Pakistan J. Zool., vol. 47(2), pp. 545-550, 2015.

Biodiversity of Spider Species, Interactions with Horticultural Crops and a New Record for Turkey

Gulay Kacar
Plant Protection Department, Agriculture and Natural Science Faculty, Abant Izzet Baysal University, Golkoy, Bolu, 14280, Turkey

Abstract.- Spiders are an important predator group across many terrestrial crop systems. A survey was conducted in 2009 to determine the compositoin and abundance of spider species in citrus, persimmon, carob, avocado, almond, loquat, fig, and pomegranate plants in the eastern Mediterranean region of Turkey. Spiders were collected by using a beating method with steiner funnel and a hand aspirator. In total, 45 spider species were identified from 21 families. The taxonomic families of Gnaphosidae, Miturgidae, Salticidae, Theridiidae and Thomosidae were commonly sorted. Twenty-nine species belonging to 16 families were found on citrus trees. Adult/juvenile rate observed was 42%, and male/female rate was 48%, with most juveniles being female. Spider biodiversity was determined using the Shannon-Wiener diversity index according to spider distribution on each crop plant. Although each crop sheltered certain spider species, no avocado-specific spiders were found. The biodiversity index was the highest for *Diponema* sp. and *Chericanthium* sp.. Among the colllected species was *Clubiona juvenis* (Simon, 1878) (Clubionidae), found on the loquat trees, and representing a new record for this spider species in Turkey.

Key words: *Clubiona juvenis*, biodiversity, horticultural crops, spider, Shannon-Wiener index.

INTRODUCTION

Spiders are an important group with regard to species diversity, ranking seventh in global diversity after insect orders (Mahalakshmi and Jeyaparvathi, 2014). Spiders can be found in nearly all habitats, surviving under a wide range of ecological conditions. Therefore, spiders can be a good indicator taxon to reflect ecological change. Spiders also have a role in ecosystem services, and are one of the main arthropod predators in many habitats (Cardosa *et al*., 2011).

Spiders include over 114 families, in nearly 4,000 genera and around 45,000 species in the world (Platnick, 2014). Spider fauna have been studied in different habitats in Turkey (Ayhan, 2004; Demir, 2004; Soysal, 2004; Yenigun, 2006; Seyyar, 2009; Demir *et al.*, 2010; Yalcın 2010; Akpınar, 2011; Kunt *et al.*, 2011; Bayram *et al.*, 2014). According to recent studies, the checklist of the spider species in Turkey includes over 930 species belonging to 42 families (Bayram *et al.*, 2014). However, surveys of spider agricultural systems and, as a result, fauna in Turkey have been less commonly made in there is little information about spider fauna in some of Turkey's more important agricultural areas. Surveys in agriculture that were conducted include studies in sainfoin fields of Van province in the east, grapes of Aegean region, almond orchards of eastern and southeastern Anatolia regions, cereal fields of Antalya province and alfalfa fields of Mardin and Şanlıurfa provinces (Bayram *et al.*, 1999; Goven *et al.*, 2002; Danısman *et al*., 2007; Bolu *et al.*, 2008; Efil *et al.*, 2012). Researchers have rarely studied in the horticultural crops, the spider species in the eastern Mediterranean region, however, with the notable exception of Ozturk *et al.* (2013) who reported 59 spiders belonging to 17 families in pomegranate and olive orchards in a small (regional) area that including 16 locations.

This study aimed to determine spider species composition and abundances, as well as characteristics of families found on different fruit trees in the eastern Mediterranean region. Because of the Mediterranean climate, which is relatively stable and includes very warm summers and mild winters, most cultivated plants are fruit trees (especially citrus, olive, grapes, pomegranate, persimmon, almond, and others) and field plants (corn, cotton, vegatables, wheat, watermelon, and others). Surveys were conducted in persimmon,

* Corresponding author: gulaysahan@yahoo.com
0030-9923/2015/0002-0545 $ 8.00/0

almond, avocado, carob, citrus, fig, loquat, and pomegranate plants in 2009. The spider species composition on different fruit trees was compared by a biodiversity analysis in terms of their family and species compositions.

MATERIALS AND METHODS

Sample sites

The sampled sites were in agricultural areas near Adana, Hatay, and Mersin provinces in the eastern Mediterranean region of Turkey (Fig. 1). The site locations range from near the coast of the Mediterranean Sea (Cukurova basin- Adana, Mersin and Amik basin- Hatay) to mountainous regions that have an altitude near 1000 meters. In total, an area of nearly 35.500 km^2 was represented by the sampled sites, ranging from 33-37º north hemisphere meridians and 36-38º north hemisphere parallels. The sampled regions represent typical Mediterranean climates: hot dry summers and wet mild winters, with the mountainous areas slightly cooler than the coastal areas sampled.

