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Interaction of snail species in the agroecosystem

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Abstract

This study has been carried out to understand the interspecific interaction of different snail species, time and host crop. The sampling was carried out in various agricultural fields of 24 villages of Faisalabad i.e. ditches, vegetables wheat, Sugarcane, fodder, for 6 months from March, 2011 through August, 2011.There is greater than 90 percent similarity among the wheat, sugarcane, vegetables and fodder however ditches are different from previously described crops i.e 35.58% in terms of species composition. In the months of March, June and August there is more than 90% similarity while the months of April and July form the second cluster which is nearly 90% similar. However, the species of snails in the month of May is highly different with least similarity i.e. 43.89% with the cluster 1 and 2. The presence absence data for fifteen species during six months (March-August) has been used in the agro ecosystem of Faisalabad. The variance ratio test, chi squares and association indices have been determined showing an overall positive association. As W=10.7767 and falls within the range of 7.261-25 so we accept the null hypothesis of no association during different months. However, we reject the null hypothesis of no association in different habitats as W=29.28572 and doesnot fall within the range of 7.261-25. The analysis of variance shows the association between the two variables of species accession number and time is highly significant, the association between species with the host crop is found highly significant showing synergetic effect of different factors on snail composition.

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Introduction

Ecosystem function is strongly affected by biodiversity (Hooper *et al.*, 2005). However, the methods given in the literature provide no information on the contribution of different species to an ecosystem function and confound the effects of species identity and diversity. These gaps were overcome by estimating a diversity effect (DE) as the performance of the mixture minus expected performance of component species' monoculture performances i.e, the species identity (ID) effect (Loreau 1998). These benefits of biodiversity can result from interspecific interactions (i.e., niche facilitation and partitioning etc.) among the species in a community (Fox 2005).

However, overall performance of the mixed community from the expected from the individual species performances even if combined, when studying species interactions and this difference is defined as diversity effect, DE (Loreau, 1998). The effects on the ecosystem as a result of the inter specific Interactions can be antagonistic or synergistic. The researches in Diversity–function predict that the overall effect of species interactions on the ecosystem performance will be positive (Hooper *et al.* 2005). These Diversity benefits are considered to be due to differences in resource use among species (niche partitioning), and facilitation. The utilization of the resources are more complete due to the niche partitioning in a more diverse community. Interspecific facilitation occurs when variety of species allow or support other species by modifying the environment to grow which favors the co-occurrence of species (Cardinale *et al.*, 2002).

Species may have an overall negative impact on the ecosystem function as they combine antagonistically as there are a number of different negative and positive that may operate simultaneously and result into diversity effect which may even lead to a net diversity effect of zero. There are strong species identity effects within guild of functional group of bivalve filter feeders, with one species (*Actinonaias ligamentina*) influencing accrual of benthic algae more than other species, but only under summer conditions showing. species within trait-based functional groups do not necessarily have the same effects on ecosystem properties, particularly under different environmental conditions (Vaughn *et al.*, 2007).

The modeling approach can be used to estimate the effects of species identity and, can reveal various patterns to study the contribution of different species interactions to the net diversity effect and it also predicts the diversity–function relationship for a pool of species. There are a number of effects of species identity in a community however, the estimation of the separate species interaction to the net diversity effect is extremely important as the overall effect could be zero due to the existence of both negative and positive interactions. The relative abundance distribution of the community changes the diversity effect. The relative abundance distribution of the species and the diversity effect for any mixture can be estimated using various models. The species identity effects need not to be discounted for as the modeling approaches also helps in estimating the species identity effects. The species interaction effects must be assessed relative to the sizes of the identity effects. If there is a species that performs particularly well, a monoculture of that species may outperform the mixtures, irrespective of the presence of positive interactions (Kirwan, 2009).

The researchers of the tropical land snail expressed and demonstrated the patterns of intraspecific rarity and commonness that have been found (Oke and Alohan, 2006; De Winter and Gittenberger, 1998; Schilthuizen *et al.*, 2002; 2005a; Schilthuizen and Rutjes, 2001). 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 understanding species abundance distribution, the rare-species tail can also provide information regarding the estimation species number missed giving true scenario of species richness.

Thirdly, the species abundance distribution helps us to understand changes in species dominance induced due to the season (De Winter and Gittenberger, 1998) disturbance on the basis of changes in physical factors (Schilthuizen *et al.*, 2005a) and to deduce the ecological processes developing the community structure.

The log normal distribution seen in the natural communities including gastropods can be approached by a model (Sugihara *et al.*, 2003; Sugihara, 1980) for the subdivision of niche space in sequence. A sigmoid shaped curve is formed in a Whittaker plot when a log normal distribution was calculated. Whenever there is the over representation of the rare species a distinct right-skew is often observed (Tokeshi, 1999). This niche free model can predict the skew in a better way (Hubbell, 2001) as it fills the slots randomly in a community. The predictions of particular models was tested by the goodness of fit to understand the potential ecological processes that structures the communities for some of the non-tropical and tropical land snail (Cameron and Pokryszko, 2005).

