Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 5, No. 3, p. 364-375, 2014
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Predation potential of foliage spiders and estimates of utilization curve, niche breadth and overlap in cotton filed from Punjab, Pakistan

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Article published on September 25, 2014

Key words: Spiders, Feeding niche, Utilization curve, Niche breadth, Niche overlap, Specific overlap.

Abstract

Production of cotton is restricted by pest infestation causing deterioration in lint quality. Spiders being generalist predators regulate insect populations. Bio diversity and relative abundance of spiders as predator as well as feeding niches of nine co-existing spider species in cotton were computed and compared for the niche breadth; niche and specific overlaps. A comparative niche analysis providing insight to the community structure is a prerequisite to observe the predation impact of spiders. Overall 320 spider predators captured belong to six families, ten genera and twenty four species. Nine species constitute 85.6% of total spider predators fauna belong to Araneidae, Oxyopidae, Salticidae and Thomisidae . Maximum predator population was observed in September 31.7% of total and lowest observed in July 8.75%. *Neoscona mukerji* was found in order 19.3 % to total synoptic species followed by *Oxyopes bermanicus* 16.7%, *O. wroughtoni* 13.5 %, *O. javanus* 11.3 %, *Neoscona theis* 10.2 %, *Runcinia albostriata* 9.2 %, *O. hindustanicus* 7.2 %, *Marpisa tigrina* 6.5 % and *O. tineatipes* forming 5.8 % respectively. The maximum spider diet comprise insect orders Hemiptera 0.28 % followed by Diptera 0.20 %, Hymenoptera 0.13 %, Orthoptera 0.10 %, Lepidoptera , 0.06 %, Odonata 0.04 %, Coleoptera , 0.05 %, Thysonoptera 0.05 %, and lastly Araneae 0.04 %. The utilization curve of *Neoscona mukerji* reflects major component of its diet comprised order Hemiptera, Diptera , and Hymenoptera i.e. 83% where as other insect order represent only 17%. The estimates of niche breadth reflects that *Neoscona mukerji* has reduced value and predates only three insect orders as diet which confirmed it is specialist predator in cotton. The Levin's diet overlap estimates represent the pair comprisig of *O. wroughtoni* with *O. Javanus,*pair *O. wroughtoni* with *O. hindustanicµs* and pair *O. tineatipes* with *M. tigrina,* pair *O. hindustanicus with R. albostriata* and pair *R. albostriata with O. tineatipes* has complete overlap. Sixteen pairs signify complete overlap test on one another during present study out of thirty-six pairs and use same resources i.e. prey items while remaining twenty three pairs represent no complete overlap and use different resources.

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Introduction

Cotton (*Gossypium hirsutum* L.) is one of the most important cash crops in Pakistan and is the source of large amount of foreign exchange. Since its extensive cultivation, as a monoculture crop, it is attacked by many chewing and sucking insects (Saeed *et al*., 2007). Cotton is one of the most commercially main fiber crops in the world and also produces seeds with a impending multi product base such as hulls, oil, lint and food for animals (Ozyigit *et al.,* 2007). Production of cotton is limited by various factors among which insect pests are also important. The key insect pests of cotton are termite, *Microtermes obesi*; cutworm, *Agrotis ipsilon*; thrips, *Thrips tabaci*; jassid, *Amrasca biguttula biguttula*; whitefly, *Bemisia tabaci*; aphid, *Aphis gossypii*; leaf-roller, *Sylepta derogate*; red cotton bug, *Dyesdercus koenigii*; mite, *Tetranychus macfarlanei*; grey weevil, *Myllocerus undecimpustuletus maculosus*; spotted bollworm, *Earias insulana*; pink bollworm, *Pectinophora gossypiella* and American bollworm, *Helicoverpa armigera* (Ishfaq *et al*., 2011). In cotton, the insect pest infestation caused deterioration in lint quality and 10–40% losses in crop production (Gahukar, 2006). Spiders are among the numerically principal insectivores in terrestrial ecosystem and reveal a very diverse range of life style and foraging behaviors. They are important stabilizing agents or regulators of insect populations and being generalist predators, can kill a large number of insects per unit time and preventing outbreaks of insect pests in crop growing (Mohsin *et al*., 2010). Spiders can be considered as an ideal biological control agents because besides being generalist predators they are capable of propagating their population rapidly. Agro-ecosystems are variable environments with wide niche dimensions that reduce the niche competition among species and allow them to coexist. Spider guilds in same area can never change their microhabitats, prey niche dimensions and separation of their members in time for their cohabiting (Butt and Tahir, 2010). Niche divergences are the result of directional selection when resources are abound in supply, species can share them without detriment to one another and niche overlap may be high with reduced competition (Molles, 2007). Spiders with similar ecological requirements are expected to partition the resources to minimize the competition for the available resources (Herderand Freyhoff, 2006; Schwemmer *et al.,* 2008; Richardson and Hanks, 2009) especially when the resources are limited. Partitioning of the available resources is only possible if there is divergence in the utilization of the resources by co-occurring species (Walter, 1991). Nyfflier (1994) reported how the different species complement each other in their insectivorous activities; it must be known to what degree their ecological niches. Thus, a comparative niche analysis, providing insight into the community structure is a prerequisite to understand the collective predation impact of spiders. Petraitis (1979) developed mathematical methods commonly used in community ecology by which niche dimensions (i.e., food, space, and time) of coexisting species can be compared quantitatively. Commonly used measures are niche breadth of species and niche overlap between species (Colwell and Futuyma, 1971).

