CHAPTER 5

COMMUNITY STRUCTURE OF SPIDERS IN PIGEONPEA AGROECOSYSTEM

INTRODUCTION

Pigeonpea is a crop of vital importance to India. It forms the major protein supplement for more than 90% of the Indian population. Apart from its dietary value to humans Pigeonpea being a leguminous plant has the ability to fix nitrogen in soil thus increases the soil fertility. Pigeonpea doesn't compete with other crops like millet and ground nut and has a long cropping season, thus most of the times it is intercropped with several other crops. The crop is also used as a wind break and shade for coffee plantations, forest seedling nurseries and vegetable beds.

Pigeonpea is cultivated in more than 25 countries of the world. The total production of the Pigeonpea in the world stood at 3.25 million tonnes grown in about 4,587,042 hectares in the world. India produces a major share of the Pigeonpea with an annual production of 2,400,000 metric tonnes. This constitutes about 90% of the total world's production. Where as Gujarat in India stands 5th position in the production of pigeonpea, producing about 100,000 tonnes per year (FAO Stat, 2003).

The seeds of the crop start germinating in two weeks time. When sowing is in July the flowering starts in upcoming October and the crop is harvested in December and January. During the flowering season there is a natural fall of flowers to compensate this loss, the plant produces a lot of flowers. However when there is an insect attack on the flowering and fruiting structure of the plant, the loss in terms of the production is severe. More than 200 species of insects have been found feeding on the pigeonpea (Lateef and Reed, 1983). More than 30 species of insect attack the Pigeonpea reproductive parts. (Shanower et al, 1999). Of these insect pests *Helicoverpa armigera (Lepidoptera:Noctuidae);Clavigralla horrens (Hemiptera:Coreidae) , Spodoptera litura (Lepidoptera:Noctuidae) and Melanogromyza obtuse (Diptera : Agromyzidae)* .Pigeonpea pod fly cause extensive damage. The loss of pulses in the storage area is also significant. The damage is mainly caused by pulse beetles belonging to Family Bruchidae in India. Three species of *Callosobruchus* genera are found, *Callosobruchus chinensis, Callosobruchus maculatus* and *Callosobruchus analis.* These three species cause considerable damage to the stored pulses.

The management of these pests using the chemical insecticides has proved futile as these insects has developed resistance to most of the chemicals insecticides, so alternative methods of the pest management and management of insecticide resistance in insects is required. Conservation biological control methods coupled with the need based spray of the chemical insecticides is one of the most promising areas in the resistance management in insects. In conservation biological control the use of natural enemies in the field to manage insect pests is given much importance however the natural enemies present in the fields of pigeonpea are poorly documented by the scientists. Huge quanta of the work on the natural enemies have been on parasitoids belonging to two insect orders, Diptera and Hymenoptera. The dipteran parasitoids namely *Mormonomyia argentifrons* and *Alophora nasalis,* parasitize on *Clavigralla* (Order: Hemiptera) belong to Family Tachinidae. Hymenopteran parasitoids belonging to the taxa *Euclerus spp* (Family: *Eulophidae*) and *Ormyrus spp* (Family: Ormyridae) are the other parasitoids found in the field.

The predators found in the Pigeonpea field are mainly represented by Reduviidae (*Cosmolestes sp*); *Antilochus coqueberti* (Pyrrhocoridae) and predatory mite *Bocharitia* (Acarina : Erythracidae). The arachinid predators are poorly documented in the pigeonpea field Shanower et al(1999) have reported 4 families of spiders comprising of a total of 8 species predating on *Helicoverpa armigera* larvae. The spiders were mainly represented from the families Araneidae (*Leucage tessellate and Neoscona theis*); Clubionidae (*Chieracanthium inornatum and Clubiona sp*); Oxyopidae (*Oxyopes ratnae* and *Oxyopes sp*) and Thomisidae (*Ozyptilla reenae and Thomisus sp*). The work from our laboratory has reported 64 species of spider belonging to 12 families over a period of three years (Siliwal, 2000), while we have identified 23 species of spiders from 9 families in the year 2002 -03 from Vadodara (Dolly Kumar and Shivakumar, 2006). Siliwal has shown that much of these spiders feed on a variety of insect pests found in the field showing that the assemblages of the spiders are more efficient in the management a wide variety of insect pests than the parasitoids. Sunderland and Nyffeler (2001); Richert and Lockley (1984); Nyffeler (1999); Greenstone and Sunderland (1999) have identified the potential of spider assemblages on the insect pest densities in various agricultural and plantation crops. They have found that in most of the crop the assemblages of spiders have a significant impact on the insect pest densities in the crop field.

Looking at the diversity of spiders in the Pigeonpea field, their role in conservation biological control cannot be neglected. A comprehensive study regarding the ecology of these spiders and their diversity during the cropping months could be useful in understanding the share of spiders in biological control programmes.

Such an approach will on one hand reduce the environmental pollution due to decreased chemical input within the field and on the other hand will be economical to the farmers. Hence in the present ever increasing demand for pigeonpea in India, ways to increase the crop yield through improving the cultivars and reduction of the loss caused to the pigeonpea in the agricultural field and godowns can increase the yield per hectare thus making India self sufficient in the production of pigeonpea. Hence with respect to the importance of the agricultural pests and stored grain pests, management measures in the above areas are imperative.

RESULTS

Species Composition (Phase I)

A total of 10 families of spiders comprising of 22 genera and 32 species formed the spider fauna of the Pigeonpea field in Phase I. The Hunting spiders formed the majority of the spiders with 63% while weavers comprised about 37% in terms of the species composition. The web building spiders were from three families namely Araeneidae, which was more diverse than any family of spiders in Pigeonpea, Linyphiidae and Therrididae, also represented the other web building spider families.

In Phase II a total of 11 families of spiders comprising of 22 genera and 32 species were collected from the pigeon pea fields in the year 2003-04. Hunting spiders dominate both the Abundance and Diversity of the spider fauna, comprising 75% of the total species diversity, while web building spiders formed the remaining 25%.

Percentage composition of Spider families

In the Phase I of the study Family Lycosidae represented the numerically abundant family throughout the cropping season, reaching their peak during November. While Araneidae and Clubionidae showed peak diversities during the Pod formation (25.2%) and Pod Maturation (26.24%) stages of the crop respectively showed peak diversities during the flowering months of September and October. Family Oxyopidae showed the peak densities during the flowering stage in the month of September (17.7 %) and October (15.68%). Table 5.1 shows the Percentage composition of the dominant spider families in the Pigeon Pea crop. The Families Araneidae, Lycosidae, Clubionidae and Oxyopidae contributed more than 80 % of the total population of the spiders throughout the cropping season starting from August till the end of the cropping season in the month of January (Graph 5.5)

During Phase II, the relative composition of spiders during various months shows that spiders from families Linyphiidae, Thomisidae and

Heteropodidae constituted 60% of the spiders in August. In the month of September Lycosidae (54.16%) and Oxyopidae (31.25%) together formed 85% of the total spider fauna. October had a more homogeneous composition of spider families each being represented equally. In November there was input of Monocrotophos pesticide wherein, the only family to be found in the field were from Salticidae and Clubionidae. All the other families were absent from the fields. One month after spray there was a gradual buildup of population and it is seen that except for Clubionidae, the percentage composition of Salticidae decreases drastically, this is due to the increase in population of Therridids and other spider families. January present a more homogeneous composition of spiders with each spider family representing equally (Graph 5.6).

Seasonal Dynamics of the Spider Families

The seasonal dynamics of the dominant spiders' families during the cropping months of Phase I shows that the individual families reach peak densities during the various stages of the crop. In family Araeneidae the spider population increases with the start of the cropping season and remains almost constant throughout the cropping season except for a slight decline in the later cropping months. The species of Clubionidae family increases in density and attain peak density during November followed by a gradual decline. Lycosidae also increase in density from August and till January they reach their highest density. Family Oxyopidae show peak density during the vegetative stage and early pod formation stage of the crop (October), followed by a gradual decline. The population of Oxyopidae is dependent on the relative humidity showing that the family is more prone to desiccation and requires high humidity microhabitat for its survival. The months of September and October represent the Monsoon and Post Monsoon season during which the relative humidity remains high. The Population of Salticidae remains low throughout the season reaching a maximum of 1 per sq.m. in the month of January. Thomisidae are sit and wait hunters found near the flowers. They have remarkable capacity of mimicry, their principal food comprises of arthropods visiting the flowers for nectar and the larvae attacking the flowers. Thus with the start of the flowering season and its establishment in the month of December when the flowering and pod formation stage coincides, Thomisidae are found in their peak density.

