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BIODIVERSITYAND DYNAMICS OF MACRO-INVERTBRATE POPULATIONS IN WHEAT-WEEDS AGRO-ECOSYSTEM OF PUNJAB (PAKISTAN)

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ABSTRACT

This study documented diversity and dynamics of foliage macro-invertebrates sampled from edges and centers of wheat-weeds agro-ecosystem of district Faisalabad (30° 31.5 N and 73° 74 E; 184.41 m l). A total of 4,228 foliage of macro-invertebrates belonging to phylum Arthropoda (92.41%) and Mollusca (7.59%) were recorded. Diptera (27.65%), Hemiptera (27.58%), Coleoptera (18.21%) and Hymenoptera (7.36%) were dominant while Orthoptera, Neuroptera, Lepidoptera and Araneae collectively formed (11.62%) arthropods. Mollusca constituted only of pulmonate gastropods (7.59%). The overall diversity was (H′ = 3.36), that varied seasonally at statistically significantly level. Maximum diversity was recorded in autumn (H′ = 3.57), that was followed by spring (H′ = 3.23) and winter (H′ = 3.09). In contrary to the general findings, Diversity of macro-invertebrate populations in the center (H′= 3.363) was significantly higher than the edges (H′= 3.299) of the fields (p = <0.001).Moreover the richness (S= 58), diversity (H´= 3.23) and evenness (E= 0.79) was recorded higher on wheatcompared to the richness (S= 61), diversity (H´= 3.16) and evenness (E = 0.77) on weeds in wheat-weeds agro-ecosystem.

Key words: Arthropods, Flora, faunal population, Mixed crop zone, Ecology, population interaction

INTRODUCTION

Wheat (*Triticumaestivum* L.) is the staple diet of almost one third of the world's population (Wajid, 2004).In Pakistan, it contributes 9% to the total household consumption, 13.1% value added in agriculture and 2.7% in GDP. It is cultivated on an area of 8890 thousand hectares and yield is 23.5 million metric tons (Anonymous, 2010; 2011; Raza, 2011). Wheat flour (Atta) is the staple diet for the peoples of Pakistan,which is also used to make various products such as flat and steamed breads, cookies, biscuits, cakes and noodles etc (Raza, 2011). About 152.5 million land owners, farmers and daily wages laborers are involved in agriculture business that produce 30 million tons of grain food in the country (Anonymous, 2005). Per hectare yield of wheat in Pakistan (2.38 tons) is far below than other wheat producing countries in the world like China (5.24 tons), India (3.13 tons), Russia (2.55 tons), USA (3.29 tons) and France (8.21 tons) (FAO, 2003). Low production rate is adversely affecting economy of the country (Nayyar*et al*., 1995).

Macro-invertebrate pests (e.g. arthropod) are one of the important factor responsible for decreased wheat yield (Shahid, 2003; Oerke and Dehne, 2004). The dipterans, aphides, cicades and thrips etc. are the major arthropods pests of wheat (Malschi, 2003). In conventional agriculture systems insecticides are sprayed to control these pests (Eisley and Hammond, 2007), whichhave adverse impacts on the environment and also harm non-target organisms (Briggs and Coortney, 1989), thereby increasing the chances of developing alternative options to control such examination macro-invertebrate pests (Joung and Côté, 2000).

Biological control is the best available option so far to control pest populations through regulation of population dynamics of their natural enemies. This type of control is self-perpetuating, environmentally friendly and safe for non-target species (Paine *et al*., 1993). Biodiversity plays a crucial role to maintain balance between pests and their natural animals providing better opportunity to control pest outbreak (Cardinale *et al.*, 2003). Weeds add phytomorphic heterogeneity, mask crop plants from pests and weed canopy provides shelter for both pests and their natural enemies, stabilizing their populations (Capinera, 2005; Norris and Kogan, 2005; Abbas *et al*., 2013).

