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Assessment of diversity and distribution of Snails (Mollusca: Gastropoda) in the Agroecosystem of Faisalabad, Pakistan

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Abstract

Gastropods have never been studied in Punjab, Pakistan with reference to its diversity and distribution. Different ecological factors have been studied which affect the distribution of the snail in the agroecosystem of this region. Total number of 19290 snails specimens, were collected from different cropland areas of 24 villages of Faisalabad including sugarcane, wheat, fodder, vegetables fields and ditches. The specimens were identified on the basis of recent identification keys and diagrammatic description provided in them to understand the biodiversity in this region. The diversity index was found highly significant in sugarcane, wheat, fodder, and vegetables fields however the results were non-significant in case of ditches. The relative abundance was maximum in sugarcane and least in ditches. The diversity index was significantly high in all months except in April whereas the relative abundance was maximum in July and August. It can be concluded that due to environmental degradation and water pollution the snail diversity is non significant, in ditches however in the agroecosystem it is a pest. It can be suggested that strategies must be developed to control water quality deterioration and its biological control as a pest.

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Introduction

Land snail biodiversity, is defined as the number of native species per unit of land area, as stated by Holland and Cowie, (2009). Next to the insects the second large and most successful invertebrate are snails as previously stated by (Abbot, 1989; Hapman, 2009). Considering the number of the species that have been described, the non marine molluscs becomes the second most diverse Phylum in Kingdom Animalia. Although the freshwater and terrestrial, the molluscs are found to be one of the most diverse groups, yet there are only a few scientists who are aware of their importance and are working on these creatures. One of the most important and effective approach to the biodiversity conservation and management is the compilation and publication of the Red Data Book as stated by Bouchet, (1997). According to a survey conducted in 2002 by the IUCN there are total 708 freshwater and 1222 terrestrial molluscs, out of which 42% of the 693 extinctions from the animal species are molluscs, comprising 260 gastropods and 31 bivalves as reported in Red List of Threatened Species by Baillie *et al.*, (2004). Invertebrates are not generally noticed by the biologists and conservation agencies as most of the work is being done on terrestrial vertebrate regarding their extinctions and has been well documented by Lydeard *et al.*, (2004). Mostly the animal taxa which are being focused are vertebrates with an apparent maturity of the taxonomy of birds and mammals due to their prevalence. This also shows a global interest in certain attractive classes. These classes are important due to public awareness and aesthetic significance. Although even common people are aware of the importance of Giant panda or White Rhinoceros yet the invertebrate species are extremely neglected subject in the Red data as reported by (Gorbatovsky, 2003). The diversity of invertebrate species is much higher than vertebrates but they are little addressed. The major reason for this negligence is the ignorance about these creatures. The continental molluscs have been less represented in the regional *Red Data Books* of Siberia and Urals which led to the conclusion that there are far few professional malacologists who can cover the malacological surveys especially due to the remoteness and absence of communication as stated by (Grebennikov and Vinarski, 2010).

The fresh water gastropods under consideration are less than 5%, for such strategies as their status has not been assessed yet. In USA, the species which have been presumed to be extinct in freshwater gastropods are nearly 60 in number. There are 20 threatened or endangered species while the remaining 290 species are of extreme conservation concern. So there are 48% of the fresh water gastropods which are important conservation targets while 9% of freshwater gastropods are extinct in USA. The destruction at this rate is more than that of any other major group exceeding the freshwater mussels also, in which the species which are conservation targets are 42% as previously stated by (Johnson, 2003).

Recently researches have been conducted on the biodiversity of soil macro invertebrate in the low and high input fields of wheat and sugarcane in District Faisalabad by Rana, (2012) and Siddiqui, (2005) with the major focus on impact of chemical on the diversity of different macro invertebrates. Rana (2000) studied the ecological distribution of earthworm species along some water bodies in the agro ecosystem of Faisalabad Division. Khanum (2010) studied the taxonomy of the plant nematodes of Sugarcane fields. Very less work has been done with reference to the taxonomy and ecology of snails in the agro ecosystem. Previously Ali, (2005), Altaf (2006) and Rahman (2011) have attempted to study the diversity of snails in agroecosystem of Faisalabad which has augmented the previous information of the malacofaunna in Faisalabad. The work of the Ali (2005) and Altaf, (2006) was limited to the sugarcane and wheat fields near Gutti village area; however Rahman (2011) described the biodiversity of only one family in few villages of Faisalabad focusing only one family of snails. The objective of the present study is to estimate the diversity of this little creature in 24 villages of Faisalabad with fifteen different species

belonging to nine families.

Materials and methods

Sampling

Collection of molluscs was carried out by random sampling from the open edges, under tree, and inside field on 25 acres of each selected village. The samples were taken from open edges of the field (without shadow) using iron quadrat (30 cm^2) whereas the core samplers were used to collect the samples under tree (with shadow) and inside field. Snails were also sampled with the help of handpicking while doing an extensive search from 24 villages of Faisalabad along the Rakh barrage, Jinnah Barrage and Ghogera Barrage. The number of samples taken from each village varied from 50-125 samples due to difference in the agricultural land area.

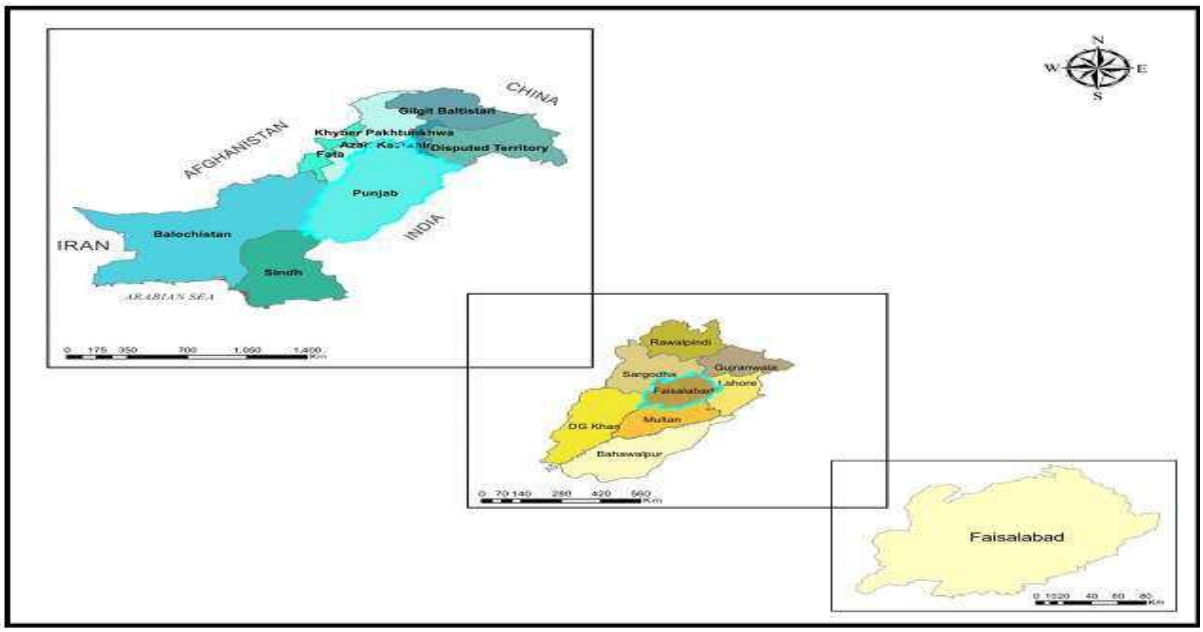

Fig. 1. Location of Faisalabad, Punjab, Pakistan (Saleem, 2014).

