International Journal of Zoology Studies
ISSN: 2455-7269
Impact Factor: RJIF 5.14
www.zoologyjournals.com
Volume 3; Issue 5; September 2018; Page No. 20-24

Functional response of spider, Salticidae (*Hyllus semicupreus*) on aphid, *Aphis craccivora* (Homoptera: Aphididae)

J Upadhyay[1*], SB Das[2], S Chakrabarti[3]
[1, 2] Department of Entomology, College of Agriculture, J.N. Agricultural University, Jabalpur, Madhya Pradesh, India
[3] Forest Ecology & Rehabilitation Division, Tropical Forest Research Institute, Jabalpur, Madhya Pradesh, India

Abstract
Predation is of great ecological, evolutionary and behavioral interest. Spider has a wide insect host range and thus can act as biological control agents of insect pests in agro ecosystems. An experiment was conducted in Biocontrol Research and Production Centre, Department of Entomology, College of Agriculture, Jawaharlal Nehru Agricultural University, Jabalpur (M.P.) India to determine the functional response of spider, *Hyllus semicupreus* (Araneae: Salticidae) as test predator on different densities of aphid, *Aphis craccivora* (Homoptera: Aphididae). The results indicated that the consumption rate of spider, *Hyllus semicupreus* ranged from 8±1 on an average; whereas maximum predation of *A. craccivora* recorded in 24 h was 91% with type II response.

Keywords: functional response, spiders, predator, aphid and prey

1. Introduction
Spiders, the most common ubiquitous animal on land constitute an essential portion of predaceous arthropods residing in almost all agro ecosystem and there by maintaining ecological equilibrium (Bastistas *et al.* 1993 and Hodge 1999) [3, 9]. Spider belongs to phylum Arthropoda, class Arachnida and order Araneae. Over 46967 spider species belonging to 112 families and 4078 genera are known currently (Anonymous, 2017) [1]. This natural control is an implementation of an ecological concept known as "community stability". Spiders of several families are commonly found in agro ecosystems, and have been documented as general predators of major crop pest species and families (Geetha and Gopalan, 1999) [5]. Their soft abdomen enables them to consume large amounts of food in relatively short period of time (Umarani and Umamaheswari, 2013) [34]. The laboratory studies provide some uniquely useful kinds of information on the 'biological control potential'' of spiders against given pests such as aphids, leafhoppers, plant hoppers, flea hoppers and Lepidoptera larvae (Greenstone, 1999 and Jeyaparvathi *et al.*, 2013) [7, 11]. The aranied fauna could be used as an efficient predator of sucking pest for the suppression of insect pests (Khuhro *et al.* 2012) [18]. The increased awareness of the negative side effects of chemical insecticides, use of the predators in insect pest management programs has been receiving increased attention for pest control (Atlihan and Bora, 2010) [2]. Despite of its importance, the role of spiders in regulation of insect pest population, their feeding potential in agricultural fields has not been systematically investigated (Khan and Rather, 2012) [17].

The aim of conducting the present study is to explore the functional response through studying the predatory potential of spider (Hyllus semicupreus) which is considered as a generalist predator of pests and to what extent it can be considered as an efficient biocontrol agent for pest management.

2. Materials and Methods
The present study was conducted in the Biocontrol Research and Production Centre, Department of Entomology, College of Agriculture, Jawaharlal Nehru Agricultural University, Jabalpur (M.P.), India. The experiments were conducted during 2016-17 and 2017-18 in completely randomized design, replicated ten times, as proposed by Khan (2016) [16]. Aphid (nymph) density of 10, 20, 40, 80, 160 and 320 per jar were released on excised cowpea leaves (Table 1). The test predators were randomly assigned to the jars and one treatment (control) was also designed for calculation of natural mortality of aphids. After 24 hours, the numbers of preys consumed by the spiders were recorded by counting the remaining live aphids present in each jar.