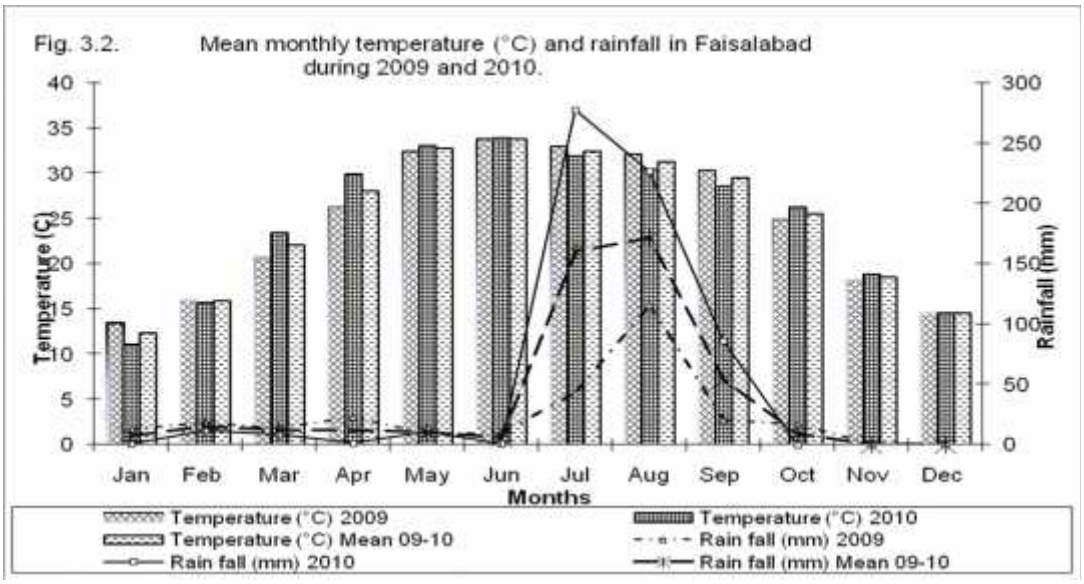
Only fragmentary knowledgeexists on the diversity of macro-invertebrate populations of wheat (Holland*et al*., 1999; Teodorescu and Cogălniceanu, 2005; Clough *et al.*, 2007; Birkhofer *et al.*, 2011) and little attention has been paid to document a complete picture of macro-invertebrate diversity found in wheat. This situation is further alarming in case of Pakistan, where such type of studies have only recently been initiated (e.g. Ruby *et al*., 2010; Inayat*et al*., 2010; Rana*et al.*, 2010; Ruby *et al*., 2011; Nasir*et al*., 2011; Mahmood*et al*., 2011, Abbas *et al*., 2012). The main

objective of present studywas to fill this gapthrough focusing on documentation of diversity of macro-invertebrate fauna in wheat-weed agro-ecosystem of Faisalabad district.

MATERIALS AND METHODS

Study area: This study was conducted in district Faisalabad (30° 31.5 N and 73° 74 E with an elevation of 184.4 m asl) that lies in northeast of Punjab (Pakistan). In Faisalabad, May, June, and July are the hottest months of the year with mean maximumtemperature reaching 39°C and maximum daily temperature up to 49°C. The monsoon rains mostly fall in July and August, which are the wettest months. December and January are the coldest months with a mean minimum temperature of 6°C and occasionally passing below freezing (Mahmood-ul-Hassan *et al*., 2010).

The total annual rainfall in the second year of sampling (2010) was (625.9 mm) above than the first year of sampling (2009) that was (285.6 mm). But the mean annual maxiumum and minimum temperature in both the sampling year was almost similar. The mean annual maximum and minimum temperature in the first year of sampling (2009) was 31.23°C, 18.07°C respectively while during second year of sampling that was 31.15°C, 18.50°C.



Sampling technique: Sampling sites (n = 20) were selected at random in almost each direction along the peripheral cultivation belt ranging from 30 to 60 km distant from the University of Agriculture Faisalabad situated amidst the Faisalabad city. The wheat fields in these selected sites were similar in their physical structure. The rectangular shaped fields of wheat were surrounded by grassy strips.

A block of 4.05 ha of wheat fields were selected from each sampling site, three plots of almost 0.405 ha were randomly selected from the block and two quadrates (1 m^2) were taken from each of the three plots of wheat field; one from the edge and other from the center of the field for foliage macro-invertebrates collection. The sampling was carried out for two consecutive years throughout the wheat cropping season; sampling was done at fortnightly intervals. Weed and crop plants of wheat in the prescribed quadrates were sampled for macro-invertebrates populations. Sweep nets were used to capture flying insects present above the canopy of the weed and crop plants. All the collected macro-invertebrates were preserved inglass vials containing 70% ethanol.

Identification The collected macro-invertebrate taxa viz., arthropods, arachnids, pulmonates and flora (weeds) were identified by consulting relevant literature and with the help of the research laboratories and museums at the University of Agriculture, Faisalabad, Pakistan and Museum of CABI (Centre for Applied Bioscience International) Regional Biosciences Centre, Daata Ganj Bakhsh Road, Rawalpindi, Pakistan.

Statistical Analysis: Shannon's diversity index (Magurran, 1988) was applied to draw inferences.

RESULTS

Macro-invertebrates belonging to the Arthropoda (92.41%) and the Mollusca (7.59%) were recorded from wheat-weeds agro-ecosytem. Diptera (27.65%), Hemiptera (27.58%), Coleoptera (18.21%), Hymenoptera (7.36%) and Orthoptera (5.82%) formed

about 80% of the arthropods in this agro-ecosystem. Hemiptera (29.09%), Coleoptera (24.77%), Diptera (23.07%), Orthoptera (5.34%) and Pulmonata (8.69%) were the most dominant taxa in wheat, whereas Diptera(30.92%), Hemiptera (26.49%), Coleoptera (13.53%), Hymenoptera (9.97%), Pulmonata (6.81) and Orthoptera (6.16%) were the dominant macro-invertebrates on weeds associated to wheat (Table 1).

Abundance of Various Macro-Invertebrate Assemblages: Foliage fauna of wheat-weed based agro-ecosystem comprised of 72 species of macro-invertebrates (n= 4228) of which a majority were arthropods (92.41%). Among arthropods, insects belonged to the orders Orthoptera, Hemiptera, Coleoptera, Diptera, Hymenoptera, Neuroptera and Lepidoptera (89.06%) while among arachnids only Araneae (3.36%) was recorded. The rest were pulmonategastropodes (7.59%). Arthropods consisted of 49 species of insects (26 families, 41 genera), twelve species of arachnids (six families, ten genera) and nine species of pulmonates (eight families, nine genera). Of the 72 species, 58 inhabited both wheat as well as weeds whereas 14 macro-invertebrate species were recorded only from weeds in this type of agro-ecosystem.