Materials and methods

Study site

Present study was conducted at Nuclear Institute of Agriculture and Biology (NIAB) in the cotton plantation around an area of in a (36000 sq. Ft = 0.82644 Acre) in 2013.

Experimental design

The study was conducted in a randomized complete block design with sixteen varieties having three replicates with plant to plant distance of one foot and row to row distance of 2.5 sq. ft. A total of 20 plants were sown in a row while the plantation was surrounded by a sprayed sugarcane.

Spiders sampling and identification

For the predation events visual observation were spent at sampling site. On an average one and a half hour/ replicate/ day was spent to capture the active predators. The spiders along with preys collected by jarring, net sweeping and hand picking methods. Normal agronomic practices were applied throughout the growing period of the crop. No pesticides were applied to the crop. The predators and prey were identified into families, genera and specie level in Araneae Laboratory, Zoology and Fisheries, University of Agriculture, Faisalabad.

Statistical and mathematical analysis

Utilization curve

The relative use of resource state was computed as Ludwig and Raynold's, 1988 statistics as:

No. of Species = % of Total Spiders.

Estimation of niche overlap

Levin's overlap (L) of two predator species was computed as:

$$LO_{1,2} = \sum j^r \; [(p_{1j})(p_{2j})] \; / \; \sum j^r (p_{1j})^2$$

Where

"p_{1j}" and "p_{2j} is the frequency of prey group "j" captured prey by predator species l and 2 of respectively (j = 1 to R) prey groups.

Niche breadth

Niche breadth of i^{th} specie was calculated by the following formula

$B_i = 1/ \sum J^r (p_1 j)^2$

Test for complete overlap

For the measurement of complete overlap measure, specific overlap "SO" the following statistics was applied

$SO^{1,2} = e^{E1,2}$

$So^{2,1} = e^{E2,1}$

Null hypothesis

To test the null hypothesis for specific overlap of species i on to k , we computed the statistics

$U_{I,\,,k} = -2\, Ni\, In\, (SO_{i,k})$.

Where $U_{I,k}$ is the distributed as chi-square with r-1 degree of freedom. Thus for specific overlap of species "1" onto species "2 ", we computed the statistics.

$$U_{1,2} = -2\, N_1 \ln (SO_{1,2})$$

And for species 2 onto species I

$U_{2,I} = -2\, N_2 \ln (SO\, 2, 1)$.

Results

Overall 320 spider predators comprising 6 families, 10 genera and 24 species were captured (Table.1) Out of 24, nine species were dominant and considered as synoptic species constituting 85.6 % of total catch. Throughout the seasonal sample Araneids, Oxyopids, Salticids and Thomisids were dominated.

Table 1. Recorded predators taxa captured by spiders captured in different months of an unsprayed cotton field.

Taxa	July	August	September	October	November	Total
Families	4	6	6	5	4	6
Genera	5	10	10	6	4	10
Species	10	23	24	17	10	24

The synoptic species were observed as *Neoscona mukerji, N. thesi, Oxyopes bermanicus, o. wroughtoni, o. javanus. o. hindustanicus, o. tineatipes, Runcinia albostriata* and *Marpissa tigrina* (Table 2). In July 24 predators forming 8.75 %, in August 50 spiders forming 18.2 %, in September 87 specimens forming 31.7 %, In October 76 specimens forming 27.7 % and in November 37 specimens forming 13.5 % respectively were recorded. *Neoscona mukerji* (n=53) was dominant in spider fauna 19.3 % to total followed by *O. bermanicus* (n=46) 16.7%, *Oxyopes wroughtoni* (n=37) 13.5 %, *O. javanus* (n=3 l) 11.3 % and *Neoscona theis* (n=28) 10.2 %, *R. albostriata* with (n=25) 9.2 %, *O. hindustanicus* with (n=20) 7.2 %, *M. tigrina* (n=18) 6.5 % and *O. tineatipes* (n=l6) 5.8 % respectively.

