CHAPTER 9

GENERAL CONSIDERATION AND POSTSCRIPT

The Community structures of the spiders in the three agricultural crops namely Paddy, Pigeon pea and Castor have different species composition. These differences are a result of the farm management practices done for each crop like pesticide input, weeding leading to disturbance, the irrigation requirements for these crops vary and the microhabitats offered by each of these crops are different. The diversity measures of the spiders in Paddy, Pigeonpea and Castor shows values which are higher for Paddy and Castor as against Pigeonpea which shows a comparatively lower measure of diversity. The reason attributed to this is due to the heavy pesticide input in the pigeonpea fields as against the remaining two fields. In terms of density the pattern of the spiders was exactly the reverse of the above. The maximum density of the spiders is found in Paddy, followed by Castor and Pigeonpea.

There are several biotic and abiotic factors which affect the spider assemblages in terms of spider density and spider diversity. Some of the factors like: Temperature, Relative Humidity Soil Temperature (Soil dwellers), Rainfall, Crop architecture, Prey Availability. The life history pattern of the spiders is not the primary factors for the changes in the spider assemblages. Since the life cycle of the spiders can go upto a year so the changes in the population as a result of life cycle is negligible. Moreover the sampling done in the two consequent years were at the same site so it can be argued that the variation in terms of soil type and the gross environmental factors like the temperature variation in both the years were not very significant. Thus other factors like the Microclimatic humidity, Temperature, Crop architecture and Prey availability were among the prime factors affecting the spider assemblages.

The Microclimatic factors like Relative humidity and the constant source of water have been found to be strong determinant of the spider assemblages belonging to at least a few families , namely Tetragnathidae , Araneidae and Oxyopidae . It has been found that at a higher humidity the population of the Oxyopidae was higher ($P<0.05$) than during the months when the humidity was low. In the case of Tetragnathidae I found that they were exclusively found in the paddy field and were entirely absent from the neighboring field (Cotton and Castor) stating that the presence of a high Relative humidity is of prime importance to these spiders. Siliwal (2000) has reported that these spiders were found exclusively in Banana agroecosystem, which has a high microclimatic humidity as compared to Cotton and Pigeonpea. Bell et al, 1999; have reported that tetragnathidae were found in the riparian habitats. The above finding shows that the presence of high humidity promotes the spider assemblages from these two spider families. Castor and Pigeonpea offer a relatively low relative humidity and hence it is seen that the population of these two families were very low. In Alfalfa ecosystem, the population of the Oxyopidae was found to be very high as compared to the other spiders which were taking shelter in the post harvesting season (personal observation). Thus it is seen that the Bunds of the fields (Field margins) along with the alfalfa ecosystems can be important reservoirs of spiders during the lean months. The diversity of the family Araneidae were found to be the highest in Paddy field as compared to the other two fields, two reasons can be attributed to this, one the prey diversity is very high and also the Humidity is also high. However when correlating the effect of the humidity on the population of the Araneidae, I found no significant effect of the humidity on spider diversity, stating that prey diversity may be the determinant in the assemblages of Araneidae spiders. Other families of spiders were not significantly affected by the microclimatic conditions like Temperature, Relative humidity and Rainfall.

With respect to crop architecture, In Paddy the Web building spiders were dominant representatives , with majority of the spiders belonging to families Araneidae , Tetragnathidae and Therrididae. In Castor the foliage hunting spiders (Arboreal hunting spiders) of the family Clubionidae were numerically dominant as well as highly diverse. Family Araneidae was also found in higher numbers. In Pigeonpea the population of the hunting spiders as well as the web builders was almost equal. The correlative patterns of the spider population in three crops shows that Orb weavers and Ground hunting spider assemblages are highly influenced by the requirement of wetness of the soil and high microclimatic humidity.