Araneae (n = 12 species) was the most abundant Order while Thomisidae was the most recorded Family (n = 4 species) among aranids. Orthoptera and Coleoptera (n = 11 species each) ranked second with respect to species richness. Coccinellidae (Coleoptera) and Acrididae (Orthoptera), were the dominant families with seven and six species, respectively. Pulmoanata (n= nine species, Oxychilidae and Planorbidae = two species each) Hemiptera (n = eight species; Aphididae = four species). Diptera and Hymenoptera (n= seven species each), Formicidae and Syrphidae were the dominant families with four and three species, respectively. Neuroptera (n=1 species) and Lepidoptera (n= 4 species) were the least abundant groups of macro-invertebrates. Species richness in percentage on wheat and associated weeds is shownin Figure 1.

Species richness of the foliage macro-invertebrate populations on wheat as well as on its associated weeds varied significantly at a statistical level (p = 0.036 df = 2.096). Araneae (n=11), Othoptera (n= 9), Coleoptera (n= 9), Hemiptera (n= 7), Pulmonata (n= 7), Diptera (n= 6), Hymenoptera (n= 6) and Lepidoptera (n= 3) were the most species rich Orders while Thomisidae, Acrididae, Coccinellidae, Aphididae, Oxychilidae, Syrphidae, Formicidae, Pieridae were the most species rich familes. Orthoptera (n= 11), Coleoptera (n= 11), Araneae (n= 9), Hemiptera (n= 7), Diptera (n= 7), Pulmonata (n= 7) and Hymenoptera (n= 6) on the other hand were the species rich Order recorded on weed leaves with Acrididae, Coccinellidae, Thomisidae, Aphididae, Syrphidae, Planorbidae, Formicidae as the species rich families. Lepidoptera (n= 3) had the same richness on both wheat and weed leaves while Neuroptera (n= 1) recorded for the first time on wheat was absent on weeds leaves.

Eight species of arachnids were recorded both from wheat and weed leaves, three from wheat leaves only and one from weed leaves. *Oxyopesjavanus*was the most recorded arachnid species on wheat (16.90%) as well as on weeds (21.83%). Among othopterans, eight species were recorded jointly from wheat and weed leaves and three from weed leaves only but orthopterans on weed leaves (23.98%) had a numerical superiority over those recorded from wheat (9.35%). Acrididae nymphs (33.33%) were the most recorded foliage taxa. Five species of pulmonates were recorded both from wheat and weed leaves, two each from wheat and weed leaves only. *Cernuellajonica* (24.92%), recorded only from wheat, was the most abundant pulmonate species. Five hemipterans species harboured both types of miro-habitats, oneharbouredwheat while the remaining two species were recorded exclusively from weed leaves. *Schizaphusgraminum* (42.62%) was the most abundant species. Two species of coleopterans were recorded exclusively from wheat and one from weed leaves while five were recorded both from wheat and weed leaves. Adults of *Coccinellaseptempunctata* (67.92%), its larvae (11.04%) and pupae (17.92%) formed a bulk of the coleopterans. Six dipteran species were sampled both from wheat and weed leaves while one was recorded from weed leaves only. *Episyrphusbalteatus* (48.25%) and *Culexpipiens* (31.31%) were the two most recorded species. Among hymenopterans, five species were recorded jointly from wheat and weed leaves and one each from wheat and weed leaves only. *Camponotus* spp. (35.37%) and *Solenopsisxyloni* (25.72%) were the two most recorded taxa (Annexure 1).

Overall richness of macro-invertebrate populations in wheat-weed agro-ecosystem was (S= 72), diversity (H´= 3.36) and evenness (E= 0.402). However, the richness (S= 58), diversity (H´= 3.23) and evenness (E= 0.79) on wheat while the richness (S= 61), diversity (H´= 3.16) and evenness (E = 0.77) on weeds in wheat-weed agro-ecosystem (Table 3).

Habitat related variation. Arthropods constituted more than 80% of all the macro-invertebrates recorded from the two microhabitats (i.e. edges and center) of the wheat-weeds agroecosystem (Table 2). Hemiptera (32.62%), Coleoptera (22.93%), Diptera (25.62%) and pulmonates (5.49%) were dominant on the wheat edges while Hemiptera (25.62%), Coleopotera (26.23%) Diptera (20.22%) and Pulmonata(12.27%) dominanted weed edges. On the other hand Coleoptera (26.23%), Hemiptera (25.63%), Diptera (20.22%) and Pulmonata (12.27%) were dominant in the center of wheat whereas Hemiptera (33.40%), Diptera (19.91%), Hymenoptera

(13.06%) and Coleoptera (12.63%) were the most abundant macro-invertebrate assemblages on the weed center. Neuroptera was exclusively found on weeds in both the microhabitats but its contribution was low (Table 2).