However species abundance distribution studies available in the literature largely suffer from biased sampling methodology. There are many patterns which are quite similar in properties with that of SAD (species abundance distribution) which are present in nature which can lead to complex dynamical properties. This limits to understand the ecological structuring processes from species abundance distribution alone (Nekola and Brown, 2007). These models are mostly applicable to only one guild in a same community, which in case of the gastropods needs a little more elaboration. If the spatial scale for the determination of species abundance diversity is quite large then the chances of obtaining patterns due to ecological reasons rather than statistical reasons declines rapidly (Sizling *et al.*, 2009). A community of species which are performing ecological function that are similar; and they compete for almost the similar resource is called a guild (Rosenzweig, 1995 and Hubbell, 2001). It would be probably wrong to consider tropical terrestrial gastropods communities as guilds.

Although meager knowledge about tropical terrestrial gastropod' autecology is available and there are many predators in the African faunas (Wronski and Hausdorf, 2008; De Winter and Gittenberger, 1998), which are in high numbers including fungivores, foliovores and detrivores, even considering the non-molluscivores, yet there is another factor to be considered and measured, is its body size.

The snail's body mass varies in several magnitude throughout its life, and there are stronger ecological interactions in the individuals of the similar size so animals of different sizes should be considered as separate communities as individuals of the same size have stronger ecological interactions so different size classes should be really considered as different communities. This gives us an idea that there is a difference in the community of the juveniles and adults. This is not necessary that this community is composed of land snails only, rather this community may include other inverteberates with low mobility and these snails will have a stronger competition than it would have with other snails (Connell, 1961; Wootton, 1994). The above mentioned aspects of the gastropod community have never been considered in this part of the world due to which this study has been planned with the objective to estimate the interactions among different snail species on the basis of their ecological niche.

Materials and method

The snails were collected from different sites in the agroecosystem of Faisalabad from March 2011 to August 2011 (Fig. 3.1-3.2). 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 following Afshan *et al.*, (2013). The samples were taken from open edges of the field (without shadow) using iron quadrat (30 cm^2) whereas the core samples 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 branch, Jinnah branch and Ghogera branch.

The number of samples taken from each village varied from 50-125 samples due to difference in the agricultural land area. All samples were taken to the Laboratoy 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 (Thompson, 2004). The snail's samples were studied under the microscope and are identified by using the keys and diagram provided by the Blandford and Godwin (1908), Bouchet and Rocroi (2005), Sturm *et al.* (2005), Anderson (2008), Watson and Dallwitz (2005) upto species level .The data was subject to following statistics.

Inter Specific Association

Usually, the association of more than a single pair of species is of interest; we may be interested in from 5 to perhaps 50 or more species. The number of all possible pair wise species association or combinations that may be computed increases rapidly according to the equation S(S-1)/2, where S is the number of species.

$$\sigma\ 2T = \sum pi(1-pi)$$

Where pi =ni/N. Next we estimate the variance in total species number as

$$S\ 2T= 1/N\sum(Tj-t)2$$

Where t is the mean number of species per sample

The variance ratio,

$$VR=S^2_T/\ \sigma^2_T$$

serves as an index of overall species association. The expected value under the null hypothesis of independence is, VR>1 suggests that overall the species exhibit a positive association. If VR <1, then a negative net association is suggested.

A statistic, W, is computed that may be used to test whether deviations from 1 are significant. For example, if the species are not associated then there is 90% probability that W lies between limits given by the chi-square distribution.

$$X^2_{0.5,N}>W< X^2_{0.95,N}$$

where

$$W=(N)(VR).$$

Two Way Analysis of Variance

The means of the two populations are often compared by two sample t-test however it is sometimes required to compare the means of populations simultaneously. For this we cannot apply two sample t-test for all possible pair wise comparisons of means. There are two disadvantages when we run multiple two sample tests when we compare their means. First of all the procedure is quite time consuming and tedious. Secondly the level of significance greatly increases as the number of t- test increases. Thus, a series of two sample t-tests is not an appropriate procedure to test the equality of several means simultaneously.

Evidently we require a procedure for carrying out a test on several means simultaneously. When each observation is classified, according to two criteria (or variables) of classification simultaneously, we use the two way analysis of variance technique.

There are two basic forms of two way analysis of variance depending upon whether the two variables of classification are independent or whether they interact. Two variables of classification are said to interact when they together have an added effect that they do not have individually (Chaudhry and Kamal, 1996). Two way analysis of variance was calculated by using Minitab version 16.