Prey texa recorded comprised nine insect orders viz., Hemiptera, Diptera, Hymenoptera, Orthoptera , Lepidoptera, Odonata, Coleoptera, Thysonoptera and Araneae, 35 families and 38 genera captured by spider in seasonal sample (Table 3). Maximum number of preys belonged to the families Aphidae, Cicadellidae, Aleurodidae, Tachiniidae, Phoridae, Tiphiidae, Tetrigidae and Thripidae. Commonly captured and utilized genera were Aphis, Nephotatix, Trialeurodes, Hyperectiena, Dilocopus, Chrysis, Neoconcocephalus, Hypena and Tribolium.

Table 2. Relative abundance of predator species captured in different months of an unsprayed cotton field.

Species	July	Aug	Sep	Oct	Nov	Total
N. mukerji	6(11.30)	9(16.9)	15(28.3)	13(24.5)	10(18.8)	53(19.3)
O. bermanicus	3(10.7)	5(17.8)	9(32.0)	8(28.0)	3(10.7)	28(10.2)
N. theis	4(8.60)	8(17.3)	15(32.0)	12(26.0)	7(16.6)	46(16.7)
O. wroughtoni	3(8.10)	7(18.9)	10(27.0)	12(32.4)	5(18.)	37(13.5)
O. javanus	2(6.04)	6(19.3)	10 (32.2)	9(29.0)	4(12.9)	31(11.3)
O.hindustanicus	2(6.04)	6(19.3)	10(32.2)	9(29.0)	4(12.9)	20(7.2)
R. albostriata	1(4.0)	4(16.0)	10(40.0)	8(32.0)	2(8.0)	25(9.12)
O. tineatipes	1(6.20)	3(18.7)	6(37.5)	4(25.0)	2(12.5)	16(5.8)
M. tigrina	2(11.1)	4(22.2)	5(27.7)	5(27.7)	2(11.1)	18(6.5)
Total	24	50	87	76	37	274
% age	8.75	18.2	31.7	27.7	13.5	99.9

A total of 274 preys formed the bulk of spiders diet, the preys consumed belonged to insect orders, Hemiptera (n=78) 0.28 %, Diptera (n=56) 0.20 %, Hymenoptera (n=37) 0.13 %, Orthoptera (n=29) 0.10 %, Lepidoptera (n=l7), 0.06 %, Odonata (n=13) 0.04 %, Coleoptera (n=l4), 0.05 %, Thysonoptera (n=l6) 0.05 %, and lastly Araneae (n=l4) 0.04 % (Table 4).

Table 3. Recorded prey taxa captured by spiders from cotton plantation in different months of an unsprayed cotton field.

Taxa	July	August	September	October	November	Total
Families	7	9	9	9	9	9
Genera	17	31	31	27	21	35
Species	18	33	31	28	21	38

The order wise consumption of prey groups by nine synoptic spider species in foliage of cotton at NIAB, Faisalabad was observed (Table 5). *Neoscona mukerji* was most dominant species whose diet mostly comprised of Hemiptera, Hymenoptera and Diptera (18:13:14) respectively. The preys belonging to other orders were very few in number (1, 2) forming only 1.5 % of its total diet. *Oxyopes birmanicus* was next predator chiefly consuming Hemiptera, Orthoptera and Diptra (15:11:7) prey items respectively and moderately on Diptera and Hymenoptera (7: 5). The preys belonging to other orders formed only 1.4 % of its total diet. *Oxyopes wroughtoni* captured 37 prey items, majority of preys belonged to the orders Hemiptera, Diptera and Orthoptera (9: 7: 6) respectively. Members of other orders ranged from (1:3) which formed 2.9% of its diet. *Oxyopes javanus* mostly consists insect orders Diptera, Hemiptera and Hymenoptera (9:7:4) respectively, other items formed 3.9 % of its diet. *Neoscona thesi* diet mostly comprised of insect order Hemiptera, Diptera and Hymenoptera (8: 6: 5) respectively and the others formed 3.2 %. *Runcinia albostriata* diet chiefly comprised of Hemiptera, Diptera, Lepidoptera and Odonata (8: 5: 4: 3) respectively remaining order formed 2.0 % of its diet. Remaining three species i.e. *Oxyopes hindustanicus, Marpissa tigrina* and *Oxyopes tinentipes* diet mostly comprised of insect order Hemiptera and Diptera (8: 5). Other orders formed 50 % of .its total diet and it is interesting to note that *Marpissa tigrina* was strictly generalist predator where *Runcinia albostriata* and *Oxyopes tineatipes* were the species whose diet comprised of 50 % Hemiptera and Diptera and 50 % on other insect orders and are specialist predator. *Oxyopes wroughtoni* was the species in which 60 % diet was based on Hemiptera, Orthoptera and Diptera and 40 % on others. Only *Neoscona mukerji* and *Oxyopes bermanicus* were considered as specialist predators of Hornopterous, Dipterous and Hymenopterous insects.

