Pakistan J. Zool., vol. 43(4), pp. 683-688, 2011.

Activity Density of Spiders Inhabiting the Citrus Field in Lahore, Pakistan

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Abstract.- A survey of the spiders associated with citrus fields of University of the Punjab, Lahore, Pakistan was conducted to identify potential biological control agents of citrus pests in the study area. A total of 1098 specimens belonging to 38 species, 22 genera and nine families were collected. Lycosidae was the most abundant family while Gnaphosidae was represented by highest number of species. The number of species gradually increased from January until the end of trapping session. Richness and diversity was highest in the month of June. However, evenness was highest during the month of January. It is concluded that a rich spider fauna exists in citrus fields of the study area. As spiders are potential biological control agents of citrus pests, so any practice that may disrupt this group should be avoided by the farmers.

Keywords: Biodiversity, citrus fields, spiders, pitfall trapping, Pakistan.

INTRODUCTION

Citrus is the leading fruit of Pakistan in terms of area, production and export, contributing 50 percent of the total fruit production and 40 percent of the country's fruit export (Arif *et al.*, 2005). Citrus pests cause up to 30% reduction in the yields in Punjab, Pakistan. Use of pesticides in agroecosystems not only eliminate the populations of useful invertebrates but also harm the population dynamics of predator-prey system. The situation will further deteriorate if some timely effective and safe management strategies other than sole dependence on pesticide spray are not developed for management of citrus pests. Furthermore it is neither feasible nor economical to manage citrus pests only through spray.

Biological control appears to be the most promising control measures against citrus insect pests. Citrus pests have successfully been controlled in many parts of the world using natural predators like spiders and beetles (Cave *et al.,* 2008). Spiders are the most abundant natural predators in agroecosystems (Marc *et al.,* 1999; Nyffeler and Sunderland, 2003; Pearce and Zalucki, 2006; Tahir and Butt, 2008). Several studies have clearly indicated that spiders can significantly reduce citrus pests both in the laboratory and in the fields (Amalin *et al.,* 2001; Hoy *et al.,* 2007; Xiao *et al.,* 2007). Spider predation is not limited to adult insects only, but includes the egg, larval and nymphal stages as well (Harwood and Obrycki, 2006).

Unfortunately, this useful natural biological control group has been overlooked and has been documented poorly in the biological literature of Pakistan. Spiders can be used as potential biological control agent of citrus pests in the study area. Many spider species can also be integrated with other methods to control insect pests. Before attempting to employ spiders economically as biological control agent in the study area, these organisms must be collected, studied and integrated into our information systems. A detailed study of their taxonomy, diversity, ecology and response to natural and agricultural disturbances is also necessary (Furlong *et al.,* 2004; Devotto *et al.,* 2007). In spite of rich spider fauna in agro ecosystems of Pakistan, no serious attempt has been made to explore it. Some very useful information on the taxonomy, distribution and abundance of the spiders of the agroecosystem has been provided by Mushtaq and Qadar (1999), Butt and Beg (2000), Ghafoor and Beg (2002), Butt and Siraj (2006), Butt *et al.* (2006) and Tahir and But (2008, 2009). The present study was designed to record the spider fauna of citrus field of University of the Punjab,

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0030-9923/2011/0004-0683 $ 8.00/0

Lahore. This study will highlight the importance of spiders in citrus orchards as a substitute for chemical pesticides, which cost millions of rupees and cause health hazards. This study will also be helpful to start an Integrated Pest Management programme in citrus orchards of Punjab, Pakistan.

MATERIALS AND METHODS

Study area

The study was conducted from January through August 2007 and 2008 in citrus field (two acres) in the west of botanical garden, University of the Punjab, Lahore, Pakistan. In the east of the citrus orchard, there was a field of Brassica and in the west a field of cucumber (from December to May). There was wheat in the north and after wheat (from December through April) rice was cultivated from May to November. In the south, field of pepper and bringel were present from December through June. After June, ground was without any crop and ploughed four times till August.

Spider collecting

Spiders were collected from the citrus field using pitfall traps. Wide mouth glass jars (6 cm diameter x 12 cm deep) were used as pitfall traps. During operation the jars were so buried in the soil that their rims were at the level with ground (Samu and Szinetar, 2002). At each site, traps were operated fortnightly for ninety six hours in 4x4 meter grid pattern at six different localities. Two hundred and fifty ml of 95% ethylene glycol and 2 drops of 5% liquid detergent were added to each trap. A plastic rain cover (18cm x 18 cm) supported by three nails (19 cm long) were placed over each trap to prevent flooding during rain (Tahir and Butt, 2008).