Cluster Analysis

The term cluster analysis (first used by Tryon, 1939) encompasses a number of different algorithms and methods for grouping objects of similar kind into respective categories. A general question facing researchers in many areas of inquiry is how to organize observed data into meaningful structures, that is, to develop taxonomies. In other words cluster analysis is an exploratory data analysis tool which aims at sorting different objects into groups in a way that the degree of association between two objects is maximal if they belong to the same group and minimal otherwise.

Given above, cluster analysis can be used to discover structures in data without providing an explanation/interpretation. In other words, cluster analysis simply discovers structures in data without explaining why they exist. Cluster analysis was used to investigate the degree of association or resemblance of sampling sites. It is a useful data reduction technique that is helpful in identifying patterns and groupings of objects. The Minitab version 16 program were used for cluster analysis using flexible strategy and chord distance, a measure of dissimilarity by following Ward's method (Ward, 1963; Lance and William, 1967; Faith, 1991).

Results

Interaction of Snail Species

The interaction has been studied among different snail species, months of year and host crops in which these snail species were found. The species have been assigned accession numbers 1-15 (Table 1).

Table 1. Accession number and Order of the Species.

Accession Number	Species
1	*Ariophanta bistrialis ceylanica*
2	*Ariophanta bistrialis cyix*
3	*Ariophanta bristrialis taprobanensis*
4	*Ariophanta bristrialis*
5	*Ariophanta solata*
6	*Ariophanta belangeri bombayana*
7	*Oxychilus draparnaudi*
8	*Monacha catiana*
9	*Cernuella virgata*
10	*Pupoides albilabris*
11	*Physa fontinalis*
12	*Zooctecus insularis*
13	*Juvenile Zooctecus insularis*
14	*Cecilioides acicula*
15	*Oxyloma elegans*

The analysis of variance of the species, month, and host crop is found highly significant. The association between the two variables of species and month is highly significant, the interaction between species with the host crop is found highly significant while the association between time and the host crop is also significant (Table 2).

Table 2. Analysis of Variance for Number of Specimen, using Adjusted SS for Test.

Sources	D.F	Seq SS	Adj SS	Adj MS	F value	P- value
Species	14	152149.4	152149.4	10867.8	32.71	0.000***
Months	5	7155.7	7155.7	1431.1	4.31	0.001***
Agroecosystem	3	55027.1	55027.1	18342.4	55.21	0.000***
Species *Months	70	73362.3	73362.3	1048	3.51	0.000***
Species *Agroecosystem	42	73580.6	73580.6	1751.9	5.27	0.000***
Months*Agroecosystem	15	9517.8	9517.8	634.5	1.91	0.019*
Error	1290	428605.7	428605.7	332.3		
Total	1439	799398.6				

In the Table 3 the presence absence data for fifteen species during six months (March-August) has been used in the agroecosystem of Faisalabad. Using BASIC program SPASSOC.BAS, the variance ratio test, chi squares and association indices have been determined. An overall positive association is suggested (VR=1.796). However, W=10.7767 and falls within the range of 7.261-25 so we accept the null hypothesis of no association during different months.

However, there does seem to be some strong possibilities that true positive associations (1-2, 1-3, 1-4, 1-5, 2-3, 2-4, 2-5, 3-4, 3-5, 4-5, 8-10) might exist (Table 3).

There are negative associations between species 1-7, 1-8, 1-9, 1-10, 1-11, 1-12, 1-15, 2-7, 2-8, 2-9, 2-10, 2-11, 2-12- 2-15, 3-7,3-8, 3-9,3-10,3-11,3-12, 3-15,4-7,4-8,4-9,4-10,4-11,4-12,4-15,5-7,5-8,5-9,5-10,5-11,5-12,5-15, 6-8, 6-10, 7-14, 8-14, 9-11, 9-14, 9-15. This is clearly indicated in the Table 4.34 showing percentage of snails in different months of the study period that species 1, 2, 3, 4, 5 have clear cut high percentages as compared to species 7, 8, 9, 10, 12, which may be due to the reason that they are competitive on the same feeding niches; however, species 11 and 15 are not much less in percentage due to which we can say that this negative relationship may be due to difference in the ecological niche as species 11 and 15 are only found in ditches.

The presence absence data for fifteen species in five habitats, in the agroecosystem of Faisalabad, has been used. Using BASIC program SPASSOC.BAS, the variance ratio test, chi squares and association indices have been determined. An overall positive association is suggested when V>1 (VR=5.857143). However, W=29.28572 and does not fall within the range of 7.261-25 so we reject the null hypothesis of no association in different habitats.

However, there does seem to be some strong possibilities that true positive associations (1-2, 1-3, 1-4, 1-7, 1-8,1-9, 2-3, 2-4, 2-7, 2-8, 2-9, 3-4, 3-7, 3-8, 3-9, 4-7, 4-8, 4-9, 5-6, 5-10, 5-12, 6-10, 6-12, 7-8, 7-9, 8-9) might exist as shown in the table. On the other hand there are strong true negative association in (1-11, 1-15, 2-11, 2-15, 3-11, 3-15, 4-11,4-15, 7-11, 7-15, 8-11, 8-15, 9-11, 9-15) (Table 4). Both of the species *Physa fontinalis* and *Oxyloma elegans* have been numbered 11 and 15 respectively. Both species are found in ditches or near water bodies while all other species are found in the agricultural crops due to which they have negative association as they cannot overlap the same habitat.

