Diversity of spider fauna in Pigeonpea (*Cajanus cajan* L.) Ecosystem

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Abstract

Pigeonpea (*Cajanus cajan* L.) is the most important crop among various pulses grown in India. Pigeonpea crop is attacked by large number of herbivores and also serves as a habitat for more number of arthropod predators. Fifteen spider families including 58 genera/species were identified in a pigeonpea ecosystem in Coimbatore, South India and the families like Araneidae, Lycosidae and Salticidae were found dominant in occurrence. Maximum numbers of individuals were recorded for *Peucetia viridana* (Stoliczka). The diversity indices *viz.*, richness index, diversity and evenness were maximum during flowering and pod filling stage. Relative occurrences of spiders belonging to Thomisidae were dissimilar and distinct in their occurrences both during 2006 and 2007.

Keywords: *Cajanus*, diversity indices, Pigeonpea, similarity, spider

INTRODUCTION

Pigeonpea, *Cajanus cajan* (L.) ranks fourth in the importance of the pulse crop in the world with major production confining to developing countries. It is the most versatile food legume with diversified uses as food, feed and fuel. Globally it is grown on about 4.16 million ha area producing 2.85 million tonnes of grains with an average yield of 686 kg ha⁻¹. India accounts for 78 per cent of the global output with current production of 2.21 million tonnes from 3.38 million ha recording average yield of 653 kg ha⁻¹. In Tamil Nadu the area under pigeonpea is around 0.86 lakh ha with a production of 0.752 lakh tonnes. The average productivity of pigeonpea in the state (875 kg ha⁻¹) is lower than the average productivity level of Uttarpradesh (1134 kg ha⁻¹), Haryana (1145 kg ha⁻¹), Bihar (999 kg ha⁻¹), Gujarat (952 kg ha⁻¹) and Punjab (880 kg ha⁻¹) (Ali and Kumar, 2004).

The major constraints that limit the farmers in achieving potential yield of pigeonpea are well known. One of the constraint is the damage by insect pests particularly the pod borer complex. In general, the pests were kept under general equilibrium level by the action of natural enemies in different ecosystems and in particular might be true for pulses of agroecosystems too. Majority of arthropod predators, both adults and immatures were often generalists rather than specialists. They were generally larger than their prey, they kill or consume many prey and they attack immature as well as the adult prey. Each group may have a unique life cycle and habit. Although the life histories of some common arthropod predators were well studied, their diversity and predatory potential were lacking in the pulses particularly on the pigeonpea ecosystem. Spiders are the major predatory arthropods, which form an important component in the management of pigeonpea pests and conservation of these predators in the field leads to natural biological control or otherwise maintains the general equilibrium position.

Biodiversity is the species richness in an ecosystem (Ehrlich and Ehrlich, 1981). It provides both opportunity and challenges how ecological communities are affected by human activity and environmental perturbations (Reaka-Kudla *et al.*, 1997). In the pigeonpea ecosystem the arthropod predatory fauna studies especially with reference to spiders are scanty. Hence, in order to gather more basic information, investigations were undertaken, to know the diversity of spiders present in the pigeonpea ecosystem by using different divesity indices and the results are presented hereunder.

MATERIALS AND METHODS

Sampling techniques

Survey and collection of spiders

Roving survey was conducted on pigeonpea ecosystem at the Department of Pulses, Tamil Nadu Agricultural University (TNAU), Coimbatore for collection of spiders during 2006 and 2007 in the long duration variety LRG 41. Spiders were collected randomly from 100 plants at different stages (vegetative, flowering and pod filling) of crop growth at fortnightly intervals. The methods followed for collecting the spiders are furnished below.

Hand picking

The spiders were collected by walking diagonally in the field and care was taken to capture them without injuring and transferred to polythene bags for further studies.

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Net sweeping

The sweeping nets used in this study were made of standard size. For carrying out net sweeps the plot was divided into 100 quadrats, measuring 10 X 10 m each. Five such quadrats from one acre field were chosen at random and the entire ground level vegetation above 1 m height in the chosen quadrat was covered during the sweeping. Net sweeps were done between 7 - 10 am, because the spider activity was more in the morning hours. The spiders collected from each quadrat were transferred into polythene bags containing cotton dipped in chloroform and later preserved in the vials containing 70 per cent alcohol.

