REVISTA IBÉRICA de Aracnología

ARTÍCULO:

Ground-dwelling spiders (Araneae) in pear orchards in the Oeste region of Portugal

Catarina A. Tavares
Biological Resources National Institute (INRB-IP), Av. da República, Quinta do Marquês, 2784-505 Oeiras, and CESAM-Centre for Environmental and Marine Studies/Faculty of Sciences, University of Lisbon, Rua Ernesto Vasconcelos, Ed. C2, Campo Grande 1749-016 Lisboa, Portugal
Email: ctavares@isa.utl.pt

Filipa Gouveia
Nuno G. Oliveira
Luís Carlos F. Crespo
Célia Mateus
M. Teresa Rebelo

Revista Ibérica de Aracnología
ISSN: 1576 - 9518.
Dep. Legal: Z-2656-2000.
Vol. **19**
Sección: Artículos y Notas.
Pp: 147−156.
Fecha de publicación: 31-Febrero-2011

Edita:
Grupo Ibérico de Aracnología (GIA)
Grupo de trabajo en Aracnología
de la Sociedad Entomológica
Aragonesa (SEA)
Avda. Radio Juventud, 37
50012 Zaragoza (ESPAÑA)
Tef. 976 324415
Fax. 976 535697
C-elect.: amelic@telefonica.net

Director: Carles Ribera
C-elect.: cribera@ub.edu

Indice, resúmenes, abstracts, vols. publicados:
http://gia.sea-entomologia.org/jour_intro_es.html

Página web GIA:
http://gia.sea-entomologia.org

Página web SEA:
http://www.sea-entomologia.org

ARTÍCULO:

Ground-dwelling spiders (Araneae) in pear orchards in the Oeste region of Portugal

Catarina A. Tavares[1,2 *], Filipa Gouveia[3], Nuno G. Oliveira[4], Luís Carlos F. Crespo[5], Célia Mateus[1], M. Teresa Rebelo[2]

Abstract:
The abundance, species richness, diversity and temporal dynamics of the ground dwelling spiders in pear orchards were studied in the Oeste region of Portugal. Pitfall traps were used. Six orchards were sampled: two of organic agriculture, two under the integrated pest management strategy, and two conventional agriculture orchards. In total, 1672 adult spiders belonging to 73 species and morphospecies and 16 families were found. Two species, *Zelotes sp.1* and *Alopecosa albofasciata* (Brullé, 1832), dominate the entire abundance of the community. The diversity of spiders is not very high, and is similar in all orchards, except in a conventional agriculture one (CA2), which presents the highest abundance of both dominant species. A new species to Portugal, *Zelotes electus*, was found.
Key-words: Arachnida, dominant species, agroecosystems, pitfall traps.

Las arañas del suelo (Araneae) en plantaciones de perales en la región de Oeste de Portugal

Resumen:
La abundancia, la riqueza de especies, la diversidad y la dinámica temporal de las arañas que viven en el suelo en campos de perales han sido estudiados en la región Oeste de Portugal. Fueron utilizadas trampas de caída. Las muestras fueron tomadas en seis campos: dos de ellos en agricultura ecológica, dos en la estrategia de manejo integrado de plagas, y dos campos en agricultura convencional.En dichas muestras fueron enontradas 1672 arañas adultas, 73 especies y morfoespecies y 16 familias. Solo dos especies, *Zelotes sp.1* y *Alopecosa albofasciata* (Brullé,1832), dominan la abundancia total de la comunidad.La diversidad de arañas no es muy alta,y es similar en todos los campos, excepto en el campo de agricultura convencional (CA2), que presenta la mayor abundancia de ambas epecies dominantes. Es la primera vez que la especie *Zelotes electus* es encontrada en Portugal.
Palabras clave: Arachnida, especies dominantes, agroecosistemas, trampas de caida.

