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VARIATION IN SPATIAL DISTRIBUTION OF SPIDER FAUNA BETWEEN AGRICULTURAL AND ARID LAND OF SHUJABAD, PUNJAB, PAKISTAN

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SMA & HRK planned the study, collected Data, Formal Analysis, NA & GM writing the manuscript, SK reviewed and modified. NS supervised the whole process and made resources available.

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Spiders, Biodiversity, Abundance, Agricultural, Arid Land

ABSTRACT

Spiders are the little creature that have key role in ecosystem especially in terms of biodiversity controlling agent. This survey-based study was conducted on spiders to assess their diversity in two different habitat conditions of Pakistan. In this study, 29 species, 15 genera and 7 families were collected. Lycosidae family had the highest diversity 55% followed by Araneidae (29%), Gnaphosidae (3%), Salticidae (3%), Oxyopidae (0.35%), Tetragnathidae (7%) and Thomisidae (3%). The Hippasa, Pardosa, Eriovixia, Araneus, Tetragnatha, Sitticus and Gnaphosa were most dominant genus out of observed 15 genera. Furthermore, the dominant species in agricultural land includes; *Pardosa sutherlandi*, *Araneus nympha*, *Eriovixia lagleizai* and *Tetragnatha javana*. The arid land was dominated by *Hippasa holmerae*, *Hippasa pisaurina*, *Pardosa leucopalpis*, *Thomisus dostinikus* and *Gnaphosa harpax*. Moreover, results for Simpson and Shannon indices revealed that the maximum diversity was found in habitat C as 82% on Simpson scale and 84% on Shannon scale. The Sorenson similarity indices revealed there is no more overlap between the different habitats species diversity. The study concluded that the agricultural land having scattered plants like mangos had higher diversity of spiders.

1. INTRODUCTION

Spiders are considered to be the most ubiquitous organisms among animals due to their diverse habitats and feeding type. Normally, spiders are present all around including; soil, woodlands, meadows, croplands, forests and even houses. Even some spiders are also reported to adopt the amphibian mode of life. Feeding mode of spiders is generally the predaceous and most feed on phytophageous. Moreover, spiders also compete with other insectivores or even become prey of some other predators. Due to their predator nature, abundance and diversity in habitat, these are considered as best biological controlling agent (Luczak, 1979). Biological control of pests in agriculture is a newly invented technique in which natural predators are used to kill pests. using various indirect methods such as trapping them in their webs (James et al., 2004).

A number of researches are available in which spiders are proved to be the best biological controller of pests (Pearce & Zalucki, 2006). Spiders not only control pests by direct killing but also control them by Furthermore, spiders have diverse biology as well as behavior such as; resting sites, methods of prey capture, diurnal rhythms, and degree of mobility (Dauber et al., 2003; Holland et al., 2004).

Concern of adverse effect of agriculture intensification on biodiversity is increasing (Plath et al., 2021). These changes have effect the biodiversity on various spatial scales that may vary from local to regions. Furthermore, the use of pesticides and synthetic fertilizers also had an adverse impact on fauna and flora (Sud, 2020). These changes resulted in the form of land use change and ultimately becoming more dominated by arable crops. Therefore, biological control of pests is the only way that can work efficiently to control pests and also remove the use of pesticides and synthetic fertilizers. Spiders have

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the best capabilities to be used as biological pest control and even to use in diversity of crops and against diversity of pests (Mushtaq et al., 2000).

It has been seen that the diversity, distribution and abundance of spiders mainly depends on habitat structure (Whitmore et al., 2002). A number of studies have been done on natural and agriculture systems to assess the influence of habitat structure on spider's diversity. Results revealed that the factors of habitat structure such as; prey abundance, shelter against enemies and suitable microclimatic conditions are the main influencers of diversity and distribution (Souza & Martins, 2004).

The present study was an attempt to explore the spider's diversity in different habitats. To catalogue the species found in agricultural, orchids and arid land. The spider's diversity found in different habitats was compared.