Pitfall traps

Pitfall traps were used for the collection of ground dwelling spiders. The pitfall traps were of size 15 cm height and 10 cm width dug into the soil to a depth of 20 cm in which two drops of sticky fluid *viz.*, teepol is added to prevent the escape of spiders from the trap. Three pitfall traps were placed in each of five randomly chosen 10 x 10 m quadrats. The specimens caught in the trap were collected during morning hours upto harvesting. These traps were placed at the rate of 15/ plot of 10 x 10 m size. The observations were recorded daily on the number and type of spiders trapped in each container. The collected spiders were preserved in 70 per cent alcohol and the taxonomic identification of spiders were done based on the available literature.

Spider diversity analysis

Measures of species diversity that simplify information on species richness and relative abundance into a single index are in extensive use (Magurran, 1988 and Melbourne, 1993).

Richness index

The richness index was worked out to know how the diversity of population is distributed among the particular species by using Margalef index (Margalef, 1958).

$$D = \frac{S-1}{\ln N}$$

Where, S = Number of species; N = Total number of individuals and D = Richness index.

Diversity index

Shannon-Weiner index

It is an information statistic index based on the proportional abundance of species. Variance in diversity was calculated using the equation of Whittaker (1972) and Pielou (1975).

$$Var H = \frac{\sum Pi\,(\ln Pi)^2 - (\sum Pi\,\ln Pi)^2}{N} - \frac{S-1}{2N^2}$$

Where, Pi = Proportional abundance of ith species; S = Number of species and N = Total number of individuals.

Species evenness or Equitability J

Equitability J or evenness is the pattern of distribution of the individuals between the species. It is an important part of the description of a community and has important applications in ecological monitoring because highly stressed environments often show low levels of equitability as the system becomes dominated by disturbance or pollution tolerant species (Henderson, 2003). The following evenness index was used for determining the spider evenness.

$$J = H / \log (S)$$

Where, H = Observer Shannon Weiner Index and S = Total number of species in the habitat.

Similarity index

The similarity values were used for cluster analysis. Sequential agglomerative hierarchical non-overlapping (SAHN) clustering was done using unweighted pair group method with arithmetic averages (UPGMA). Data analysis was done using NTSYSpc version 2.02 (Rolff, 1998).

RESULTS

Diversity of spider fauna

The different spider species that were recorded and identified based on available literature during 2006 and 2007 are presented in Plates 1-5. The diversity studies on the pigeonpea ecosystem revealed 51 and 46 genera/ species of spiders during 2007 and 2006, respectively comprising of 15 various families. Among the different families, Lycosidae recorded 12 genera/species followed by Araneidae (10). Families like, Filistatidae, Philodromidae, Scytodidae, Tetragnathidae and Zodariidae recorded only one genera/species during the years of study. Among the predominantly distributed families, four genera were recorded in Lycosidae comprising of 12 species and three genera were observed in Araneidae with 10 species. The jumping spiders (Salticidae) were also equally dominating in distribution recording 6 genera and 8 species. Regarding the dominant distribution of species *Peucetia viridana* (Stoliczka) (Oxyopidae) recorded maximum number of spiders (168±1.22) followed by *Hippasa greenalliae* (Blackwall) (Lycosidae) (163.75±2.90) and *Neoscona mukerji* Tikader (Araneidae) (142.5±4.25) during 2006. During 2007, the same trend was observed in *P. viridana* and *Pardosa birmanica* Simon (Table 1). In general low populations of spiders were observed during 2007.

Richness index (Margalef)

Richness index values of spiders in pigeonpea was worked out for two years, namely, 2006 and 2007 are

Arctosa mulani (Dyal)

Argiope aemula (Walckenaer)

Argiope anasuja Thorell

Clubiona sp.

Argiope sp.

Chrysilla sp.

Argiope sp.

Cheiracanthium sp.

Plate 1. Predatory spiders observed in pigeonpea ecosystem

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Neoscona mukerjei Tikader

Neoscona theisi (Wakkenaer)

Neoscona sp.

Oedignatha sp.

Neoscona sp.

Olios milleti (Pocock)

Neoscona sp.

Olios sp.

Plate 2. Predatory spiders observed in pigeonpea ecosystem

Drassylus sp.

Lycosa sp.

Hermippus sp.

Neoscona cf.vigilans Blackwall

Hippasa sp.

Neoscona cf .vigilans Blackwall

Leucauge decorata Blackwall

Neoscona cf.bengalensis Tikader

Plate 3. Predatory spiders observed in pigeonpea ecosystem

Olios sp.