Introduction

Spiders constitute one of the most important arthropod groups in agroecosystems, since they play a major role in pest limitation, and are naturally quite abundant (Marc *et al.,* 1999; Wyss *et al.*, 1995). They colonize virtually all terrestrial habitats and have a great ability to resist in adverse ecological conditions (Marc & Canard, 1997). However, abundance (number of individuals) and species richness (number of species) depends on the environmental characteristics of the agroecosystem, the application of chemicals and the presence of prey (Marc *et al.*, 1999; Pekár, 1999a). Diversity of the vegetation surrounding the crop plots can act as a refugee for spiders during the time when pesticides are in effect (Samu *et al.*, 1999), allowing posterior recolonization (Bishop & Riechert, 1990; Bogya *et al.*, 2000).

[1] Biological Resources National Institute (INRB-IP), Av. da República, Quinta do Marquês, 2784-505 Oeiras, Portugal. [2] CESAM-Centre for Environmental and Marine Studies/Faculty of Sciences, University of Lisbon, Rua Ernesto Vasconcelos, Ed. C2, Campo Grande 1749-016 Lisboa, Portugal. [3] AmBioDiv ~ Valor Natural, Lda, R. Filipe da Mata, 10, 1º Frente, 1600-07 Lisboa, Portugal. [4] NaturSitta, Gabinete de Projectos Ambientais Lda. Rua Corpo de Deus, 126 - 4º - 3000-121 Coimbra, Portugal [5] IMAR – Marine and Environment Research Centre, Department of Life Sciences, University of Coimbra, Largo Marquês de Pombal, 3004-517 Coimbra, Portugal.

The ground-dwelling spider fauna is mostly constituted by active hunter spiders and some web weaving species, and is considered a very important guild in agroecosystems since they are natural enemies of insect pests (Pekár, 1999a; Uetz *et al.*, 1999). The majority of studies carried out in European orchards were done in arboreal spiders (e.g. Bogya *et al.*, 2000; Markó *et al.*, 2009; Pékar, 1999a, 1999b) and very few on ground-dwelling spiders (e.g. Bogya & Markó, 1999; Jenser *et al.*, 1999; Miliczky *et al.*, 2000; Pekár, 2003). In Portugal, the role of spiders in agroecosystems is largely unexplored, with many species still to be described (Cardoso, 2008).
This seems to be the first study about ground-dwelling spiders done in pear orchards, and one of the few studies made in Portugal that analyses the spider community in agroecosystems (e.g. Nobre & Meierrose, 2000; Santos *et al.,* 2007; Silva *et al.*, 2010). It also provides new data for the Portuguese Spider Catalogue (Cardoso, 2010), to which new species to science or unknown to Portugal are regularly being added.
The objective of the present study was to evaluate the temporal dynamics, abundance, species richness and diversity of ground-dwelling spiders in pear orchards, in the Oeste region of Portugal - where pear production is of major economic importance - considering that they play a functional role as predators in pest control.

Material and methods

Sites
Work took place in the Oeste region of Portugal, in Cadaval, Caldas da Rainha and Torres Vedras districts located in the Oeste region of Portugal (fig. 1). Six pear orchards under the three production systems used in the region, were studied: two orchards under organic agriculture OA1 (39º1'33.30"N, 9º19'1.90"W) and OA2 (39º10'59.95"N, 9º6'26.88"W); two integrated pest management orchards, IPM1 (39º25'36.97"N, 9º6'17.73"W) and IPM2 (39º15'59.77"N, 9º4'24.47"W) and two conventional agriculture orchards, CA1 (39º15'40.35"N, 9º4'33.79"W) and CA2 (39º15'45.43"N, 9º6'11.16"W). Conventional Agriculture (CA) uses broad-spectrum pesticides applied rigidly at certain established periods; Integrated Pest Management (IPM), which uses chemical control together with other control measures when considered necessary after previous monitoring procedures; and using only selective pesticides; and Organic Agriculture (OA), which does not apply synthetic pesticides (Amaro, 2003).