Table 1: Treatment details

Treatment code	Aphid density (nymph /jar)
T_1	10
T_2	20
T_3	40
T_4	80
T_5	160
T_6	320

2.1 Experimental procedure
The spiders (*Hyllus semicupreus*) Araneae: Salticidae were collected from fields of J. N. Agricultural University farms during 2016-17 and 2017-18 in the month of September-October and maintained in cages (Plate 1a). Simultaneously prey aphid, *Aphis craccivora* Koch was reared on potted cowpea plants, under caged condition (plate 1b). Spiders of

about similar size and weight were used for the study as test predators. The cut end of the cowpea twigs was wrapped with moist cotton to protect the leaf from desiccating (plate 1c). Newly emerged nymphs of aphids (0-24 hours age) were used as prey of the spiders. The twigs were kept on petriplates which were further kept in plastic jars separately. After 24 hours of starvation, single predator per jar was assigned to different prey density treatments (Plate 1d). The number of prey consumed by the predator was recorded after 24 hours of their release.

2.2 Statistical Analysis

The data were subjected to statistical analysis as proposed by Gomez and Gomez (1984) and Steel and Torrie (1997) [32]. The type of functional response was determined by using logistic regression analysis. For this purpose, the data were fitted to polynomial logistic regression equation as proposed by Khan (2016) [16] as mentioned below:

$$\frac{N_a}{N_0} = \frac{P_0 + P_1 N_0 + P_2 N_0^2 + P_3 N_0^3}{1 + \exp(P_0 + P_1 N_0 + P_2 N_0^2 + P_3 N_0^3)}$$

Where,
Na = Number of prey eaten
No = Number of prey offered
P0 = Intercept
P1 = Linear coefficient
P2 = Quadratic coefficient
P3 = Cubic coefficient

3. Results

Studies on predatory potential provide insights into the suitability of a predator as a biocontrol agent. Aphids can be considered to be the major food source for the spider (Provencher and Coderre, 1987) [23]. The impact of *A. craccivora* population densities had a significant impact on the predation. Among the treatments, T_1 (10 aphids/twig) was found to be most effective prey density as it recorded highest predation (91.46%) followed by T_2 (47.96%), T_3 (22.65%) and T_4 (11.67%) and they differed significantly from each other. The least effective treatments were T_5 and T_6 as the recorded 5.88 and 3.03% predation respectively, but both were at par with each other. Similar trend was recorded in the second year also (Table 2 and Figure 1).

However, irrespective of the prey population density, the consumption rate of *Hyllus semicupreus* was 8±1 aphids per day but non-significant differences were observed

Table 2: Impact of *A. craccivora* population density on predation by spider, *Hyllus semicupreus* under in vitro conditions

Treatments	Mean predation of aphids by spiders (%)*		
	2016-17	2017-18	Pooled
T_1	91.46 (76.86) a	90.48 (74.99) a	90.74 (72.28) a
T_2	47.96 (43.83) b	48.49 (44.13) b	48.22 (43.98) b
T_3	22.65 (28.35) c	21.98 (27.92) c	22.31 (28.19) c
T_4	11.67 (19.95) d	11.09 (19.43) d	11.38 (19.71) d
T_5	5.88 (13.91) e	5.54 (13.52) e	5.71 (13.82) e
T_6	3.03 (9.89) e	3.37 (10.54) e	3.20 (10.31) f
SEm±	1.64	1.49	1.10
CD at 5%	4.66	4.23	3.13

*Temperature 25±2 °C RH 80±10 % ( ) Figures in parentheses are arcsine transformed values
Means in a column followed by same letter do not differ statistically (DMRT; $P < 0.05$)

It can be inferred that the consumption rate of spider remained same irrespective of the numbers of aphids provided, as the spider could feed according to its feeding capacity depending upon its abdominal size.