2. MATERIALS AND METHODS

Spider fauna was collected from four different kinds of habitats including; agricultural and arid land that were further divided into two replicas. Most of the fauna found on orchids, Ornamental, Agricultural and wild plants was collected for the comparative study using direct hand picking technique. Collection was made early in the morning or late evening. Specimens were placed in 500 ml jars containing 70% ethanol and brought back to the laboratory. Furthermore, addition data such as; host plant, date of collection, locality and place of presence of each specimen was also noted in the field data book.

Collected specimens were washed with xylene and each specimen was preserved in a separate vial in 70% ethyl alcohol, glycerin, and glacial acetic acid and identification was done on the basis of morphometric characters of various body parts of specimens. This help was mainly taken from the keys and catalogue provided by Tikader (1982). All the specimens were also noted for additional information such as; scientific name, family name, host plant, and date of collection and locality. After collection, specimens were shifted to Zoology Laboratory, Department of Life Sciences, Baughdad-ul-jadeed campus, The Islamia University of Bahawalpur.

Spiders were collected from four different types of habitats including; vegetation cover, soil type and irrigation period in each fields of study. These study sites were localized in Bhana, Khairpur, Rukanhatti and Dhondhoo named as study site A, B, C and D respectively. Study area A, Bhana was a non-cultivated land. The soil type was loamy with large amount of sand particles. The vegetation cover was with trees such as Shesham, Acacia and Date Palm very few in numbers, the wild shrubs and plants such as were present very much. Study site B, Khairpur was agricultural land with greater humid soil. Site B were an agricultural land irrigated regularly. The plantation cover was Acacia, Date palm, Shesham and Neam. The different agricultural crops such as Cotton, Wheat, Tomato, Onion, Sugar Cane and grasses were present during collection. Site C, Rukanhatti was an orchid land. The Mango and Orange plants were present very much in number. Agricultural crops were also present in this field of study. Site D, Dhondhoo was completely arid land. The soil was sandy; no irrigation was occurred artificially only rain fall is the source of water. Only wild herbs and shrubs such as *Alhegi murrorum*, Colocynths, Lani, *Calotropis procera* and Khip were present. The spider diversity at each site was analyzed by using the Simpson's index that is used to assess the most abundant species in a community (Sebastian et al., 2005). The Simpson's index was calculated using the equation

$$D = \sum p_i^2$$

Where

N = Total number of individual of all species.

N = number of individual of a species.

P_i^2 = the proportion of each species in the sample.

Simpson's index which varies from 0 to 1, gives the probability that two individuals drawn at random from the population belong to the same species. If, the probability is high that both individuals belong to the same species, then the diversity of the community sample is low.

Dominance index D = 1 – Simpson

The Margalef index was used to calculate species richness. The Margalef index was computed based on the relationship between species richness and total number of individual observed which increase with increasing the sample size. The Margalef index is defined as:

$$R1 = S - 1/ \ln (n)$$

Where

S = number of spider species, n = number of individuals of species.

Shannon's index of evenness is calculated from the diversity index. The equation used:

$$H = -\sum (P_i \ln P_i)$$

The similarities between the habitats were checked by Sorensen similarity index. This is the very simple measure of beta diversity, ranging from a value of 0 where there is species overlap between the communities, to a value of 1 when exactly the same species are found in both communities. It can calculate by the following formula:

$$\beta = C / S1+S2$$

Where

S1 = number of species in first community,

S2 = number of species in second community,

C = Common species in both communities.

3. RESULTS AND DISCUSSION

The total eight field trips were made in each type of habitat that resulted in the capture of 314 specimens. Out of these, 281 specimens were identified up to species level. A total of 29 species belonging to 7 families under 15 genera were recognized. 18 species were belonging to Lycosidae family. Most of the rest of specimens were belonged to Thomisidae, Araneidae, Tetragnathidae, Gnaphosidae, Salticidae and Oxyopidae (Table 1).

A total of 281 specimens of spiders belonging to 7 families and 29 species under 15 genera were collected from four different types of habitats. The cropped habitats with excess amount of water availability were found to be most populated. The harsh climate in the arid area D had low life supporting capabilities so had lower population due to less availability of prey for the spiders with low population.