Soil samples were packed in the bags and were assigned a number, labeled with the site, collector's number and date of collection. All samples were taken to the Laboratory for molluscan separation with hand sorting and for smaller specimen different sieves were used (0.2 mm, 2.0 mm, 4.75 mm). The dry shells were packed in air tight plastic bags, while the living snails collected were preserved in 70% ethanol following Thompson, (2004).

Identification

The identification of the specimens was carried out on the basis of following characteristics such as number of whorls, coiling of the shell, umbilicus, shape, colour of shell, shape of the aperture, presence or absence of operculum, height and diameter of the snails. The diameter of the aperture was measured with the help of vernier caliper. The snails' samples were studied under the microscope and were identified by using the keys and diagrams provided by the Blandford and Godwin (1908), Bouchet and Rocroi (2005), Sturm *et al.*, (2005), Anderson, (2008), Watson and Dallwitz (2005) .

Statistical analysis

The software of interactive basic programs SP Divers.BAS (Ludwig and Reynolds 1988) was used to calculate shannon's index for both abundance and evenness of the species present. The proportion of species relative to the total number of species (p_i) was calculated, and then multiplied by the natural logarithm of this proportion (ln p_i). The resulting product was summed across species, and multiplied by -1.

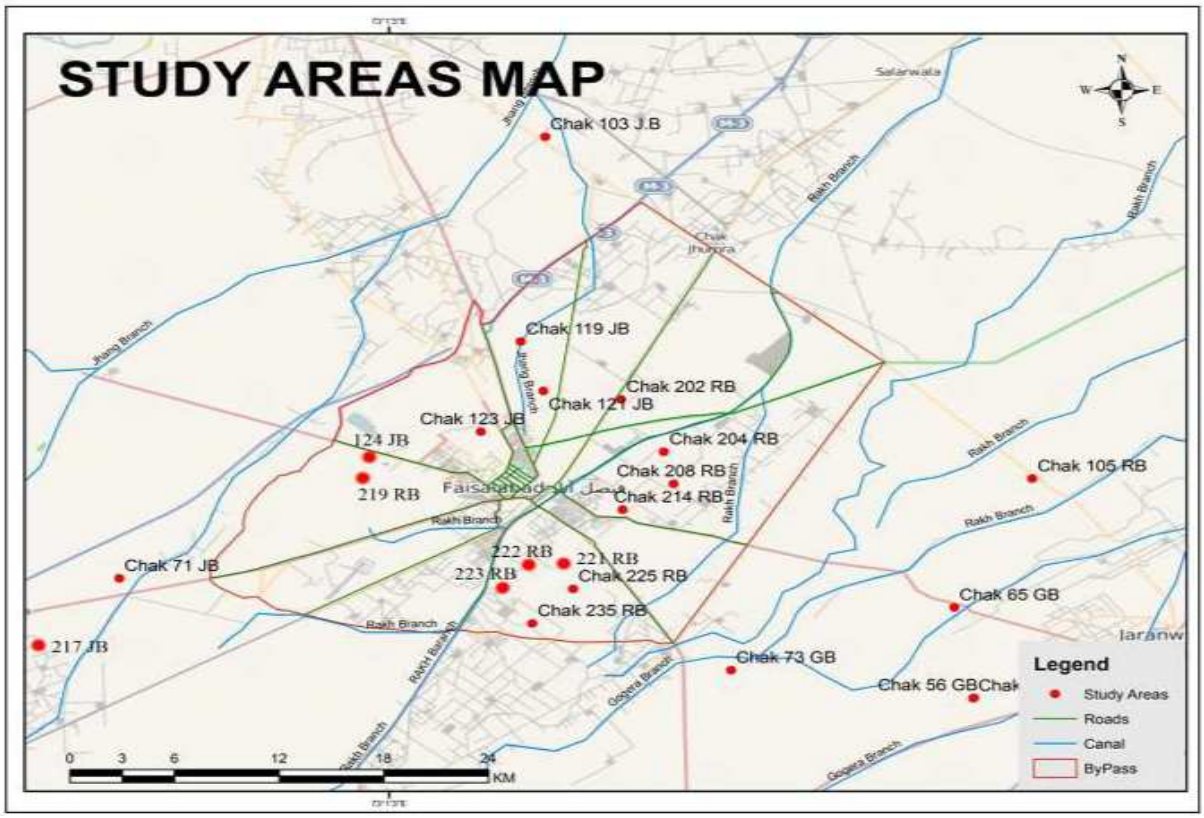

Fig. 2. Map of Study Area.

H is a more reliable measure as sampling size increases.

Relative abundance was calculated by the following formula and pie charts were designed

$$\text{Relative Abundance} = \frac{\text{Number of snails found in a habitat or month} \times 360}{\text{Total Number of snails}}$$

Results

Population density is population size in relation to some unit of space. It is generally assayed and expressed as the number of individuals or population biomass per unit area or volume. Often it is important to know whether a population is increasing or decreasing than to know its size at any one moment. In such cases indices of relative abundance are more important.

In the Figure 1, the species have been numbered according to the sequence shown in the Table 3. Total 3276 individuals of *Ariophanta bistrialis* were collected and it was found maximum in number. The species found with the least number was of *Cecilioides acicula* followed by juvenile *Zooctecus insularis*. The species *Ariophanta bistrialis ceylanica*, *Ariophanta bistrialis cyix*, *Ariophanta bristrialis taprobanensis* range from 2392 to 2558 in number respectively. The *Oxyloma elegans* was 1840 followed by *Ariophanta solata,* 1185. The species which were found in a few hundreds were *Physa fontinalis,* 955, followed by *Cernuella virgata*, 936, followed by *Zooctecus insularis*, 846, followed by *Oxyloma elegans*, 739, Ariophanta belangeri bombayana, 731, *Monacha catiana,*632, *Oxychilus draparnaudi, 570*.