Table 3. Interspecific association indices and test statistics between fifteen snail species in different months.

Species pair		Association type	Association Indices				
			Chi-Square Value	Yate's Chi-Square	Ochiai	Dice	Jaccard
1	2	Positive	6.000	0.960	1.000	1.000	1.000
1	3	Positive	6.000	0.960	1.000	1.000	1.000
1	4	Positive	6.000	0.960	1.000	1.000	1.000
1	5	Positive	6.000	0.960	1.000	1.000	1.000
1	6	Positive	1.200	0.000	0.775	0.750	0.600
1	7	Negative	1.200	0.000	0.516	0.500	0.333
1	8	Negative	1.200	0.000	0.516	0.500	0.333
1	9	Negative	0.600	0.150	0.671	0.667	0.500
1	10	Negative	1.200	0.000	0.516	0.500	0.333
1	11	Negative	0.600	0.150	0.671	0.667	0.500
1	12	Negative	0.600	0.150	0.671	0.667	0.500
1	13	Positive	0.240	0.960	0.447	0.333	0.200
1	14	Positive	0.240	0.960	0.447	0.333	0.200
1	15	Negative	0.600	0.150	0.671	0.667	0.500
2	3	Positive	6.000	0.960	1.000	1.000	1.000
2	4	Positive	6.000	0.960	1.000	1.000	1.000
2	5	Positive	6.000	0.960	1.000	1.000	1.000
2	6	Positive	1.200	0.000	0.775	0.750	0.600
2	7	Negative	1.200	0.000	0.516	0.500	0.333
2	8	Negative	1.200	0.000	0.516	0.500	0.333
2	9	Negative	0.600	0.150	0.671	0.667	0.500
2	10	Negative	1.200	0.000	0.516	0.500	0.333
2	11	Negative	0.600	0.150	0.671	0.667	0.500
2	12	Negative	0.600	0.150	0.671	0.667	0.500
2	13	Positive	0.240	0.960	0.447	0.333	0.200
2	14	Positive	0.240	0.960	0.447	0.333	0.200
2	15	Negative	0.600	0.150	0.671	0.667	0.500
3	4	Positive	6.000	0.960	1.000	1.000	1.000
3	5	Positive	6.000	0.960	1.000	1.000	1.000
3	6	Positive	1.200	0.000	0.775	0.750	0.600
3	7	Negative	1.200	0.000	0.516	0.500	0.333
3	8	Negative	1.200	0.000	0.516	0.500	0.333
3	9	Negative	0.600	0.150	0.671	0.667	0.500
3	10	Negative	1.200	0.000	0.516	0.500	0.333
3	11	Negative	0.600	0.150	0.671	0.667	0.500
3	12	Negative	0.600	0.150	0.671	0.667	0.500
3	13	Positive	0.240	0.960	0.447	0.333	0.200
3	14	Positive	0.240	0.960	0.447	0.333	0.200