Table 4. Prey relative abundance captured by nine synoptic species in different months of an unsprayed cotton field.

Prey group	July	Aug	Sep	Oct	Nov	Total
Hemiptera	8(0.10)	12(0.15)	22(0.28)	24(0.30)	12(0.15)	78(0.28)
Diptera	6(0.10)	10(0.17)	18(0.32)	10(0.27)	6(0.16)	56(0.20)
Hymenoptera	3(0.08)	8(0.21)	10(0.27)	10(0.27)	6(0.16)	37().13
Orthoptera	2(0.06)	7(0.24)	8(0.27)	7(0.24)	5(0.17)	29(0.10)
Lepidoptera	1(0.05)	5(0.29)	6(0.35)	4(0.23)	1(0.05)	17(0.06)
Odonta	1(0.07)	2(0.51)	4(0.03)	4(0.30)	2(0.15)	13(0.04)
Coleoptera	--	2(0.14)	7(0.50)	4(0.28)	1(0.06)	16(0.05)
Thysonoptera	1(0.06)	2(0.12)	4(0.28)	3(0.21)	3(0.21)	14(0.05)
Araneae	2(0.14)	2(0.14)	4(0.28)	3(0.21)	3(0.21)	14(0.05)
Total	24(0.08)	50(0.18)	87(0.31)	76(0.27)	37(0.13)	274(100)

Utilization curve shows the competitive interaction among the species occupying the same trophic level. These species formed a small part of community, but the interaction was insignificant, therefore the species having similar patterns of resource usage are considered having a high degree of overlap. The degrees of specific overlap have been removed by utilization curve. These utilization curves were used to estimate niche overlap and breadth in term of selection of prey group by the spiders. The relative use of resource states is turned as utilization curve. Table -6- show combined utilization curves of nine synoptic spider species. The utilization curve of *Neoscona mukerji* shows that the major components of its diet comprised of insect order Hemiptera, Diptera and Hymenoptera in high number i.e. >0.24. Whereas the remaining insect, orders were least in numbers i.e. <0.03. In the case of *Oxyopes bermanicus* Hemiptera, Diptera and Orthoptera insects were high i.e. > 0.15 where as the remaining orders were lower i.e. < 0.04. In *Neoscona theis* the diet ratio Hemiptera , Diptera and Hymenoptera were abundant i.e. > 0.17 whereas the remaining orders were lower i.e. < 0.07. *O. wroughtoni* diet chiefly based on insect order Hemiptera, Diptera and Orthoptera, which were on higher side i.e. > 0.16 and remaining orders were on lower side i.e. < 0.10. In *O. javanus* diet Hemiptera was high in number i.e. > 0.12 and lower i.e. <0.09. *O. hindustanicus* feeds chiefly on Hemiptera, Diptera, Lepidoptera and Odonata was high > 0.12 and lower i.e. <0.10. *R. albostriata* the diet is chiefly based on insect orders Hemiptera, Diptera, Lepidoptera and Odonata was high i.e. > 0.12 and others were low i.e. 0:04. *O. tinentipes,* Hemiptera, Diptera and Coleoptera were high i.e. > 0.12.and others were low i.e.< 0.06. *M. tigrina* Hemiptera, Diptera, Orthoptera, Lepidoptera, Thysonoptera and Araneae were high i.e. > 0.11 and remaining orders were low i.e. <0.05. Complete utilization curves of nine synoptic spider species are also given in table 6.

Table 5. Prey records of nine synoptic foliage spider species recorded in different months of an unsprayed cotton field.