The number of specimens of species *Ariophanta bristalis* was found maximum in number i.e.17%. The

species found with the least number was of *Cecilioides acicula* (0.3%) followed by juvenile *Zooctecus insularis* (0.5%). The species *Ariophanta bistrialis cyix*, *Ariophanta bistrialis ceylanica*, *Ariophanta bristrialis taprobanensis* range from 12.4% to 13.3% respectively. The *Oxyloma elegans* was 9.5% followed by *Ariophanta solata,* 6.1%. The species which were found in a few hundreds were *Physa fontinalis,* (5.0%), followed by *Cernuella virgata*, 4.9%, followed by *Zooctecus insularis*, 4.5%, followed by *Pupoides albilabris* and *Ariophanta belangeri bombayana*, 3.8%. The species *Monacha catiana,* was 3.3%, *Oxychilus draparnaudi,* 3.0% (Figure 3).

The diversity indices of the snails, in different villages of Faisalabad, were found to be highly significant i.e. in 204 R.B., 07J.B., 119J.B., 214 G.B., 221J.B., 124 J.B., 202 R.B., 208 R.B., 103 J.B., 222 R.B., 223 R.B., 235 R.B., 71 J.B., 56G.B. and 73 G.B. while the other villages have a significant diversity with a p-value of 0.01 (Table 1).

Table 1. Species Diversity Indices for Snails in Different Villages of Faisalabad.

Villages	N°	H'	N1	N2	E1	E5	t value	p-value
204 R.B	15	2.22	9.24	7.40	0.82	0.78	3.68	0.00***
07 J.B	12	2.08	7.96	6.38	0.84	0.77	3.37	0.00***
119 J.B	11	2.05	7.76	6.66	0.85	0.84	3.88	0.00***
214 G.B	12	2.13	8.40	6.79	0.86	0.78	3.72	0.00***
121 J.B	8	1.87	6.47	5.66	0.90	0.85	4.07	0.00***
123 J.B	8	1.55	4.72	4.11	0.75	0.84	2.71	0.02**
124 J.B	7	1.74	5.70	5.09	0.89	0.87	3.97	0.00***
217 J.B	10	1.78	5.95	9.92	0.77	0.79	2.94	0.00**
202 R.B	15	2.36	10.63	8.56	0.87	0.78	4.25	0.00***
208 R.B	13	2.14	8.48	6.78	0.83	0.77	3.57	0.00***
103 J.B	13	2.29	9.91	8.29	0.89	0.82	4.47	0.00***
214 R.B	10	1.91	6.77	5.50	0.83	0.78	3.27	0.01**
221 R.B	10	1.88	6.58	5.23	0.82	0.76	3.13	0.01**
219 R.B	12	1.83	6.26	4.63	0.74	0.69	2.62	0.01**
222 R.B	14	2.38	10.79	9.50	0.90	0.87	5.17	0.00***
223 R.B	14	2.25	9.45	7.47	0.85	0.77	3.82	0.00***
225 R.B	13	2.04	7.67	5.66	0.79	0.70	3.03	0.01**
235 R.B	10	1.98	7.27	5.84	0.86	0.77	3.52	0.00***
295 R.B	7	1.61	5.03	4.27	0.83	0.81	3.05	0.01**
71 J.B	13	2.37	10.66	9.28	0.92	0.86	5.40	0.00***
105G.B	13	2.15	8.59	7.07	0.84	0.80	3.76	0.00***
65 G.B	14	2.34	10.43	8.88	0.89	0.84	4.69	0.00***
56 G.B	11	1.63	5.12	2.98	0.68	0.48	1.93	0.04*
73 G.B	9	1.79	5.98	4.83	0.81	0.77	3.03	0.01**

When we compare the diversity indices and the evenness of different villages of Faisalabad it can be clearly observed that the villages having a diversity index more nearly 2.25 are 202 R.B., 103 J.B., 222 R.B., 223R.B. and65 G.B. (Group 1) with highly significant results whereas the evenness (E5) is greater than 0.8 only in 103 J.B. 222 R.B. and 65 G.B. while the other villages have a value of greater than 0.77. These results show that with increasing trend of diversity indices the species have been found to be quiet evenly distributed in the above mentioned group of villages however in the latter group of villages species have been found less evenly distributed.

Table 2. Species Diversity Indices for Snails in Different Villages of Faisalabad.

Months	N°	H'	N1	N2	E5	t-value	df	p value
Villages R.B	15	2.46	11.65	10.31	0.87	5.45	14	0.000***
Villages G.B	15	2.35	10.53	8.96	0.84	4.51	14	0.000***
Villages J.B	15	2.27	9.65	7.93	0.80	3.93	14	0.001***

The diversity indices ranges from 2.0 to 2.2 in the villages, 07 J.B., 119 J.B., 214 G.B. 225 R.B. and 105 G.B. (Group 2) with the the evenness greater than 0.8 in 119 J.B. and 105 G.B. showing a trend that there is an decrease in the diversity index the species have been found to be more evenly distributed. However in the villages of 07 J.B.and 214 G.B. the species are comparatively less evenly distributed with E5 value of 0.77 and 0.78 respectively. The E5 value has greatly reduced in the 225 R.B. reaching 0.70.

Table 3. Distribution of Snails in Different Habitats of Agroecosystem.

Sr.no	Species/Habitats	Wheat	Fodder	Sugarcane	Vegetables	Ditches	Total
1	*Ariophanta bistrialis ceylanica*	555	1127	717	52	0	2451
2	*Ariophanta bistrialis cyix*	794	859	659	80	0	2392
3	*Ariophanta bistrialis taprobanensis*	680	1105	727	46	0	2558
4	*Ariophanta bistrialis*	743	1583	898	52	0	3276
5	*Ariophanta solata*	236	439	510	0	0	1185
6	*Ariophanta belangeri bombayana*	152	316	263	0	0	731
7	*Oxychilus draparnaudi*	244	70	219	37	0	570
8	*Monacha catiana*	169	74	377	12	0	632
9	*Cernuella virgata*	266	106	544	20	0	936
10	*Pupoides abilabris*	138	193	408	0	0	739
11	*Physa fontinalis*	0	0	0	0	955	955
12	*Zooctecus insularis*	221	340	303	0	0	864
13	*Juvenile Zooctecus insularis*	84	12	0	0	0	96
14	*Cecilioides acicula*	65	0	0	0	0	65
15	*Oxyloma elegans*	0	0	0	0	1840	1840
	Total	4347	6224	5625	299	2795	19290

Table 4. Species Diversity Indices for Snails in Different Crops of Faisalabad.