While in the subsequent season (Phase II), the density of Araeneidae initially was at 4.4 per sq.m and with the progress of the season there was a decline in the population. In the month of November the field received an input of Monocrotophos, in the same month the members of family Araeneidae were totally absent. In the subsequent months there was recolonisation of Araeneids. The density of Clubionid spiders showed a gradual increase from August till the end of the cropping season reaching a maximum density of 4.92 per sq.m. in January. Similar pattern of increase was seen in the case of families Salticidae, Lycosidae and Therrididae.

Population Dynamics of Web Builders (Phase I)

Five species of web builders were found in very high numbers throughout the cropping season, namely *Argiope anasuja, Argiope aemula and Neoscona theis* from the family Araeneidae; *Theridion manjithar* from the family Therrididae and *Hippasa lycosina* from the family Lycosidae, the latter has been included in the web builder because the genera *Hippasa* is peculiar, as its members build ground webs (Graph 5.7). The Population of *Neoscona theis* reached its peak density of 1.5 per sq.m during October, with a steady increase in density from 0.5-0.75 per sq.m in August and maintaining density of about 0.25 per sq.m at the end of the cropping season. While the two species of the genus *Argiope*, i.e. *Argiope aemula* and Argiope *anasuja* makes their appearance in November at the rate of 1 per sq.m. and reaching their peak densities during the pod formation (December) and Pod Maturation (January) stages of the crop. *Theridion manjithar* shows a wavy distribution with a density of 3.5sq.m in August and 4.5sq.m. in September and disappearing during October , and making its appearance in November. *Hippasa lycosina* increased in density from August, reaching maximum density during the flowering stage and at the start of the fruiting stage of the crop.

Population Dynamics of Web Builders (Phase II)

Neoscona theis of the Family Araeneidae kept on decreasing in density from the start of the season in August till January. Two species of *Hippasa* genera showed an increase in the population from November to January. For both the species during the start of the season *Hippasa lycosina* and

Hippasa mahabaleshwarensis were absent. *Theridion manjithar* showed low population peaks in its population one during the start of the season in August and the other from December till January. During the post monsoon season in the months of September and October the population was absent (Graph 5.8).

Population Dynamics of Hunting Spiders (Phase I)

Two species from the family Clubionidae namely *Chieracanthium melanostoma* and *Clubiona drassodes* are numerically abundant in pigoenpea fields (Graph 5.9). Both these species reached peak densities in the month of December and October respectively. *Clubiona drassodes* showed a gradual decline in the month of November, followed by a gradual increase in subsequent month. *Oxyopes shweta* reached its peak during September, followed by a gradual but steady decline in population till the end of the cropping season. *Thomisus cherapunjeus* is a crab spider which is a sit and wait hunter usually found near the flower. In Pigeonpea agroecosystems *Thomisus cherapunjeus* is found with the flowering season (October) and the population remains constant till the end of the cropping season, except for the decline in the month of November associated with the spraying of Monocroptophos. The Population of *Pardosa biramanica* increases in density steadily, reaching its peak in January (5.2 sq.m) .

Population Dynamics of Hunting Spiders (Phase II)

Members of the family Clubionidae *Chieracanthium melanostoma and Clubiona drassodes* showed their peak population at the end of the cropping season (Graph 5.10). During the start of the season the population was higher and later decreased during September and October and then in November till January the population buildup was steady (Graph 5.10). Two crab spiders species, *Thomisus cherapunjeus* and *Thomisus krishnae* showed opposite peaks. *Thomisus krishnae* was present during August and September while in the remaining months it was absent, while *Thomisus cherapunjeus* was absent initially and slowly increased in population from September till January. *Oxyopes shweta* reached its peak density in September, while during the remaining months the population was steady except for the month of November. *Lycosa pictula* showed an initial increase in population till September (1.75 per sq.m) then a steep decline and becoming absent in October and November and Making a reappearance in the month of December and January thus no distinct life history pattern is observed for *Lycosa pictula*. *Salticus ranjithus* showed an irregular population dynamics with population present during September and January and being absent in the rest of the cropping months.

Rank Abundance of the spiders (Phase I)

The months of November and October exhibit a very high density of individual spiders during the same months the evenness or equitability index is low. While for the month of December the Evenness is high, diversity is high and the individual species of spiders exhibiting very high densities is low, stating that a large number of species (Graph 5.11) approx 20 contribute to the abundance of spiders.

In the Phase II of the study the month of August represents, high abundance and low diversity, (Graph 5.12) only 4 species in the month of August have contributed significantly as compared to other species. In the months of September and January the density is about half what is found in the month of August. October and December shows lower abundance and a high evenness among the spider community. The month of November showed that the abundance was at the lowest, an effect attributed to the input of pesticide (Monocrotophos).

Generic and species diversity (Phase I)

Family Araeneidae is the most diverse family in pigeonpea represented by 6 genera and 12 species, followed by Lycosidae with 5 species and Salticidae with 4 species (Table 5.3). The total species composition includes 32 species belonging to 22 genera. The maximum diversity was observed H= 2.77; in the month of December. In the month of October and November the diversity was H= 2.61-2.62. While the Simpson Index D in the December was at 14.0, while in the month of October and November D= 11.0 -11.92. The month of December the species number was 20 which were at its maximum. The Equitability index was also maximum during December, which represented the pod maturation stage of the crop which is also the economically most important of the crop. Berger-Parker index is the lowest during December and being highest in the month of

August, November, and January. The value of Berger Parker index during December remains high showing that the evenness of the community is very less.

Renyi Diversity Ordering

The Renyi diversity ordering shows (Graph 5.13) that in the December is the month of high diversity, followed by October and November. The month of January shows the least diversity among all the cropping seasons. Showing that the order of diversity from highest to lowest is in the following order

December > October>November>August> September > January

Generic and species diversity (Phase II)

A total of 32 species belonging to 22 genera and 11 families were collected during phase II (Table 5.4). Three families represented the maximum species diversity; namely Lycosidae (8 species), Salticidae (7 species) and Araeneidae (5 species). The Shannon Weiner index indicates that maximum diversity was seen during December (2.19) and January (2.59). The corresponding Simpson D for December (8.92) and January (11.24). The species number during December and January were 12 and 19 respectively. The Evenness index for the month of December and January was highest as compared to the other months stating that the species composition as well as their relative abundance was high during the pod formation and pod maturation stage of the crop. The Berger-

Parker Index of dominance showed the least value (0.176) fir the month of January. The Data Distribution fits in the geometric model.

Renyi Diversity Ordering (Phase II)

The Renyi diversity ordering shows (Graph 5.14) that December is the month of high diversity, followed by October and November. The month of January shows the least diversity among all the cropping seasons. Hence the order of diversity from the highest to the lowest is in the following order

December > October>November>August> September > January

During both the cropping seasons the data distribution showed both geometric as well as logarithmic distribution.