Sampling
Sampling took place from June to November 2006 and from April to June 2007, except for CA2, in which the sampling period started on August 2006. According to Cardoso *et al.*, 2007 these are the optimal periods for spider sampling in Mediterranean ecosystems. In the first sampling period, there was no pesticide application and in the second one, pesticides were regularly applied (Table I). Pitfall traps, 10 cm diameter, filled up to 30% with a commercial anti-freezing mixture of ethylene glycol, were covered with a 10 by 10 cm plywood square roof, 2-3 cm above the trap opening. Ten pitfall traps were used in each field, separated by 5 meters, along the inter-tree strips. Spiders inside the traps were collected every two weeks. Adult spiders were identified up to species level.

Statistical analysis
To evaluate if the number of orchards was enough to predict the diversity of the spiders' community, randomized accumulation curves were calculated using PRIMER 6, 2006. To evaluate species richness, estimators were used: Chao 1, Chao 2, first and second order Jackknife; Michaelis-Menten and UGE (Ugland, Gray & Ellingsen, 2003), with 999 randomizations.
Spider communities at the different orchards were characterised by their temporal dynamics, abundance, species richness, species diversity and equitability, using the Shannon-Wiener function (H') and the Pielou's evenness index (H'/Hmax) (Krebs, 1989). Multiple k-dominance curves were also calculated to compare the cumulative percentage contribution of each species to the total abundance of individuals on each orchard (Clarke & Warwick, 2001). Analyses were performed on EXCEL 2002 and PRIMER 2006.

Results

A total of 1672 adult spiders were collected in pitfall traps corresponding to 16 families and 73 species and morphospecies (Table II). Three families represented 78.05% of all sampled specimens: Gnaphosidae (45.04%), Lycosidae (17.64%) and Linyphiidae (15.37%). Seven species account for almost 70% of all the individuals collected: *Zelotes tenuis* (L. Koch, 1866) (11.6%), *Zelotes* sp.1 (25.1%), *Trachyzelotes fuscipes* L. Koch, 1866 (4.2%), *Tenuiphantes tenuis* (Blackwall, 1852) (8.2%), *Pardosa proxima* (C. L. Koch, 1847) *(C. L. Koch, 1847)* (5.9%), *Palliduphantes stygius* (Simon, 1884) (4%) and *Alopecosa albofasciata* (Brullé, 1832) (10.5%). Gnaphosidae and Linyphiidae were also the richest families, presenting respectively 14 and 15 species

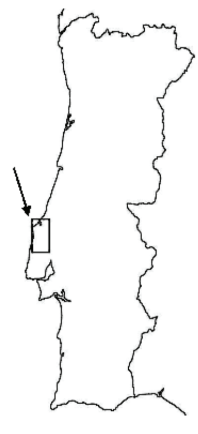

Fig. 1. Map of Portugal: the Oeste region, where the orchards were sampled is indicated by the square.

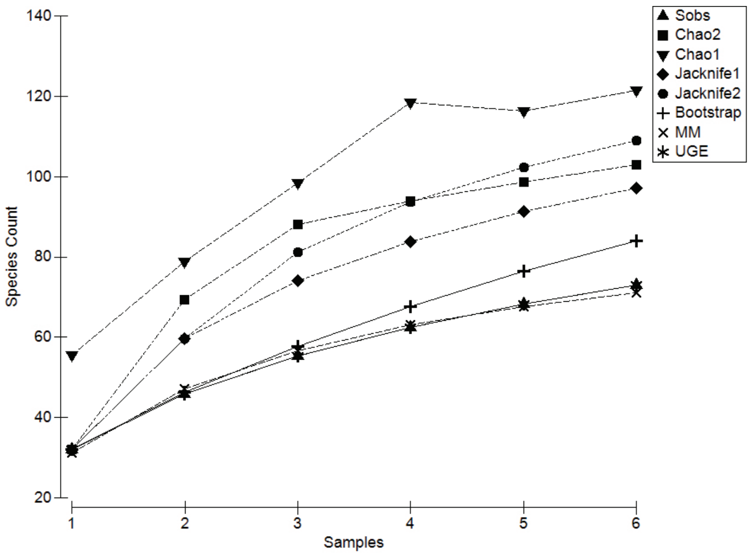

Fig. 2. Species accumulation curves for the observed number of spider species (Sobs) and the estimators Chao 1, Chao 2, first and second order Jackknife, Michaelis-Menten (MM), Bootstrap and UGE. Samples stands for the six orchards surveyed in the Oeste region of Portugal (CA1 and CA2 - conventional agriculture, IPM1 and IPM2 - integrated pest management, OA1 and OA2 - organic agriculture).