Crops	N°	H'	N1	N2	E5	t-value	Df	p value
Wheat	13	2.30	9.97	8.34	0.82	4.62	12	0.000***
Sugarcane	12	2.03	7.59	6.25	0.80	3.46	11	0.003***
Fodder	11	0.11	10.11	9.44	0.93	7.74	10	0.000***
Tomatoes and vegetables	7	0.17	6.16	5.73	0.92	5.00	6	0.001***
Ditches	2	0.55	1.90	1.82	0.91	3.16	1	0.098 NS

In the villages, 121 J.B., 123 J.B., 124 J.B., 217 J.B., 214 R.B., 221 R.B., 219R.B., 235 R.B., 295 R.B., 56 G.B., and 73 G.B. (Group 3) the value of diversity index ranges from 1.55- 2.0 showing that these areas are less diverse in terms of snails species. However, the evenness ranges from ranging from 0.83-0.85 in 121 J.B., 123 J.B., 124 J.B., and 295 R.B. showing that although these snails species are more evenly distributed in these areas than the villages of Group 1 yet these villages are less diverse giving significant results. The villages 217 J.B., 214 R.B., 221 R.B., 219 R.B., 235 R.B., 73 G.B., show lesser evenness 0.7-0.79 which is nearly similar to Group 2 villages but the villages of Group 3 are less diverse in terms of snail species. 56 G.B. has the least evenness in all the villages i.e. 0.48 (Figure 4 and Figure 5).

The map of the Faisalabad shows that 123 J.B. is towards the north eastern direction of Faisalabad with least diversity of snail species which increases in 103 J.B. with decrease in diversity again in 121 J.B. 121 J.B. that are towards south of the 103 J.B.

Table 5. Distribution of snails in different months.

Sr.no	Species/Habitats	March	April	May	June	July	August	Total
1	*Ariophanta bistrialis ceylanica*	456	589	82	181	810	333	2451
2	*Ariophanta bistrialis cyix*	356	810	52	365	341	468	2392
3	*Ariophanta bristrialis taprobanensis*	535	614	43	516	478	372	2558
4	*Ariophanta bristrialis*	521	803	46	637	597	672	3276
5	*Ariophanta solata*	227	217	65	204	202	270	1185
6	*Ariophanta belangeri bombayana*	65	71	95	119	258	123	731
7	*Oxychilus draparnaudi*	77	47	159	127	127	33	570
8	*Monacha catiana*	152	41	183	145	62	49	632
9	*Cernuella virgata*	69	111	248	243	181	84	936
10	*Pupoides albilabris*	147	11	273	224	61	23	739
11	*Physa fontinalis*	214	55	145	41	219	281	955
12	*Zooctecus insularis*	84	12	138	225	160	245	864
13	*Juvenile Zooctecus insularis*	8	0	32	34	0	22	96
14	*Cecilioides acicula*	1	0	18	7	13	26	65
15	*Oxyloma elegans*	470	8	145	408	89	720	1840
	Total	3382	3389	1724	3476	3598	3721	19290

Table 6. Average environmental variables in different months.

Envoirnmental variables	March	April	May	June	July	August
Average Maximum Temperature	32^{0}C	34 ^{0}C	26^{0}C	35^{0}C	39^{0}C	41 ^{0}C
Average Minimum Temperature	22 ^{0}C	25 ^{0}C	19^{0}C	26^{0}C	27^{0}C	28 ^{0}C
Average Relative Humidity	55%	60%	50%	65%	70%	75%
Average Rainfall	1mm	2mm	1mm	3mm	4mm	5mm
Average Sunshine	8hours	9hours	8hours	9hours	6hours	5hours
Total Snails Specimens	3382	3389	1724	3476	3598	3721

Considering the villages linked to the Rakh branch, the 202 R.B. is in Group 1 with highest diversity. To the south of 202 R.B. there is 204 R.B. in same group with similar diversity. However, in 208 R.B. the diversity is least which is at south of 204 R.B. The village 235 R.B. is to the extreme south in the villages linked to Rakh branch in the Group 3 with the least species diversity. In villages linked with Ghogera Branch the diversity indices are least, showing that as we progress towards the south, the diversity of the snail species in Faisalabad is highly reduced.

Table 7. Species Diversity Indices for Snails in Different Months in Faisalabad.

Months	N°	H'	N1	N2	E5	t-value	df	p value
March	15	2.34	10.41	8.98	0.85	4.55	14	0.000***
April	13	1.90	6.67	5.49	0.79	2.96	12	0.01**
May	15	2.49	12.08	10.53	0.86	5.69	14	0.000***
June	15	2.42	11.26	9.61	0.84	4.98	14	0.000***
July	14	2.30	10.01	8.09	0.79	4.21	13	0.001***
August	15	2.29	9.90	8.27	0.82	4.14	14	0.001***

All species were found in all villages linked with Rakh branch, Ghogera branch and Jinnah branch which are distributries of the irrigation system of province of Punjab. While the species diversity and the eveness was found maximum in R. B villages and minimum in J. B villages. However the diversity indices and eveness in all the villages is quite similar ranging from 2.27-2.46 and 0.80-0.87 respectively and the results are highly significant (Table 2, Figure 6-7). The regression analysis of species diversity and evenness of snails in different irrigation canals in Faisalabad shows that there 97.03% relationship beween species diversity and species evenness in the irrigation canal linked to Rakh Branch, Ghogera Branch and Jhang Branch (Figure 8).

The maximum number of snails was found in sugarcane, 6224, with the least number of snails in vegetables, 299.

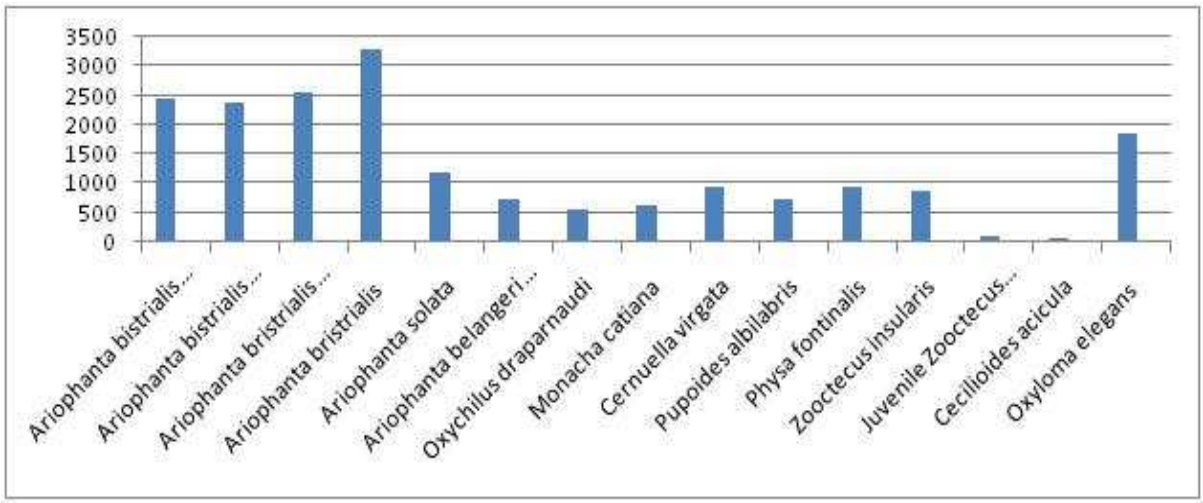

Fig. 3. Number of Individuals of Each Species From Different Agro- Regions of Faisalabad.