Spider spp.	Hem	Dip	Hym	Ort	Lep	Odo	Col	Thy	Ara	Total
N. mukerji	18	13	14	2	1	1	2	1	1	53
N. theis	15	7	5	11	2	1	2	2	1	46
O. bermanicus	8	6	5	1	2	1	1	2	2	28
O. wroughtoni	9	6	4	7	1	2	3	3	2	37
O. javanus	7	9	4	3	1	1	1	2	3	31
O. hindustanicus	6	4	2	1	2	1	1	2	1	20
R. albostriata	8	5	1	1	4	3	1	1	1	25
O. tineatipes	5	3	1	1	1	1	2	1	1	16
M. tigrina	2	3	1	2	3	2	1	2	2	18
Total	78	56	37	29	17	13	14	16	14	274

Estimation of niche breadth

The calculated and standardized values of niche breadth of nine synoptic spider species were ranged from 0.0 to 1.0. *Marpissa tigrina* utilized all the resource states equally without any discrimination and having widest niche breadth, i.e. 1.0. *Neoscona mukerji* utilizing maximum number of preys (n=53) has lowest niche breadth capturing only the member of insect orders Hemiptera, diptera, Hymenoptera as compared to the remaining six orders, in which utilization of preys ranged between 1-2 (Table 7), therefore it can be regarded as specialist predator of the preys belonging to these orders. Among the remaining species *o.wroughtoni* is the species having largest niche breadth (0.81) reflecting that this species utilized all prey groups while highly depends on Hemiptera (n=9), least dependent on Lepidoptera (n=l) In *o. javanus* niche breadth is of medium size (0.66 to 0.68) which show that generally the preys utilized by this species comprised on Hemiptera and Diptera. Therefore it can also be regarded as a specialist.

Table 6. Utilization curve of nine synoptic spider predators in different months of an unsprayed cotton field.

Spider spp.	Hem	Dip	Hym	Ort	Lep	Odo	Col	Thy	Ara	Total
N. mukerji	0.33	0.24	0.26	0.01	0.01	0.01	0.03	0.01	0.01	0.95
N. theis	0.32	0.15	0.1	0.23	0.04	0.02	0.04	0.02	0.02	0.96
O. bermanicus	0.28	0.21	0.17	0.03	0.07	0.03	0.03	0.07	0.03	0.92
O. wroughtoni	0.24	0.16	0.1	0.18	0.02	0.05	0.08	0.08	0.05	0.96
O. javanus	0.22	0.29	0.12	0.09	0.03	0.03	0.03	0.06	0.09	0.96
O. hindustanicus	0.3	0.2	0.05	0.05	0.1	0.05	0.05	0.1	0.05	1.00
R. albostriata	0.32	0.2	0.04	0.04	0.16	0.12	0.04	0.04	0.04	1.00
O. tineatipes	0.31	0.18	0.06	0.06	0.06	0.06	0.12	0.06	0.06	0.97
M. tigrina	0.11	0.16	0.05	0.11	0.16	0.11	0.05	0.11	0.11	0.95

Estimation of Levin's diet overlap

Levin's overlap shows values between 36 species pairs calculated with the help of utilization curve of one species on that of other species. The overlap values ranged between 1.0 - 0.0. The pairs having overlap value 1.0 has a complete overlap in utilization of resource states. *N. mukerji* bas no complete overlap with respect to any other species. Later species show complete overlap while the former species show more than 0.63 overlap on later species. In other pairs former species show more than 0.83 overlap values. The pair comprising of *O. bermanicus* and

O. wroughtoni, former species which show 0.85 overlap, while later have complete overlap whereas with others it shows more than 0.55 overlap while the later species show more than 0.83 overlap on former species. *N. theis* show more than 0.67 overlap while later show more than 0.85 overlap on former. Any pair does not show complete overlap on one another. The pair comprisig of *O. wroughtoni* with *O. Javanus,* former show complete overlap on later, later species show more than 0.86 overlap on former. In other cases former species has more than 0.78 overlap on farmer species while the later have more than 0.73 overlap on former. The pair comprising of *O.Wroughtoni* with *M. tigrina* former has 0.70 overlap on later while later species have complete overlap on former with the remaining pair former species has 0.93 overlap on later specie while the later species have more than 0.81 overlap on former species. The pair consisting of *O. hindustanticµs* and *O. tineatipes* showed complete overlap on one another. In the pair of *O. hindustanicus* and *R. albostriata* former species has complete overlap on later, but later species has 0.91 overlap on former, and the pair of *O. hindustanicus* and *M. tigrina,* former has 0.76 overlap on later while later has complete overlap on former. The pair comprised of *R. albostriata* and *R. tineatipes* and *M. tigrina,* former species show more than 0.67 overlap on later while later species show complete overlap on former species. The pair comprised of *O. tineatipes* and *M. tigrina,* former has 0.98 overlap on later species has 0.98 overlap on former species.

Table 7. Niche breadth of nine synoptic spider species in different months of an unsprayed cotton field.