Comparison of the diversity (H′) indicated a highly significant difference in species richness (S) and evenness (E) in all the habitat combinations except wheat edge and center with wheat weeds edge and center (Table 4). The diversity (H′), richness (S) and evenness (E) was higher at the edge than the center of both habitats under consideration except in the wheat center (Table 3).

Table 1. Relative abundance (%) of macro-invertebrates recorded from Wheat and its associated weed plants (n is the number of individuals of each order).

Phylum/Order	% Relative abundance (n)		
	Crop	Weeds	Total
Arthropoda	91.31 (1607)	93.19 (2300)	92.41 (3907)
Orthoptera	5.34 (94)	6.16 (152)	5.82 (246)
Hemiptera	29.09 (512)	26.49 (654)	27.58 (1166)
Coleoptera	24.77 (436)	13.53 (334)	18.21 (770)
Diptera	23.07 (406)	30.92 (763)	27.65 (1169)
Hymenoptera	3.69 (65)	9.97 (246)	7.36 (311)
Neuroptera	-	0.73 (18)	0.43 (18)
Lepidoptera	1.93 (34)	2.07 (51)	2.01 (85)
Araneae	3.41 (60)	3.32 (82)	3.36 (142)
Pulmonata	8.69 (153)	6.81 (168)	7.59 (321)
Total	**1760**	**2468**	**4228**

Table 2. Relative abundance (%) of macro-invertebrates recorded from edge and center of Wheat and its associated weed plants (n is the number of individuals of each order).

Phylum/Order	% Relative abundance (n)			
	Wheat crop		Wheat weeds	
	Edge	Center	Edge	Center
Arthropoda	**92.25 (857)**	**83.03 (690)**	**90.90 (1819)**	**85.44(399)**
Orthoptera	5.17 (48)	5.54(46)	6.40 (128)	5.14 (24)
Hemiptera	32.62 (303)	25.63(213)	24.89 (498)	33.40 (156)
Coleoptera	22.93 (213)	26.23(218)	13.74 (275)	12.63 (59)
Diptera	25.62 (238)	20.22(168)	33.48 (670)	19.91 (93)
Hymenoptera	3.88 (36)	3.61(30)	9.25 (185)	13.06 (61)
Neuroptera	-	-	0.80 (16)	0.43 (2)
Lepidoptera	2.05% (19)	1.81(15)	2.35 (47)	0.86 (4)
Araneae	2.26 (21)	4.69(39)	2.60 (52)	6.42 (30)
Pulmonata	**5.49 (51)**	**12.27(102)**	**6.50 (130)**	**8.14 (38)**
Total	**929**	**831**	**2001**	**467**

Table 3. Richness, diversity and evenness values for macro-invertebrates recorded from Wheat and its associated weed plants.

Wheat field	S	H´	E	S	H´	E	*df*	t-value	*p*-value
Wheat edge/wheat center	50	2.984	0.762	48	3.210	0.829	>120	4.920	<0.001***
Wheat edge/wheat weeds edge	50	2.984	0.762	60	3.163	0.772	>120	3.716	<0.001***
Wheat edge/wheat weeds center	50	2.984	0.762	38	2.925	0.804	>120	1.480	0.139ns
wheat center/wheat weeds edge	48	3.210	0.829	60	3.163	0.772	>120	1.585	0.113ns
wheat center/wheat weeds center	48	3.210	0.829	38	2.925	0.804	>120	4.682	<0.001***
wheat weeds edge/wheat weeds center	60	3.163	0.772	38	2.925	0.804	>120	3.192	<0.001***
Wheat crop/ Wheat weeds	58	3.23	0.79	61	3.16	0.77	2.096	4010	0.036**

Seasonal variation. The abundance data of all foliage macro-invertebrates recorded from edges and centers of wheat-weeds agro-ecosystems were pooled season-wise. Phenological patterns for the two years data of macro-invertebrates in the edges and enters of the fields between wheat and its associated weeds have been depicted in Figure 2 and 3. .Hemipterans, coleopterans, dipterans, and pulmonates emerged commonest and most recorded macro-invertebrates both from wheat and its associated weeds throughout the study period. But their order of abundance varied seasonally (Table 4).

Species richness (S), evenness (E) and diversity (H') of various macro-invertebrate groups was significantly higher in weeds than wheat in all the seasonal samples except winter when their evenness (E) was higher in wheat. A comparison of these values for three seasonal samples of wheat and their weeds depicted that macro-invertebrate diversity did not vary significantly in autumn and spring but washigher than winter (Table 5a,b).

