63)
56.	Truxalinae	*Truxalis indica* (I. Boliver)	-	+	-	-
		Total	0	1 (1)	0	0
		Total of Acrididae	30 (730)	36 (1444)	22 (629)	27 (805)
		Grand total of Acridoidea (Acrididae + Pyrgomorphidae)	34 (899)	42 (1653)	28 (697)	30 (835)
Total number of species in agriculture and forest ecosystem (2015-16) – 42			Total number of species in agriculture and forest ecosystem (1985-86)- 48			

+ Present
- Absent
Abundance (number of individuals during the entire study period- ()*

Table 2: Diversity of shorthorned grasshoppers between agriculture and forest ecosystem

Ecosystem	Simpson index (1-D)		Shannon index (H)		Similarity index (%)	
	2015-16	1985-86	2015-16	1985-86	2015-16	1985-86
Agriculture (MARS)	0.92	0.95	2.67	3.33	67	72
Forest (Prabhunagar)	0.89	0.87	2.68	2.62		

Table 3: Diversity of Acrididae and Pyrgomorphidae between two ecosystems

Ecosystem	Name of family	Simpson index (1-D)		Shannon index (H)	
		2015-16	1985-86	2015-16	1985-86
Agriculture (MARS)	Pyrgomorphidae	0.69	0.80	1.25	1.70
	Acrididae	0.87	0.94	2.40	3.13
Forest (Prabhunagar)	Pyrgomorphidae	0.79	0.64	1.23	1.02
	Acrididae	0.86	0.86	2.44	2.52

Table 4: Similarity index of shorthorned grasshoppers between agriculture and forest ecosystems (Sorensen similarity index)

Ecosystem	Name of family	2015-16 (%)	1985-86 (%)
Agriculture (MARS) and Forest (Prabhunagar)	Pyrgomorphidae	80	66
	Acrididae	60	73

Table 5: Diversity of subfamilies belonging to agriculture and forest ecosystem

Ecosystem	Simpson index (1-D)		Shannon index (H)	
	2015-16	1985-86	2015-16	1985-86
Agriculture (MARS)	0.80	0.81	1.77	1.98
Forest (Prabhunagar)	0.82	0.83	1.95	1.98

Table 6: Similarity index of grasshoppers sub families between agriculture and forest ecosystems

Ecosystem	1985-86 (%)	2015-16 (%)
Between Agriculture (MARS) and Forest (Prabhunagar)	90%	90%

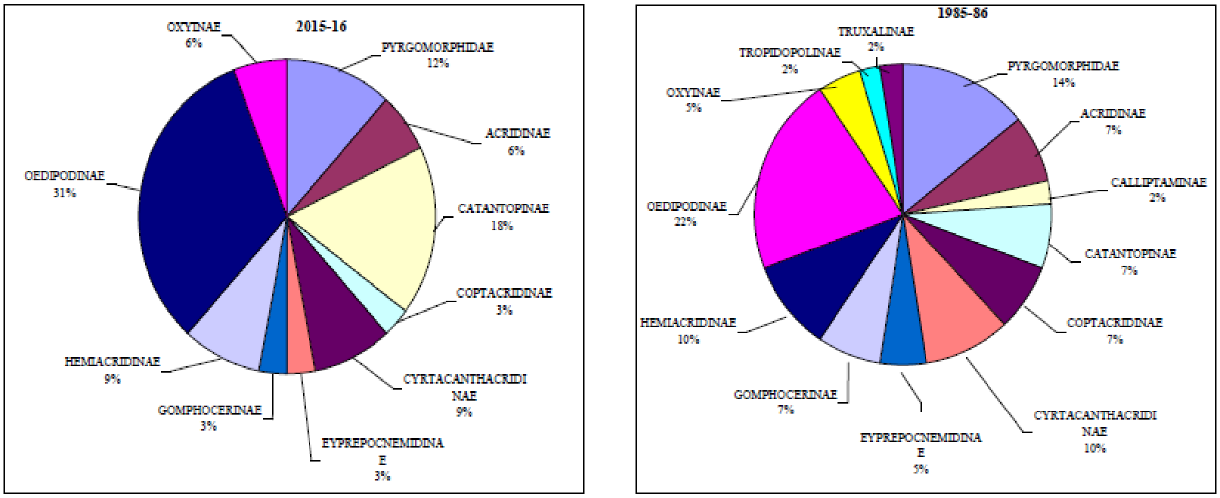

Fig 1: Relative abundance of shorthorned grasshoppers in Agriculture Ecosystem (MARS, Dharwad) during 2015-16 and 1985-86

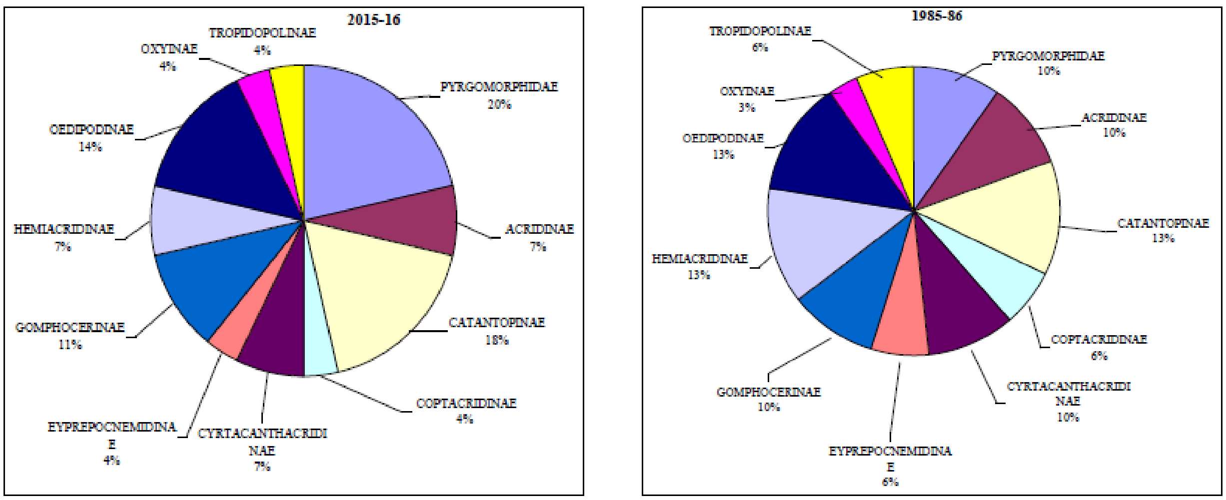

Fig 2: Relative abundance of shorthorned grasshoppers in Forest Ecosystem (Prabhunagar) during 2015-16 and 1985-86

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