Species pair		Association type	Association Indices				
			Chi-Square Value	Yate's Chi-Square	Ochiai	Dice	Jaccard
3	15	Negative	0.600	0.150	0.671	0.667	0.500
4	5	Positive	6.000	0.960	1.000	1.000	1.000
4	6	Positive	1.200	0.000	0.775	0.750	0.600
4	7	Negative	1.200	0.000	0.516	0.500	0.333
4	8	Negative	1.200	0.000	0.516	0.500	0.333
4	9	Negative	0.600	0.150	0.671	0.667	0.500
4	10	Negative	1.200	0.000	0.516	0.500	0.333
4	11	Negative	0.600	0.150	0.671	0.667	0.500
4	12	Negative	0.600	0.150	0.671	0.667	0.500
4	13	Positive	0.240	0.960	0.447	0.333	0.200
4	14	Positive	0.240	0.96	0.447	0.333	0.200
4	15	Negative	0.600	0.150	0.671	0.667	0.500
5	6	Positive	1.200	0.000	0.775	0.750	0.600
5	7	Negative	1.200	0.000	0.516	0.500	0.333
5	8	Negative	1.200	0.000	0.516	0.500	0.333
5	9	Negative	0.600	0.150	0.671	0.667	0.500
5	10	Negative	1.200	0.000	0.516	0.500	0.333
5	11	Negative	0.600	0.150	0.671	0.667	0.500
5	12	Negative	0.600	0.150	0.671	0.667	0.500
5	13	Positive	0.240	0.960	0.447	0.333	0.200
5	14	Positive	0.240	0.960	0.447	0.333	0.200
5	15	Negative	0.600	0.150	0.671	0.667	0.500
6	7	Positive	0.667	0.000	0.667	0.667	0.500
6	8	Negative	0.667	0.000	0.333	0.333	0.200
6	9	Positive	0.000	0.750	0.577	0.571	0.400
6	10	Negative	0.667	0.000	0.333	0.333	0.200
6	11	Positive	0.000	0.750	0.577	0.571	0.400
6	12	Positive	3.000	0.750	0.866	0.857	0.750
6	13	Positive	1.200	0.000	0.577	0.500	0.333
6	14	Positive	1.200	0.000	0.577	0.500	0.333
6	15	Positive	0.000	0.750	0.577	0.571	0.400
7	8	Positive	0.667	0.000	0.667	0.667	0.500
7	9	Positive	3.000	0.750	0.866	0.857	0.750
7	10	Positive	0.667	0.000	0.667	0.667	0.500
7	11	Positive	0.000	0.750	0.577	0.571	0.400
7	12	Positive	3.000	0.750	0.866	0.857	0.750
7	13	Positive	1.200	0.000	0.577	0.500	0.333
7	14	Negative	1.200	0.000	0.000	0.000	0.000
7	15	Positive	0.000	0.750	0.571	0.571	0.400
8	9	Positive	0.000	0.750	0.577	0.571	0.400
8	10	Positive	6.000	2.667	1.000	1.000	1.000
8	11	Positive	0.000	0.750	0.577	0.571	0.400
8	12	Positive	0.000	0.750	0.577	0.571	0.400
8	13	Positive	1.200	0.000	0.577	0.500	0.333
8	14	Negative	1.200	0.000	0.000	0.000	0.000
8	15	Positive	3.000	0.750	0.866	0.857	0.750
9	10	Positive	0.000	0.750	0.577	0.571	0.400
9	11	Negative	1.500	0.094	0.500	0.500	0.333
9	12	Positive	0.375	0.094	0.750	0.750	0.600
9	13	Positive	0.600	0.150	0.500	0.400	0.250
9	14	Negative	2.400	0.150	0.000	0.000	0.000
9	15	Negative	1.500	0.094	0.500	0.500	0.333

VR, Index of overall association= 1.796

W, Test statistic= 10.7767.

Table 4. Interspecific association indices and test statistics between fifteen snail species in different habitats of agroecosystem.

Species pair		Association type	Association Indices				
			Chi-Square	Yate's Chi-Square	Ochiai	Dice	Jaccard
1	2	Positive	5.000	0.703	1.000	1.000	1.000
1	3	Positive	5.000	0.073	1.000	1.000	1.000
1	4	Positive	5.000	0.703	1.000	1.000	1.000
1	5	Positive	1.875	0.052	0.866	0.857	0.750
1	6	Positive	1.875	0.052	0.866	0.857	0.750
1	7	Positive	5.000	0.703	1.000	1.000	1.000
1	8	Positive	5.000	0.703	1.000	1.000	1.000
1	9	Positive	5.000	0.703	1.000	1.000	1.000
1	10	Positive	1.875	0.052	0.866	0.857	0.750
1	11	Negative	5.000	0.703	0.000	0.000	0.000
1	12	Positive	1.875	0.052	0.866	0.857	0.750
1	13	Positive	0.833	0.052	0.707	0.667	0.500
1	14	Positive	0.313	0.703	0.500	0.400	0.250
1	15	Negative	5.000	0.703	0.000	0.000	0.000
2	3	Positive	5.000	0.703	1.000	1.000	1.000
2	4	Positive	5.000	0.703	1.000	1.000	1.000
2	5	Positive	1.875	0.052	0.866	0.857	0.750
2	6	Positive	1.875	0.052	0.866	0.857	0.750
2	7	Positive	5.000	0.703	1.000	1.000	1.000
2	8	Positive	5.000	0.703	1.000	1.000	1.000
2	9	Positive	5.000	0.703	1.000	1.000	1.000
2	10	Positive	1.875	0.052	0.866	0.857	0.750
2	11	Negative	5.000	0.073	0.000	0.000	0.000
2	12	Positive	1.875	0.052	0.866	0.857	0.750
2	13	Positive	0.833	0.052	0.707	0.667	0.500
2	14	Positive	0.313	0.703	0.500	0.400	0.250
2	15	Negative	5.000	0.703	0.000	0.000	0.000
3	4	Positive	5.000	0.703	1.000	1.000	1.000
3	5	Positive	1.875	0.052	0.866	0.857	0.750
3	6	Positive	1.875	0.052	0.866	0.857	0.750
3	7	Positive	5.000	0.703	1.000	1.000	1.000
3	8	Positive	5.000	0.703	1.000	1.000	1.000
3	9	Positive	5.000	0.703	1.000	1.000	1.000
3	10	Positive	1.875	0.502	0.866	0.857	0.750
3	11	Negative	5.000	0.703	0.000	0.000	0.000
3	12	Positive	1.875	0.052	0.866	0.857	0.750
3	13	Positive	0.833	0.052	0.707	0.667	0.5
3	14	Positive	0.313	0.703	0.500	0.400	0.250
3	15	Negative	5.000	0.703	0.000	0.000	0.000
4	5	Positive	1.875	0.052	0.866	0.857	0.750
4	6	Positive	1.875	0.052	0.866	0.857	0.750
4	7	Positive	5.000	0.703	1.000	1.000	1.000
4	8	Positive	5.000	0.703	1.000	1.000	1.000
4	9	Positive	5.000	0.703	1.000	1.000	1.000
4	10	Positive	1.875	0.052	0.866	0.857	0.750
4	11	Negative	5.000	0.703	0.000	0.000	0.000
4	12	Positive	1.875	0.052	0.866	0.857	0.750
4	13	Positive	0.833	0.052	0.707	0.667	0.500
4	14	Positive	0.313	0.703	0.500	0.400	0.250
4	15	Negative	5.000	0.703	0.000	0.000	0.000
5	6	Positive	5.000	1.701	1.000	1.000	1.000

