CHAPTER 7

Functional and Numerical Responses of *Oxyopes shweta* to insect prey

INTRODUCTION

There has long been a debate as to the merits of specialists versus generalist bio-control agents in insect pest management. Spiders being the major components of predatory arthropods in natural ecosystems including agroecosystems, they play a major role in the biological control of insect pests (Pimentel et al, 1992; Nyffeler and Benz, 1987). The spiders being generalist predators have the advantage of influencing a wide array of insect pests in the agricultural fields and do not require frequent releases in the fields as against the stenophagous biocontrol agents. There is good evidence that spiders do indeed locate their webs in areas of overall greatest prey density. Their preys are so different that it suggests simple aggregation to the highest density of prey that, in arable ecosystems, is often pests. Such a strategy could, therefore, have advantages for biological control. However at the same time, there is a need to develop a better understanding of dynamic interactions between predators and their prey within complex ecosystems, both in theory and practice (Symondson et al, 2002). Now the importance of spiders in the conservation biological control is being increasingly realized due to their abundance and ubiquitous nature (Richert and Lockley 1984; Sunderland et al, 1996) and the diverse variety of the habitats occupied by them. Spiders also use a variety of hunting tactics; the web builders use their webs for catching prey while the hunting spiders actively chase the insect prey.

The success of a biocontrol agent will depend partly on the rate at which they consume the prey and partly on their ability to increase in abundance and feeding in a cooperative manner Solomon (1949) described the variation in per capita rates of prey consumption and variation in predator abundance as Functional and Numerical response of a predator. Spiders are known to be generalist predators, which usually live in a food limited environment (Wise, 1975; Nyffeler and Breene, 1990). The response of the spiders to the prey density is an important aspect for the incorporation of the spiders in biological control of insects.

Holling (1959) described three types of functional response. All the three forms represent the capacity of the predator to capture and consume a prey item once it has been located. Type I: It describes the proportional or linear increase in consumption from 0 to maximum with increasing prey availability. Type II: It describes the hyperbolic responses i.e. the proportion of the prey consumed is the highest at low levels of prey availability and a possible 100% consumption at low levels, which implies that predator have potential to eliminate the resource entirely. Type III: It represents an accelerating increase from low levels of prey availability to the proportion of the prey consumed is highest at intermediate level of prey availability. The numerical response of the predators is a function of increase in the prey density in the environment. There are two types of numerical responses which are used to elaborate the interactive dynamics of the predator and the prey population (Bayliss and Choquenot, 2002); Demographic response which links the rate of change of predator abundance to prey availability and Isocline Numerical response links the predator and the resource abundance (Holling 1965, 1966). A Total response involving the functional response along with numerical response together will provide a comprehensive account of predator –prey interaction.

The Type I functional responses are more frequent among filter feeders than among other consumers, which include: suspension feeders e.g. protozoans like sponges; trap builders like web building spiders; and sediment filter feeders like sea cucumbers etc (Jeschke et al, 2004). The coccnellid predator *Coccinella septumpunctata* shows a type II response to *Aphis gossepii* (Omkar and James, 2003). Kumar et al (1999) have shown that *Coccinella septempunctata* shows a type II response to *Lipaphis erysimi* (Aphidididae). According to Ambrose and Clavers (2002) the reduvid predator *Rhynocornis longifrons* shows a TYPE II response to the insect prey Clavigralla gibbosa and *Rhynocornis fuscipes* feeding on *Spodoptera litura* also shows Type II response (Ambrose and Claver 1997). The functional response studies on spiders are comparatively low as compared to the work done on Reduvidae and Coccinellidae. Mansour and Heimbach (1993) have shown that spiders from three families namely Lycosidae (*P*ardosa agrestis), Linyphiidae (*Lepthyphantes tenuis*) and Micryphantidae (*Erigone atra*) show type II functional responses. Samu and Biro (1993) have shown type II responses in *Pardosa hortensis.* Maupin and Richert (2000) have shown that the wolf spider *Agelenopsis aperta* shows a type III functional response. The studies conducted by the earlier scientist's shows that the Coccinelldid predators and Reduvid predators show a typical TYPE II functional response. While in the case of spiders, both web building and Hunting spiders usually shows a type II functional response and seldom show a TYPE III response (Wise 1993).The feeding ecology studies with respect to the biological control are usually effective when the feeding guild of the predator and the feeding Niche of the prey overlap. This increases the probability of predation. The above work on spiders is mainly done on the ground predators (Lycosidae). The feeding responses on the aerial hunting spiders could give a better understanding on the feeding potential of the spiders on insect pests.