Table 5.1 Percentage composition of Spiders in Pigeon pea (Phase I)

Family	Aug	Sept	Oct	Nov	Dec	Jan
Araeneidae	23.32	9.72	18.98	24.8	25.2	23.92
Clubionidae	5.89	6.07	22.4	21.93	20.26	26.24
Lycosidae	38.6	33.15	30.66	36.42	24.87	20.43
Oxyopidae	11.26	17.7	15.68	8.48	7.9	3.32
Therrididae	18.76	16.84	0	0	9.88	6.47
Others	2.14	4.68	12.25	8.35	11.85	19.57

Table 5.2 Percentage composition of spiders in pigeon pea (Phase II)

Family	Aug	Sept	Oct	Nov	Dec	Jan
Araeneidae	16.30	8.3	20.58	0	2.5	1.96
Clubionidae	3.26	0	29.41	25	28.2	29.41
Lycosidae	4.3	54.16	17.64	12.5	10.25	19.6
Salticidae	7.6	4.1	2.94	62.5	7.69	8.82
Oxyopidae	4.34	31.25	23.52	0	5.1	5.88
Therrididae	4.13	0	0	0	23.07	16.66
Others	60.86	2	5.8	0	23.07	16.66

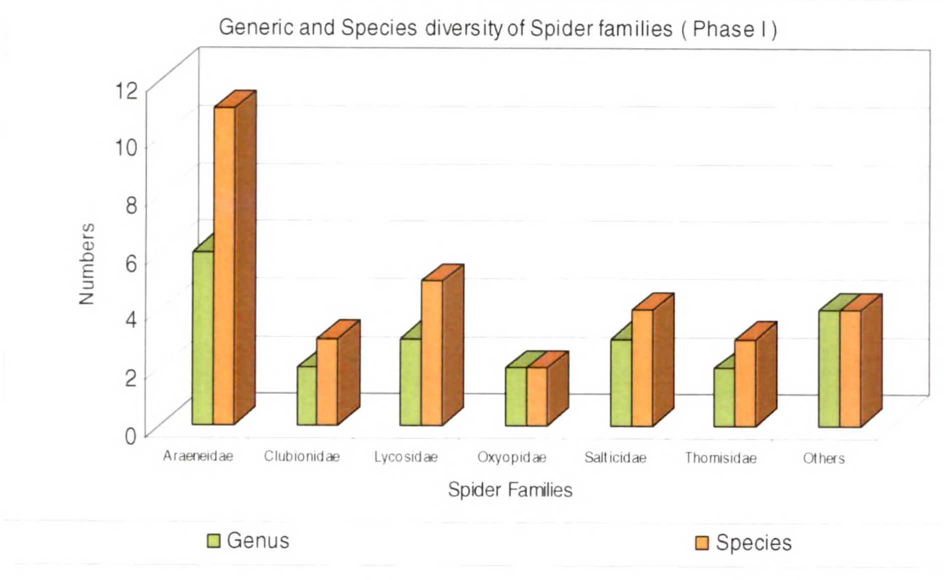
Table 5.3: Species diversity and evenness measures for Phase I

Diversity Measure	Aug	Sept	Oct	Nov	Dec	Jan
H	2.51	2.41	2.62	2.61	2.77	2.47
D	9.8492	9.2893	11.92	11.039	14.046	9.5644
Evenness	0.7252	0.6963	0.7577	0.7544	0.8006	0.7135
Fisher alpha	3.6748	3.0526	3.2317	3.5315	3.9785	3.7371
Berger - Parker	0.1876	0.1770	0.1568	00.1827	0.1322	0.1827
Species Number	17	16	18	19	20	19

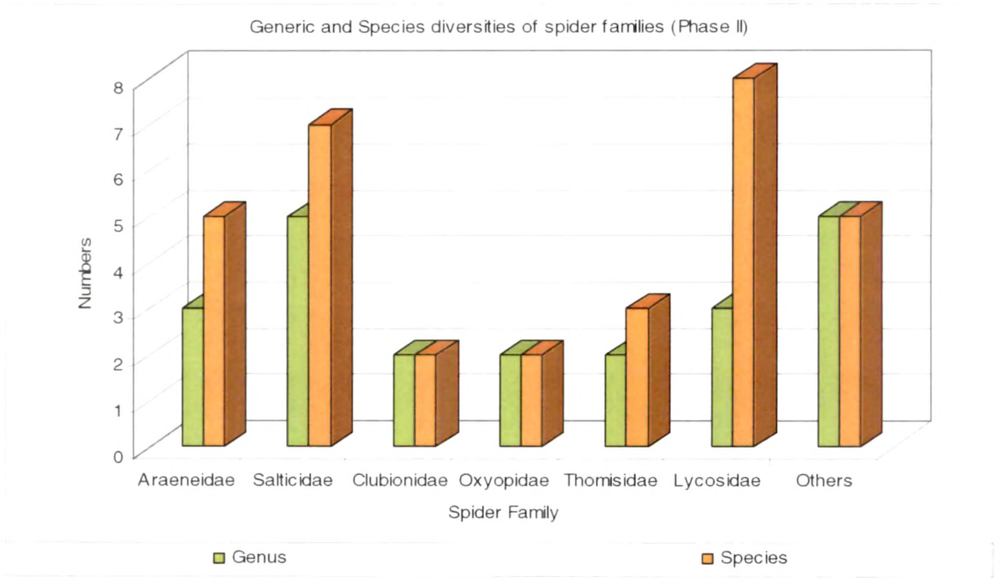
Table 5.4: Species diversity and evenness measures for Phase II

Diversity Measure	Aug	Sept	Oct	Nov	Dec	Jan
H	1.96±0.01	1.86	1.93±0.01	1.32±0.03	2.19±0.01	2.59
D	4.972	6.1304	6.5233	5.6	8.9277	11.247
Evenness	0.5663	0.5381	0.5588	0.3811	0.6331	0.7473
Fisher alpha	3.9514	2.7407	3.9966	3.1836	5.9214	6.8786
Berger - Parker	0.3921	0.3125	0.2941	0.375	0.2307	0.1764
Species Number	13	8	9	4	12	19

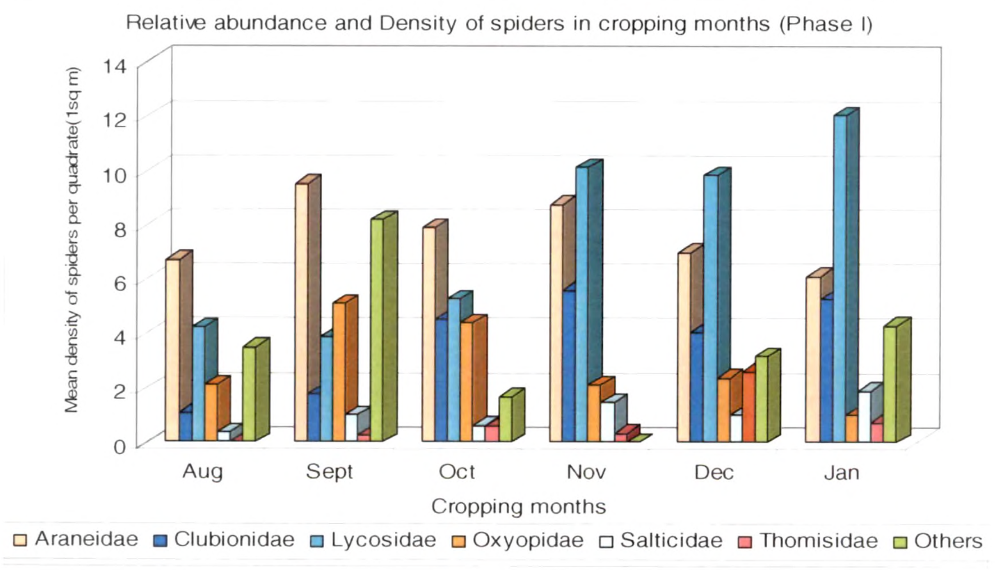
Graph 5.1: Generic and Species Diversity of spider families - Phase I