Preservation

Spiders collected at each trapping session were brought to laboratory, washed with alcohol, stored in a mixture of 80% alcohol and 20% glycerol with proper labeling of locality, date of collection and other notes of importance. Spiders of all life stages collected during sampling were counted and identified to the species level with the help of available literature, *i.e.,* Dyal (1935), Tikader and Malhotra (1980), Tikader (1987), Tikader and Biswas (1981), Proszynski and Zechowska (1981), Barrion and Litsinger (1987), Proszynski (2003), Platnick (2007). Collected specimens were deposited at Biological Control Laboratory, Department of Zoology, University of the Punjab, Lahore, Pakistan.

Statistical analyses

Kolmogorov-Smirnov test was used to check the normality of the data. As there was no significant difference in the data of two years, so it was pooled together for statistical analysis. Mann-Whitney test was used to compare the active density of spiders (all species combined) during different trapping sessions of each year. However, paired t-test was used to compare the active density of spiders during trapping session of two years. Simpson's index, which is sensitive to changes in the most abundant species in a community, was used to analyze the diversity of spiders. To calculate the richness of spider species, the Margalef index was used. Modified Hill's ratio (E5) was used to calculate the evenness. Accumulation curve was prepared to check the completeness of inventory. Ludwig and Reynolds (1988) was consulted for statistical analyses.

RESULTS

A total of 1098 specimens (561 in 2006 and 537 in 2007) of spiders represented by nine families, 22 genera and 38 species (Table I) was captured in the pitfall traps. Of the total, 25% were adult males, 21% were adult females while remaining 54% were immatures. Five species were found most abundant and comprised 67.77% of the total sample. The abundance of *Pardosa oakleyi* and *Pardosa birmanica* was 23.5% and 19.31% respectively. Contribution of *Lycosa terrestris, Lycosa nigricans* and *Plexippus paykulli* was 8.93%, 11.66% and 4.37% respectively. The remaining 32 species were comparatively uncommon and contributed approximately 32.24% to the total sample.

The percent relative abundance of the spider families collected from citrus field for the two study years is given in Figure 1. Three most dominant families were Lycosidae (68.85%), Gnaphosidae

Table I.- Abundance of ground spiders collected from citrus fields (combined for two years).

Family species	Total abundance	Percent of total
Araneidae		
Neoscona mukerjei Tikader, 1980	2	0.18
Neoscona theisi (Walckenaer, 1842)	22	2.00
Neoscona sp. 1	2	0.18
Zygeilla sp.	4	0.36
Gea sp.	4	0.36
Clubionidae		
Clubiona sp.	12	1.09
Gnaphosidae		
Zelotus illustris Butt & Beg, 2004	38	3.46
Zelotus sp. 1	2	0.18
Zelotus sp. 2	6	0.55
Zelotus sp. 3	10	0.91
Drassodes sp. 1	16	1.46
Drassodes sp. 2	4	0.36
Drassodes sp. 3	14	1.28
Gnaphosa sp. 1	18	1.64
Gnaphosa sp. 2	6	0.55
Linyphiidae		
Linyphiidae sp. 1	4	0.36
Gnathonarium dentatum (Wider, 1834)	2	0.18
Erigone sp. 1	10	0.91
Erigone sp. 2	8	0.73
Lycosidae		
Lycosa maculata Butt, Anwar & Tahir, 2006	26	2.37
Lycosa nigricans Butt, Anwar & Tahir, 2006	128	11.66
Lycosa terrestris Butt, Anwar & Tahir, 2006	98	8.93
Pardosa oakleyi Gravely, 1924	258	23.50
Pardosa birmanica Simon, 1884	212	19.31
Hippasa sp.	34	3.10
Oxyopidae		
Oxyopes javanus Thorell, 1887	36	3.28
Oxyopes sp.	4	0.36
Salticidae		
Plexippus paykulli (Audouin, 1826)	48	4.37
Pseudicius sp.	4	0.36
Bianor albobimaculatus (Lucas, 1846)	2	0.18
Thyene imperialis (Rossi, 1846)	28	2.55
Hasarius adansoni (Audouin, 1826)	2	0.18
Marpissa tigrina Tikader, 1965	2	0.18
Dendryphantes sp.	6	0.55
Tetragnathidae		
Tetragnatha javana (Thorell, 1890)	2	0.19
Tetragnatha virescens Okuma, 1979	8	0.73
Thomisidae		
Thomisus pugilis Stoliczka, 1869	8	0.73
Runcinia affinis Simon, 1897	8	0.73
Total	**1098**	