Table 4. Relative abundance (%) of macro-invertebrates recorded from Wheat and its associated weed plants during autumn, winter and spring (n is the number of individuals of each order)

Phylum/Order	% Relative abundance (n)					
	Crop			Weeds		
	Autumn	**Winter**	**Summer**	**Autumn**	**Winter**	**Summer**
Arthropoda	75.758(125)	95.659 (617)	91.053 (865)	79.724(173)	95.233(939)	93.913(1188)
Orthoptera	19.394(32)	7.442 (48)	1.474 (14)	9.217(20)	5.680(56)	6.008(76)
Hemiptera	13.333(22)	32.868 (212)	29.684 (282)	12.903(28)	36.815(363)	20.791(263)
Coleoptera	9.091(15)	12.868 (83)	35.053 (333)	12.442(27)	14.097(139)	13.281(168)
Diptera	16.364(27)	35.349 (228)	15.895 (151)	22.581(49)	22.718(224)	38.735(490)
Hymenoptera	10.909(18)	2.791 (18)	3.158 (30)	13.825 (30)	9.229(91)	9.881(125)
Neuroptera	-	-	-	-	0.507(5)	1.028(13)
Lepidoptera	-	0.775 (05)	3.053 (29)	3.226(7)	2.738(27)	1.344(17)
Araneae	6.667(11)	3.566 (23)	2.737 (26)	5.530(12)	3.448(34)	2.846(36)
Pulmonata	24.242(40)	4.341 (28)	8.947 (85)	20.276(44)	4.767(47)	6.087(77)
Total	**165**	**645**	**950**	**217**	**986**	**1265**

Table 5a. Temporal variations in richness, diversity and evenness values for macro-invertebrates recorded from wheat fields in Faisalabad district

Season	Wheat			Weeds			*Df*	t-value	*p*-value
	S	H´	E	S	H´	E			
Autumn	29	2.812	0.573	35	3.228	0.721	>120	4.682	$<0.001^{***}$
Winter	18	2.154	0.479	35	2.538	0.361	>120	3.607	0.003^{**}
Spring	21	2.562	0.617	52	3.308	0.525	>120	10.936	$<0.001^{***}$

Table 5b. A comparison of diversity of foliage macro-invertebrates recorded from wheat and associated weed plants in different seasons

Seasons	Wheat			Weeds		
	Autumn	**Winter**	**Spring**	**Autumn**	**Winter**	**Spring**
Autumn						
Winter	0.200ns			1.238ns		
Spring	0.035^{*}	3.228ns		<0.133ns	$<0.001^{***}$	

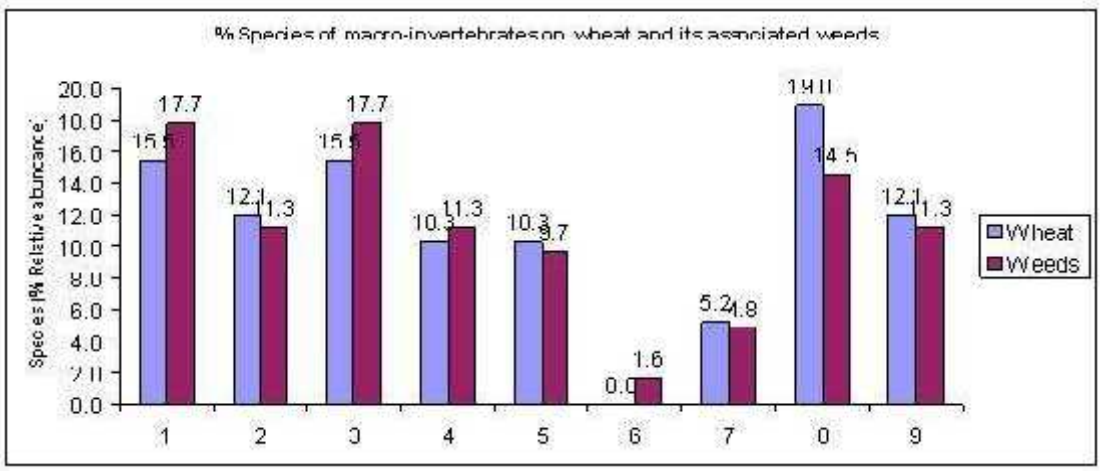


Fig. 1.Species (%) of macro-invertebrates in wheat and associated weeds (1.Orthoptera 2.Hemiptera 3.Coleoptera 4.Diptera 5.Hymenoptera 6.Neuroptera 7.Lepidoptera 8.Araneae 9.Pulmonata)