The numerical abundance of spider in Paddy is very high as against other crops. This is primarily due to the diversity and the abundance of the pest and non pest insect's fauna in the field. The web building spider assemblages have shown to be positively correlated with the prey abundance (Greenstone, 1984) and by the presence of adequate web attachment sites. Though the prey abundance in other ecosystems like castor and pigeonpea is also quite high, it is seen that the presence of high humidity and dense vegetation offers adequate hiding places and hunting sites for the hunters and secondly the web placement of the web builders can be done on any angle, which can maximize the efficiency of catching insects. In castor and pigeonpea the Orb Web builders have to depend mainly on the rows of plants as the webs cannot be large as the webs have to be placed between two rows. Apart from this in paddy fields the amount of human disturbance inside the field is comparatively less and hence the web building spiders are not affected as their web are not disturbed while in castor and pigeonpea the disturbance is comparatively higher.

A comparison between pigeonpea and Castor shows that the density as well as diversity is higher in Castor as broad leaves provide more web attachment sites than the smaller leaves of pigeonpea. The branching pattern of the pigeonpea is less favored as compared to Castor. The Clubionids build their web sac along the leaf margins by curling of the leaf on the underside, this serves two advantages one of being protected from the direct spray and secondly by escaping from the predators during the day time. While other spiders like *Castinaeria sp* (Family: Clubionidae) build their webs along the leaf margins in Castor.

In the **Paddy** agroecosystem results show that in both the sites the overall agrobiodiversity is almost the same in the case of spiders. However the reasons for the same are not due to the non toxic effect of pesticides on spiders but due to the fact that the time lag between the spray of the chemicals allowed the spiders to colonize the fields from the field margins and adjacent habitats. In both the sites a total of 36 – 45 species of spiders were found in paddy in both the sites. The seasonal pattern seen in the organic field shows that with the progress of the cropping season there was a temporal variation in the species composition of spiders in the field. During the start of the cropping season the population of the Ground hunters (family: Lycosidae) was much higher than the web builders. Later with the growth of the crop it is seen that the population of the web builders mainly the orb web builders belonging to Families Araneidae and Tetragnathidae increased considerably. This was mainly due to the presence of sites requiring for the attachment of the webs. The population of the foliage hunting spiders also increased during the grain filling stage of the crop in the month of September and October. The dominant guild structure of the spiders was Orb – Web builders showing maximum species diversity and Numerical abundance. The Ground hunting spiders from Family Lycosidae showed high species diversity. In total the dominant families found in the field were from Araneidae, Tetragnathidae, Lycosidae, Oxyopidae, Thomisidae, Salticidae, Clubionidae, Therrididae and Linyphiidae in both the sprayed and unsprayed fields. The dominant spiders which constituted more than 10% of the total catch found in the organic fields were *Cytrophora cicatrosa* , *Tetragnatha mandibulata* , *Neoscona theis* , *Oxyopes shweta* , *Hippasa mahabaleshwarensis* , *Chieracanthium melanostoma* , *Pardosa birmanica and argiope aemula.* While in the conventionally managed field the dominant spiders included *Neoscona mukerjei, Cytrophora cicatraosa* , *Argiope aemula* , *Tetragnatha mandibulata* , *Theridion manjithar* , *Hippasa mahabaleshwarensis.*

In the conventional field immediately after the spray of insecticides, the sampling after two days revealed that the population of the hunting spiders decreased significantly, the reasons are the direct contact with the insecticides killed the spiders and the hunting spiders being mobile moved to the safer areas, only to return with the return of habitable conditions. While in the case of the web builders the population also decreased but was more tolerant to the spray as these spiders descended to the lower regions of the crops. In total the seasonal dynamics and the percentage composition of the spider families in the various cropping months shows that the families Lycosidae, Oxyopidae and Thomisidae are highly susceptible to the spray as the population of these spiders never recovered after the pesticide spray. A correlation with the abiotic factors like Temperature, Microclimatic humidity and the presence of water has shown that the population of spiders from Oxyopidae are affected by a decrease in the moisture levels, Family Tetragnathidae have been found to be always found in the areas having stagnant water and high humidity (Bell et al, 1999; Siliwal, 2000; Siliwal et al, 2003). Lycosidae are negatively affected with the growth of the plant as it has been shown in the grasslands that the areas which are open have a higher amount of herbivores than in the areas having shade (Kronk and Richert, 1979). I however did not find any significant effect on the abiotic factors on the members of other spiders families in Paddy. The spiders from the families Araneidae, Tetragnathidae were more resistant to the spray of pesticides. In terms of the measures of the diversity values from both the sites reveal that Organic fields have a much higher value of species diversity (Shannon –wiener index, Simpson index) and Evenness index is also higher as compared to the conventionally managed sites. Spiders belonging to family Therrididae were seen in higher numbers in the conventionally managed fields as compared to the organic field. The reason for the above can be linked to the habitat where these spiders live is always hidden from the pesticide spray and after the spray in the absence of competition the population of therridids shows an increase.