Oxyopes sp.

Oxyopes shweta Tikader

Peucetia viridana (Stoliczka)

Oxyopes sp.

Salticius sp.

Oxyopes sp.

Scytodes thoracica (Latreille)

Plate 4. Predatory spiders observed in pigeonpea ecosystem

Telemonia dimidata (Simon) female

Thomisus sp.

Telemonia dimidiata (Simon) male

Thyene sp.

Thomisus cf.*Projectus* Tikader

Xysticus sp.

Thomisus sp.

Oxyopes sp.

Plate 5. Predatory spiders observed in pigeonpea ecosystem

Table 1. Density (no / 100 plants)of predatory spider fauna in pigeonpea (*C. cajan* L.) ecosystem

Family	Genera/Species	2006	2007
Araneidae	*Argiope* sp.	48.75±1.89	29.75±1.97
	A. anasuja Thorell	54.75±0.75	27.75±0.85
	A. aemula (Walckenaer)	0	16.25±1.75
	Cyrtophora citricola (Forskal)	0	21±1.78
	Neoscona theisi (Walckenaer)	56.5±5.52	20.5±1.66
	N. poonaensis (Tikader and Bal)	34.25±1.31	36.25±0.48
	N. cf. bengalensis Tikader andBal	50.25±3.38	38.25±2.21
	N. mukerji Tikader	142.5±4.25	36±1.47
	N. vigilans (Blackwall)	0	24.25±0.75
	Neoscona sp.	11.75±0.85	0
Clubionidae	*Simalio* sp.	0	31.75±0.85
	Clubiona filicata Cambridge	19.25±2.02	26.25±0.63
	Clubiona sp.	44.5±1.32	15±0.71
	Chrysilla sp.	0	15±1.08
Corrinnidae	*Oedignatha* sp.	40.75±1.65	27.25±2.50
	Castianeira zetes Simon	18±2.12	19±2.55
Gnaphosidae	*Callilopis*	11.75±0.85	14±0.91
	Unidentified *Gnaphosid*	30.25±2.14	18.5±1.04
	Drassodes sp.	24.25±1.31	11.75±1.89
	Drassyllus sp.	9.75±1.38	0
	Sosticus sp.	41±1.22	39.5±1.85
Filistatidae	*Filista* sp.	12.5±0.65	14.25±1.31
Lycosidae	*Evippa* sp.	0	38.75±2.02
	Evippa rajasthanea Tikader and Malhotra	0	44.25±1.11
	Hippasa greenalliae (Blackwall)	22.5±0.65	17.25±2.39
	Hippasa sp.	12±0.91	0
	Arctosa mulani (Dyal)	7.25±2.02	44±0.91
	Lycosa sp.	80.75±1.60	42.25±1.60
	Lycosa sp.	66.75±0.63	46±4.71
	Lycosa tista Tikader	11.5±0/65	78.25±0.85
	Lycosa mackenziei Gravely	15.75±1.31	64.5±1.32
	Lycosa bistriata Gravely	37±0.82	50±1.87
	Pardosa birmanica Simon	57±1.78	113±0.91
	Hippasa greenalliae (Blackwall)	163.75±2.90	0
Miturgidae	*Cheiracanthium danieli* Tikader	23±0.91	29±4.97
	C. melanostomum (Thorell)	24.25±0.85	36.5±1.32
	Cheiracanthium sp.	0	22±0.58
Oxyopidae	*Oxyopes shweta* Tikader	133.5±7.96	65±0.71
	Oxyopes sp.	86.5±4.09	0
	Oxyopes ratnae Tikader	0	72.5±1.19
	Peucetia viridana (Stoliczka)	168±1.22	127.25±1.11
Philodromidae	*Tibellus elongatus* Tikader	11.25±0.48	24±1.08
Salticidae	*Phintella* sp.	42.25±0.85	65.25±0.63
	Myrmarachne sp.	0	27±0.91
	Phidippus punjabensis Tikader	3.5±0.87	29.25±3.88
	Plexippus paykulli (Audouin)	25.5±0.65	47.5±2.33
	Plexippus sp1.	74.25±0.75	0
	Plexippus sp2.	34.5±1.89	0
	Thyene imperialis (Rossi)	28.5±0.65	102±5.24
	Telamonia dimidiata (Simon)	56.25±1.60	41±2.16
Scytodidae	*Scytodes thoracica* (Latreille)	11.25±1.11	29.25±1.55
Sparrasidae	*Olios milleti* (Pocock)	134±1.41	74.75±1.70
	Olios sp.	0	34.25±2.32
Tetragnathidae	*Leucauge decorata* (Blackwall)	9.25±1.65	35.5±1.19
Thomisidae	*Thomisus projectus* Tikader	29.25±1.89	27.25±2.32
	Thomisus sp.	15.5±1.85	16±0.71
	Xysticus minutus Tikader	0	37.5±1.94
Zodariidae	*Hermippus* sp.	12±0.82	48.25±1.80

Table 2. Diversity indices of spiders in different crop stages of *C. cajan* L.