(10.38%), and Salticidae (8.38%). Family Gnaphosidae was represented by highest number of species and contributed 23.68% to the total of species composition (Fig. 2). Contribution of Salticidae, Lycosidae, Araneidae and Linyphiidae was 18.42%, 15.79%, 13.16%, and 10.53% respectively. Family Tetragnathidae, Thomisidae, and Oxyopidae, each were represented by two species and family Clubionidae by one species. Species accumulation curve is represented in Figure 3. According to accumulation curve, the number of species increased gradually from January till the end of trapping (August).

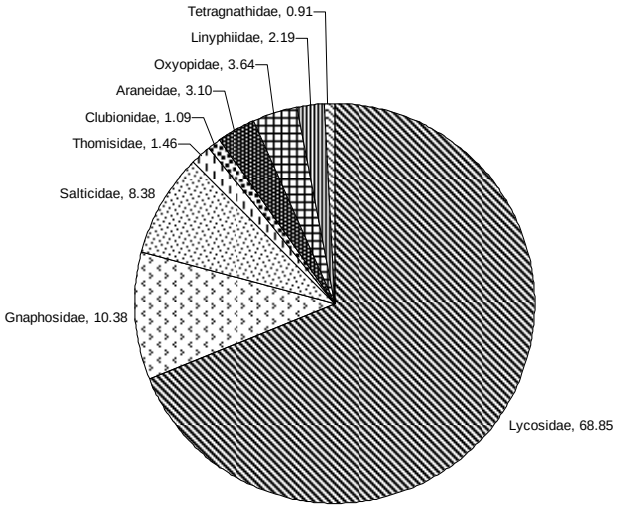

Fig. 1. Percent relative abundance of spider families collected from citrus field.

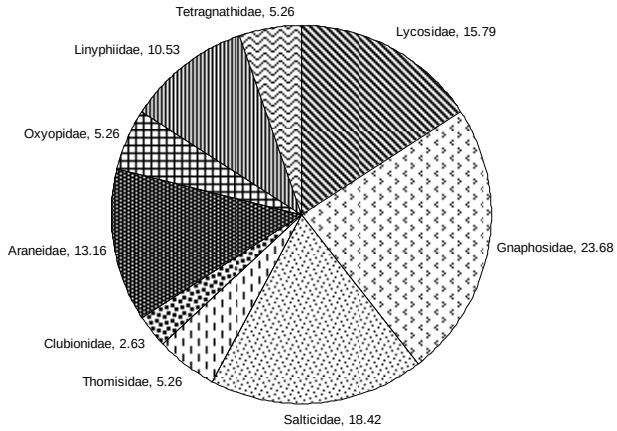

Fig. 2. Relative richness of spider families sampled from citrus field from January through August 2006-2007.

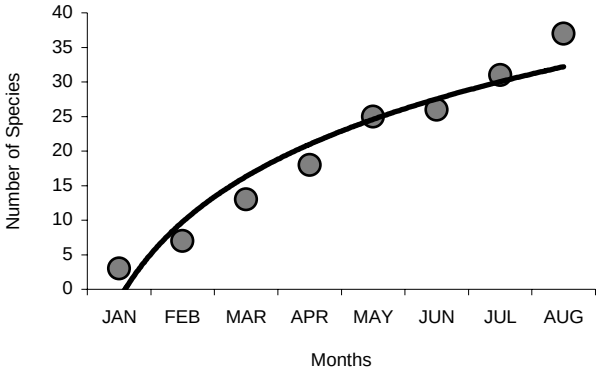

Fig. 3. Accumulation number of spider species trapped in pitfall traps from citrus field.