Sample plants

Spider species were sampled from eight cultivated plants: almond, avocado, carob, citrus, persimmon, fig, loquat, and pomegranate. Citrus is the one of the main crops in the eastern Mediterranean region and is grown primarily in the flat basin regions where there is irrigation available. Oranges, mandarins, lemons, and grapefruits are the main citrus varieties. Lemons are cultivated in Mersin province, while mandarins and oranges are grown in Adana and Hatays. Because of the intensity of agricultural production, chemicals are used to control pests in citrus orchards in the Cukurova and Amik basins. Loquat is also grown, but there are only a few loquat orchards in the sampled regions. Pomegranate orchards have been increasing in acreage in recent years and can be found separately at the edge of the other orchards (especially citrus). Avocado and alligator pears are commonly found as individual or small clusters of trees in the home gardens, with larger commercial orchards more difficult to find. Fig, almond, and carob are also commonly found as individual or small clusters of trees, often at the edge of the other orchards. Persimmon can be found within the sampled region in home gardens or fully grown plants in the orchards.

Collecting and identifying spiders

Spider collections were taken monthly, from March to September in 2009. At each site, trees were sampled at random and on each tree branches were sampled from the four cardinal directions (north, east, south and west). The collected samples were sorted from trees according to Lazarov and Grigorov (1961) (Table I). For each sample, spiders were collected by shaking and knocking the branch three times over a 1 m² section of tree foliage and the dislodged spiders would drop into a funnel shaped collector and then were collected with a hand aspirator and placed into glass jars. The collected samples were brought to the laboratory of Adana Biological Research Control Station where the spiders were killed, put into 70% alcohol, labeled and then sent to taxonomic expert for identification. We pooled 199 total samples from eight crops in 49 different orchards.

Table I.- The number of samples collected varied according to the number of trees available for sampling, based on sampling progression described by Lazarov and Grigorov (1961)

Total trees in orchard	Number of trees sampled
1-20	All trees
21-70	10–30
71-150	31–40
151-500	41–80
501-1000	All trees %15
More than 1000	All trees %5

Data analysis

The Shannon-Wiener (S-W) diversity index (H) was used to determine the biodiversity of the spider species for each horticultural plant. H is calculated as $H= -\sum Pi(lnPi)$. Pi is the proportion of the each spider species every plant. Lnpi is the natural log, PilnPi, a part of whole species and natural log of Pi, is found multiplying with Pi and Lnpi. The value range of using the natural log is from 0 to ~4.6, where 0 shows that every species in the sample is the same species in the same species and 4.6 is evenly distributed. Larger value reports that species found on many plant species and in

different places of the sampling areas.

RESULTS

A total 45 spider species from 21 families were found in all horticultural orchards in this study. The common families were determined as Gnaphosidae, Miturgidae, Salticidae, Theridiidae and Thomosidae. The most common families recorded were Salticidae and Theridiidae. On citrus, 29 species belonging to16 families were recovered. On loquat, 15 species belonging to 10 families were found, with the most commonly represented family the Salticidae (4 species). On carob, 13 species, 13 genera and 11 families were recorded, with the most abundant family being the Theridiidae (3 species). From the other crops, we collected 12 species, 12 genera, and 7 families, primarily from the Theridiidae (4 species) and Thomosidae (3 species). Across all surveyed crops, 45 different spider species were recorded, from the 244 spider individuals from 172 sampling areas, 92 individuals from 22 citrus orchards, 66 individuals from 8 loquat areas, 43 individuals from 9 carob areas and 43 individuals from other orchards areas (Table II). The new species record for Turkey of *Clubiona juvenis* was collected in loquat.

Adult/juvenile rate observed was 42%, and male/female rate was 48%, with most juveniles being female. The male: female ratio was found as 35% in the citrus orchards, 23% in the loquat trees, 43% in the carob trees and 50% in the other sampled crops, indicating that female were more commonly collected than males in the major crop systems surveyed. Among identified species, the most variation of spider stages was determined in loquat and the lowest was found in fig trees. There was also a difference in the development stage and gender based on the crop system surveyed, with most juveniles found in pomegranates, most males found in avocado, and most females found in loquat, respectively (Fig. 1). There was also a difference in where different spider families were found; for example Clubionidae were most common in citrus and loquat trees.