Crop stages/ Days After Sowing		Richness index (Margalef)		Diversity (Shannon-Weiner)		Evenness (Equitability J)	
		2006	2007	2006	2007	2006	2007
Vegetative	15	3.7857	1.9236	2.4411	1.5596	0.6866	0.4387
	30	3.7456	2.9121	2.3571	2.1025	0.6630	0.5914
	45	5.0053	5.1277	2.7798	2.8245	0.7819	0.7944
	60	4.6279	5.7168	2.7146	3.0673	0.7635	0.8627
Flowering	75	5.174	5.8132	2.9852	3.1962	0.8396	0.8990
	90	4.9786	5.7235	2.8029	3.1419	0.7884	0.8837
	105	4.5773	5.5327	2.7756	3.1809	0.7807	0.8947
	130	4.561	5.5627	2.7625	3.1729	0.7770	0.8924
Pod filling	145	4.908	5.7428	2.7562	3.1408	0.7752	0.8834
	160	4.6893	6.2166	2.8707	3.1577	0.8074	0.8881
	175	4.4763	5.6337	2.6958	2.9655	0.7582	0.8341
	180	4.7911	5.1718	2.7417	2.8377	0.7711	0.7981

given in Table 2. Species richness was maximum on 45 Days After Sowing (DAS) (5.0053) and 60 DAS (5.7168) on 2006 and 2007, respectively, during vegetative stage. Whereas, in the flowering stage maximum richness was noticed with an index of 5.174 (2006) and 5.8132 (2007) on 75 DAS. High richness was recorded on 145 DAS (2006) and 160 DAS (2007) during pod filling stage. With regard the overall crop duration, maximum richness was found on the flowering stage with an index of 5.174 during 2006 (75 DAS), and in the pod filling stage during 2007 (160 DAS).

Diversity index (Shannon-Wiener)

Diversity of spider fauna was maximum during 45 DAS (2.7798) in 2006 and 60 DAS (3.0673) in 2007 during vegetative stage. In the flowering stage maximum diversity index was noticed on 75 DAS on both the years. On the other hand in the pod filling stage the diversity was high on 160 DAS in both the years. Overall the diversity was found to be maximum during 75 DAS (Table 2).

Evenness (Equitability J)

Evenness was maximum on 45 DAS (0.7819) during 2006 and it was 60 DAS (0.8627) in the vegetative stage.

On the other hand in the flowering stage maximum evenness was found to be similar *i.e.,* at 75 DAS in both the years of study. In the case of pod filling stage the same trend was found on both the years *i.e.,* maximum at 160 DAS. On the whole, maximum evenness was found to be in the flowering stage at 75 DAS with an index of 0.8396 and 0.8990 during 2006 and 2007, respectively. Minimum index values were recorded on the vegetative stage (Table 2).