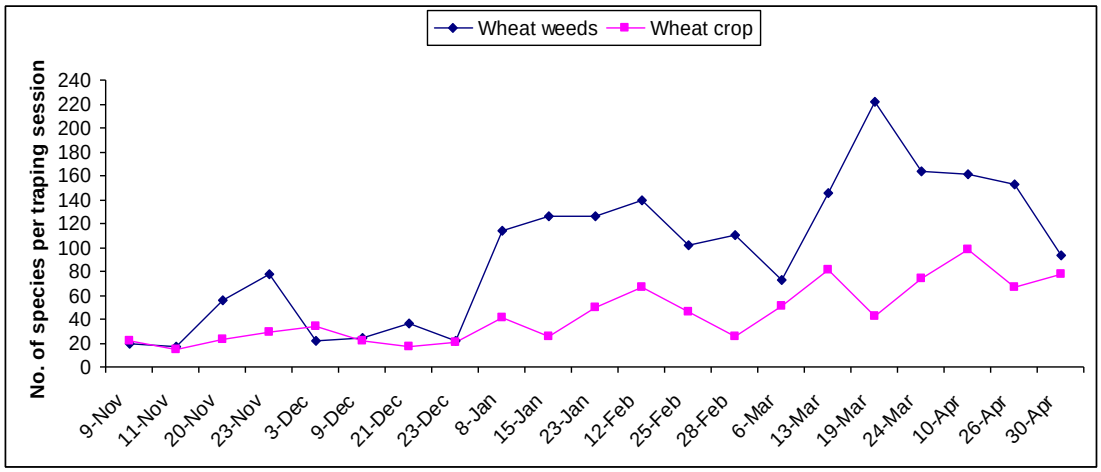


Fig. 2. Seasonal dynamics of macro-invertebrates of wheat fields edge

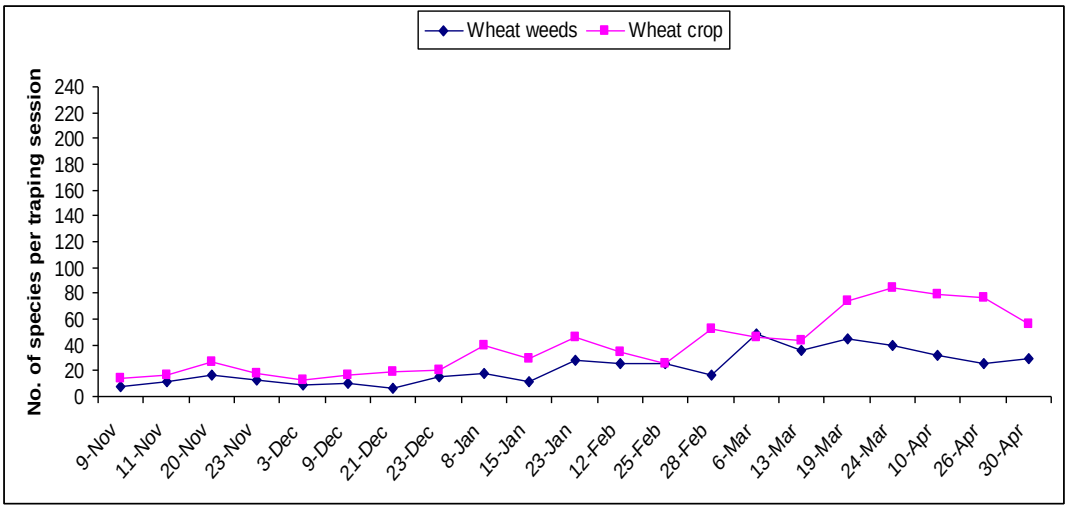


Fig. 3. Seasonal dynamics of macro-invertebrates of wheat fields center

Annexure 1. Relative abundance (%) of macro-invertebrate species in wheat and associated weeds

Order/**Family**/Species	**Wheat**	**Weeds**	**Total**
Orthoptera	**94(5.34)**	**152(6.16)**	**246(5.82)**
Pyrgomorphidae	**-**	**2(0.08)**	**2(0.05)**
Chrotogonusrobertsi	-	2(0.08)	2(0.05)
Acrididae	**60(3.41)**	**115(4.66)**	**175(4.14)**
Acridaexaltata	14(0.80)	22(0.89)	36(0.85)
Hypochlora alba	3(0.17)	16(0.65)	19(0.45)
*Melanoplus*spp.	9(0.51)	6(0.24)	15(0.35)
Aiolopusthalassinus	9(0.51)	9(0.36)	18(0.43)
Duroniallalaticornis	2(0.11)	3(0.12)	5(0.12)
Acrididae nymph	23(1.31)	59(2.39)	82(1.94)
Tettigoniidae	**1(0.06)**	**12(0.49)**	**13(0.31)**
Neoconocephalustriopes	1(0.06)	2(0.08)	3(0.07)
Meconemathalassinum	-	10(0.41)	10(0.24)
Gryllidae	**14(0.80)**	**15(0.61)**	**29(0.69)**
*Lepidogryllus*spp.	14(0.80)	15(0.61)	29(0.69)
Trigonidiumcicindeloides	19(0.80)	8(0.32)	27(0.64)
Hemiptera	**512(29.09)**	**654(26.50)**	**1166(27.58)**
Geometroidea	**117(6.65)**	**12(0.49)**	**129(3.05)**
Pyrillaperpusilla	117(6.65)	12(0.49)	129(3.05)
Lygaeidae	**1(0.06)**	**-**	**1(0.02)**
Lygaeidae nymph	1(0.06)	-	1(0.02)
Pyrrhocoridae	**63(3.58)**	**121(4.90)**	**184(4.35)**
Dysdercuscingulatus	63(3.58)	121(4.90)	184(4.35)
Aphididae	**331(18.81)**	**519(21.03)**	**850(20.10)**
Acyrthosiphongossypii	58(3.30)	98(3.97)	156(3.69)
Acyrthosiphonpisum	52(2.95)	17(0.69)	69(1.63)
Schizaphusgraminum	183(10.40)	314(12.72)	497(11.75)
Aphis nerii	38(2.16)	90(3.65)	128(3.03)
Membracidae	**-**	**2(0.08)**	**2(0.05)**
Ceressabubalis	-	2(0.08)	2(0.05)
Coleoptera	**436(24.77)**	**334(13.53)**	**770(18.21)**
Coccinellidae	**427(24.26)**	**302(12.24)**	**729(17.24)**
Coccinella pupae	101(5.74)	37(1.50)	138(3.26)
Coccinella larvae	69(3.92)	16(0.65)	85(2.01)
Coccinellaseptempunctata	128(7.27)	172(6.97)	300(7.10)
Hyperaspismaindroni	2(0.11)	7(0.28)	9(0.21)
Micraspisallardi	11(0.63)	-	11(0.26)
Hippodamiaconvergens	7(0.40)	6(0.24)	13(0.31)
Chilomenessexmaculata	109(6.19)	64(2.59)	173(4.09)
Tenebrionidae	**-**	**16(0.65)**	**16(0.38)**
Strongyliumsaracenum	-	16(0.65)	16(0.38)
Chrysomelidae	**3(0.17)**	**3(0.12)**	**6(0.14)**
Disonychastenosticha	3(0.17)	3(0.12)	6(0.14)
Curculionidae	6(0.34)	1(0.04)	7(0.17)
Chilorophanusviridis	6(0.34)	1(0.04)	7(0.17)
Staphylinidae	**-**	**12(0.49)**	**12(0.28)**
Paederuslittoralis	-	12(0.49)	12(0.28)
Diptera	**406(23.07)**	**763(30.92)**	**1169(27.65)**
Cecidomyiidae	**81(4.60)**	**40(1.62)**	**121(2.86)**
Mayetiola destructor	81(4.60)	40(1.62)	121(2.86)
Syrphidae	**265(15.06)**	**329(13.33)**	**594(14.05)**
Episyrphusbalteatus	251(14.26)	313(12.68)	564(13.34)
Syrphusribesii	9(0.51)	8(0.32)	17(0.40)