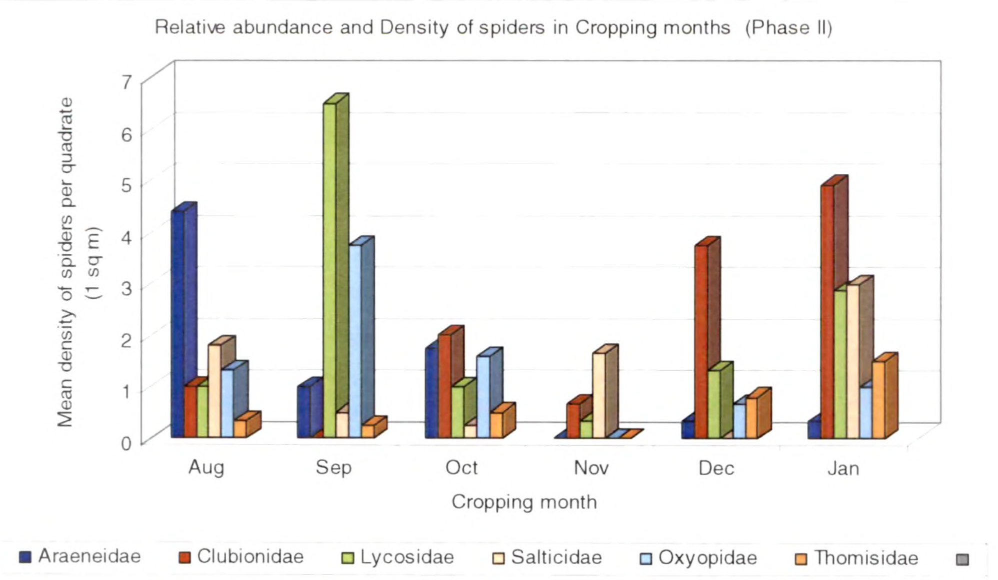
Graph 5.2: Generic and Species Diversity of spider families - Phase II



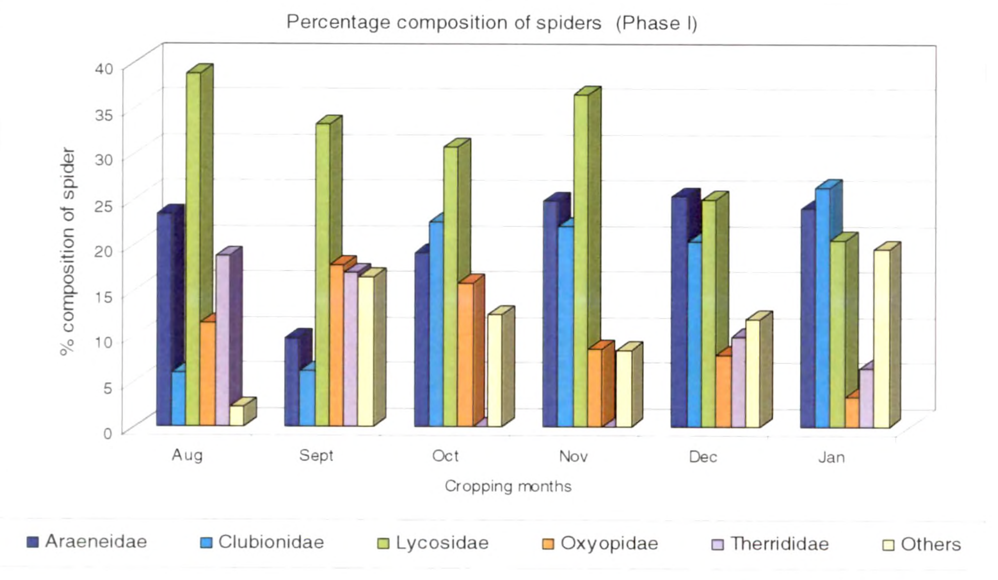
Graph 5.3: Generic and Species Diversity of spider families - Phase I



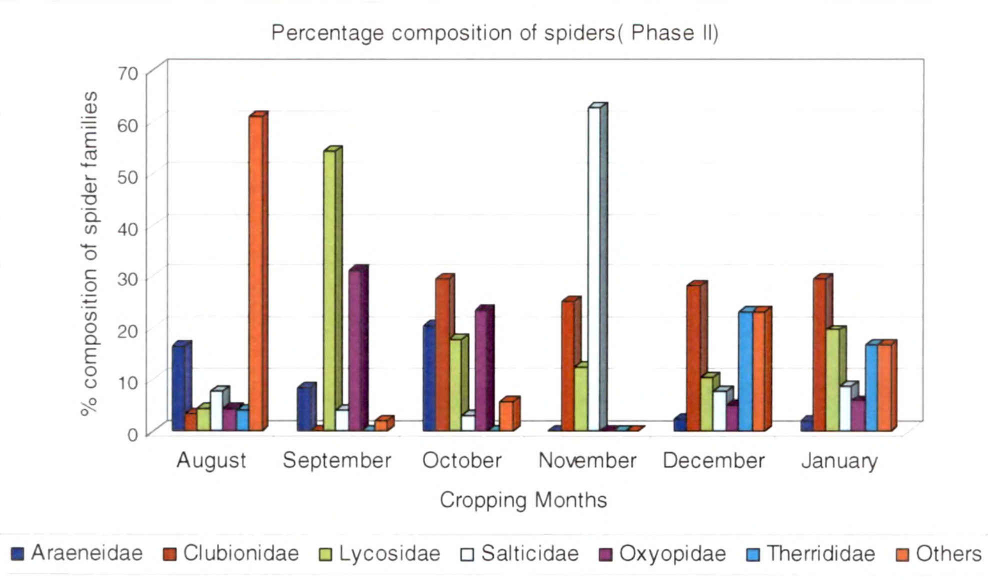
Graph 5.4: Generic and Species Diversity of spider families - Phase II



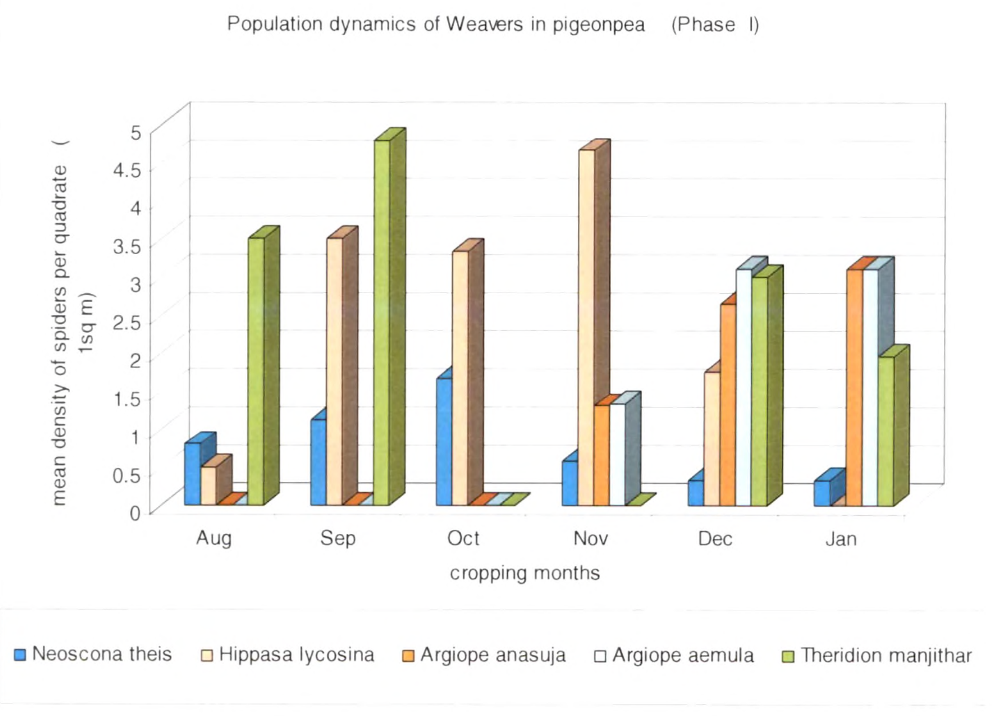
Graph 5.5: Percentage composition of spiders in Pigeonpea - Phase I