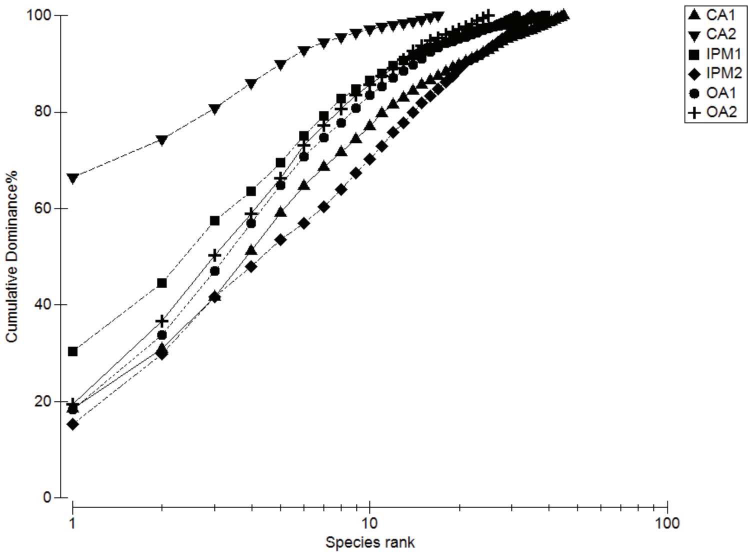

Fig. 3. Species multiple k-dominance curves for all pear orchards surveyed in the Oeste region of Portugal (CA1 and CA2 - conventional agriculture, IPM1 and IPM2 - integrated pest management, OA1 and OA2 -organic agriculture).

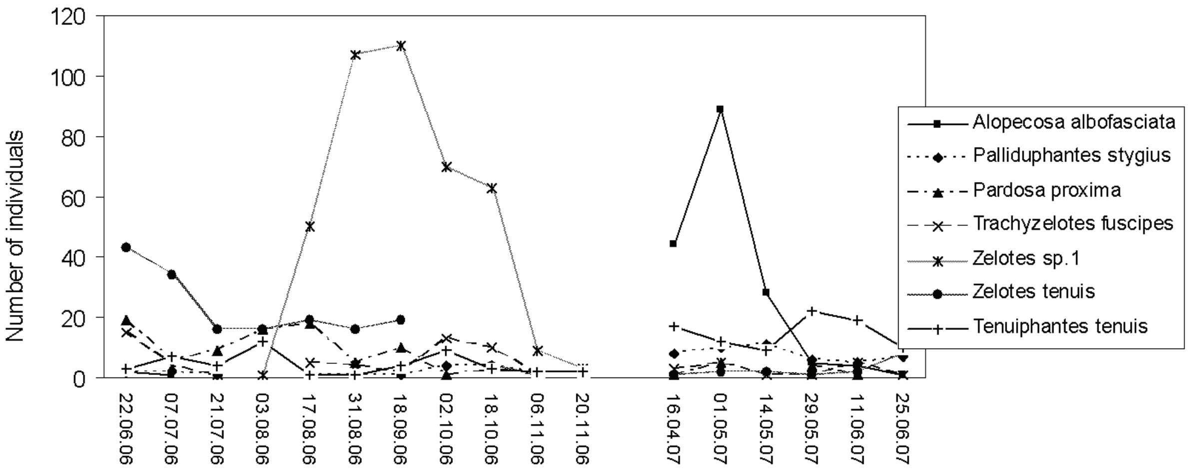

Fig. 4. Temporal dynamics of the seven most abundant spider's species captured in pear orchards surveyed in the Oeste region of Portugal.