In the present study family Lycosidae (55%) represented by 18 species belonging to 6 genera were most dominant. A number of species also reported that Lycosidae species are the dominant species (Monzo et al., 2009; Tahir et al., 2011). Most of the species were studied from the Study area A. the study area A is also an arid land but due to its occurrence near to agricultural land and with greater number of plantation it was with greater number of spider species. The 6 lycosid species out of 18 were only present in this habitat (Table 1). Most of the agricultural lands in Pakistan have scattered plants as well that support greatly to biodiversity especially the spiders. Therefore, this might be the reason for higher population rate of spiders in agricultural land. Furthermore, the agricultural lands also have great diversity and population of pests that are the feed for spiders that in this way agricultural land also support the spider population (Uetz, 1991; Malhotra et al., 2019).

The diversity indices reveals that there is greater diversity at study site B and C with 72% and 82% at Simpson scale and 63% and 84% at Shannon scale of diversity indices (Table 8) which is greater than the study sites A and D with 77% and 52% at Simpson scale and 73% and 55% at Shannon scale of diversity indices. Tahir et al. (2011) reported a study on diversity and abundance of spiders in Lahore in various seasons, where they observe Simpson Index range from 2.3 to 10.8 and Margalef's Index range from 0.7 to 4.5.

The present study revealed that the species *Hippasa holmerae*, *Hippasa pisaurina*, *Pardosa leucopalpis*, *Thomisus dostinikus* and *Gnaphosa harpax* are the most dominant species of the arid land habitat (Table 4, 7). The species *Pardosa sutherlandi*, *Araneus nympha*, *Eriovixia lagleizai* and *Tetragnatha javana*are the dominant species of agricultural habitats (Table 5, 6).

4. CONCLUSION

The agricultural land was most populated and with greater number of species. The present study revealed that the overall diversity on Simpson scale is 71% and 68% at Sorenson scale of diversity indices. The maximum diversity was in the Study Area C 82% on Simpson Scale and 84% diversity on Shannon scale of diversity indices (Table 8), which was due to greater availability of prey, shelter and very low disturbance of habitat in orchid land.

5. CONFLICT OF INTEREST

All authors have declared that there is no conflict of interests regarding the publication of this article.

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Table 1: Relative Abundance of Different Spider Species at Each Study Site.

Family	Genus	Species	Site A	Site B	Site C	Site D	Total
Lycosidae	*Hippasa*	*holmerae*	41	1	11	31	84
		Pisurina	4	0	0	0	4
		madrasptana	3	1	0	0	4
		himalayensis	0	0	0	1	1
	Pardosa	*chambaensis*	1	0	3	1	5
		annandalei	3	0	0	0	3
		mysorensis	2	1	0	0	3
		mukundi	1	0	0	0	1
		amkhasensis	2	1	0	0	3
		leucopalpis	6	0	2	0	8
		sutherlandi	6	15	6	1	28
		kapupa	1	1	0	1	3
		rhenockensis	0	1	0	0	1
	Arctosa	*khudiensis*	1	0	0	0	1
	Evipa	*sohani*	1	0	0	0	1
		banarensis	1	0	0	0	1
	Lycosa	*himalayensis*	0	1	0	0	1
	Trochosa	*punctipes*	0	0	3	0	3
Thomisidae	*Thomisus*	*dostinikus*	4	1	0	1	6
		iswadus	0	0	2	0	2
Araneidae	*Araneus*	*nympha*	9	35	15	3	62
	Eriovixia	*laglaizei*	1	2	16	0	19
Gnaphosidae	*Gnaphosa*	*harpax*	5	0	0	1	6
		poonaensis	0	0	2	0	2
Salticidae	*Marpissa*	*tigrina*	0	1	1	0	2
	Phlegra	*swanii*	0	1	0	0	1
	Sitticus	*dyali*	0	0	0	6	6
Oxyopidae	*Peuceta*	*myanmarensis*	0	1	0	0	1
Tetragnathidae	*Tetragnatha*	*javana*	0	19	0	0	19
7	*15*	*29*	92	82	61	46	281

Table 2: Spiders family diversity at different habitats

Family	Site A	Site B	Site C	Site D	Total	Percentage
Lycosidae	73	22	25	35	155	55 %
Thomisidae	4	1	2	1	8	3 %
Araneidae	10	37	31	3	81	29 %
Gnaphosidae	5	-	2	1	8	3 %
Salticidae	-	2	1	6	9	3 %
Oxyopidae	-	1	-	-	1	0.35 %
Tetragnathidae	-	19	-	-	19	7 %