Species pair		Association type	Association Indices				
			Chi-Square	Yate's Chi-Square	Ochiai	Dice	Jaccard
5	7	Positive	1.875	0.052	0.866	0.857	0.750
5	8	Positive	1.875	0.052	0.866	0.857	0.750
5	9	Positive	1.875	0.052	0.866	0.857	0.750
5	10	Positive	5.000	1.701	1.000	1.000	1.000
5	11	Negative	1.875	0.052	0.000	0.000	0.000
5	12	Positive	5.000	1.701	1.000	1.000	1.000
5	13	Positive	2.222	0.313	0.816	0.800	0.667
5	14	Positive	0.833	0.052	0.577	0.500	0.333
5	15	Negative	1.875	0.052	0.000	0.000	0.000
6	7	Positive	1.875	0.052	0.000	0.000	0.000
6	8	Positive	1.875	0.052	0.866	0.857	0.750
6	9	Positive	1.875	0.052	0.866	0.857	0.750
6	10	Positive	5.000	1.701	1.000	1.000	1.000
6	11	Negative	1.875	0.052	0.000	0.000	0.000
6	12	Positive	5.000	1.701	1.000	1.000	1.000
6	13	Positive	2.222	0.313	0.816	0.800	0.667
6	14	Positive	0.833	0.052	0.577	0.500	0.333
6	15	Negative	1.875	0.052	0.000	0.000	0.000
7	8	Positive	5.000	0.703	1.000	1.000	1.000
7	9	Positive	5.000	0.703	1.000	1.000	1.000
7	10	Positive	1.875	0.052	0.866	0.857	0.750
7	11	Negative	5.000	0.703	0.000	0.000	0.000
7	12	Positive	1.875	0.052	0.866	0.857	0.750
7	13	Positive	0.833	0.052	0.707	0.667	0.500
7	14	Positive	0.313	0.703	0.500	0.400	0.250
7	15	Negative	5.000	0.703	0.000	0.000	0.000
8	9	Positive	5.000	0.703	1.000	1.000	1.000
8	10	Positive	1.875	0.052	0.866	0.857	0.750
8	11	Negative	5.000	0.703	0.000	0.000	0.000
8	12	Positive	1.875	0.052	0.866	0.857	0.750
8	13	Positive	0.833	0.052	0.707	0.667	0.500
8	14	Positive	0.313	0.703	0.500	0.400	0.250
8	15	Negative	5.000	0.703	0.000	0.000	0.000
9	10	Positive	1.875	0.052	0.866	0.857	0.750
9	11	Negative	5.000	0.703	0.000	0.000	0.000
9	12	Positive	1.875	0.052	0.866	0.857	0.750
9	13	Positive	0.833	0.052	0.707	0.667	0.500
9	14	Positive	0.313	0.703	0.500	0.400	0.250
9	15	Negative	5.000	0.703	0.000	0.000	0.000

VR, Index of overall association=5.857143

W, Test statistic= 29.28572.

The villages of 204 R.B, 219 R.B, 56 G.B, are approximately ninety percent similar and can be referred as cluster 1, and the other group of villages of 07 J.B, 235 R.B, 119J.B, 123 J.B, 73G.B, 124J.B, 217 J.B, 221 R.B, 222R.B, 65 G.B 225 R.B, 295 R.B, 121 J.B, are approximately ninety percent similar and can be referred as cluster 2. The third cluster of villages is 214 G.B, 103 J.B, 202 R.B, 223 R.B, 208 R.B is nearly 75 percent similar and can be referred as cluster 3. The cluster 1 and 2 are nearly 80 percent similar and the village of 105 G.B is nearly 78 percent similar to the cluster 1 and 2. The village of 71 J.B is nearly 70% similar to the cluster 1, 2, and 3. The village of 214 R.B is least similar to the all clusters i.e. 64.72%. Still more investigations are required to evaluate the immediate environmental conditions of the soil and water of these villages to understand reasons of similarity in the snail diversity (Fig. 1).