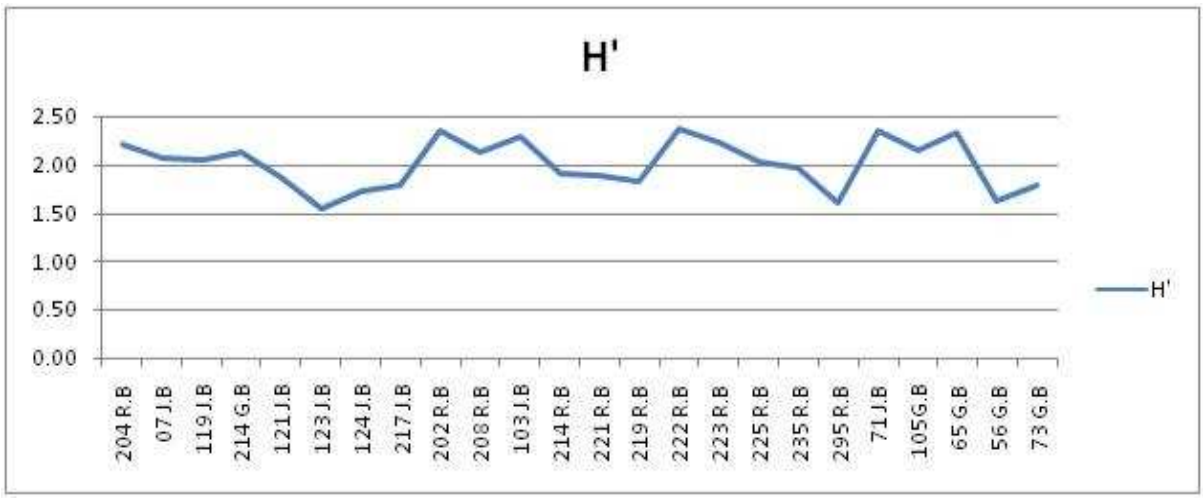

Fig. 4. Species Diversity Indices for Snails in Different Villages of Faisalabad.

The number of snails in wheat, fodder and sugarcane ranges from 4347-6224. However the number of snails was 2795 in ditches (Table 3).

The relative abundance of snails was maximum in sugarcane is 32% while least in the vegetables i.e. 2%. However, the relative abundance of wheat and fodder is quite similar. The relative abundance of snails in ditches is nearly one half of sugarcane i.e. 14% (Figure 9).

The maximum number of species was found in wheat crop with highest diversity index of 2.30 but having evenness with a value of 0.82. However the diversity index was least in the fodder with maximum evenness of 0.93 showing that it has least diversity of snail species which are evenly distributed.

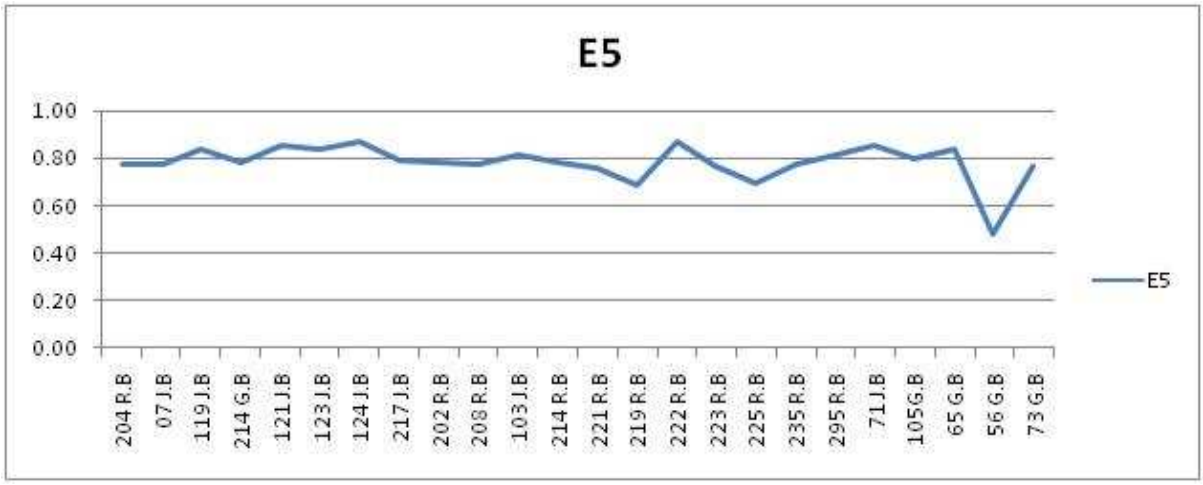

Fig. 5. Species Diversity Indices for Snails in Different Villages of Faisalabad.

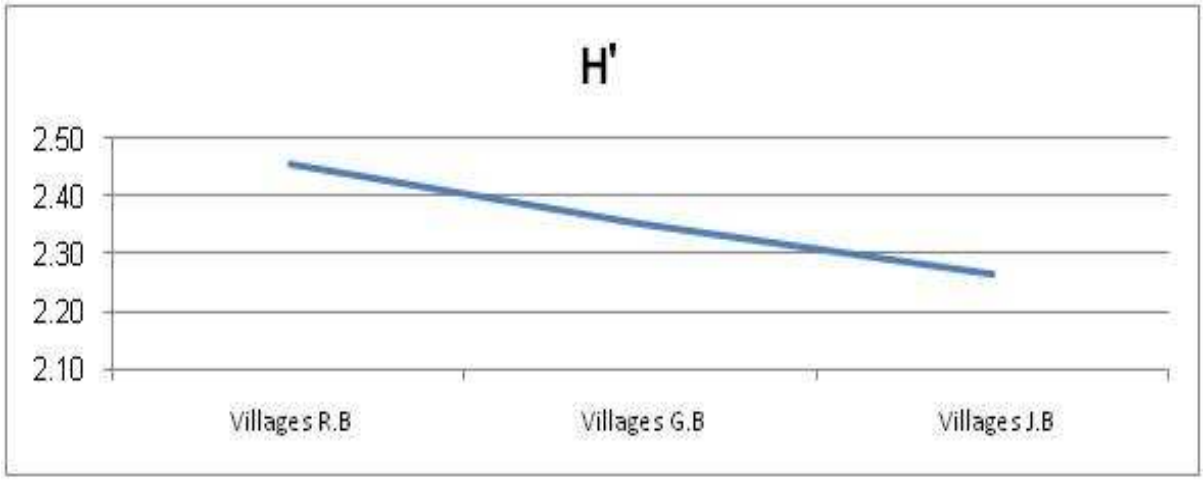

Fig. 6. Species Diversity Indices for Snails in Villages through Different Irrigation Canal of Faisalabad.