The above study states that a calendar based spray is not suitable for the survival of the spiders in paddy agroecosystem a need based spray would be helpful in allowing the spiders to colonize the field after the spray of the pesticides. Paddy agroecosystem is a self sustaining systems and with decreased human interference the problem of pest attack can be reduced in an environment friendly way.

In the **Pigeonpea** agroecosystem present study a total of 32 species of spiders from 10 families were identified and the seasonal pattern of these families were studied. In the both the phases of the study (Phase I and Phase II) the hunting spiders were the dominant spiders and comprised more than 63% and 75% of the total species diversity in the Phase I and Phase II of the study. The dominant spider families of spiders found in both the phases were from Araneidae, Lycosidae, Clubionidae and Oxyopidae. The numerically abundant spiders in the cropping field comprising of more than 10 % of the total spider collected were *Chieracanthium melanostoma, Clubiona drassodes , Oxyopes shweta , Neoscona theis , Theridion manjithar , Pardosa birmanica , Hippasa lycosina.* The diversity and the evenness measures showed that the months of December (Flowering stage) and January (Pod formation stage) the values of Shannon – Wiener (H), Simpson index (D) and Evenness index were the highest. It was found that the spray of monocrotophos was detrimental to the spider population leading to a significant decrease in the species diversity in the month of November during the spray of the pesticide. Families Clubionidae and Araneidae were significantly affected by the soil temperature ($P < 0.1$) while in the case of Oxyopidae relative humidity ($P<0.05$) was the major one affecting the spider assemblages. The weather factor affecting the spider species individually shows that *Thomisus krishnae* was significantly affected by Soil temperature ($P<0.05$) and Air Temperature ($P<0.05$) while *Thomisus cherapunjeus* showed a positive correlation with soil temperature. *Hippasa lycosina and Hippasa mahabaleshwarensis* showed negative correlation with soil temperature ($P<0.02$ and $P< 0.01$) respectively. *Oxyopes shweta* showed a positive correlation with relative humidity ($P<0.1$).

In the **Castor agroecosystem,** apart from the preliminary study undertaken, the data of two cropping seasons Phase I and Phase II were used for analysis. The Phase I cropping season a late sowing season represented the while the Phase II Early sowing season. The two seasons were taken to know the effect of the environmental factor on the spider assemblages. However we did not find any significant differences in the spider composition in the two phases.

In the two phases of the study in the **Castor** Agroecosystem, a total of 63 species from 29 genera and 10 families were collected of which 59 species were identified to the species level. The web builders are the dominant spider guild found in castor but in terms of numerical abundance and the diversity of the spiders, family: Clubionidae is dominant comprising 25.62% and 41.12% of the total spiders caught. , next in order of abundance were Families Araneidae and Therrididae. The seasonal dynamics of the spiders shows that Family Clubionidae is abundant in the month of February (Phase I) and November (Phase II), comprising the flowering and capsule formation stage of the crop. Family Araneidae was present in higher densities later in the cropping season. The dominant spiders in the castor crop are as follows *Chieracanthium melanostoma,* *Clubiona drassodes, Clubiona filicate, castineria zetes* from the hunting spider guild. The population of C.melanostoma is correlated with the increase in the density of the white flies. Argiope *anasuja* , *Zygeilla melanoconia* , *Neoscona mukerjei* , *Zygeilla indica* , *Theridion manjithar* , *Argyrodes projeles* , *Argyrodes gazades* are some of the numerically abundant web building spiders in castor crop. On the basis of the results it can be inferred that, Families Araneidae and Clubionidae are the dominant spider families in both the phases of the study. Diversity and evenness is high during the flowering stage which is the economically most important stage of the crop. The factors which promote the colonization of the spiders in castor are , (1) input of pesticide in the castor field is almost absent (2) the broad leaves provides adequate sites for web attachment (3) least human disturbance as the crop is drought resistant and doesn't require frequent irrigation. All these factors promote the colonization by the web building spiders as well as by the sac spiders which build retreats along the leaf margins. It is observed that the leaf margins, underside of the leaves and the regions between the veins are the important areas where the spiders build their webs for capturing the prey and for making retreat.