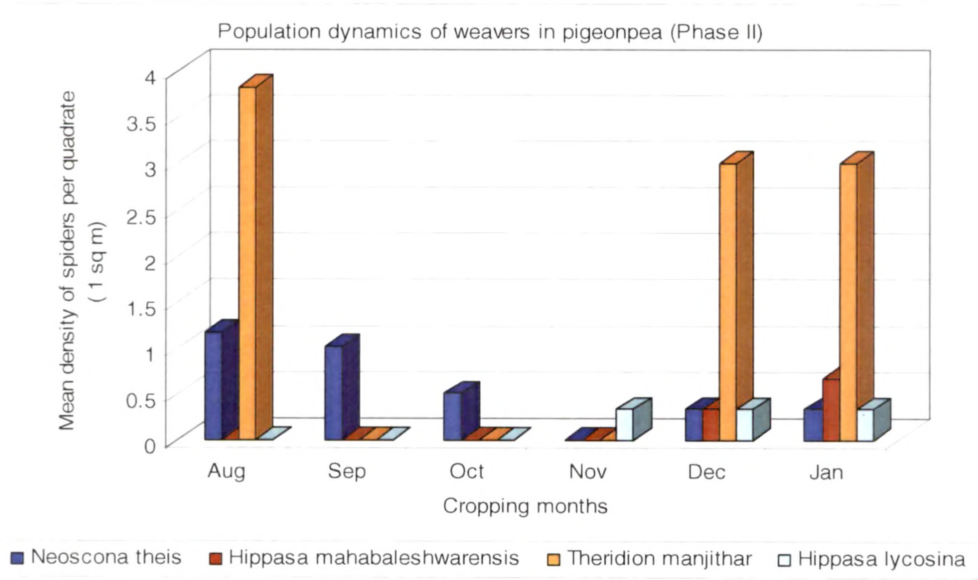
Graph 5.6: Percentage composition of spiders in Pigeonpea - Phase II



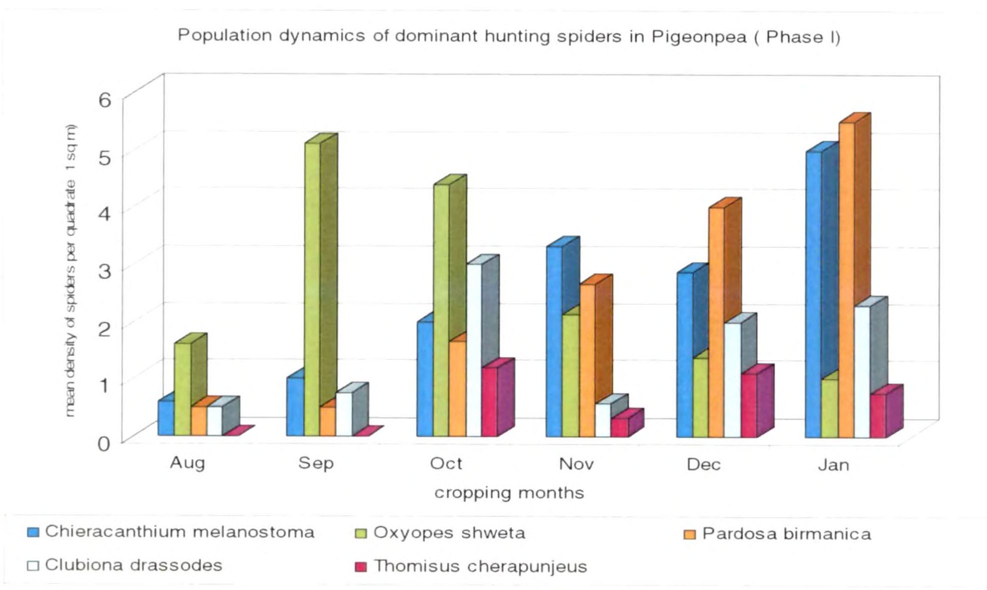
Graph 5.7: Population Dynamics of Web Building spiders - Phase I



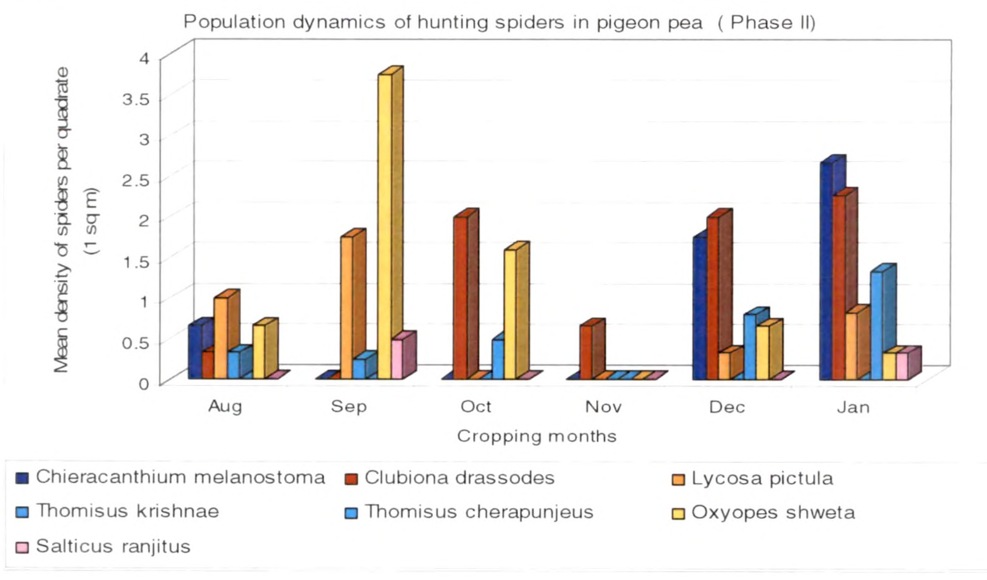
Graph 5.8: Population Dynamics of Web Building spiders - Phase II



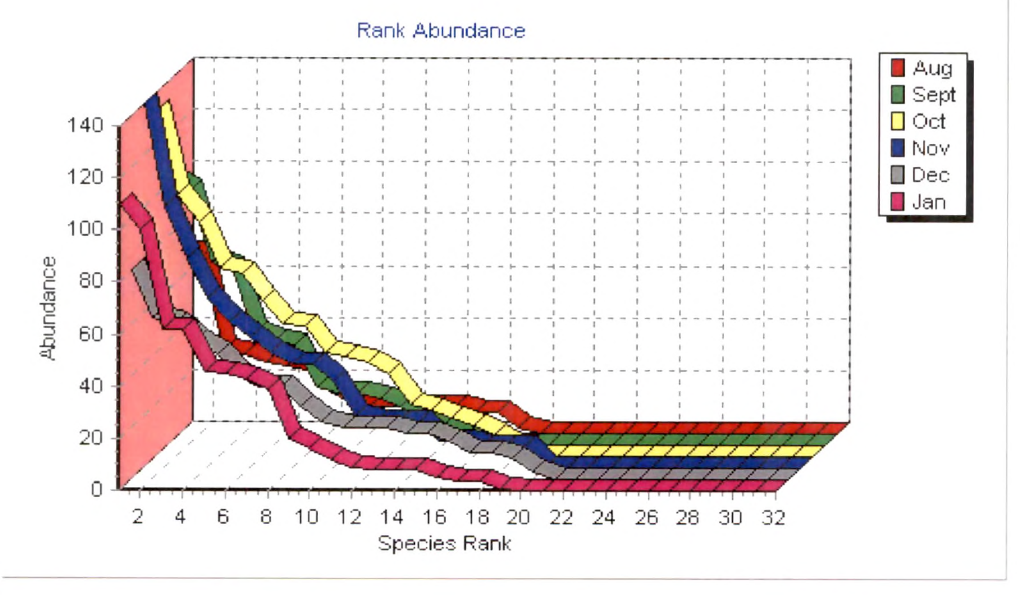
Graph 5.9: Population Dynamics of Hunting spiders - Phase I