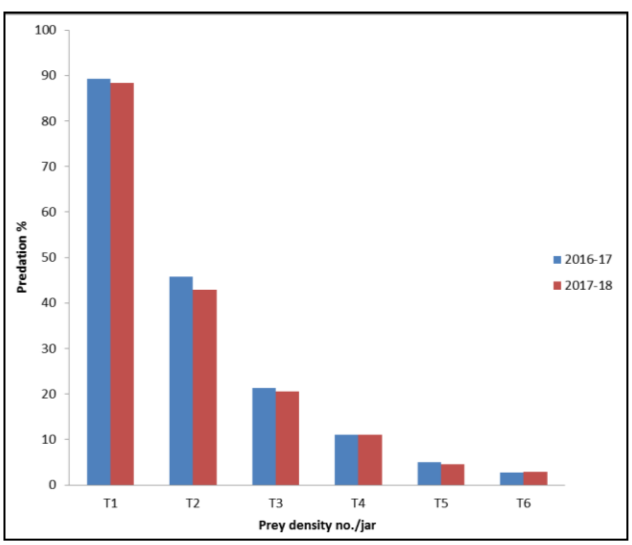

Fig 1: Impact of *A. craccivora* population density on predation by spider, *Hyllus semicupreus* in vitro conditions

3.1 Correlation studies

Correlation studies revealed that prey density showed significant negative impact on predation of *Hyllus semicupreus* (r= -0.66)

The linear regression equation being:

$$\hat{Y} = 50.76 - 0.19x \ (R^2 = 0.44)$$

From the above equation it may be expressed that with every unit increase in prey density, there was a decrease in 0.20% predation (Figure 2) and the coefficient of predation R^2 was found to be 44%.

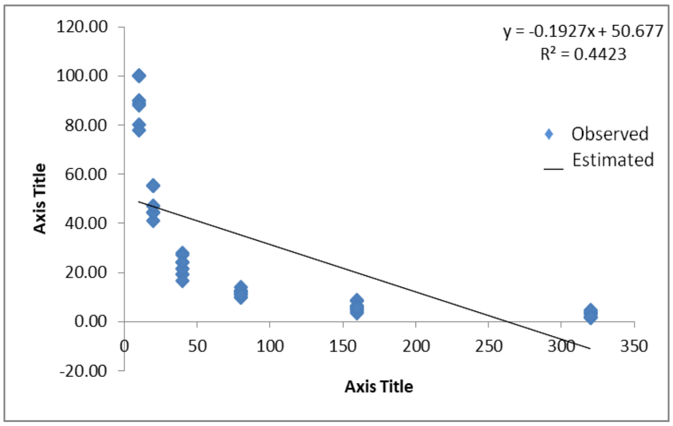

Fig 2: Linear regression of prey density on predation of *Hyllus semicupreus*

The polynomial quadratic (order two) equation computed was:

$$\hat{Y} = 72.52 - 0.80x + 0.001x^2 \ (R^2 = 0.72)$$

The above equation indicates that it is a better fit than the linear regression as the coefficient of predation R^2 was found to be 72% (Figure 3).

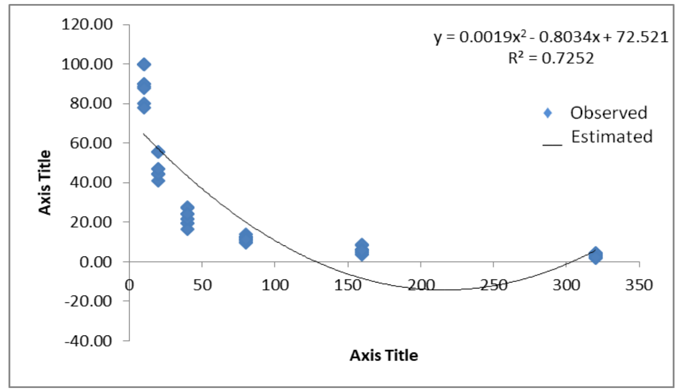

Fig 3: Quadratic regression of prey density on predation of *Hyllus semicupreus*

The polynomial cubic (order three) equation computed was:

$$\hat{Y} = 99.22 - 2.23x + 0.01x^2 - 2.74x^3 (R^2 = 0.89)$$

The above equation indicates that it is the best fit as the coefficient of predation R^2 was found to be 89% (Figure 4).