Spider spp.	SUM $(p,j)^2$	Niche breadth value	St. Value
N. mukerji	0.23	4.24	0.49
N. theis	0.19	5.20	0.60
O. bermanicus	0.16	6.06	0.70
O. wroughtoni	0.14	6.95	0.81
O. javanus	0.16	5.90	0.68
O. hindustanicus	0.16	6.15	0.71
R. albostriata	0.19	5.25	0.61
O. tineatipes	0.16	6.07	0.70
M. tigrina	0.11	8.56	8.56

Estimation of specific overlap

Petraitis specific overlap ranges from 0 to +1, based on likelihood of the utilization curve of predator species I could have been drawn from that of species 2, is not necessarily that of species 2 to 1, because the utilization curve of a species may completely overlap that of a second species, whereas the utilization curve of that second species may overlap only part of the first species. Thus specific overlap is computed for species 1 to 2 and vice versa. Specific overlap values of nine synoptic species in 72 pairs (Table 9). Maximum specific overlap between *N. mukerji* and other eight spiders is 0.88 with *N theis* and minimum specific overlap is 0.41 with *M. tigrina*. The maximum overlap between *O. bermanicus* and other eight species is 0.93 with *O. wroughtoni,* and minimum specific overlap is 0.52 with *N mukerji*. Maximum specific overlap between *N. theis* and other eight species is 0.94 with *O. javanus* and minimum specific overlap is 0.73 with *M tigrina*. The maximum value of specific overlap between *O. wroughtoni* and other eight species is 0.89 with *O. tineatipes* and minimum value of specific overlap is 0.49 with *N. mukerji* . Maximum value of specific overlap between *O. javnnus* and other eight species is 0.89 with *O. wroughtoni* and minimum specific overlap is 0.64 with *N. mukerji*. Maximum specific overlap between *O. hindustanicus* and other eight species is 0.97 with *R. albostriata* and minimum specific overlap is 0.56 with *N. mukerji*. Maximum specific overlap between

R. albostriata and other eight species is 0.88 with *O. hindustanicus* and minimum is 0.45 with *N. mukerji.* Maximum specific overlap between *O. tineatipes* and other eight species is 0.93 with *O. hindustanicus* and minimum is 0.58 with *N. mukerji.* Maximum value of specific overlap between *M. tigrina* and other eight species is 0.82 with *R. albostriata* and minimum value of specific overlap is 0.28 with *N. mukerji.*

Table 8. Levin's overlap values of nine synoptic species of foliage spiders in different months of an unsprayed cotton field.

Spider spp.	*N. muk*	*O. bir*	*N. the*	*O. wro*	*O. jav*	*O. hin*	*R. alb*	*O. tin*	*M. tig*
N. mukerji	0.00	0.73	0.81	0.63	0.75	0.70	0.72	0.71	0.40
N. theis	0.89	0.00	0.79	0.83	0.80	0.80	0.82	0.82	0.55
O. bermanicus	1.00	0.92	.0.00	0.85	0.97	0.97)	0.98	0.95	0.67
O. wroughtoni	1.00	1.12	0.98	0.00	1.00	1.00	0.97	1.00	0.78
O. javanus	1.00	0.90	0.94	0.86	0.00	0.92	0.91	0.9	0.70
O. hindustanicus	1.00	0.95	0.99	0.89	0.96	0.00	1.00	1.02	0.76
R. albostriata	0.89	0.83	0.85	0.73	0.81	0.91	0.00	0.89	0.67
O. tineatipes	1.00	0.96	0.95	0.88	0.92	1.00	1.00	0.00	0.98
M. tigrina	0.82	0.91	0.95	0.96	1.00	1.00	1.00	0.90	0.00

Test for complete overlap through null hypothesis

After the computation of specific overlap values of nine predator's species for null hypothesis. The values obtained were compared with critical value of chi-square test i.e. l5.50 (8 df, p= 0.05). Those pairs which show null hypothesis value above the critical value rejected the hypothesis while those pairs which show null hypothesis values below critical value accept the hypothesis and show complete overlap over one another.

Table 9. Specific overlap of nine synoptic species of foliage spiders in different months of an unsprayed cotton field.

Spider spp.	*N. muk*	*O. bir*	*N. the*	*O. wro*	*O. jav*	*O. hin*	*R. alb*	*O. tin*	*M. tig*
N. mukerji	0.00	0.74	0.88	0.71	0.81	0.67	0.64	0.71	0.47
N. theis	0.52	0.00	0.70	0.93	0.83	0.75	0.71	0.80	0.66
O. bermanicus	0.80	0.81	0.00	0.86	0.94	0.92	0.87	0.91	0.73
O. wroughtoni	0.49	0.86	0.73	0.00	0.88	0.82	0.74	0.89	0.79
O. javanus	0.64	0.78	0.85	0.89	0.00	0.86	0.80	0.87	0.77
O. hindustanicus	0.56	0.75	0.88	0.84	0.87	0.00	0.97	0.96	0.84
R. albostriata	0.45	0.64	0.75	0.66	0.69	0.88	0.00	0.85	0.77
O. tineatipes	0.58	0.77	0.80	0.88	0.84	0.93	0.91	0.00	0.82
M. tigrina	028	0.56	0.65	0.71	0.71	0.82	0.82	0.79	0.00

Table 10. Null hypothesis values of nine synoptic spider species captured in different months of an unsprayed cotton field.