Oxyopes shweta (Tikader) is a dominant foliage hunting spider found in several types of agroecosystems (Sunderland and Greenstone, 1999; Dolly Kumar and Shivakumar 2004, 2006). It has been observed found feeding on a variety of insect prey belonging to Diptera, Lepidoptera, Hemiptera, and Orthoptera. *Spodoptera litura* is one of the dominant polyphagous insect pests found in a variety of agroecosystem. The larvae of *Spodoptera* feed in a gregarious manner on the leaves and fruits of several crops and hence are always found in high densities. Since the habitat of both the spider and the larvae overlap, an attempt was made to observe the interaction between the predator (*Oxyopes shweta*) and the prey (*Spodoptera litura larvae).*

OBJECTIVES

1. Impact of increase in prey density on spider predation.
2. Does predator density influence the prey consumption rate?

PLATE XXX

MESOCOSM SETUP FOR FEEDING ECOLOGY STUDIES

OXYPOPES SHWETA PREDATING ON THE LARVAE IN PREY CHOICE EXPERIMENT

MESOCOSM SETUP FOR FEEDING ECOLOGY EXPERMENTS

OXYOPES SHWETA FEEDING ON LEPIDOPETRAN LARVA

Objective 1: Impact of increase in prey density on spider predation.

Design and Methods

The spiders of both the sexes were fed ad-libitum and were later fasted for one week prior to the experiment. Microcosm Studies involving cotton plant twigs of 7-9 leaves kept in plastic vials containing water which id then enclosed by a plastic cylinder test arena (Dinter 2002 ; Symondson et al 1999).The larvae were transferred to the leaves and allowed to acclimatize for one hour. The experiment started with the introduction of the spider into the test arena. The test ended after 24 hours.

Objective 2: Does predator density influence the prey consumption rate?

Design and Method

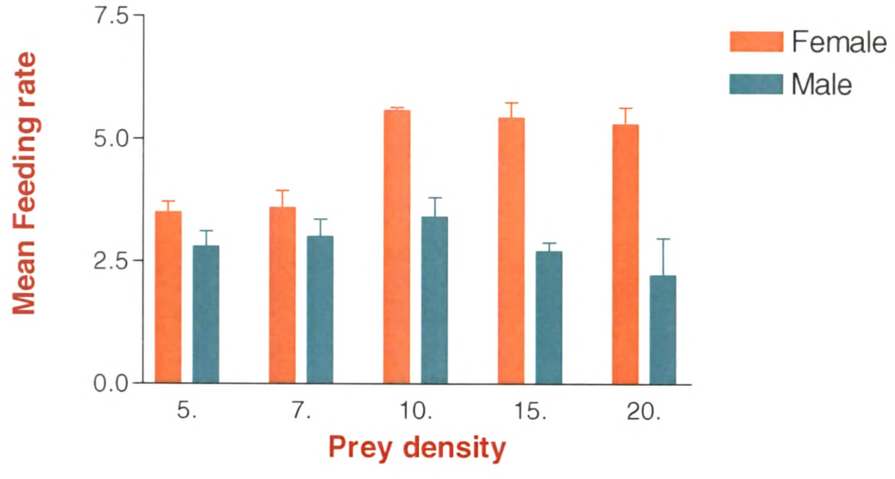
The spiders of both the sexes were fed ad-libitum and were later fasted for one week prior to the experiment. Microcosm involving cotton plant twigs of 7-9 leaves were kept in plastic vials containing water. 10 larvae per test arena were released on the leaves and were allowed to acclimatize for one hour and later on the spiders at varying densities viz.1,2,3,5 and 7 were introduced in respective test \ trials and the whole setup was enclosed by a plastic cylinder test arena. The test was conducted for 12 hours starting at 0600 hrs and terminating it at 1800 hrs. The photoperiod was maintained at 12:12 light: Dark

RESULTS

OBJECTIVE I: FUNCTIONAL RESPONSE

The female spider shows a gradual increase in prey consumption rates till intermediate prey density and then there is a slight decrease. In the male spiders the prey consumption shows a hyperbolic shape, showing a decline in prey consumption rates after reaching a maximum density. The female spider shows a typical Type II functional response while the male spiders show a mixed type of response comprising of Type I and Type II.