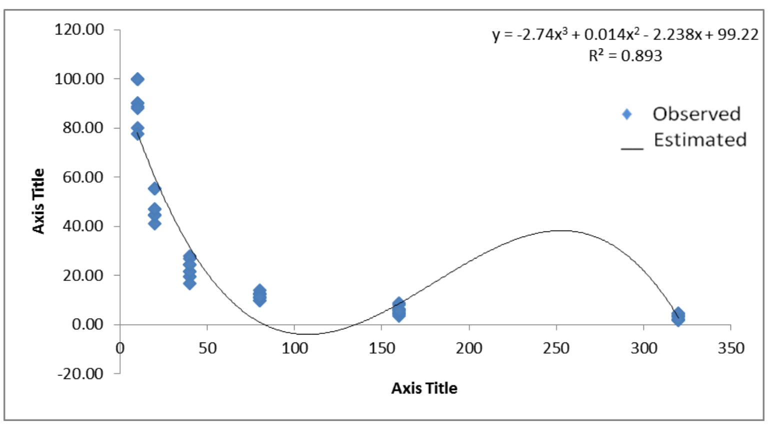

Fig 4: Cubic regression of prey density on predation of *Hyllus semicupreus*

Table 3: Logistic regression analysis of the proportion of cowpea aphid (*A. craccivora*) devoured by spider against initial number of aphids offered

Spider species	Coefficient	Estimate	SD	Chi-Square value	Pr(>|Chi²|)
Hyllus semicupreus	Constant (P_0)	0.818	0.207	15.630	<0.0001
	Linear (P_1)	-3.773	0.421	80.208	<0.0001
	Quadratic (P_2)	18.001	1.260	204.233	<0.0001
	Cubic (P_3)	-13.895	0.851	266.844	<0.0001

The results revealed that the number of aphids consumed by spider, *Hyllus semicupreus* decreased with increase in the prey density (Tables 3). The linear coefficient (P_1) in the polynomial logistic regression of the proportion of aphid consumed versus initial density was negative for predator together with a positive quadratic parameter (P_2) which indicated a type II functional response.

4. Discussion

In the resent study the predatory potential of spider *Hyllus* *semicupreus* on aphid *A. craccivora* ranged from 3% to 91%, which is in accordance with the finding of Khan A.A. (2016) [16]. Better adaptations of body parts of spider proved them as better predators for their prey. Three commonly accepted types of functional response that depict how capture rate is influenced by prey density (Holling, 1966) [10]. In type I response, prey consumption is proportional to the prey density until satiation. This type of response is representative of filter feeding organism and is not seen in spiders (Richert and Lockely 1984, Richert 1999) [26]. Predation appears to rise exponentially above a certain threshold of prey density, thus producing the characteristic lag and acceleration response (Riechert and Lockley 1984, Provincher and Coderre 1987) [26, 23]. Functional response of spider often has a very high plateau, since often the spiders will kill many prey before the first one is digested. Numbers of prey killed may be much greater than the amount needed for the spider to reach satiation (Riechert and Lockley 1984, Nyffeler *et al.* 1994, Persons 1999) [23, 26]. The estimates of linear regression between the predation of spider on aphid versus density were negative. The polynomial logistic regression demonstrated that spider exhibited type II functional response as there was decrease in the proportion of the prey consumed with increase in the prey (aphid) density. These findings are in conformity with the findings of Khan A.A. (2016) [16]. This type of response is often called ‘invertebrate curve’ and indeed seems to be common in spiders (Smith and Wellingoton 1983, Riechert and Harp 1987, Heong and Rubia 1989, Samu and Biro 1993, Khan and Misra 2009) [24, 8, 27, 15]. In the present findings at higher prey densities, a significant decline in the consumption rate was observed which might be attributed to the attainment of satiation and commemorates the findings of Mills (1982) [19]. Spiders have highest host finding ability and capacity to consume greater number of prey (aphids) than other field inhabiting predators (Kamal *et al.*, 1990) [12] and maintain the insect pest population below the economic injury level (Sherawat and Butt 2014) [26]. The role of predatory spider species for the consumption of insect pests are in agreement with those of Sebastian and Sudhikumar (2003) [28] and Khuhro (2012) [12].