Melanostomamellinum	5(0.28)	8(0.32)	13(0.31)
Scathophagidae	**10(0.57)**	**7(0.28)**	**17(0.40)**
Scathophagastercoraria	10(0.57)	7(0.28)	17(0.40)
Muscidae	**50(2.84)**	**21(0.85)**	**71(1.68)**
Muscadomestica	50(2.84)	21(0.85)	71(1.68)
Culicidae	**-**	**366(14.83)**	**366(8.66)**
Culexpipiens	-	366(14.83)	366(8.66)
Hymenoptera	**65(3.69)**	**246(9.97)**	**311(7.36)**
Aphidiidae	**19(1.08)**	**5(0.20)**	**24(0.57)**
*Aphidius*spp.	19(1.08)	5(0.20)	24(0.57)
Vespidae	**16(0.91)**	**-**	**16(0.38)**
Polistesolivaceus	16(0.91)	-	16(0.38)
Apidae	**-**	**35(1.42)**	**35(0.83)**
Apismellifera	-	35(1.42)	35(0.83)
Formicidae	**30(1.70)**	**206(8.35)**	**236(5.58)**
*Camponotus*spp.	7(0.40)	103(4.17)	110(2.60)
Solenopsisxyloni	7(0.40)	73(2.96)	80(1.89)
Linepithemahumile	5(0.28)	6(0.24)	11(0.26)
Formica spp.	11(0.63)	24(0.97)	35(0.83)
Neuroptera	**-**	**18(0.73)**	**18(0.43)**
Chrysopidae	**-**	**18(0.73)**	**18(0.43)**
Chrysoperlacarnia	-	18(0.73)	18(0.43)
Lepidoptera	**34(1.93)**	**51(2.07)**	**85(2.01)**
Pieridae	**13(0.74)**	**12(0.49)**	**25(0.59)**
Pierisrapae	11(0.63)	12(0.49)	23(0.54)
Pieris larvae	2(0.11)	-	2(0.05)
Noctuidae	**21(1.19)**	**39(1.58)**	**60(1.42)**
Pseudaletiaunipuncta	21(1.19)	38(1.54)	59(1.40)
Amsactalactinea	-	1(0.04)	1(0.02)
Araneae	**60(3.41)**	**82(3.32)**	**142(3.36)**
Theridiidae	**12(068)**	**7(0.28)**	**19(0.45)**
Enoplognathamalapahabanda	10(0.57)	6(0.24)	16(0.38)
Chryssoargyrodiformis	2(0.11)	1(0.04)	3(0.07)
Oxyopidae	**24(1.36)**	**31(1.26)**	**55(1.30)**
Oxyopesjavanus	24(1.36)	31(1.26)	55(1.30)
Thomisidae	**6(0.34)**	**8(0.32)**	**14(0.33)**
Thomisusilocanus	3(0.17)	1(0.04)	4(0.09)
Misumenoidespabilogus	-	4(0.16)	4(0.09)
Diaeatadtadtinika	2(0.11)	1(0.04)	3(0.07)
Misumenamenoka	1(0.06)	2(0.08)	3(0.07)
Tetragnathidae	**8(0.45)**	**34(1.38)**	**42(0.99)**
Tetragnathavermiformis	6(0.34)	34(1.38)	40(0.95)
Tetragnathajavana	2(0.11)	-	2(0.05)
Salticidae	**7(0.40)**	**2(0.08)**	**9(0.21)**
Phintellapiatensis	5(0.28)	2(0.08)	7(0.17)
Phintellabunyiae	2(0.11)	-	2(0.05)
Lycosidae	**3(0.17)**	**-**	**3(0.07)**
Hippasa partita	3(0.17)	-	3(0.07)
Pulmonata	**153(8.69)**	**168(6.81)**	**321(7.59)**
Hygromiidae	**80(4.55)**	**-**	**80(1.89)**
Cernuellajonica	80(4.55)	-	80(1.89)
Planorbidae	**15(0.85)**	**84(3.40)**	**99(2.34)**
Biomphalaria peregrine	15(0.85)	10(0.41)	25(0.59)
Euomphaliastrigella	-	16(0.65)	16(0.38)
Planorbariuscorneus	-	58(2.35)	58(1.37)
Punctidae	**16(0.91)**	**25(1.01)**	**44(1.04)**