Table 3: Habitat preferences of dominant species in different habitats

Dominant Species	No. of Individuals	Percentage	No. of individuals in each habitat				Mean composition
			Site A	Site B	Site C	Site D	
Hippasa holmerae	84	29.89	41	1	11	31	A>D>C>B
Araneus nympha	62	22.06	9	35	15	3	B>C>A>D
Pardosa sutherlandi	28	9.96	6	15	6	1	B>C>A>D
Eriovixiala glaizei	19	6.76	1	2	16	0	C>B>A
Tetragnatha javana	19	6.76	0	19	0	0	B>A,C>D
Thomisus dostinikus	6	2.13	4	1	0	1	A>D>B>C
Gnaphosa harpax	6	2.13	5	0	0	1	A>D
Sitticus dyali	6	2.13	0	0	0	6	D

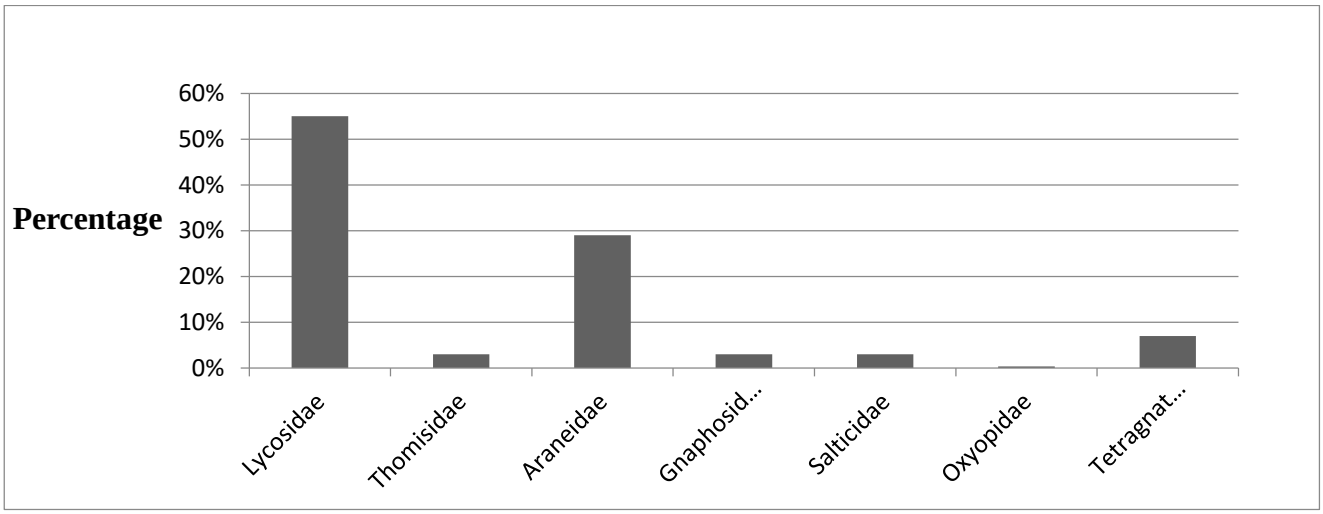

Figure 1. Diversity of Spiders.

Table 4: Simpson and Shannon Indices of the Study Site A Data

Genus	Species	No. of Individuals	P_i	P_i^2(Simpson)	∑(PiInPi) Shannon
Hippasa	*holmerae*	41	0.4457	0.198648	0.360174
	pisurina	4	0.04348	0.001890	0.136330
	madrasptana	3	0.03261	0.001064	0.111628
Pardosa	*chambaensis*	1	0.01087	0.000118	0.049151
	annandalei	3	0.03261	0.001064	0.111628
	mysorensis	2	0.02173	0.000472	0.083205
	mukundi	1	0.01087	0.000118	0.049151
	amkhasensis	2	0.02173	0.000472	0.083205
	leucopalpis	6	0.06522	0.004253	0.178050
	sutherlandi	6	0.06522	0.004253	0.178050
	kapupa	1	0.01087	0.000118	0.049151
Arctosa	*Khudiensis*	1	0.01087	0.000118	0.049151
Evipa	*sohani*	1	0.01087	0.000118	0.049151
	banarensis	1	0.01087	0.000118	0.049151
Thomisus	*dostinikus*	4	0.04348	0.001890	0.136330
Araneus	*nympha*	9	0.09783	0.009571	0.227408
Eriovixia	*laglaizei*	1	0.01087	0.000118	0.049151
Gnaphosa	*harpax*	5	0.05435	0.002953	0.158284
Total	18	92	D =	0.227356	2.108349
			1-D=	0.7726	