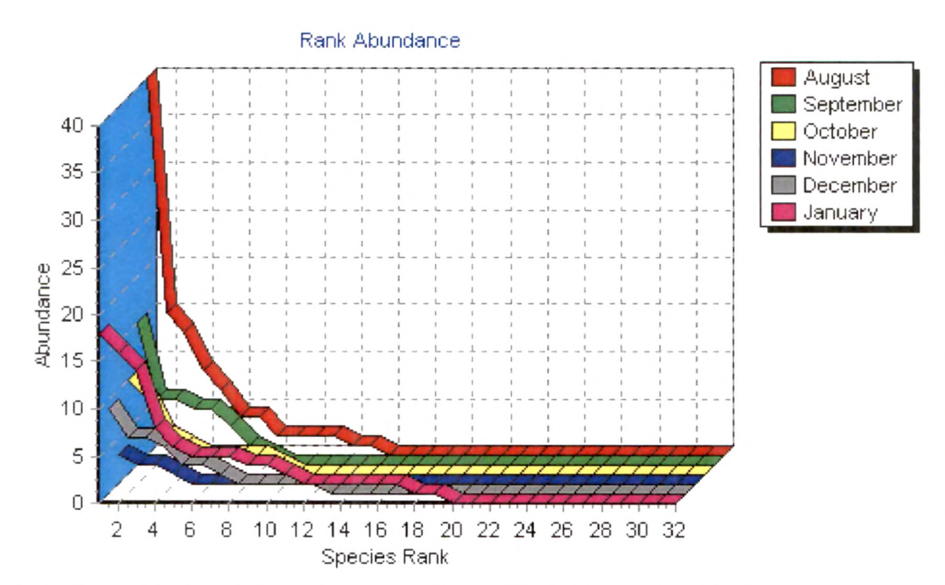
Graph 5.10: Population Dynamics of Hunting spiders - Phase II



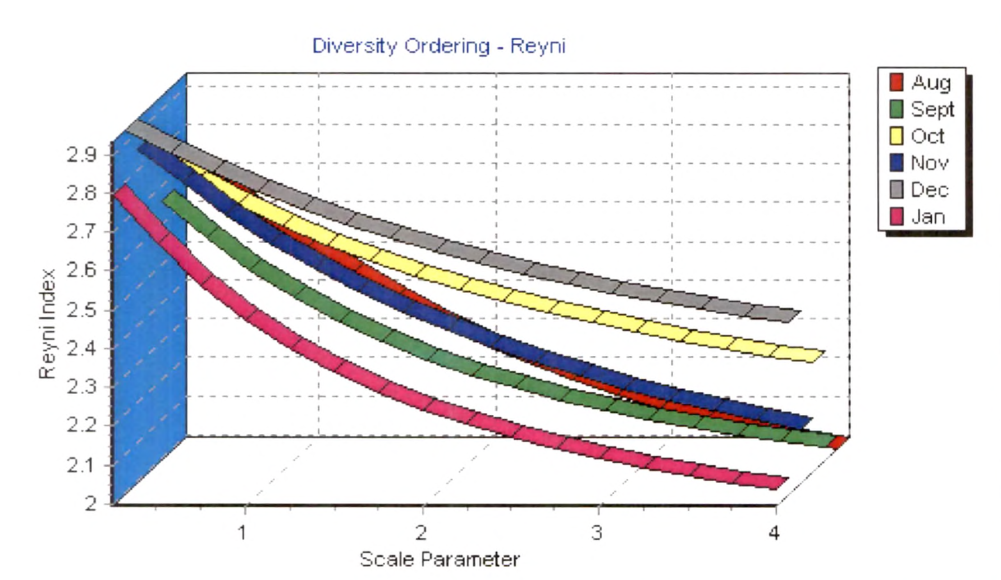
Graph 5. 11 Rank Abundance of the spiders - Phase I



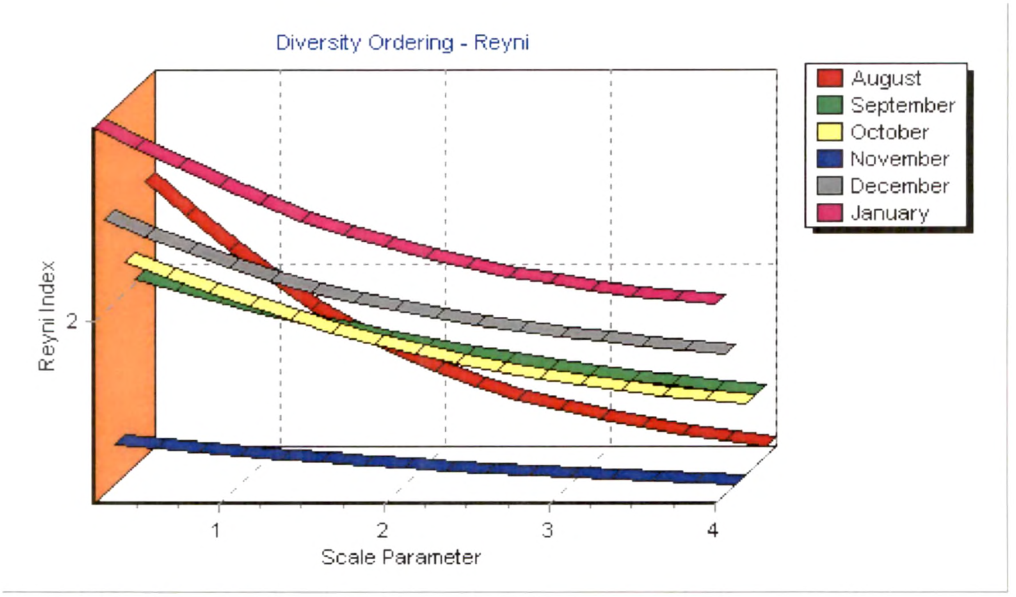
Graph 5. 12 Rank Abundance of the spiders - Phase II



Graph 5. 13: Renyi Diversity Ordering - Phase I



Graph 5. 14: Renyi Diversity Ordering - Phase II



DISCUSSION

The management of insect pest in Pigeonpea is very complicated since several types of insect pests with varying biology are present in the crop field. These differences in insect pests are in the (i) mode of feeding (ii) location of the pests and (iii) the range of host on which they feed. The heavy reliance on the calendar spray of chemical pesticides (Monocrotophos and Synthetic Pyrethroid) by the farmer (3-6 times per season) starting from the flowering period till the pod maturation stage has resulted in *Helicoverpa armigera* developing high resistance to organophospharous and synthetic pyrethroids (Armes et al,1996)

Improving the natural enemies is the most neglected area the Pigeonpea pest management research. Much of the focus is on resistant cultivars and chemical insecticides. A large number of natural enemies have been recorded from the key pests of pigeonpea (Jackai and Singh, 1991;