However, other factors, such as biology of prey and predator, including host preference, switching behaviour, intrinsic growth rates, consumption rate of predator, preying nature, prey patchiness, host plant, effect of biotic and abiotic factors, intra and inter specific competition could be important effects on the ability of a biological control agent in managing the prey population (Sunderland *et al.*1986, Snyder and Wise 1999, Nilsson 2001, Farhadi *et al.*2010, Khan 2012a, b) [16, 17].

5. Conclusions

Laboratory experimental provide the most powerful demonstrations of the efficacy of spider species as biological control agents, and they can also serve as realistic trials for proposed management approaches. Direct observation is a powerful tool that will continue to provide useful information on prey spectrum and feeding rates. The results indicated that the consumption rate of spider, *Hyllus semicupreus* ranged from 8±1 on an average; whereas maximum predation of *A. craccivora* recorded in 24 h was 91% with type II response.

6. References

1. Anonymous. World Spider Catalog. Natural History Museum Bern, Online At Http://Wsc. Nmbe. Ch, Version, 2017.
2. Atlihan R, Bora KM. Functional Response of the Coccinellid Predator, *Adalia fasciatopunctata revelierei* to Walnut Aphid (*Callaphis juglandis*). *Phytopara*. 2010; 38:23-29.
3. Bastistas H, *et al.* Recognition of spiders on cotton in the Cauca valley. Manejo Integrade de plages. 1993; 32:33-35.
4. Farhadi R, *et al.* Functional Response of larval and adult stages of *Hippodamia variegata* (Coleoptera: Coccinellidae) to different densities of *Aphis fabae* (Hemiptera: Aphididae). Environmental Entomology. 2010; 39:1586-1592.
5. Geetha N, Gopalan M. Effect of Interaction of Predators on The Mortality of Nymphs of Brown Plant Hopper, *Nilaparvata Lugens* Stal. J Ent. Res. 1999; 23:179-181.
6. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. Publ. John Wiley and Sons. Inc. NY. 1984; 2:361-388.
7. Greenstone MH. Spider Predation: How and why we study it. Plant Sciences and Water Conservation Laboratory, 1301 N. Western Street, Stillwater, Oklahoma 74075 USA. The Journal of Arachnology. 1999; 27:333-342.
8. Heong KL, Rubia EG. Functional Response of *Lycosa pseudoannulata* on Brown Plathoppers (BPH) and Green Leafhoppers (GLH). International Rice Res Newsletter. 1989; 14:29-30.
9. Hodge MA. The implications of Intraguild Predation for the Role of Spiders in Biological Control. Journal of Arachnology. 1999; 27(1):351-362.
10. Holling CS. The Functional Response of Invertebrate Predators to Prey Density. Memoirs of the Entomological Society of Canada. 1966; 48:5-86.
11. Jeyaparvathi S, *et al.* Biological control potential of spiders on the selected cotton pests. International Journal of Pharmacy & Life Sciences. 2013; 4:2568-2570.
12. Kamal NQ, *et al.* The Spider Fauna in and Around Bangladesh Rice Research Institute Farm and Their Role as Predator of Rice Insect Pests. Philippine entomology. 1990; 8:771-77.
13. Khan AA. Functional Response of Four Spiders, *Pardosa Altitudis* Tikader and Malhotra, *Teragnatha Maxillosa* Thorell, *Neoscona Mukherjei* Tikader and *Theridion* Sp. to Rice Grass Hopper. Oryza. 2012a; 49:39-44.
14. Khan AA. Comparison of Spider Diversity in Relation to Pesticide use in Apple Orchards of Kashmir. Journal of Biological Control. 2012b; 26:1-10.
15. Khan AA, Misra DS. Impact of Prey-Size and Predator Size on Predation of Rice Green Leafhopper, *Nephotettix Virescens* (Distant) By Wolf Spider, *Lycosa Pseudoannulata* Boeseberg and Strand (Araneae: Lycosidae). Indian Journal of Ecology. 2009; 36:65-70.
16. Khan AA. Assessment of Predation Capability of Four Species of Spiders (Arachnida: Araneae) to Green Apple Aphid, *Aphis pomi* De Geer (Homoptera:

Aphididae). International Journal of Ecology and Environmental Sciences. 2016; 42:9-16.
17. Khan AA, Rather AQ. Diversity And Foraging Behavior of Spider (Arachnida: Araneae) In The Temperate Maize Ecosystem of Kashmir. Journal of Biological Control. 2012; 26:179-189.
18. Khuhro R, *et al.* Assessment of Potential of Predatory Spiders in Controlling the Cotton Jassid (*Amrasca Devastans*) Under Laboratory Conditions. The Journal of Animal & Plant Sciences. 2012; 22:635-638.
19. Mills NJ. Satiation and the Functional Response: A Test of a New Model. Ecological Entomology. 1982; 7:305-315.
20. Nilsson PA. Predatory Behaviour and Prey Density: Evaluating Density-Dependent Intraspecific Interactions on Predator Functional Responses. Journal of Animal Ecology. 2001; 70:14-19.
21. Nyffeler M. *et al.* How Spiders Make A Living. Environmental Entomology. 1994; 23:1357-1367.
22. Persons MH. Hunger Effects on Foraging Responses to Perceptual Cues in Immature and Adult Wolf Spider (Lycosidae). Animal Behaviour. 1999; 57:81-88.
23. Provencher L, Coderre D. Functional Response and Switching of *Tetragnatha Laboriosa* Hentz (Araneae: Tetragnathidae) and *Clubiona Pikei* Gertsh (Araneae: Clubionidae) for the Aphids *Rhopalosiphum Maidis* (Fitch) And *Rhopalosiphum Padi* (L.) (Homoptera: Aphididae). Environmental Entomology. 1987; 16:1305-1309.
24. Riechert S, Harp J. Nutritional Ecology of Insect, Mites, Spiders and Related Invertebrates. John Wiley, New York. 1987; 1:645-672.
25. Riechert SE. The Hows and Whys of Successful Pest Suppression by Spiders: Insights from Case Studies. Journal of Arachnoloy. 1999; 27:387-396.
26. Riechert SE, Lockely T. Spiders as Biological Control Agents. Annual Review of Entomology. 1984; 29:299-320.
27. Samu F, Biro Z. Functional Response, Multiple Feeding and Wasteful Killing in Wolf Spider (Araneae: Lycosidae). European Journal of Entomology. 1993; 90:471–476.
28. Sebastian PA, Sudhikumar AV. Feeding Potential of Spiders (Order: Araneae) on *Aphis Craccivora* Koch Occurring on Cotton. Entomon. 2003; 28:153-156.
29. Sherawat SM, Butt A. Role of Hunting Spiders in Suppression of Wheat Aphid. Pakistan Journal of Zoology. 2014; 46:309-315.
30. Smith RB, Wellington WG. The Functional Response of a Juvenile Orb-Weaving Spider. In: Proceeding of 9th International Congress of Arachnology. Smithsonian Institute Press, Panama. 1983, 275-279.
31. Snyder WE, Wise DH. Predator Interferences and the Establishment of Generalist Predator Populations for Biocontrol. Biological Control. 1999; 15:283-292.
32. Steel RD, Torrie JH. Principles and Procedures of Statistics: A Biometrical Approach 3rd Edi. Mcgraw Hill Book Co., Inc. New York. 1997, 35-46.
33. Sunderland KD, *et al.* Field and Laboratory Study on Monkey Spiders (Linyphidae) as Predator Cereal Aphid. Journal of Applied Ecolology. 1986; 23:433-447.
34. Umarani S, Umamaheswari S. Spiders are of Economic Value to Man. Journal of Entomological Research. 2013; 37:365-368.