Species accumulation curves did not reach the asymptote in any of the estimates performed, and all showed high variation on the estimated number of species (fig. 2). The exceptions were Michaelis-Menten and UGE (Table III), whose estimates values were very close to the number of species sampled.

Shannon-Wiener index values did not differ much between the different orchards (2.49 to 3.00), except for CA2 that presented a much lower value (1.38) (Table IV). Pielou's evenness index was relatively high for all orchards (>0.65), except again for CA2. The multiple k-dominance curves (fig. 3) showed that CA2 had the highest number of individuals of the dominant species, being also the site with the lowest number of species. When the Shannon-Wiener diversity index and the Pielou's evenness index were computed for all sites together, values did not vary much (except CA2).

Temporal dynamics of the seven most abundant species was relatively stable along the two sampling periods, except for *Zelotes* sp.1, which presents a marked peak in August-October, and *A. albofasciata*, with a peak in April-May (fig. 4). *Zelotes* sp.1 and *A. albofasciata* dominated the entire temporal dynamics of the spiders community and strongly influence the curve of the temporal dynamics of all spiders captured in the orchards studied (fig. 5). In relation to the number of species detected (species richness), the highest peak was detected at the end of June, followed by another peak in August. Another one occurred in May of the following year (fig. 6). The species richness pattern follows the "partial" one presented in figure 5. There are no sound differences in spiders' richness between types of production system: standard errors frequently overlap in each sampling date (fig.6).

Discussion

Spiders were studied for the first time in pear orchards in Portugal, which constitutes one more step in the knowledge of their presence in Portugal. A total of 1672 adult spiders corresponding to 16 families and 73 species and morphospecies were collected. However, species accumulation curves showed that the number of samples was not enough to predict the total richness of the habitat, which is a limitation of this study.

Most of the spiders sampled (78.05%) in the six pear orchards belong to only three families: Gnaphosidae, Lycosidae and Linyphiidae, which are very common on the ground surface of agroecosystems (e.g. Miliczky *et al.*, 2000; Pekár, 2003), and expected to be highly captured in pitfall traps due to their predatory activity in the ground (Jenser *et al.*, 1999; Uetz & Unzicker, 1976).

Gnaphosidae is considered the dominant family captured in pit-fall traps in the Mediterranean region (Chatzaki *et al.*, 1998). In fact, in the study here presented, Gnaphosidae and Linyphiidae were the richest families, presenting, 14 and 15 species each. A high number of species of these two families was also observed by Cardoso *et al*. (2009) in Mediterranean scrublands in Portugal.

Both Lycosidae and Gnaphosidae are active hunting spiders and, as cursorial spiders, they have a great mobility potential which allows them to vacate locally disturbed areas and re-colonize them later (the so called cyclic colonization strategy), henceforth their presence in disturbed agroecosystems (Miliczky *et al.*, 2000; Pekár & Haddad, 2005; Rypstra *et al.*, 1999). Lyniphiidae are sheet-web-building spiders that colonize agroecosystems through ballooning from both adjacent and distant habitats at great speed (Bishop & Riechert, 1990; Uetz *et al.*, 1999).

Zelotes sp.1 and *A. albofasciata* dominated the temporal dynamics of all the community, but did not present an overlap of abundance peaks, which could serve to prevent competition between them. The presence of these two generalist spiders, dominating the ground-dwelling spiders fauna is typical of a disturbed agroecosystem, according to Samu *et al*. (2002). Agroecosystems are by definition disturbed ecosystems because of the human systematic interference, in irrigation, soil fertilization, monitoring, pesticides application or harvesting.

A. albofasciata is the most common species of its genus to be captured in pitfall-traps and it ranges from Mediterranean to Central Asia. It is a stenochronous species: adults moult in April and remain present until the end of May (Cardoso *et al.*, 2007; Thaler *et al.*, 2000) which is coincident with the temporal dynamics registered in this study. Attention, however, should be given to the application of pesticides that occurred during that period, which may have influenced the results obtained.