Similarity index

Diversity analysis was performed based on Jaccard's similarity matrices calculated from different spider fauna in pigeonpea ecosystem to construct a dendrograms (Figs. 1 & 2). The dendrogram for 2006 separated 15 families into four major clusters based on 62, 63 and 65 per cent similarity. The relative occurrences of spiders of the Araneidae, Clubionidae, Corrinnidae, Gnaphosidae, Filistatidae, Miturgidae, Oxyopidae, Philodromidae, Salticidae, Sparrasidae, Tetragnathidae and Zodariidae (Fig. 1) were highly similar. In 2007, based on similarity values, the spider families were separated into three clusters. When compared with the other spider families, 65 and 64 per cent similarity were noticed in Oxyopidae and Thomisidae (Fig. 2).
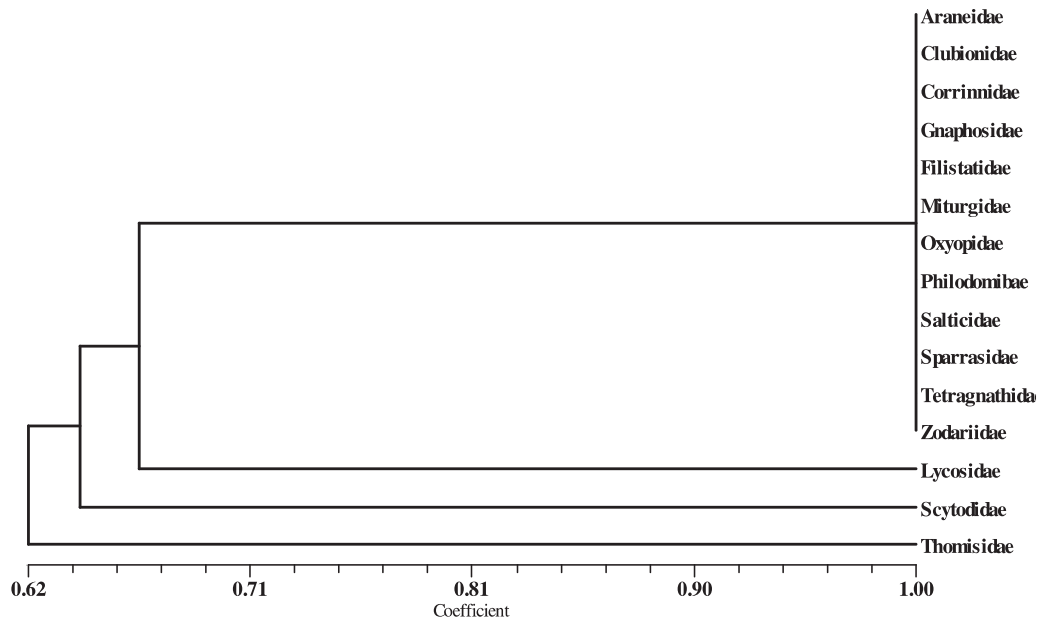
Figure 1. Dendrogram showing the similarity in the occurrence of different spider families recorded in different stages of pigeonpea ecosystem based on Jaccard's similarity coefficient - 2006
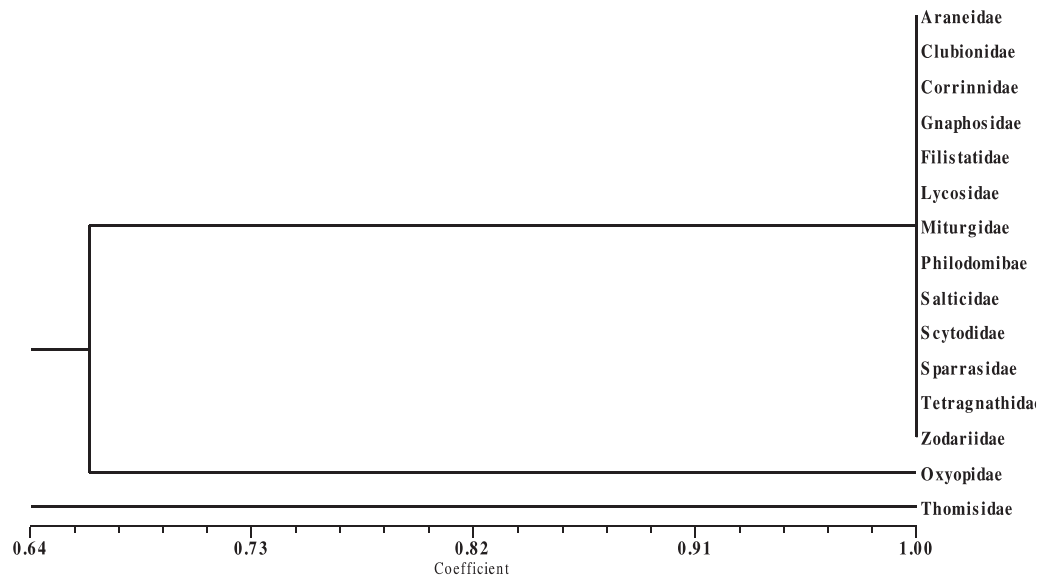

Figure 2. Dendrogram showing the similarityin the occurrence of different spider families recorded in different stages of pigeonpea ecosystem based on Jaccard's similarity coefficient - 2007

DISCUSSION

A rich and abundant predatory spider community was recorded in pigeonpea. This could be attributed to the complexity of ecosystem which sustains a variety of organisms and continuous availability of leaf litters throughout the year and offers an undisturbed patch for recolonization of predatory arthropods. Murdoch *et al.* (1972) reported that insect diversity highly correlated to plant structure diversity. The activities of spiders were high in vegetative and flowering stage in pigeon pea

ecosystem. This is in accordance with Sahoo and Senapati (2000).