PLATE XV

SITE I – PIGEONPEA AGRICULTURAL FIELD

EXPERIMENTAL PLOT AND ADJOINING GEOGRAPHICAL FEATURES

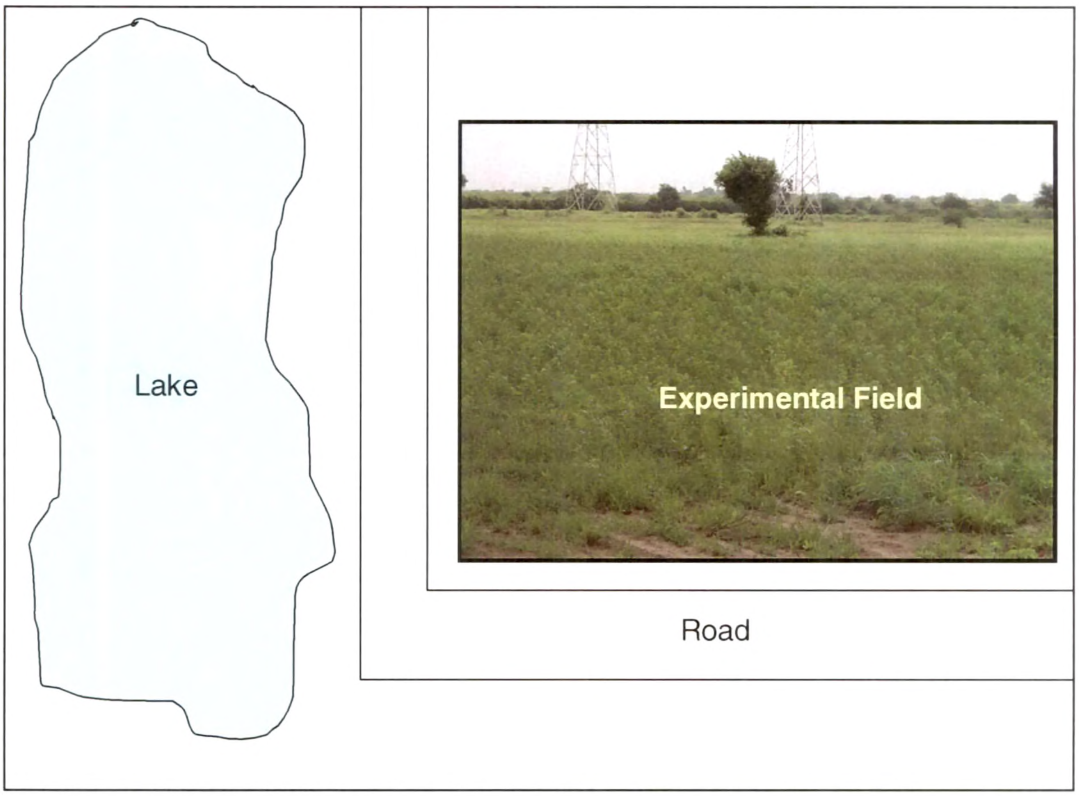


PLATE XVI

CROPPING STAGE OF PIGEONPEA CROP

PIGEONPEA TWIG SHOWING THE BUD FORMATION STAGE

SPACING OF THE PIGEONPEA PLANTS

PLATE XVII

CROPPING STAGE OF PIGEONPEA CROP

A & B PHOTOS SHOW THE FLOWERING STAGE OF PIGEONPEA CROP

A

B

PLATE XVIII

Thomisus sp and Neoscona sp surviving on margins of pigeonpea field

CRAB SPIDER FEEDING ON HONEYBEE

NEOSCONA THEIS (ORB WEB SPIDER)

PLATE XIX

Clubionid web on the weeds surrounding the pigeon pea field.

Thomisus krishnae abundant during flowering season controlling pests which attack the reproductive parts of the plant.

SAC WEB SPIDER (CLUBIONIDAE)

CRAB SPIDER (THOMISUS KRISHNAE)

PLATE XX

Thomisus charapunjeus abundant during flowering season controlling pests which attack the reproductive parts of the plant

Araenids as generalist predators

CRAB SPIDER (THOMISUS CHERAPUNJEUS)

ORB WEB SPIDER (NEOSCONA SP)

PLATE XXI

Neoscona theis found on the base of pigeonpea leaf camouflaging with the midrib of the leaf.

Jumping spider commonly found along the ground and on the aerial parts of the plant

ORB WEB SPIDER (NEOSCONA THEIS

JUMPING SPIDER

PLATE XXII

Adult Heteropteran damaging the early pods and flowers of pigeonpea.

Blue Butterfly as seen on Pigeonpea flowers

POD BUG (CLAVIGRALLA HORRENS)

GRAM BLUE BUTTERFLY

PLATE XXIII

Larva of Spodoptera litura skeletinising the leaves of pigeonpea

Helicoverpa armigera bores in the Pod of Pigeonpea

TOBACCO CUTWORM (SPODOPTERA LITURA)

POD BORER (HELICOVERPA ARMIGERA)

Shanower et al, 1999; 1998). However no concrete and comprehensive studies on generalist predators of the pigeonpea pests, their population dynamics and the ecology are available. These parameters are essential before pest control strategies can be developed. The study should include composition, population dynamics, factors affecting density and diversity, agro biodiversity of the spiders. The long term solution of insect pest management in pigeonpea can be brought by only the natural control process by the introduction of exotic species or enhancing the efficacy of the native species.

The species composition of spiders in both the phases \ cropping years was the same with 32 species belonging to 22 genera and 11 species and hunting spiders dominated the spiders found in pigeonpea in terms of diversity.The ground hunting spiders belonging to the Family Lycosidae comprised of the major share of spiders among the entire cropping season in both the phases and during the pod maturation stage of the crop (January) the percentage composition of the spiders decreased. The family density when correlated with the abiotic factors showed that, soil temperature, and relative humidity or temperature did not significantly affect the population density of the lycosidae. The maximum density of the lycosidae ranged between 10.13 – 12.07 spiders per square meter in the reproductive season during the months of November till January. Lycosidae (ground hunting spiders) are numerically abundant in several types of Agroecosystems, Pastures, Grasslands and Orchards. In Citrus orchards they are the most abundant spiders (Marc et al, 1999). In the paddy fields the population of the spiders is very high (Okuma et al, 1978; Sigsgaard, 2000; Ishijima et al, 2004; Dolly Kumar and Shivakumar, 2004). In the hay fields and pastures of Iceland lycosids are the found to comprise of the dominant spider fauna (Gudleifsson and Bjarnadottir, 2004).

Pardosa birmanica was present in high density in Phase I; (5.5 spiders per sq m) during the end of the cropping season while in Phase II; *Lycosa pictula* was the dominant lycosid with 1.75 spiders per sq. m. density in the month of September. The Lycosidae spiders were not found to be effected by the pesticidal spray and these also did not show any significant correlation with the environmental factors like Relative Humidity, Temperature, and Soil Temperature. Bogya and Marko (1999) also found that the ground dwelling spiders were more resistant to the insecticides. The population of Lycosidae was shown to be affected by the weed cover. The reason for this is that the spray is always directed to the aerial parts of the plant and the amount of the chemicals reaching the ground level is higher.

Spiders of the genus *Hippasa* (Family: Lycosidae) are the only ones to build webs for trapping insects (prey). The location of the webs is along the base of the pigeonpea plant or between the two plants or between the field margins and the ground. The webs are always located on the ground. The population of *Hippasa lycosina* was maximum in November (4.66 spiders per sq m) during the phase I. The correlation with the environmental factors like soil temperature showed that with a decrease in the soil temperature there is an increase in the web building rate ($P < 0.10$). *Hippasa lycosina* also showed a significant negative correlation with Relative humidity ($P<0.05$). While in Phase II the spiders in the months of September and November were absent. *Hippasa mahabaleshwarensis* was present in higher numbers during the Phase II of the study. The population of the spiders was higher during the later stages of the crop.

The Orb weavers of the Family Araneidae also constituted a major share of spiders in pigeonpea field. It was observed that the percentage composition remained uniform in the crop in Phase I while in Phase II in the month of November, Araneidae was entirely absent as in November (Flowering season). There was input of monocrotophos during November. In terms of population density of Araneidae in Phase I the density was more or less constant with about 7 spiders per sq m while in Phase II population density of the araneids a greater fluctuation.

The seasonal variation in the density of the spider was attributed to the pesticide spray during the Phase II was severe. The spray was done during September and November. The climatic factors, field area and the relative composition of the spider fauna were similar in both the phases. Thus the only major factor contributing the fluctuation in the density in the two phases is the pesticides spray seen in the phase II. We have found that the overall density of the spiders in the Phase II was lower than that of Phase I (Table 5.1 and 5.2).We found that the density or buildup of

Araneidae was not significantly affected by the presence of Rainfall, Humidity or Temperature. This shows that some other factors should be influencing the population buildup of the spiders. Two of the factors are the insect prey density and crop architecture.

The web building spider species which were numerically abundant spider species were from the families Araneidae, Therrididae and Lycosidae. *Neoscona theis* from Araneidae was present at a maximum density of 1.66 spiders per sq m in Phase I in October. While in Phase II *Neoscona* density was higher in August (1.16 spiders per sq m) and in the month of November *Neoscona* was totally absent from the field. It is known that *Neoscona theis* are found along the field margins in higher numbers throughout the cropping season. Hence after the pesticide spray the spiders migrate into the fields.

Two other spider species *Argiope aemula and Argiope anasuja* were observed during the phase I, their maximum population was observed in the month of November, December and January. The correlation with the environmental factors shows that there is no significant impact on the life cycle of the spider. The Family Therrididae was adequately represented by *Theridion manjithar.* The density during the early season and later in the season the population was present during the post monsoon season the spider was absent.