Evenness:

E = H/InS, H = 2.108349, S = 18

E = 2.108349/2.890372

E = 0.73

Table5: Simpson and Shannon Indices of the Study Site B data

Genus	Species	No. of Individuals	Pi	Simpson Pi2	Shannon ∑(PiInPi)
Hippasa	*holmerae*	1	0.012195	0.000149	0.053740
	madrasptana	1	0.012195	0.000149	0.053740
Pardosa	*mysorensis*	1	0.012195	0.000149	0.053740
	amkhasensis	1	0.012195	0.000149	0.053740
	sutherlandi	15	0.182926	0.033462	0.310732
	kapupa	1	0.012195	0.000149	0.053740
	rhenockensis	1	0.012195	0.000149	0.053740
Lycos	*himalayensis*	1	0.012195	0.000149	0.053740
Thomisus	*dostinikus*	1	0.012195	0.000149	0.053740
Araneus	*nympha*	35	0.426829	0.182183	0.363390
Eriovixia	*laglaizei*	2	0.024390	0.000595	0.090574
Marpissa	*Tigrina*	1	0.012195	0.000149	0.053740
Phlegra	*Swanii*	1	0.012195	0.000149	0.053740
Peuceta	*myanmarensis*	1	0.012195	0.000149	0.053740
Tetragnatha	*javana*	19	0.231707	0.053688	0.338820
Total	15	82	D =	0.271567	1.694656
			1-D =	0.728433	

Evenness:

E = H/InS, H = 1.694656, S = 15

E = 1.694656/2.708050

E = 0.63

Table6: Simpson and Shannon Index of the Study Site C Data

Genus	**Species**	**No. of Individuals**	**P_i**	**Simpson P_i^2**	**Shannon ∑(PiInPi)**
Hippasa	*holmerae*	11	0.180328	0.032518	0.308898
Pardosa	*chambaensis*	3	0.049180	0.002418	0.148143
	leucopalpis	2	0.032787	0.001075	0.112056
	sutherlandi	6	0.098361	0.009675	0.228110
Trochosa	*punctipes*	3	0.049180	0.002418	0.148143
Thomisus	*iswadus*	2	0.032787	0.001075	0.112056
Araneus	*nympha*	15	0.245902	0.060468	0.344957
Eriovixia	*laglaizei*	16	0.262295	0.068799	0.351026
Gnaphosa	*poonaensis*	2	0.032787	0.001075	0.112056
Marpissa	*tigrina*	1	0.016393	0.000269	0.067390
Total	10	61	D =	0.17979	1.932835
			1-D =	0.82021	

Evenness:

E = H/InS, H = 1.932835, S = 10

E = 1.932835/2.302585

E = 0.84

Table7: Simpson and Shannon Index of the Study Site D data

Genus	**Species**	**No. of Individuals**	**P_i**	**Simpson P_i^2**	**Shannon ∑(PiInPi)**
Hippasa	*holmerae*	31	0.673913	0.454158	0.265963
	himalayensis	1	0.021739	0.000473	0.083231
Pardosa	*chambaensis*	1	0.021739	0.000473	0.083231
	kapupa	1	0.021739	0.000473	0.083231
	sutherlandi	1	0.021739	0.000473	0.083231
Araneus	*nympha*	3	0.065217	0.004253	0.178045
Thomisus	*dostinikus*	1	0.021739	0.000473	0.083231
Gnaphosa	*harpax*	1	0.021739	0.000473	0.083231
Sitticus	*dyali*	6	0.130435	0.017013	0.265680
Total	9	46	D =	0.478262	1.209074
			1-D =	0.521738	