There is greater than 90 percent similarity among the wheat, sugarcane, vegetables and fodder, while the similarity index of ditches is much less than the previously described crops i.e 35.58% (Table 5, Fig. 2).

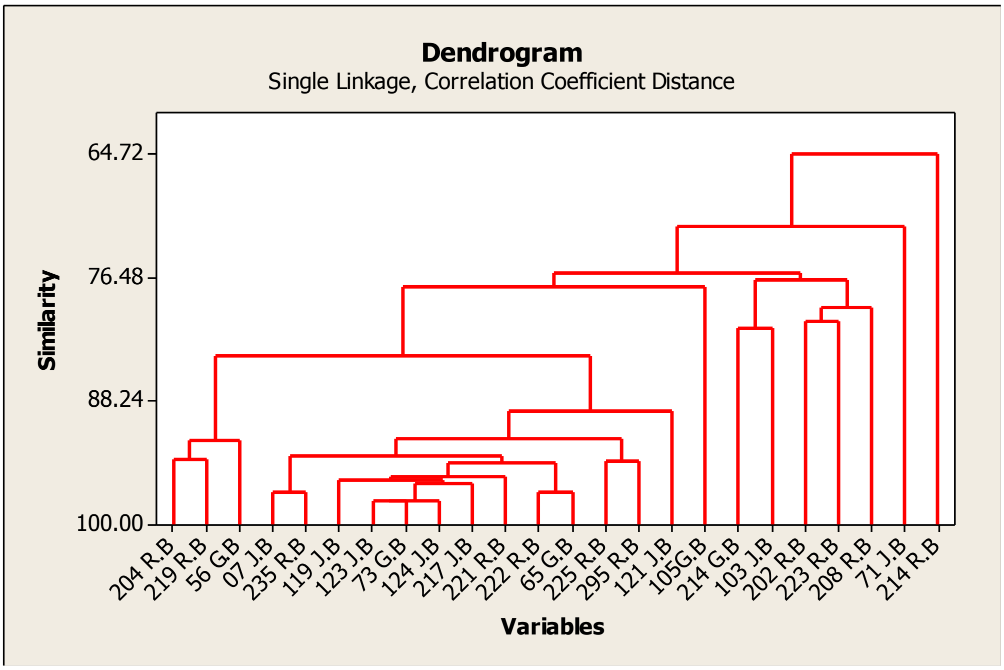

Fig. 1. Cluster analysis of Variables: Villages.

Table 5. Cluster Analysis of the Variables: Wheat, Sugarcane, Fodder, Vegetables, Ditches.

Steps	No. of Clusters	Similarity	Distance level	Cluster joined		New clusters	No. of obs. in new cluster
1	4	96.0676	0.07865	1	4	1	2
2	3	95.5965	0.08807	1	2	1	3
3	2	94.4595	0.11081	1	3	1	4
4	1	35.5769	1.28846	1	5	1	5

Correlation Coefficient Distance, Single Linkage.

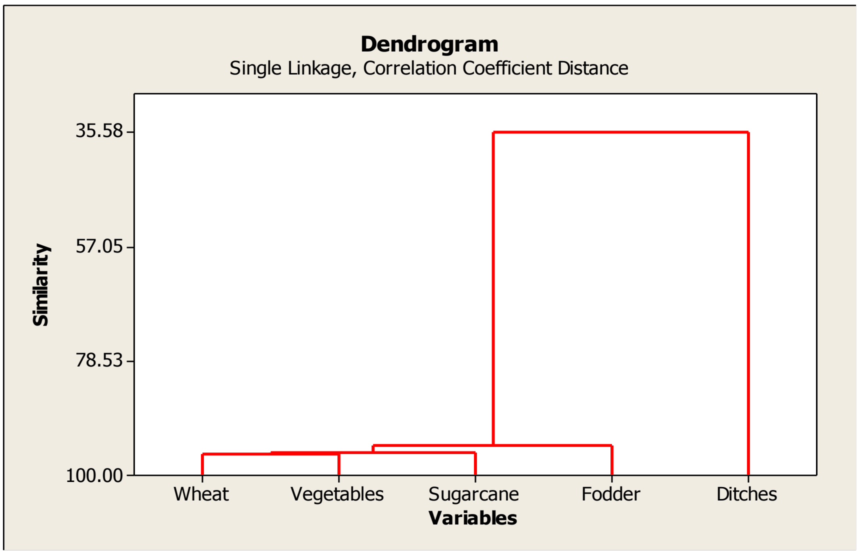

Fig. 2. Cluster Analysis of the Variables: Wheat, Sugarcane, Fodder, Vegetables, Ditches.