It was not possible to identify *Zelotes* sp.1 This is a species described by Machado (1941) as *Z. fuscipes*, that was later incorrectly synonymized to the species *Trachyzelotes fuscipes* L. Koch, 1866, although it is now known to be a species of *Zelotes* (Platnick, 2010). It probably belongs to the *Zelotes subterraneus* species group, but since this species was never properly identified by any specialist, we cannot go further than that. Still, Machado (1941) stated that this species appeared to be the most abundant *Zelotes* species throughout the west coast of Portugal.

In this study, the temporal dynamics of the community did not follow entirely the pattern described by Cardoso *et al.* (2009) for Mediterranean ecosystems: a high peak of abundance and diversity was noticed in May, but not a smaller and pronounced one in October, indicated by those authors. This may be due to the fact that this work was conducted in a disturbed agroecosystem, while the one mentioned above took place in a natural habitat. Further data are needed to confirm this hypothesis.

The dynamics of spiders in disturbed habitats are usually different from those occurring in natural habitats (Samu *et al*., 2002): prey availability is also disturbed and spiders have to adapt to human intervention, as referred above (Marc *et al.*, 1999; Wyss *et al.*, 1995).

For the different sampled orchards, the Shannon-Wiener diversity index was relatively similar, except for CA2, which presented a very low diversity index value as well as a very low evenness index value. The vegetation structure of this orchard (inter-tree strips, inter-rows, orchard borders and even orchard surroundings) was similar to the other orchards studied; pesticides application was no different to the other CA orchard. However

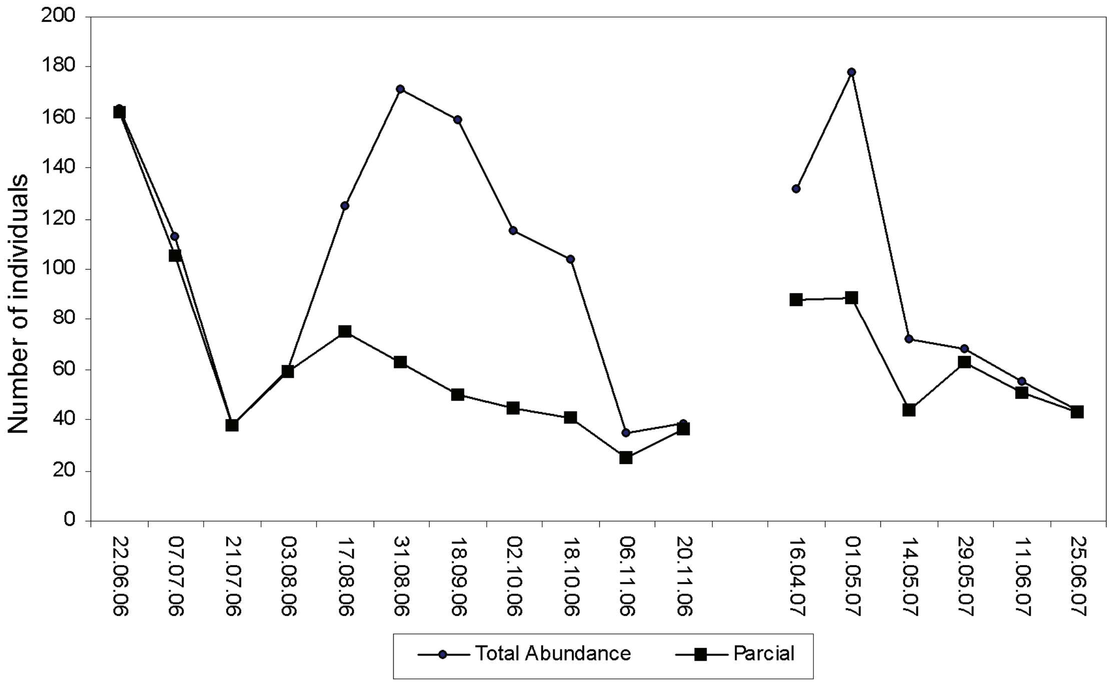

Fig. 5. Temporal dynamics of all the spiders' species (Total) and of all the spiders' species except *Alopecosa alfofasciata* and *Zelotes sp.* (Parcial), captured in the six pear orchards surveyed in the Oeste region of Portugal.