Species pairs	spp. i, k	Values	Hypothesis		spp. i, k	Values	Hypothesis	
			Acc	Rej			Acc	Rej
(1)*N. mukerii* × *O .bermanicus*	1*2	30.87	Rej		2*1	60.05	Rej	
N. mukerji × *N. theis*	1*3	13.2	Acc		3*1	20.32	Rej	
N. mukerji × *O . wroughtoni*	1*4	35.13	Rej		4*1 '	64.67	Rej	
N. mukerji × *O.javanus*	1*5	21.29	Rej		5*1	40.65	Rej	
N. mukerii × *O . hindustanicus*	1*6	41.519	Rej		6*1	52.66	Rej	
N. mukerji × *R. albostriata*	1*7	45.77	Rej		7*1	72.99	Rej	
N. mukerji × *O. tineatipes*	1*8	35.13	Rej		8*1	49.89	Rej	
N. mukerji × *M liflrina*	1*9	78.73	Rej		9*1	115.49	Rej	
(2) *O. bermanicus* × *N. theis*	2*3	32.33	Rej		3*2	11.24	Acc	
O. bermanicus × *O. wroughtoni*	2*4	6.467	Acc		4*2	7.87	Acc	
O.bermanicus × *O.javanus*	2*5	16.63	Rej		5*2	13.49	Acc	
O. bermanicus × *O. hindustanicus*	2*6	25.87	Rej		6*2	15.74	Rej	
O. bermanicus × *R. albostriata*	2*7	30.49	Rej		7*2	24.74	Rej	
O. bermanicus × *O. tineatipes*	2*8	19.4	Rej		8*2	14.62	Acc	

O. bermanicus × *M. tigrina*	2*9	36.95	Rej	9*2	32.05	Rej
(3) *N. theis* × *O.wroughtoni*	3*4	8.43	Acc	4*3	22.29	Rej
N. theis × *O. iavanus*	3*5	3.37	Acc	5*3	11.89	Acc
N. theis × *O. hindustanicus*	3*6	4.49	Acc	6*3	8.91	Acc
N. theis × *R. albostriata*	3*7	7.31	Acc	7*3	20.8	Rej
N. theis × *O. tineatipes*	3*8	5.06	Acc	8*3	15.6	Rej
N. theis × *M. tiJZrina*	3*9	16.87	Rej	9*3	31.21	Rej
(4) *O. wroughtoni* × *O. javanus*	4*5	8.91	Acc	5*4	6.84	Acc
O.wroughtoni × *O. hindustanicus*	4*6	14.12	Acc	6*4	10.58	Ace
O.wroughtoni × *R.albostriata*	4*7	21.55	Rej	7*4	25.52	Rej
O.wroughtoni × *O.Tineatioes*	4*8	8.17	Acc	8*4	7.47	Rej
O. wroughtoni × *M tigrina*	4*9	17.09	Rej	9*4	21.17	Ace
(5) *O. javanus* × *O. hindustanicus*	5*6	9.34	Acc	6*5	5.24	Ace
O.javanus × *R. albostriata*	5*7	13.69	Acc	7*5	14.46	Ace
O.javanus × *O. tineatioes*	5*8	8.09	Acc	8*5	6.82	Ace
O.javanus × *M tigrina*	5*9	15.56	Acc	9*5	13.2	Ace
(6) *O. hindustanicus* × *R. albostriata*	6*7	1.04	Acc	7*6	6.02	Ace
O. hindustanicus × *O. tineatipes*	6*8	1.32	Acc	8*6	3.51	Ace
O.hindustanicus × *M tigrina*	6*9	6.82	Acc	9*6	9.54	Ace
(7) *R.albostriata* × *O.tineatipes*	7*8	8.03	Acc	8*7	2.89	Ace
R. albostriata × *M tigrina*	7*9	12.55	Acc	9*7	6.1	Ace
(8) *O. tineatipes* × *M tigrina*	8*9	6.1	Acc	9*8	8.31	Ace