The diversity index of the sugarcane and wheat fields ranges from 2.03-2.30 with evenness ranging from 0.80-0.82. The diversity index of fodder and vegetable field ranges from 0.11-0.17 while the diversity index of ditches is 0.55. The evenness of species in ditches, vegetables and fodder, range from 0.91-0.93 showing that despite lesser diversity the species are quite evenly distributed. The results are highly significant in all the crops while in ditches the results are non-significant (Table 4, Figure 10-11).

The month wise distribution of the Table 5, explains that there were maximum number of snails in the month of August, 3721, and the least number of snails were found in May, 1724. The number of snails found in the month of July, 3598, June, 3476, April, 3389, and March 3382 was quite similar.

The maximum relative abundance of snails was found in August and July,19% where the average maximum temperature and average minimum temperature was highest in August followed by July, however in May the relative abundance was just 9% where the average maximum temperature and average minimum temperature was lowest (Figure 12).

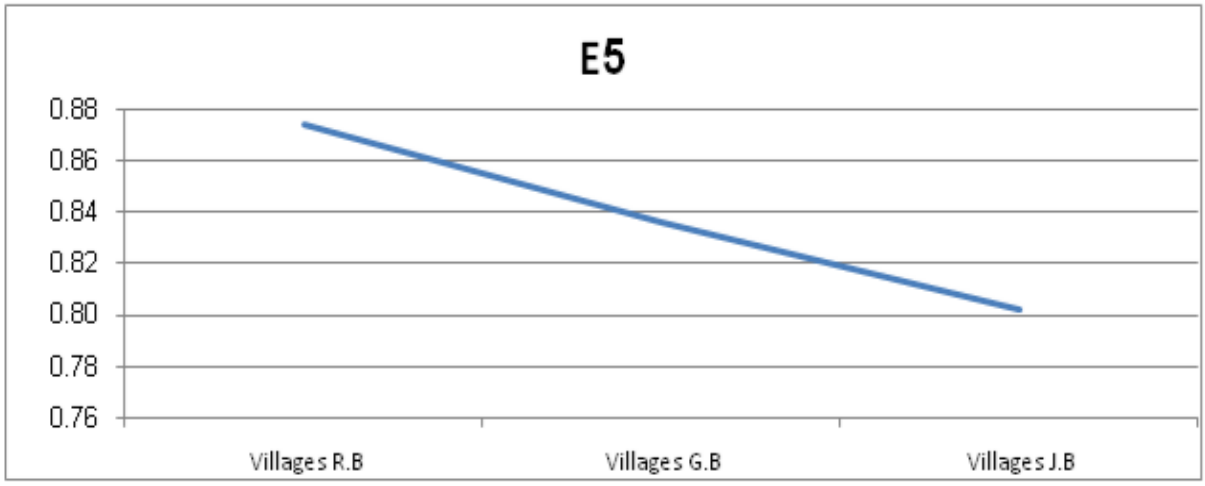

Fig. 7. Evenness for Snails in Villages through Different Irrigation Canal of Faisalabad.

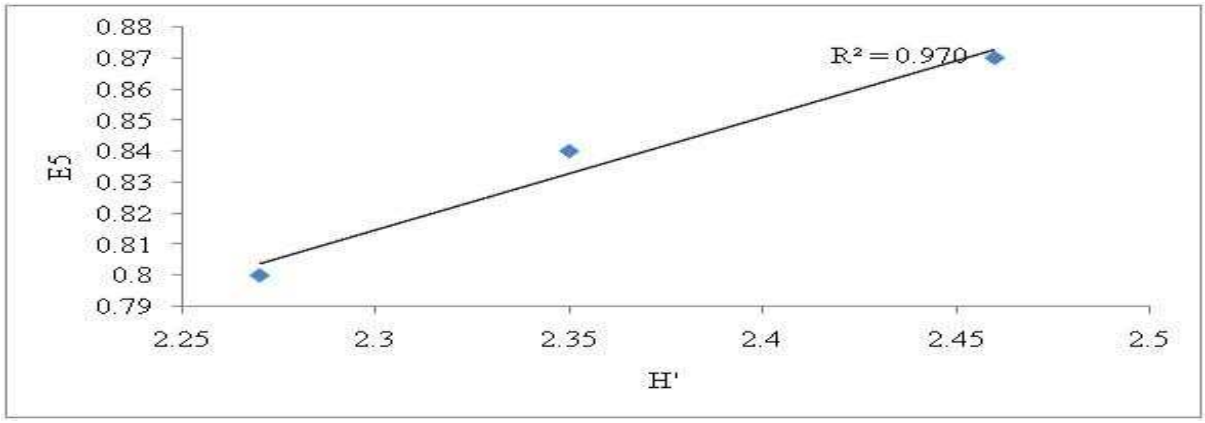

Fig. 8. Regression Analysis of Species Diversity and Evenness of Snails in Different Irrigation Canals in Faisalabad.

The average maximum temperature was least in May and highest in the August, with a similar pattern observed when average maximum temperature was noted. The humidity and rainfall were least in the month of August. Considering the average sunshine, there were least number of average sunshine hours in the month of August, 5 hours, however in May there were 8 hours of average sunshine (Table 6).

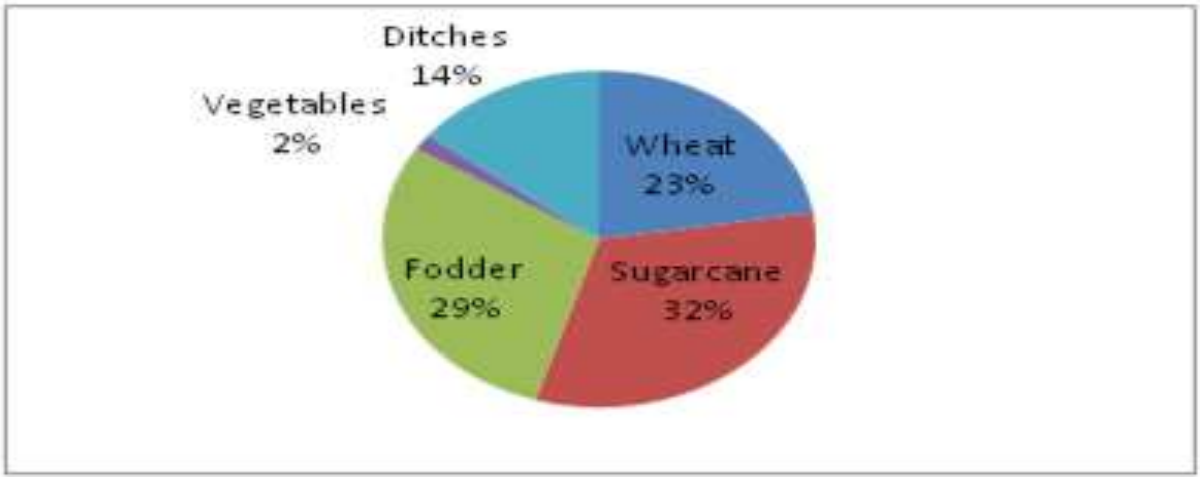

Fig. 9. Relative Abundance of Snails in different Habitats of the Agroecosystem of Faisalabad.