The Shannon-Wiener diversity index showed spider species were generally well distributed among the all samples (H=3.35). Larger PilnPi values were found in *Dipoena* sp. (-0.33), *Chericanthium* sp. (-0.21), *Xysticus* sp. (-0.17), *Theridion* sp. (-0.14), *Cheiracanthium mildei* (-0.13), *Enoplognatha* sp. (-0.12), *Micaria* sp. (-0.12), *Clubiona caerulescens* (-0.10), *Clubiona* sp. (-0.09), *Dictyna lateens* (-0.08), *Linyphia tenuipalpis* (-0.08). The greatest diversity in terms of samples (*e.g.*, crop systems) was found in *Diponema*. Although spider species were found on many of the difference sampled crops, *Ebrechtella* sp., *Macaroeris* sp., *Mimetus* sp., *Anyphaena accentuate*, *Aulonia albimana*, *Diplocephalus picinus*, *Gibbaranea* gibbosa, *Harpactea* sp., *Heliophanus auratus*, *Micaria dives*, *Neon* sp., *Plexippoides gestroi*, *Prodidomus* sp., *Scotophaeus scutulatus*, *Thomisus onustus*, *Trochosa* sp. and *Zelotes gracilis* had the lowest H values. The new species *C. juvenis* was found as -0.06 on the loquat (Fig. 2).

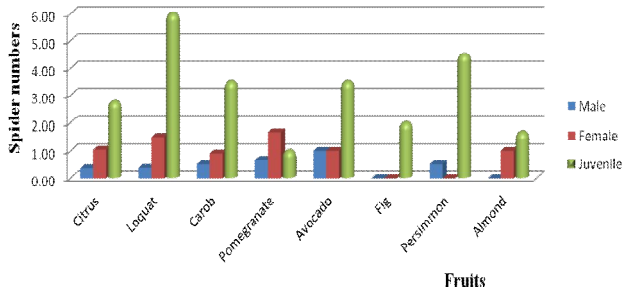

Fig. 1. Juvenile, male and female and rate of Araneae in different horticultural plants in the eastern Mediterranean region of Turkey.

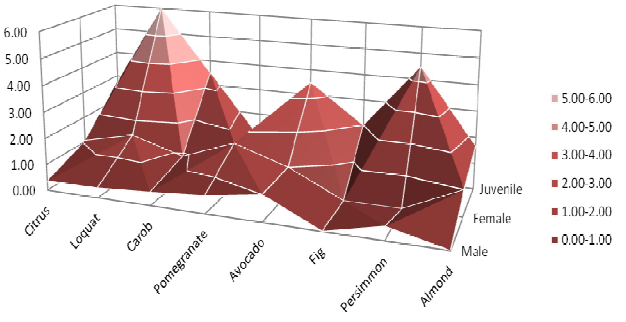

Fig. 2. Frequency of spider stages per plant in different horticultural plants in the eastern Mediterranean region of Turkey.

Table II.- Spider species in the citrus plants in the eastern Mediterranean region of Turkey