Punctumpygmaeum	16(0.91)	25(1.01)	41(0.97)
Subulinidae	**3(0.17)**	**5(0.20)**	**8(0.19)**
Subulinaoctona	3(0.17)	5(0.20)	8(0.19)
Oxychilidae	**18(1.02)**	**35(1.42)**	**53(1.25)**
Daudebardiarufa	15(0.85)	35(1.42)	50(1.18)
Aegopinellanitidulla	3(0.17)	-	3(0.07)
Zonitidae	**21(1.19)**	**19(0.77)**	**40(0.95)**
Retinellaolivetorum	21(1.19)	19(0.77)	40(0.95)
Total	**1760**	**2468**	**4228**

DISCUSSION

The diversity, richness and abundance of foliage microhabitats varied in both types of microhabitats (Marshall and Moonenb, 2002; Turner *et al.*, 2003) but contrary to the general findings it was more diverse at centers than the edge while richness was recorded higher on edges. These results are in-line with the findings ofAnjum-Zubair *et al*. (2010) they documented higher diversity of Carabid beetles in the center of fields compared to edges. However, when diversity of foliage macro-invertebrates of either wheat or its weeds is compared alone in the present study, edges emerge as more diverse habitat then the centers. Similar results had also described byClough *et al*. (2007). Mainly the wheat plants near edges were sparsely distributed due to anthropogenic disturbances. Furthermore shade of woody plants on the edges did not allow more wheat to grow on the edge thereby allowing more macro-invertebrates to establish over there (Honek, 1988) and distribution of macro-invertebrates in wheat-weeds agro-ecosystem (Riedel, 1995; Holopainen, 1995).

Weeds either annual, biennial and perennial naturally flourished on crop edges provide phytomorphic heterogeneity (Speight and Lawton, 1976; Capinera, 2005; Ruby *et al*., 2011) food, overwintering sites (Pfiffner and Luka, 2000; Thomas and Marshall, 1999), significantly more diverse on edges than in centers of crop (Perfecto and Vandermeer 2002; Duelli and Obrist 2003; Van Buskirk and Willi 2004; Hof and Bright, 2010), weedy field margins in agro-ecosystem have fundamental effects on increasing the abundance of macro-invertebrate populations (Hof and Bright, 2010). Abundance of macro-invertebrate populations was recorded significantly higher on weeds present on edges (Burgio*et al*., 2007). Many reported that weedy field edges have life-supporting functions and have a vital impact on diversity of macro-invertebrate population and self emerging plants (Perfecto and Vandermeer 2002; Duelli and Obrist 2003; Van Buskirk and Willi 2004). Similarly, in the present study overall weeds and weeds on the field edges constituted significantly higher diversity of macro-invertebrate populations (H'=3.16) and (H'=3.163) respectively.

Arthropods were the most diverse and dominant group of macro-invertebrates recorded on both wheat and its allied weeds. Of which Archnida (Twelve spp.) Orthoptera (Eleven spp.), Hemiptera (Eight spp.), Coleoptera (Eight spp.), Diptera (Seven spp) and Hymenoptera (seven spp) were most recorded group of macro-invertebrates. Basset *et al*. (2003) described that arthropods are the most diverse group of macro-invertebrates in agroecosystem and forests. In India, Kadappa *et al*. (2008) documented seventeen and eighteen groups of arthropods in the consecutive years 2007-07 respectively. Moreover Ruby *et al*. (2010) reported eleven groups viz., Orthoptera, Araneae, Hemiptera, Coleoptera, Lepidoptera, Hymenoptera, Odonata, Diptera and Thysanoptera, Neuroptera, Prostigmata.

Temporal fluctuation in abundance and diversity of macro-invertebrate fauna depicted statistically significant differences in all the seasons (autumn, winter and spring). A sharp decline in the abundance macro-invertebrate groups were recorded during autumn season (n= 382) and significantly higher during winter and spring seasons (n= 1631) and (n= 2415), respectively. Kutschbach-Brohl, *et al*. (2010) reported the temporal variations in abundance and diversity of various macro-invertebrate groups such as Orthoptera, Hemiptera and Auchenorrhyncha. Seasonal flactuations can be explained as macro-invertebrate species have different phenologies and as a result difference in activity periods depending on temperature (Booij, *et al*., 1995).

Conclusion: Biodiversity always offers great potential for controlling insect pests of agricultural crops. As it constituted a huge range of predatory and parasitic natural enemies of pests, which plays significantly important role in the suppression of agricultural pests and in turn enhance productivity of economically important crops like wheat.

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