The maximum species diversity Index was found in May, 2.49, with maximum evenness in this month. It shows the diversity of species in this month which are evenly distributed. The least species diversity was found in April, 1.90, and having the lowest value of evenness in April and July, 0.79 (Table 7).

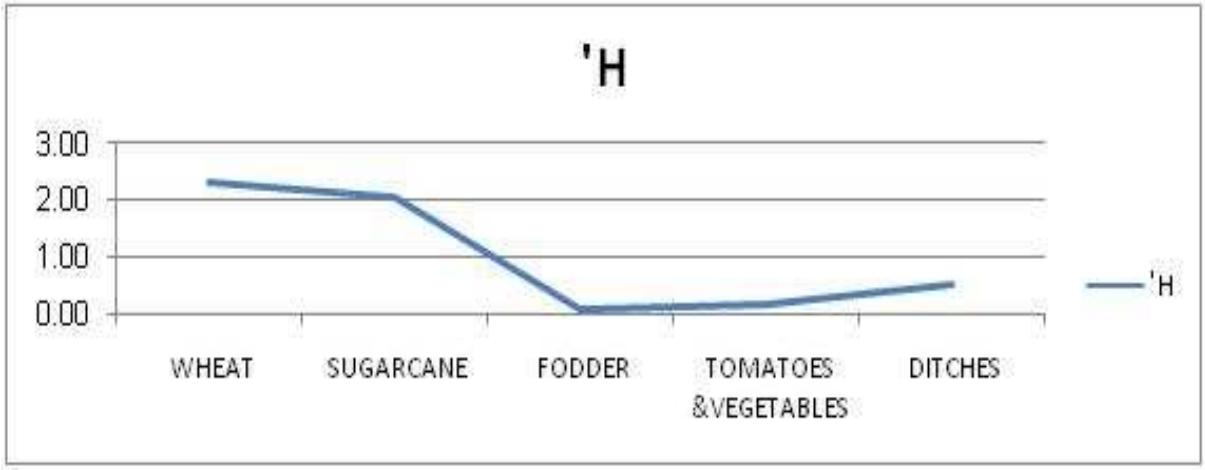

Fig. 10. Species Diversity Indices for Snails in Different Crops of Faisalabad.

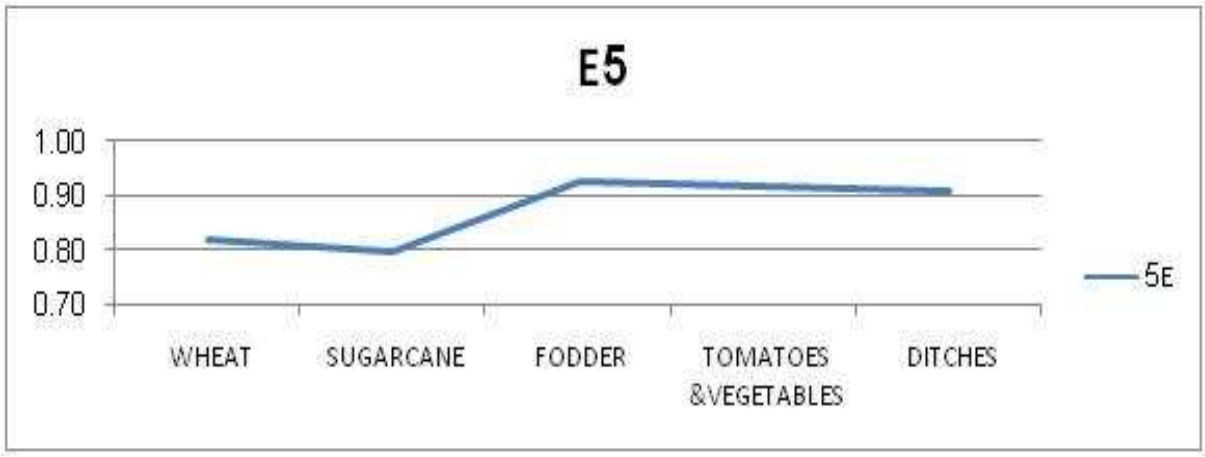

Fig. 11. Evenness for Snails for Snails in Different Crops of Faisalabad.

The species diversity in the month of March, May, June, July, and August ranges from 2.29-2.42 which are quite similar. However, the evenness is 0.85 in March which suddenly reduces in April after which a sharp rise occurs in the month of May after which there is a gradual decrease to minimum in July as it is in April, with a rise in August (Figure 13-14). These results lead us to the conclusion that possibly there was a strong synergetic impact of these abiotic factors on the distribution of the snails.

Discussion

Species abundance distribution has been a point of interest for the scientists and researchers due to many reasons. This is because in this way the community can be understood in a more better way rather than by just counting the species, as in this way heterogeneity and abundance can be incorporated which is the basis for the calculations as stated by Magurran, (2004). Secondly in species abundance distribution, the rare-species tail can also provide information regarding the estimation of the numbers of species missed altogether and, therefore, of the true species richness. Chao (1984) estimated the number of singletons and doubletons in the sample with the help of a simple non parametric estimator. Various scientists found high percentages of singletons i.e. (11%, 12%, and 23%) as previously

stated by (De Winter and Gittenberger, 1998; Fontaine *et al.*, 2007b; Liew *et al.*, 2010), leading to relatively high richness estimations. Thirdly, the species abundance distribution helps us to understand changes in species dominance induced due to the season as stated by (De Winter and Gittenberger, 1998) physical disturbance as reported by (Schilthuizen *et al.*, 2005a) and to deduce the ecological processes developing the community structure.