Evenness:

E = H/InS, H = 1.209074, S = 9

E = 1.209074/2.197224

E = 0.55

Table 8: Margalef species richness, Shannon index, Simpson index, and evenness estimated from various sites

Habitat	**No. of Species**	**No. of Individuals**	**Richness**	**Simpson Index**	**Shannon Index**	**Evenness**
Site A	18	92	3.76	0.7726	2.108349	0.73
Site B	15	82	3.18	0.728433	1.694656	0.63
Site C	10	61	2.19	0.82021	1.932835	0.84
Site D	9	46	2.09	0.521738	1.209074	0.55

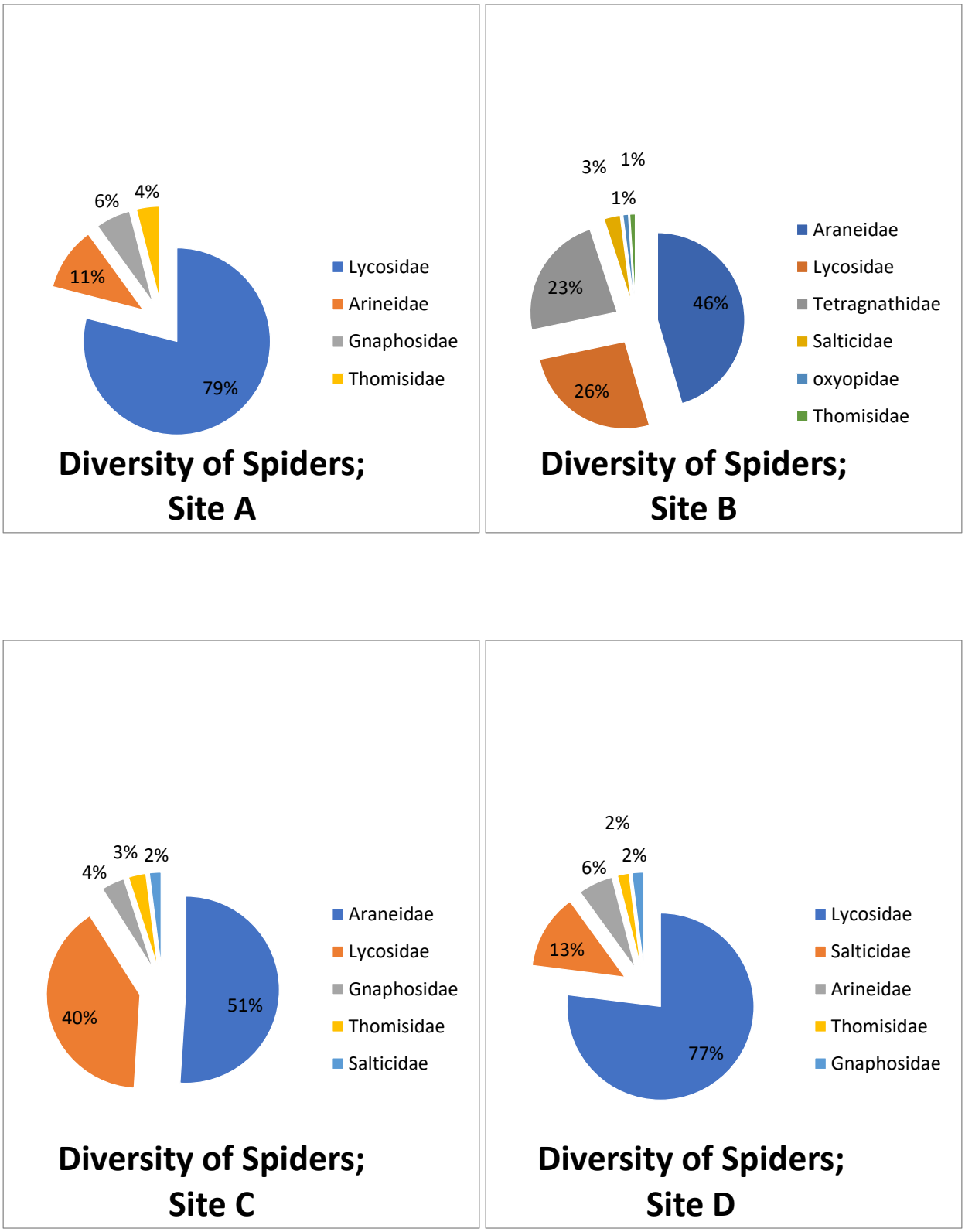

Figure 2. Diversity of spiders in various sites

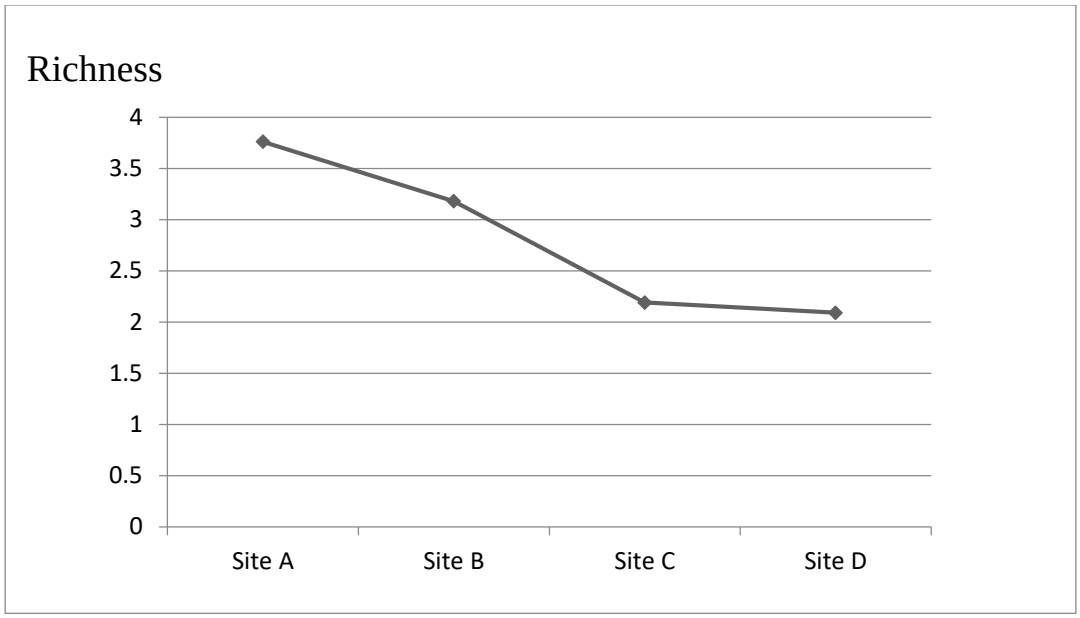

Figure 3. Species Richness at Four Habitat types.