Vegetation architecture played a major role in establishment of spiders which was clearly indicated by the variation in spider population collected from pigeonpea ecosystem. This could be attributed to longer duration and bushy nature of plant architecture. The pigeonpea showed maximum spider diversity on both the years because of longer duration and bushy nature of the plant. Basset and Burckhardt (1992) reported that

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more structurally complex vegetation supported a greater diversity of arthropods and other insects than structurally simpler vegetation. Greater habitat heterogenity and niche diversity with increasingly complex plant architecture available to arthropods was attributed to their diversity by Lawton (1978) as well.

In species richness indices, the highest predatory species number and the other maximum values were observed in flowering to pod filling stages. These values coincide with pest population. The indices were minimum during vegetative stage because of less foliage, minimum pest population, dried foliages, etc. In species richness indices, the highest predatory species number and the other maximum values were observed in flowering to pod filling stages. James and Shugart (1970) studied the species richness of upland Ozark forest in Arkansas and ensured that value of the index increased with increasing diversity. In the past, efforts to measure organism or species level diversity have often focused on documenting a single taxonomic group containing relatively few species (Wilson, 1988) and therefore failed to meet the need of management. Efforts have been made to overcome these problems by using highly diverse arthropod fauna as indicators of organism diversity (Rushton *et al.*, 1987) and as such the present study highlights the sifnificance of community level studies specially with regard to spider population that play a critical role in insect pest control in agricultural crops.

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REFERENCES

Ali, M. and Kumar, S. 2004. An overview of pigeonpea research in India. *Indian J. Pulses Res.*, 17: 111-120.

Basset, Y. and Burckhardt, K. 1992. Abundance, species richness, host utilization and host specificity of insect flivores from a woodland site, with particular reference to host architecture. *Revue Suisse Zool.*, 99: 771-791.

Ehrlich, P.R. and Ehrlich, A.H. 1981. *Extinction: the causes and consequences of the disappearance of species.* Random House, New York.

Henderson, P. A. 2003. *Practical Methods in Ecology.* Blackwell Publishers, United Kingdom. P. 151.

James, F.C. and Shugart, H.H. 1970. *A Quantitative Method of Habitat Description.* Audubon Field Notes, December, 727-36. Chapman and Hall, London. P. 152-153.

Lawton, J.N. 1978. Population dynamics and the length of food chains. *Nature.*, 272: 189-90.

Magurran, A.E. 1988. *Ecological Diversity and Its Measurement.* Croom-Helm, London.

Margalef, D.R. 1958. Information theory in ecology. *Genetics and Systematics.*, 3: 36-71.

Melbourne, B. 1993. *Insect biodiversity and its assessment in terrestrial ecosystems: a review of the literature.* Division of Botany and Zoology. The Australian National University.

Murdoch, W.W., Evans, F.C. and Peterson, C.H. 1972. Diversity and pattern in plant and insects. *Ecol.*, 53: 819-829.

Pielou, E.C. 1975. *Ecological diversity*, New York: Wiley. P.23-145.

Reaka-Kudla, M.L., Wilson, D.E. and Wilson, E.O. (Eds.). 1997. *In: Biodiversity* II: Understanding and protecting our biological resources. Joseph Henry, Washington, DC.

Rolff, J. 1998. NTSYS-pc. 2.02i. *Numerical taxonomy and multivariate analysis system.* Applied Biosystem Inc., New York.

Rushton, S.P., Topping, C.J. and Eyre, M.D. 1987. The habitat preferences of grassland spiders as identified using Detrained Correspondence Analysis (DECORANA). *Bull. Br. Arachnol. Soc.*, 7: 165-170.

Sahoo, B.K. and Senapati, B. 2000. Natural enemies of podborers in pigeonpea. *International Pigeonpea Newsletter*, 7: 57-59.

Whittaker, R.H. 1972. Evolution and measurement of spices diversity. *Taxon.*, 21: 213-251.

Wilson, E.O. 1988. *Biodiversity*. Washington DC, National Academy press.