From the three crops studies the species richness of all the three fields shows some variation, the richness in the paddy and pigeonpea crop is lower as compared to the castor crop. This shows that different crops provide different microhabitats spider assemblages. In terms of diversity and abundance Paddy shows the maximum diversity, followed by castor and pigeonpea. This is attributed to several factors like presence of water, High microclimatic humidity, Presence of adequate web placement sites and cover for the hunting spiders, reduced pesticide usage, prey abundance.

Of all these factors crop architecture is the single most important factor favoring the colonization of the web builders as well as the hunting spiders? Apart from it the moisture levels and the reduced insecticide usage are also other factors which affect the density and diversity of the spiders. However there is no clear consensus to the impact of the any single factor on the assemblages of spiders of all the species. Certain families of spiders are known to prefer certain habitats as compared to the others like Tetragnathidae prefer sites which is near water body, Oxyopidae prefer habitats having high microclimatic humidity. Therrididae are found in high numbers in the habitat having human disturbance in the form of farm management practices and input of pesticides. Clubionidae prefers dense habitats like paddy and Castor which provide ideal sites for building their sac like retreats. Hence it is seen that each of the spider families require a different set of condition for their colonization.

The results of the **functional studies** show that the females exhibit a Type II response while the males show a combination of Type I and II responses. **Numerical Response** shows that No cannibalism was observed in the test animals maintained at constant prey densities of 15 larvae per test cages. They showed a density dependent feeding on the larvae. A **Total Response** incorporating both the functional and Numerical response studies shows that Females are more effective against larvae than the males; however males also consume a sizable amount of larvae.

The **Predatory behaviour and Prey preference** studies show that *Oxyopes shweta* exhibits a sex specific predatory behaviour against *Spodoptera litura and Clavigrella horrens.* The males prefer to feed on Clavigrella subadults while the females show preference for *Spodoptera* larvae. The predatory behaviour of both males and females was the same when they attacked *spodoptera* litura and *Clavigralla* horrens. The attack strategy of the capture of either prey differed. The spider attacked the larvae from the rear while the spider attacked *Clavigralla* subadult head on. This difference in the attack strategy was on the basis on the type of movement and the shape of the prey. *Spodoptera* larvae were more active in the test containers in the search of food whereas *Clavigralla* were relatively stationary. Another reason may be the *Spodoptera* larvae form a high quality diet and have a thin cuticle as compared to *Clavigralla.* Further work needs to be done on the nutritional aspect of the prey on the development of spider, which can provide support for the above.

From all the above observations and results it can be concluded that the diversity and Abundance of the spiders is higher than any other natural enemy found in the agroecosystem. The potential of the spiders in the biological control of insect pests shows that by conservation biological control the input of pesticides in the field can be reduced which can prove useful in the decreasing the production cost to the farmer and being a more ecofriendly method of pest management the environmental pollution and biomagnification of chemical pesticides in the higher trophic levels of the food chain can be brought down.

The interaction of the spider assemblages with prey and environmental factors provides us information regarding the conditions which can promote the spider assemblages. The knowledge of the prey preference, functional and numerical responses of the spider can be utilized for incorporating Spiders in the **Integrated Pest Management (IPM)** programmes in Pigeonpea, Castor and Paddy agroecosystems.