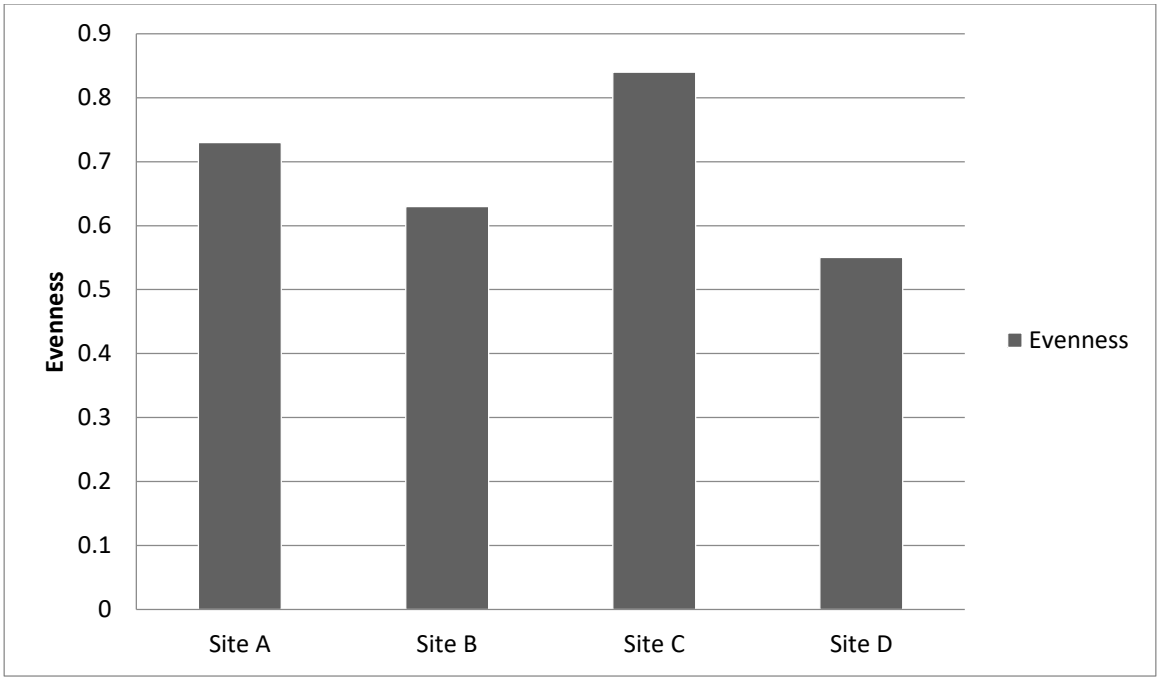

Figure 4. Spider Species Evenness at Four Study Sites.

Table 9. Sorenson Similarity Index.

Study Area	(S) Sorenson Index	1 – S
A & B	0.27	0.73
A & C	0.21	0.79
A & D	0.25	0.75
B & C	0.20	0.80
B & D	0.20	0.80
C & D	0.21	0.79

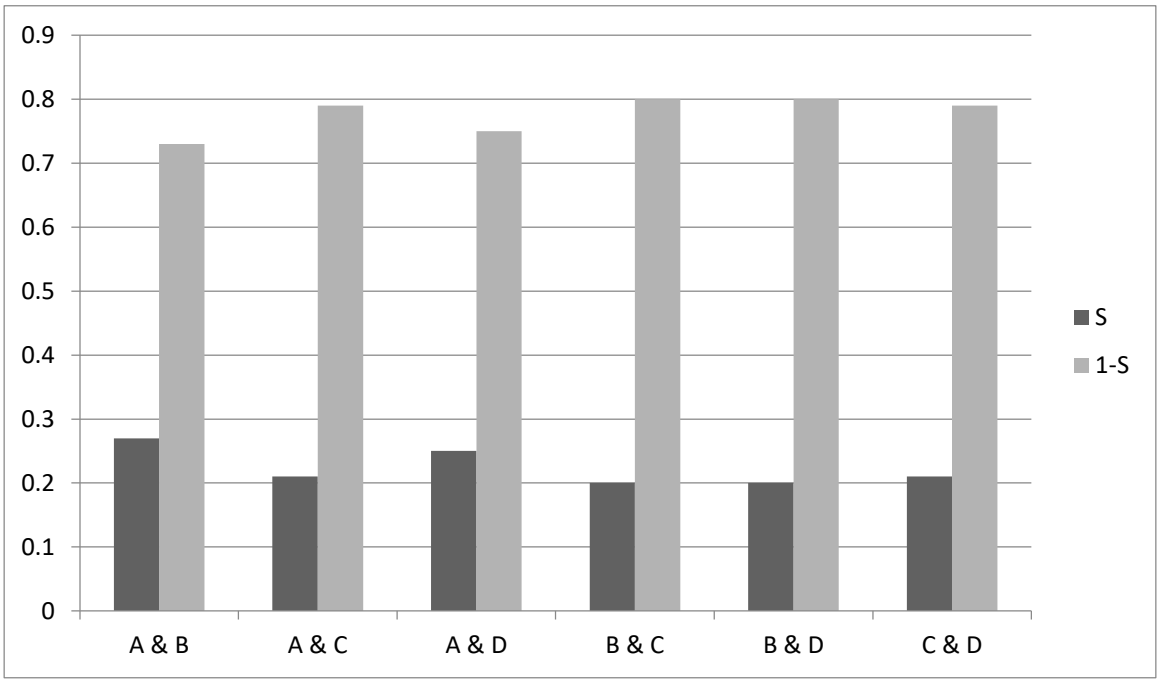

Figure 5. Similarity index of Spiders collected from different Habitat.