Family name	Species name	Citrus	Carob	Loquat	Pome-granate	Parsi-mon	Fig	Almond	Avakado
Agelenidae	*Tegenaria* sp.		4						
	Tegenaria domestica (Clerck, 1757)				3				
Amaurobiidae	*Amaurobius* sp.	2							
	Anyphaena accentuata (Walckenaer, 1802)	1							
Anyphaenidae	*Anyphaena accentuata* (Walckenaer, 1802)	1							
Araneidae	*Araneus* sp.	1							
	Gibbaranea gibbosa (Walckenaer, 1802)	1							
	Gibbaranea sp.		3						
Clubionidae	*Clubiona* sp.	2		4					
	Clubiona caerulescens L. Koch, 1867			7					
	Clubiona juvenis Simon, 1878 *****			3					
Dictynidae	*Dictyna latens* (Fabricius, 1775)	3	2						
Dysderidae	*Harpactea* sp.			1					
Filistatidae	*Pritha* sp.		2						
Gnaphosidae	*Micaria* sp.	2	2	2				3	
	Micaria dives (Lucas, 1846)							1	
	Scotophaeus scutulatus (L. Koch, 1866)	1							
	Zelotes gracilis (Canestrini, 1868)	1							
Hahniidae	*Hahnia ononidum* Simon, 1875			2					
Linyphiidae	*Bolyphantes* sp.	3							
	Diplocephalus picinus (Blackwall, 1841)	1							
	Linyphia tenuipalpis (Simon, 1884)	5							
Lycosidae	*Trochosa* sp.		1						
	Aulonia albimana (Walckenaer, 1805)	1							
Mimetidae	*Mimetus* sp.	1							
Miturgidae	*Cheiracanthium mildei* L. Koch, 1864	10							
	Chericanthium sp.	5	3	10		2	1		
Pisauridae	*Pisaura mirabilis* (Clerck, 1757)								
Philodromidae	*Philodromus* sp.	3		2					
	Thanatus sp.	2		2					
	Philodromus margaritatus (Clerck, 1757)		4						
Prodidomidae	*Prodidomus* sp.	1							
Salticidae	*Evarcha michailovi*	3							
	Macaroeris sp.	1							
	Platnickia sp.	4							
	Heliophanus auratus C.L.Koch, 1835			1					
	Sitticus sp.	1		2					
	Ballus sp.			4					
	Salticus sp.	2							
	Salticus zebraneus (C.L.Koch, 1837)		2						
	Plexippoides gestroi (Dalmas, 1920)				1				
	Neon sp.						1		
	Thyene imperalis (Rossi, 1846)			3					
Tinaoecidae	*Nurscia* sp.	2							
Theridiidae	*Dipoena* sp.	20	11	18		2			4
	Enoplognatha sp.	2	4	3					
	Euryopis flavomaculata (C.L.Koch,1836)	2							
	Robertus arunduneti (O.P.-Cambridge, 1871)	3							3
	Theridion sp.	4	4						3
Thomisidae	*Ebrechtella* sp.		1						
	Thomisus sp.						2		
	Thomisus onustus Walckenaer, 1805							1	
	Xysticus sp.			2	6	3		4	
Zodariidae	*Zodarion* cyprium Kulczynski, 1908	3							
	Total	**92**	**43**	**66**	**10**	**9**	**4**	**9**	**11**

* new record for Turkey fauna

DISCUSSION

Our results provide one of the first descriptions of spider species in agricultural crops systems in eastern Mediterranean region of Turkey. One of our more exciting finds was the new record for *C. juvenis* in Turkey. Previously, only ten *Clubiona* species have been recorded in Turkey (Bayram *et al.*, 2014), and the addition of *C. juvenis* bring the total number of Clubionidae species to eleven in Turkey. The Clubiona (Genus Clubiona Latreille, 1804) is not a large group, with only 19 species represented in Europe. Spider species in this genus typically have a dull brownish or reddish gray abdomen, are between 5-12 mm long, and hunt at night and spend the day in a cell of silk that can be found under stones and bark (Nieuwenhuys, 2015). To put this into context with other Clubionidae, the family contains 577 species in 15 genera in the world (Platnick, 2014). Clubionids have been recorded previously in citrus, but were numerically abundant; for example, *Clubiona leucaspis* has been commonly found on citrus in a number of countries (Benfatto and Franco, 1995) and *Clubiona reichlini* was the dominant species from citrus in China (Zhi, 2002a, 2002b).

Because citrus is a key crop in this region of Turkey, some comparisons between our survey results and spiders found on citrus in other parts of the work is warranted. For example, spiders representing 89 species that belonged to 17 families were collected on citrus in Italy; the common families were Theridiidae (18 species), Thomisidae (13 species), Araneidae (13 species) and Salticidae (10 species) (Benfatto and Franco, 1995). Additionally, on citrus in Queensland, Australia, a survey found spiders belonging to 20 families, 77 genera and 140 species (Green, 1999). Twenty-eight species of spiders, belonging to 22 genera and 12 families, were found in citrus orchards in China (Zhi, 2002a) and 34 spider species, 32 genera and 13 families were reported in Iran with the Araneidae and Salticidae being the most common families (Ghavami and Ghanadamooz, 2008). Finally, on citrus in Valencia, Spain, collected spiders represented 19 families (53 species) with Salticidae comprising 36.7% and Theridiidae with 27.7% of the collected spiders (Barrientos *et al.*, 2010). Knowledge of spider species composition and distribution in other fruits is very limited from Turkey and nearby regions. Ghavami (2008) reported that 1231 specimens were classified in 45 species and 36 genera belonged to 17 families from pomegranate in Iran (the families Lycosidae, Linyphiidae, Gnaphosidae and Theridiidae were most common). Mansoure *et al.* (1985) studied the spider fauna on avocado foliage in Israel and reported that *Theridion* spp. represented 63% and *Clubiona* 20% of all spiders collected.