There is more than 90% similarity in March and August in terms of species of snail, which is nearly 90% similar to the species composition in June and can be referred as cluster 1 while the similarity between April and July is nearly 90% which can be referred as cluster 2 while the species of snails in the month of May is highly different with least similarity i.e. 43.89% with the cluster 1 and 2. This may be due to the difference in the environmental variables in May when compared with other months (Table 6, Fig. 3).

Table 6. Cluster Analysis of the Variables: March, April, May, June, July, August.

Steps	No. of Clusters	Similarity level	Distance level	Cluster joined		New clusters	No. of obs. in new cluster
1	5	93.0347	0.13931	1	6	1	2
2	4	91.2916	0.17417	2	5	2	2
3	3	90.5105	0.18979	1	4	1	3
4	2	88.0106	0.23979	1	2	1	5
5	1	43.8922	1.12216	1	3	1	6

Correlation Coefficient Distance, Single Linkage.

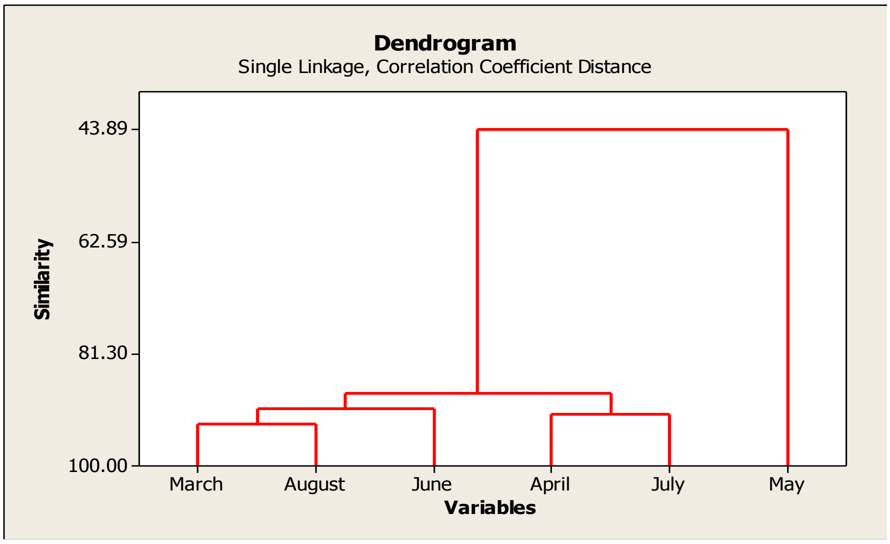

Fig. 3. Cluster Analysis of the Variables: March, April, May, June, July, August.

Discussion

All macrofaunna community should be considered as indicators as they have wide ranges of adaptive mechanishms than a single group as previously stated by (Nahamani and Lavelle 2002, Koehler, 1996). The snails prefer certain habitats and migrate to these habitat, which may be in response to temperature as stated by Bates *et al.* (2005), or to a chemical species as documented by Le Bris *et al.*, (2006), Alternatively, a gastropod may occupy a particular space because of its interaction with a potential predators or competitors as reported by (Micheli *et al.*, 2002; Mullineaux *et al.*, 2003). There are factors that may be physical, chemical or/and biological which likely affect gastropod species distributions to some extent. There are certain phylogenetic constraints on physiological adaptations that may restrict the habitats available to certain gastropod species as reported by Mills *et al.*, (2007). For the characterization of the physicochemical environment, new techniques are being used to make feasible measurements on scale of the individual gastropods as stated by Le Bris *et al.*, (2006). There is a dire need of behavioral studies at multiple stages in species' life histories, and under controlled conditions as previously stated by (Lee, 2004; Bates *et al.*, 2005). However, in order to understand the role of gastropods in the ecosystem and to answer the questions regarding their assemblage in the discrete assemblages is either associated with specific environments or not. Studies are required in the context of their interactions with other species in the community—prey, predators, competitors, and even potential facilitators as documented by Mills *et al*., (2007). Due to the changing ecological communities i.e., the loss of native species and the translocation of invaders, there is a need of a broader understanding of community structure, which has both applied and theoretical importance as stated by Keesing *et al*., (2010).

In India, there is little information on potential impact of climate change on land snails as stated by Sen *et al*. (2012). There is a remarkable difference of the identified species in our study when comparing it with the studies already done by the Ali, (2005). There were only 3 species of the snails that had been identified, which may be due to the fact that he mainly focused on the diversity of snails in sugarcane fields. It is hoped that this work would be a step forward to investigate this highly ignored fauna to identify and document in Faisalabad, Pakistan.

Moreover, the rate of introduction of alien species such as snails and slugs appears to be on the increase in the region and was particularly noticed in Qatar (Al-Khayat, 2008) and the study will help to identify the alien species introduced and the effect they are causing on the local environment of Faisalabad.

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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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