The crop height is also a major factor contributing to the spider assemblages. As with the growth of the plant, more the foliar cover is available for web attachment for web builders and helps in concealing the hunting spiders. Greenstone (1984) has shown a positive correlation between the vegetation tip height diversity and diversity of web builders. Bishop and Richert (1990); Rypstra and Carter (1995) have also shown that the vegetation complexity has a positive effect on the spider density and diversity by providing habitat availability for the colonization of the spiders. The plant species diversity is also shown to influence the spider diversity. According to Duffey (1978) the density of Microphantid *Erigone atra* was significantly affected by the plant species diversity. Alderweireldt,(1989); Toth et al (1996); Kromp and Steinberger,(1992) have shown that the field margins harbour a higher diversity of the spider fauna as compared to the agricultural field itself, as these margins receive a comparatively lower input of the chemicals and the vegetation structural diversity provides ideal environment for the colonization of the spiders. The prey availability is also thought to determine the density and diversity of the spiders; however the contribution of the prey availability is a minor factor may not be a significant determinant of spider assemblages.

The percentage composition of Family clubiondiae was more than 20% of the total spider density from the start of the flowering stage (in October) till the end of the cropping season (In January) in both the seasons. It was seen that Clubionidae were not significantly affected by the pesticide spray (in November) with 0.66 spiders per sq. m. The population also did not show any correlation with Temperature, Relative Humidity and Rainfall. The maximal density of Clubiondiae was at 4.92 spiders per sq m in Phase

II and 5.88 spiders per sq m in Phase I (Graph 5.4 and 5.4) . Clubionidae members are abundant more abundant in the Castor Agroecosystems (Chapter 6) and they comprise 20% of the total population in Citrus orchards (Marc et al, 1999).

The population dynamics of the numerically dominant spiders in Phase I and II showed that Family Clubionidae represented the field with two species namely *Chiearacanthium melanostoma and Clubiona drassodes. Chiearacanthium melanostoma* was seen in maximum density during the flowering season and pod formation season in November and January. In Phase II, as a result of pesticide spray the spiders are entirely absent from September till November showing that these spider species is susceptible to monocrotophos spray. As a result of pesticide spray the spiders was entirely absent from September till the end of the cropping season showing that the spider species is susceptible to monocrotophos spray. In the apple orchards Mansour et al (1980) has shown that *Chieracanthium meildei* to be an important predator of *Spodoptera litoralis. Clubiona drassodes* was present in more or less uniform density in both the seasons except that during November and September in the Phase II the population was low.

Oxyopidae was present in high numbers during the start of the season showing density of 3.75 spiders per sq m in Phase II in September (Graph 5.4) and 4.4 spiders per sq m in October. It was found that the population of oxyopidae was significantly affected by relative humidity ($P < 0.05$). The population of Therrididae during both the cropping season in Phase I and

II was highly uneven. *Oxyopes shweta* (Tikader) was the dominant spider during the start of the cropping season. The population of these spiders have been observed by me to be positively correlated with the relative humidity ($P<0.05$). In the later stages of the crop the population decreases in density. Similar pattern of the seasonal dynamics in another species of *Oxyopes* as shown by Dean and Sterling (1987); Young and Edwards (1980), according to them Oxyopes salticus is the most numerically abundant spider in Cotton and Soybean agroecosystem in United States. The population of *Oxyopes salticus* decreases with the decrease in humidity. This shows that the Oxyopids of the genus *Oxyopes* are sensitive to the changes in the Relative humidity of the environment. *Oxyopes shweta* was found at maximum density in September and October in monsoon season (r; $P<0.1$) shows that relative humidity has some impact on the buildup of Oxyopid population. The spider is highly susceptible to pesticidal spray. As Against *Oxyopus salticus* which was shown to be resistant to the insecticides in the field (Young and Lockley; 1985). Mansour (1989) also found that in the sprayed fields the population of Oxyopid was higher in the sprayed fields. However I found that the population of *Oxyopes shweta* was significantly affected by spray of monocrotophos. During the same months in the phase I the population was comparatively higher.

During Phase II , Salticidae was present in high composition in November (during pesticide spray) (Graph 5.4) however I could not find any correlation between the density and abiotic factors . The maximum density of salticids was seen during January. The remaining families of spiders were present in low density and diversity in both the cropping seasons of the Pigeonpea. No single species of Salticid was numerically abundant in the field. I found no significant correlation between the abiotic factors and the salticid population.

Thomisus cherapunjeus (Crab spider) is an aerial crab spider found along the flowers of pigeonpea. The body colour of these spiders varies along with the colour of flowers. This change in the body colour is brought about by the type of diet intake. The prey colour is incorporated in its own body. This ability of the crab spider helps the spider in blending with the surrounding background. *Thomisus cherapunjeus* is a sit and wait predator which waits near the flowers for the insects to come near it. The food consists of both the insects which are pests and also the insects which are the pollinators. The population buildup of *Thomisus cherapunjeus* starts in October (Flowering Stage) and reaches its peak density during December and January (Pod formation and Pod Maturation stages of the crop). During the phase II in the months of pesticide spray the population of the Thomisid spiders are entirely absent showing that these spiders are also highly susceptible to monocroptophos spray. These spiders are mainly nocturnal spiders and they are present in lower densities as compared to other spiders.

The study has shown that the hunting spider community is negatively affected by the spray of organophosphorous pesticide in the field. Several studies have shown that pesticides are highly toxic to the spider communities. Powell et al, (1985), Brown et al, (1983) has shown Organophosphates pesticides are toxic to spiders, Kuijpers (1992) has shown toxicity of Diflubenzuron, and Fenoxcarb toxicity was shown by Schoeman (1995). In general it is seen that the population of the hunting spiders decrease as a result of the pesticide spray (Phase II) as against the Phase I when the spray of the chemicals was not there. However immediately in the subsequent months it is found that the population of hunters increases in number very quickly. This may be due to the immigration of the spiders from the field margins into the field. Since the field margins receive a low pesticidal input and the plant diversity in the margins is very high this allows the field margins to harbour a diverse variety of the spider species. Studies done by Alderweireldt (1989); Kromp and Steinberger, (1992); Toth et al (1998) have shown that the field margins harbour a high density of the spiders. Since the hunting spiders are highly mobile it is thought that the spiders migrate from the adjoining fields during pesticide sprays. A drastic reduction in the population size increases the reproductive potential and fecundity of the surviving adults. Thus in either of the two ways the hunting spiders are increasing in the Numbers. In the case of the web building spiders making three dimensional space webs, they are the highly represented in the sprayed fields as the webs protect them from direct contact with the chemical insecticides (Pekar 1999; Siliwal 2000).

The Alpha diversity measures during Phase I and Phase II shows that in the month of December the value of H (2.77± 0.0) and D (14.046) was highest. This season represents the capsule formation stage with the presence of white flies and *Amsacta albustriga* in high numbers. The Equitability index (Q) for December was at 0.80 and the Berger-Parker Dominance index was at 0.1322 which was the lowest in the entire cropping season. It is seen that the progressive buildup of spider diversity starts from October (Flowering stage) and reaches maximum diversity in December (Capsule formation stage) later on during January with the maturation and drying of the capsule the diversity of spiders becomes lower (decreases).

During Phase II, the diversity of spider remains the more or less constant till September while in November the diversity decreases due to the spray of pesticides. The values of various alpha diversity measures show that during the phase I of the study where the spider diversity was higher in the flowering stage of the crop. In phase II during the same time the values of D and H for November were at 1.32 ± 0.03 and 5.6 respectively. The values of Q and B-P dominance index were at 0.38 and 0.37 respectively. The diversity measures shows that as a result of the pesticide spray the population of the spiders and the diversity of spiders decreases in the Pigeonpea fields. The spiders present in the field are those which can avoid direct contact with the chemical sprays. It was found that the Therridids and Clubionid spiders were present in the sprayed fields during the pesticide spray and after the spray. These two groups of the spiders build webs, the therridids build 3 dimensional space webs (frame webs), according to Siliwal (2000); Pekar (1999), the frame webs were effective in protecting the spiders against the pesticide spray. The value of the B-P dominance index shows that very few species are present in the field after the spray. Dondale et al (1979); Olszak et al (1992) have shown that the usage of pesticides reduces the seasonal pattern of abundance as well as the composition of the spiders in the field.

From the Phase I and Phase II of the study, it is seen that the diversity of spiders is higher during the reproductive season of the crop. This coincides with the economically important stage of the crop and the correlation with the abiotic factors have shown that the relative humidity and soil temperature are the major factors which determine the diversity and density of spiders in Pigeonpea agroecosystem.