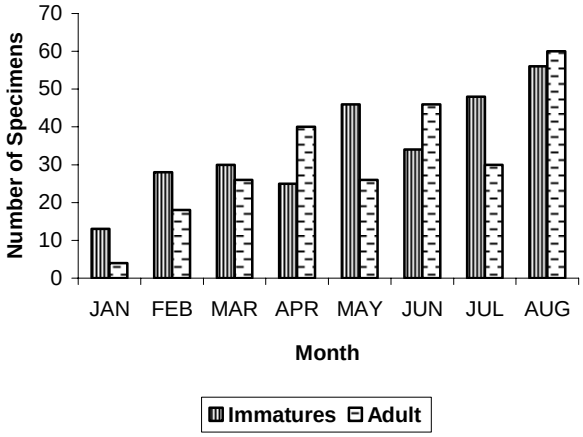

Fig. 4. Seasonal dynamics of immature and adult spiders in citrus field.

The relative abundance of the data of all species in the monthly sample revealed that the numbers of adults increase from January through April (Fig. 4). In May, number of adults decreased but again improved in June. In July, abundance again decreased but highest peak was observed in August. Overall, the number of immature ones increased from January through August. Although a decrease in the abundance was recorded in April and June (Fig. 4). The number of species gradually increased from January through June. However, a decline was recorded in the month of August. Comparison of active density of spiders during trapping sessions of two years showed non significant difference (T-value = 1.40; P = 0.23). However, active density of spiders among different trapping sessions of each year differed statistically (Mann-Whitney Test, U = 36; P = 0.04 for 2006 and Mann-Whitney Test, U = 30; P = 0. 014 for 2007).

Highest value for the Simpson's diversity index was recorded for the month of June (Table II). Diversity increased continuously from January to June and after maximum peak in June, it declined till August. Species richness also increased from January to July. The maximum number of species was recorded in July. Evenness values showed a different trend, peak of evenness was recorded in January and after that a decline is recorded till March sample. In April and May, it was higher than March but remained low compared to January (Table II).

DISCUSSION

In the present study, ground spider fauna of citrus field was recorded. Pitfall traps were used in the study. Pitfall trapping as sampling method has been criticized in ecological studies, because catch can be influenced by factors other than abundance (Topping and Sunderland, 1992). Problems include different trap ability of species, different activity patterns, variable capture rates of males and females, and effect of habitat structure. Nevertheless, pitfall trapping is extensively used to study ground living arthropods (including spiders) because pitfall traps are inexpensive, can be easily monitored, and trap a large number of a wide range of species. As sampling is continuous in pitfall trapping, therefore problems connected with the spot sampling are not important. Additionally, the results of pitfall trapping often show strong correlation at community level with those desired from other observations.

In the present study, Lycosidae was found to be the most dominant species in the citrus field as reported by Monzó *et al.* (2009). A number of studies carried out in agroecosystems of the tropical region showed that wolf spiders are typically epigeic predators (Nyffeler and Breene, 1992). They are common ground spiders on heliophil and xerophil sites in agricultural areas. The overall

Table II.- Spider diversity indices for monthly sample collected from January through August 2006-2007.

Indices	January	February	March	April	May	June	July	August
Diversity Simpson Index	3.2	2.3	3.2	6.6	9.0	10.8	5.0	5.3
Richness Margalef's Index	0.7	1.1	2.0	2.2	2.9	4.5	4.1	3.9
Evenness E (5)	1.2	0.7	0.6	0.9	0.9	0.8	0.5	0.6

abundance data indicated that the number of ground spiders peaked in June, while the abundance in earlier months (January to March) was very low. This might be due to the fact that at low temperature the activity of spiders itself as well as that most arthropods, which are the main source of nutrient for the spiders, decreases to avoid unfavorable winter climate as they enter a stage of dormancy or they become less active (Tauber and Tauber, 1976; Ford, 1978).

The number of species gradually increased from January until last trapping session (August). This continuous increase in the number of species even in the last trapping session indicated that the study areas had not been sufficiently sampled. Highest value for the diversity and richness were recorded for the month of June. This might be due to availability of resources in this month. But further study is needed to establish the fact whether it is so or some other factor is responsible for this increase in abundance and richness in this month (June). High evenness value recorded during the month of January was expected as in this month only few species were active (due to low temperature) and were represented in high number in the pitfall traps leading to high evenness values.

The present study has shown that a rich spider fauna exists in citrus field of the study area, which can be effective in suppressing the pest populations. To conserve spider fauna those management practices (restriction of pesticide use, increase in allochthonous and autochthonous inputs and complex surrounding habitat, etc.) should be adopted which do not have any negative effects on natural arthropod predators including spiders. Furthermore, any practice that may disrupt the indigenous predatory fauna should be discouraged.

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(Received 8 May 2010, revised 25 November 2010)