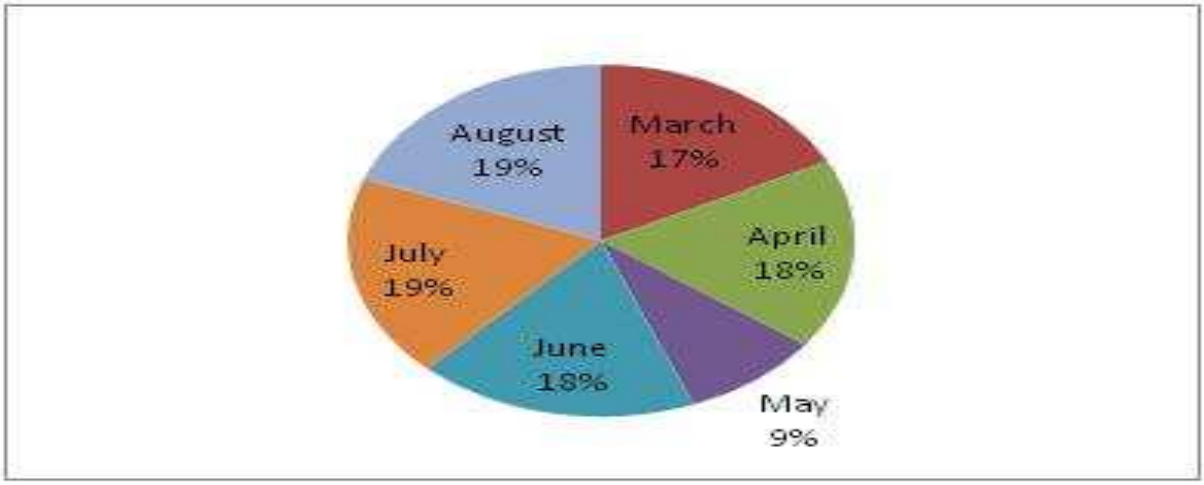

Fig. 12. Relative Abundance of snails in different Months in Faisalabad.

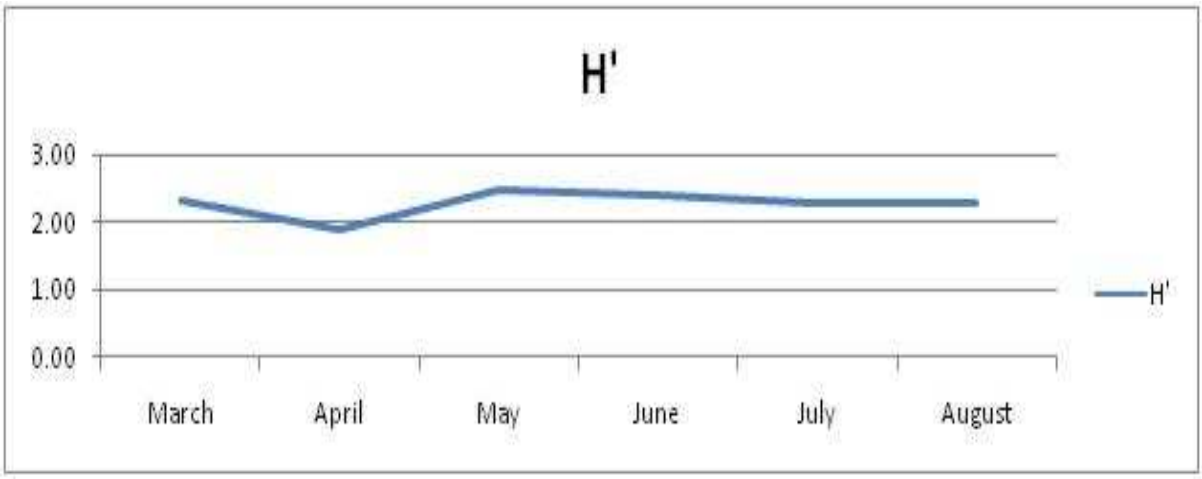

Fig. 13. Species Diversity Indices for Snails in Different Months in Faisalabad.

The diversity indices are highest for fauna in the sugarcane crop which is followed by fodder, wheat and brassica, respectively. This may be due to the lesser use of chemicals i.e. weedicides and insecticides in contrast to the other crops and the second probable reason is that sugarcane crop is available round the year in the field while in contrast to this the excessive use of insecticides was recorded on other crops. Sugarcane was found to be the preferred crop by majority of faunal species followed by fodder, wheat and brassica as documented by Inayat *et al.* (2010).

Considering wheat a major crop and staple food in Pakistan, has less faunal diversity due to regular use of weedicides when compared with sugarcane crop, with greater diversity, has been confirmed by the studies of Cartea *et al.* (2009).

The immediate environment and cropping patterns are very important in structuring the arthropod communities in crop varieties of the agroecosystem as previously stated by (Heong *et al.* 1991).

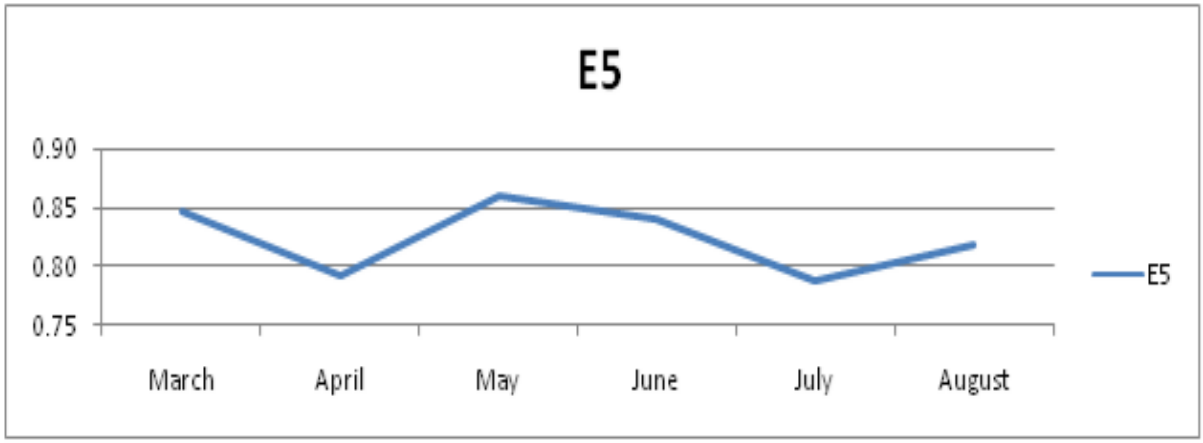

Fig. 14. Evenness for Snails in Different Months in Faisalabad.

There is maximum faunal similarity between wheat and brassica and in sugarcane and fodder. This is probably because both grew in the same season and are grown in the similar environmental conditions and result in similar faunal distribution while in ditches there were found snails belonging to a separate order, having preference for aquatic habitat (Inayat *et al*., 2010). Still more studies are required to evaluate the quality of environmental parameters of different villages and their impact on the snail diversity.

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Conflict of interest

The authors hereby confirm that there are no known conflicts of interest associated with this publication.

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