Discussion

Spiders of several families are commonly found in the agro eco system and many have been documented as predators of major crops. Mahalakshmi and Jeyaparvathi (2014) reported that the family Salticidae harboured highest population followed by three families such as, Araneidae, Lycosidae and Oxyopidae and the least number of spiders were recorded under the family, Tetragnathidae, Gnaphosidae, Sparassidae and Thomisidae. Khuhro *et al.*, (2013) reported in an unsprayed venue maximum predatory spiders were *Pardosa . birminica* followed by *Thomisus* sp. and *Lycosa tista*. Ghavami1 *et al.*, (2007) reported a total of 632 specimens were classified in 45 species and 59 genera belonged to 19 families. *Cheiracanthium pennyi*, *Neoscona adianta*, *Aulonia albimana* and *Thanatus formicinus* were the most abundant species in cotton fields, respectively. During present study nine species of predatory spiders were identified which belong to 6 families, 10 genera and 24 species from which nine species were dominant and considered as synoptic species constituting 85.6 % of total catch. The synoptic species viz., *Neoscona mukerji, N. thesi, Oxyopes bermanicus, O. wroughtoni, O. javanus. O. hindustanicus, O. tineatipes, Runcinia albostriata* and *Marpissa tigrina* were recorded. Prey records belonging to 9 insect orders, 35 families and 38 genera. Over all nine insect orders, viz., Hemiptera, Diptera, Hymenoptera, Orthoptera, Lepidoptera, Odonata, Coleoptera, Thysonoptera and Araneae were recorded. Maximum number of preys belonged to the families Aphidae, Cicadellidae, Aleurodidae, Tachiniidae, Phoridae, Tiphiidae, Tetrigidae and Thripidae. Commonly captured and utilized genera were Aphis, Nephotatix, Trialeurodes, Hyperectiena, Dilocopus, Chrysis, Neoconcocephalus, Hypena and Tribolium. Maximum, preys were consumed during the month of September followed by October, August, November and least in July (n=24) respectively. Solangi *et al.*, (2013) revealed that the maximum numbers of *Bemisia tabaci* 19.84%, *Aphis gossypii* 23.14%, *Mrasca devastan* 13.42% and mealybug 50.62% per leaf were found on cotton crop. Muhammad and Anjum (2012) reported that Cotton jassid, whitefly and thrips are important sucking insect pests in cotton fields in the Punjab, Pakistan. Uetz (1999) reported that the species of spider co exist because of differences in space and time and due to the prey and utilization curves. During present study the utilization curves of nine synoptic spider species were calculated which indicated that all spider species employing the similar foraging strategy which is in accordance with the study of Turner and Polis (1979). During this study utilization curve of nine predators synoptic spider species were mostly dependent on the insect orders hemiptera, diptera and hymenoptera constitute 63.2% while less dependent on odonata and araneae. Feeding niche separation reduces inter specific competition for food and evidently allows a great diversity of spider species to coexist in cotton fields (Whitcomb and Bell 1964. Diet breadth is inversely related to the feeding specialization (Colwell and Futuyma, 1971). Although the spider species compared in this study are both specialists and generalists. The species *N. mukerji, O. bermanicus, O.javanus* and *R. albostriata* exhibited a more specialized feeding behaviour as compared with *N. theis, O. hindustanicus, O. tineatipes, O. wroughtoni* and *M tigrina*. A less specialized feeding behavior may be advantageous from a nutritional point of view, by optimizing a balanced diet and having essential amino acid composition in diet (Greenstone 1979). The high diet breadth of *M. tigrina* with relations to other species evidently reflects wide variety of prey types encountered during movements of this predator on the plant surface (Whitecomb *et al*., 1964). Nentwig (1986) investigated cotton field the prey of genus Nephotatix were abundant arthropods i.e. 14 % followed by genus Trialeurodes i.e. 8.12%, Aphis 6.5%, Hyperectiena 5.3% and Aneuria 5.0 %. Applying Nentwig's theory to our study, one would expect that specialists among the cotton spiders concentrated on the genera of preys mentioned above as a primary food source. The specific overlap values of predator species of 36 pairs were tested for null hypothesis or complete overlap. Sixteen pairs showed the complete overlap values on one another and use the same resources i.e. prey items, while thirteen pairs showed no overlap on one another and used different resources.

Conclusion

The niche breadth estimates reflects that *Neoscona mukerji* has lowest niche breadth and predates only three orders of insect pest which confirmed it is specialist predator in cotton. The Levins diet overlap estimates represent the seven pairs of predatory spiders have complete overlap. Sixteen pairs represent complete overlap test on one another during present test out of thirtysix pairs and use same resources i.e. prey items while remaining twenty three pairs represent no overlap and use different resources.

Acknowledgements

Grateful acknowledgements are due to Mr. Mwema Felix, Research Scientist, Tropical Pesticides Research Institute, Tanzania for statistical analysis and his helpful suggestions for the completion of manuscript.

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