There have been other surveys of spider fauna in some Turkish crop systems. Bolu *et al.* (2008) reported that 129 specimens were collected in Turkish almond orchards studied in the eastern (Elazıg) and southeastern Anatolia (Diyarbakır and Mardin provinces) regions, representing 21 species belonging to 16 genera and 9 families (Agelenidae Araneidae, Dictyniidae, Gnaphosidae, Linyphiidae, Philodromidae, Salticidae, Theridiidae, Thomisidae). Because there have been relatively few surveys of spider fauna in Turkey's crop systems, there are still many new records yet to be found. For example, *Anyphaena sabina* L. Koch, 1866 (Anyphaenidae) is a new species from İzmir and Antalya orchards for Turkish spider fauna (Guven *et al.*, 2008). In this study, 502 specimens were captured in pitfall traps and 284 specimens collected using an aspirator; a total of 63 species were determined (belong to 16 families) and of only 63 species there was one new record for Turkey. The most encountered families recorded by Guven *et al.* (2008) were Gnaphosidae, Lycosidae and Thomisidae; the most captured species was *Xysticus robusta* (Hahn). In two other relatively recent surveys, *Gnaphosa opaca* Hermann, *Gnaphosa microps* Holm, *Zelotes aurantiacus* Miller and *Cicurina cicur* (Fabricius) were recorded in Turkey for the first time by Bayram *et al.* (1999) and ten new species were record from citrus orchards of Antalya by Teksam *et al.* (2010).

The findings from our research and the other recent surveys of spider fauna in Turkey indicate that there is still much to be done and with greater efforts more new records and new species will be found in Turkey's agricultural crops. For example, only seven Clubionid species were previously reported from Turkey and it is believed and

expected that more species will be added to the list in the future. What must also be studied is the role of the different spider species in crop protection as biological control agents against agricultural pests.

ACKNOWLEDGEMENTS

I thank Dr. Kadir Bogac Kunt (Turkish Aracnology Assosiation, Ankara, Turkey), who identified these spider species.

REFERENCES

AKPINAR, A., 2011. *The spider fauna, systematic and their zoogeographic distribution of Kahramanmaraş and Adıyaman provinces (Arachnida: Araneae).* PhD thesis, Gaziantep, University of Gaziantep, Turkey, pp. 239.

AYHAN, H., 2004. *A systematical investigation on the spiders (Araneae: Salticidae) in Hatay province and its surrounding*. Ms thesis, University of Nigde, Nigde, Turkey, pp. 96.

BAYRAM, A., KUNT, K. B. AND DANISMAN, T., 2014. *The checklist of the spiders of Turkey*. Version 10.1.0. Turkish Arachnological Society, Ankara. Version 2014. http://www.kazimcapaci.com/spidersofturkey (accessed 24.07.2014).

BAYRAM, A., VAROL, M. I., ALLAHVERDI, H. AND BULUT, M., 1999. Van'da bir korunga tarlasının orumcek faunası (Spider fauna of a Sainfoin field in Van). *Ekoloji*, **9**: 6-11.

BARRIENTOS, J. A., VILLALBA, M., ALVIS-DAVILA, L. AND GARCIA-MAR, F., 2010. Identification and abundance of spiders (Araneae) in citrus crops of Valencia. *Bol. Sanidad Vegetal*, Plagas, **36**: 69-85.

BENFATTO, D. AND FRANCO, F., 1995. Spiders of citrus groves. *Inform. Agrar*., **51**: 47, 65-70.

BOLU, H., OZGEN, I. AND BAYRAM, A., 2008. Spider fauna of almond orchards in eastern and south eastern Anatolia. *Turkish J. Zool*., **32**: 263-270.

CARDOSO, P., PEKAR, S., JOCQUE, R. AND CODDINGTON, J. A., 2011. Global Patterns of Guild Composition and Functional Diversity of Spiders. *PLoS ONE*, **6**: (1-10).e21710

DANISMAN, T., BAYRAM, A., CORAK, I. AND YIGIT, N., 2007. An investigation on spider fauna of cereal fields in Antalya (Araneae). *Internat. Journ. of Nat. and Engg. Scien*., **1**:17-23.

DEMIR, H., 2004. *Systematic of Aranea (Familia:Thomisidae, Philodromidae and Pholcidae) in the surrounding of Gülek pass*. Master thesis, University of Nigde, Nigde, Turkey, pp.123.