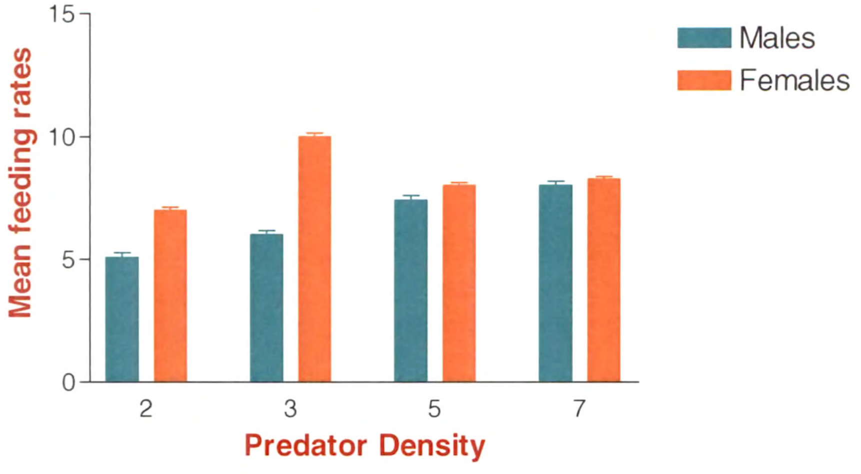
Graph 7.1



OBJECTIVE II: NUMERICAL RESPONSE

Oxyopes shweta females and Males do not show any cannibalism, though the number of prey consumed in both the cases remain the almost constant at varying predator densities. The spiders show a cooperative feeding at low predator densities while at the higher predator densities there is a competition among the predators for the resource which is in short supply. Showing that competition among the spiders is prevalent.

Graph 7.2



The Total response involving the male and female spider shows that the female spiders show more feeding rates as compared to males; it may be due to the increased requirement of food required for production of more number of eggs. The numerical response shows that there is a certain degree of cooperative feeding but at higher predator densities the competition results in comparatively less feeding. The total response in males shows that the feeding rates increases with an increase on the prey density to a certain extent and later on show a decrease. The Numerical response studies shows there is only some amount of competition, however further studies needs to be done pertaining to the conspecific behaviour of the spider with respect to larval predation. The Functional and Numerical Response studies show that the feeding rates of the females are higher than that of the male spiders. Both the sexes are equally potent in reducing the population of *Spodoptera litura*. Hence Oxyopes shweta is an ideal biocontrol agent which can be incorporated in IPM programmes of various agricultural crops.

DISCUSSION

The Predator – Prey interaction is an important aspect of studying the efficiency of biological control of the predators to the insect prey. For a predator to be effective in the field, the feeding rate has to increase with the increase in the prey density. The foraging studies have two components functional response and the numerical response. A combination of the two responses gives an idea of the potential of the biocontrol agent.

In the present study male and female *Oxyopes shweta* were chosen for the experiments. Two set of experiments were kept one for understanding the foraging efficiency of the predator to the increase in prey density and the other to test whether the cooperative feeding by the spider was present or absent?. Another objective was to see whether there is any difference in the foraging rates of the male and female spiders. The results show that the foraging efficiency of the male spider is comparatively less as compared to the female spider. The Male Spiders show a Type II functional response (Graph 7.1) and in the case of female a type III response (Graph 7.2) which is weak at the prey density of 1-15 individuals might increase with the increasing prey density.

Spiders usually show a TYPE II response, as they eat fewer insects when the insects become abundant (Rypstra and Carter, 1995; Marc et al, 1999). Type III functional responses are also seen in the spiders, but these are very rare, these responses of the spiders are considered to be an important component for stabilizing the insect populations and hence are of potential interest in biological control. This is achieved by two ways, firstly by the prey switching by the predator i.e. prey preferences of the predator (Richert and Lockley 1984; Morin, 1999). Usually the Type III functional responses are exhibited by the vertebrates. However the recent studies have shown that certain spiders do infact show a Type III response. Mansour (1987) have shown that *Chieracanthium meildei* feeding on *Spodoptera litoralis, Philodromus rufus* feeding on drosophila and lycosid spiders feeding on rice leaf hoppers exhibit such responses. Type III responses are achieved by the ability of the predator to learn from the previous experiences to prefer some prey and avoid others.

We collected the spiders (*Oxyopes shweta*) from the fields and kept them in laboratory for two months on the diet composed of *Tribolium* larvae. In the prey preference tests done in the laboratory showed that they preferred spodoptera litura to *Tribolium* larvae. These results are consistent with the work of Punzo and Kukoyi (1997), the field collected lynx spider *Oxyopes salticus,* preferred grasshopper and cricket odour to the mealworm while the laboratory reared spiders which were not exposed to the different prey types failed to show any preference. The prey preference by the spider is discussed in the later chapter. Maytnz et al (2005) have shown that the invertebrate predators especially spiders (both Hunting as well as web building spiders) can regulate the nutrient intake by learning. The above experiments show that the learning is observed in spiders to a greater extent than was thought earlier.