DEMIR, H., AKTAS, M. AND TOPCU, A., 2010. Notes on two crab spiders (Araneae: Thomisidae) from Turkey. *Acta zool. Bulg*., **62**: 253-257.

EFIL, L., BAYRAM, A. AND DELTSHEV, C., 2012. The determination of spider species (Araneae) in alfalfa areas in southeast Anatolia region. *Turkiye entomol. Bult.*, **2**: 31-35.

GHAVAMI, S., 2008. Investigation fauna and density of population of spiders in the desert and pomegranate orchards in Tehran and Semnan provinces. *Pakistan J. biol. Sci*., **11**: 686-691.

GHAVAMI, S. AND GHANADAMOOZ, S., 2008. Investigation of spider (order Araneae) fauna of citrus orchards in the northern part of Iran. *J. appl. Biol. Sci.*, **2**: 73-76.

GOVEN, M. A., BAYRAM, A. AND GUVEN, B., 2002. *Studies on Spider fauna of grape areas in Aegean region*. *V. Biological control Congress of Turkey*), 04 Eylul (December) 2002, Erzurum, pp. 315-318.

GREEN, J., 1999. Sampling method and time determines composition of spider collections. *J. Arachnol*., **27**: 176–182.

GUVEN, B., AKPINAR, A., VAROL, I., BAYRAM, A., MADANLAR, N., TEKSAM, I. AND DANISMAN, T., 2008. A new record for the Turkish spider fauna: *Anyphaena sabina* L. Koch, 1866 (Araneae: Anyphaenidae). *Turkish J. Arachnol*., **1**: 85-90.

KUNT, K. B., OZKUTUK, R .S. AND ELVERICI, M., 2011. A survey of east Mediterranean *Dasumia* (Araneae, Dysderidae) with description of new species. *ZooKeys*, **137**: 89–101.

LAZAROV, A. AND GRIGOROV, P. 1961. *Karantina na Rastenijata*. Zemizdat. Sofia. p. 258.

MAHALAKSHMI, R. AND JEYAPARVATHI, S., 2014. Diversity of spider fauna in the cotton field of Thailakulam, Virudhunagar district, Tamil Nadu, India. *J. Zool. Stud*., **1**: 12-18.

MANSOUR, F., WYSOKI, M. AND WHITCOMB, W. H., 1985. Spiders inhabiting avocado orchards and their role as natural enemies of *Boarmia selenaria* Schiff. (Lepidoptera: Geometridae) larvae in Israel. *Acta Oecol*., **6**: 315–321.

NIEUWENHUYS, E., 2015. Sac or tube spiders, Family Clubionidae. http://ednieuw.home.xs4all.nl/Spiders/Clubionidae (accessed 24.03.2015).

OZTURK, N., DANISMAN, T., TUFEKLI, M. AND ULUSOY, M. R. 2013. Spider fauna of pomegranate and olive orchards in the eastern Mediterranean region of Turkey. *Turkiye entomol. Bult.*, **3**: 67-73.

PLATNICK, N. I., 2014. *The World spider catalog*. http :// research.amnh.org/iz/spiders/catalog/ Counts.html (accessed 10.09.2014).

SEYYAR, O., 2009. *Ground spiders (Araneae: Gnaphosidae) fauna of the east Mediterranean region of Turkey*. PhD thesis. University of Erciyes, Kayseri, Turkey, pp. 167.

SOYSAL, H., 2004. *A systematical Investigation on the spiders (Araneae: Gnaphosidae, Dysderidae) in Gulek Pass and its surrounding*. Ms thesis, University of Nigde, Nigde, Turkey, pp. 83.

TEKSAM, I., BAYRAM, A. AND TUNC, I., 2010. *Ten new species for Spider fauna from citrus orchards of Antalya*. XX. National Biology Congress, 21-25 June 2010, p. 184, Denizli.

YALCIN, E., 2010. *A study faunistic on Araneae: Salticidae Family of east Meditteranean region*. Ms thesis, University of Nigde, Nigde, Turkey, pp. 139.

YENIGUN, A., 2006. *Morphometric researchs about crab spider (Thomisidae) in the surrounding of Gulek pass*. Ms thesis, University of Nigde, Nigde, Turkey, pp. 103.

ZHI, W., 2002a. Study on the diversity of spider community hibernating in different citrus orchards. *J. Fruit Sci.*, **19**: 433-435.

ZHI, W., 2002b. Investigation of the mixed citrus mite species population in a citrus orchards and its dynamic distribution. *South China Fruits*, **31**: 5.

(Received 25 August 2014, revised 11 January 2015)