The females of *Oxyopes shweta* kill and consume more prey than do the males; indicating that the energy needs of both males and females for reproduction are different (Walker and Rypstra, 2002; Givens, 1978). According to Wise (1993) foraging success dictates the number of eggs a female can lay and thus could strongly influence the female fitness. As a result a Type III functional response can be expected from the female spider.

The recent studies have shown that learning in spiders leading to a strong prey dependent switching has been observed in several studies (Nyffeler et al, 1996; Richert and Lawrence 1997). Nyffeler et al (1994) have shown that Oxyopes salticus switches the dietary intake composition in response to prey availability. The web building spiders of *Argiope sp.* and *Nephilia sp.* build their webs specially to attract the flower visitors and they have been seen to feed preferentially on pollinators. The light reflecting ability of their webs is utilized for attracting the prey (Craig and Bernard, 1990; Craig et al, 1996). Thus it is seen that the prey switching by the predator can stabilize the insect population and hence can be utilized in biological control studies.

The Numerical response of the predator can compensate for a weak functional response. A predator showing a type I or type II response can be effective if it shows a strong numerical response. Numerical responses are easily studied in the web building spiders in rice fields, as it is seen that with the growth of crops the spiders migrate from field margins to the interior in high numbers. They abandon their earlier patches to colonize patches with high prey densities. Since the predation pressure is high, thus the population is regulated. These views support the earlier finding of Richert and Lockley (1984); Harwood et al (2001). Web relocation in Therridids and immigration to foraging patches having high prey densities have been observed in funnel web spiders *(Agelenopsis aperata)* showing that numerical response by immigration is well pronounced in spiders. However there are certain drawbacks of the numerical response, these are competition, Intraguild predation and predator interference, cannibalism.

The territorial behaviour of spiders prevents them from aggregating in high densities, as a result of competition there is a decreased density of the predator. This reduces the predatory pressure on the herbivore population (Marshall and Rypstra, 1999; Provencher and Vickery, 1988). Intraguild predation is very common among hunting spiders of Salticidae family , it is seen that some species of these spiders show a strong arenophagic behaviour (Jackson and Pollard, 1996) , others like Oxyopids have been observed to feed on the Araneidae in the Alfalfa system when there is a low prey density (personal observation). The interaction between the predators in the field is very difficult, as each system offers a variety of predators and the interaction among them can be studied using serological methods, these methods are still in their infancy and in future these studies will become the robust techniques for understanding the interaction among predators. Lang et al (1999) found that the predators found in maize beetles and spiders showed a positive interaction in reducing the population of leaf hoppers (Cicadellidae).Cannibalism is another factor, especially very prominent very prominent among the Lycosids. The population of juvenile *Schizocosa* showed self regulation their by dampening biological control mechanism (Richert and Lawrence 1997; Wise and Chen 1999).The reproductive response is less studied; some of the web builders produce large egg sacs as a function of increased prey ingestion. The extent to which fecundity can permit tracking of the prey population is not known. Spiders because of their long life cycle can exert only a meager pressure by the reproductive numerical response. The numerical response study pertaining to Oxyopes shweta found that no cannibalism occurred in any prey density kept at 20 cu m. testing arenas. The above result shows that the territorial behaviour and competition were very low when the prey availability is high. A preliminary study conducted to observe the preference of *Oxyopes shweta* to lady bird beetle grubs versus *Spodoptera litura* and *Clavigralla horrens* showed that the spider tended to avoid the grubs showing that *Oxyopes shweta* and ladybird grubs can utilize the common resource in a cooperative manner. the increased predator density of *Oxyopes shweta* also showed a positive feeding and showed 100% elimination of *Spodoptera litura* larvae as a predator density of 4 and above in the test arena.

The total response of *Oxyopes shweta* of male and female shows that the male represents a Type II and female represents a Type III response. Both the sexes show a cooperative feeding on the prey item (*Spodoptera litura*). From the above study it is seen that the Lynx spider (*Oxyopes shweta*) is an effective in regulating the population of *Spodoptera litura* larvae by showing a Type II and Type III functional response which was accompanied by a strong numerical response. The relative abundance to the prey ladybird grubs shows that these spiders show a very less intraguild predation in the field when the prey is less abundant. Studies on the interspecific competition among spiders might further substantiate the potential of the lynx spiders in the biological control of the lepidopterous larvae.