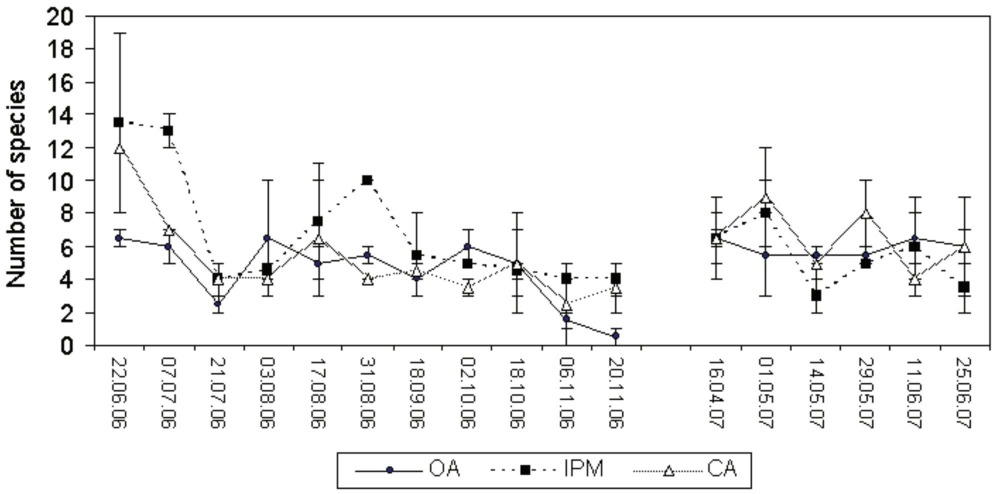

Fig. 6. Temporal variation of the number of spiders' species captured in the six pear orchards surveyed in the Oeste region of Portugal: means and standard errors for each type of production system. CA (conventional agriculture), IPM (integrated pest management), OA (Organic agriculture). No standard errors are presented for the first 4 samples of CA – only a plot was sampled.

there is a difference in the number of samples taken (lack of four samples in relation to the other orchards), and the fact that *A. albofasciata* is present in more than 50% of the samples.

A large number of rare species (only one individual trapped per species) was caught in this study: a total of 22 species, corresponding to 22 individuals. Some species, like *Nemesia bacelarae* Decae, Cardoso & Selden, 2007, were only found in a single orchard. These observations support the idea that most ground-dwelling spider species are habitat specialists, found only in one or two sites (Buddle & Rypstra, 2003; Mallis & Hurd, 2005). A new species to Portugal was found: *Zelotes electus* (C. L. Koch, 1839).

In the second sampling period, pesticides (fungicides and/or insecticides) were applied in the orchards, which may have influenced the temporal dynamics observed. The mean number of spider species seems also to have been influenced: in IPM and CA orchards it is lower in the second period. Further studies should focus on this issue for a sound conclusion.

Acknowledgements

This study was finnanced by AGRO programme as part of the project AGRO 545: "Os indicadores ambientais para avaliar a prática da protecção integrada, da produção integrada e da agricultura biológica e o uso sustentável de pesticidas em Portugal." The authors would like to thank the reviewers of this manuscript for their valuable suggestions.

References

AMARO, P. 2003. *A Protecção Integrada.* ISA Press. Portugal.

BISHOP, L. & S.E. RIECHERT 1990. Spider colonization of agroecosystems: mode and source. *Environ. Entomol.*, **19**:1738-1745.

BOGYA, S. & V. MARKÓ 1999. Effect of pest management systems on ground-dwelling spiders assemblages in an apple orchard in Hungary. *Agr. Ecosyst. Environ.*, **73**: 7-18.

BOGYA, S., V. MARKÓ & CS. SZINETÁR 2000. Effect of pest management systems on foliage - and grass-dwelling spider communities in an apple orchard in Hungary. Int. *J. Pest. Manage.*, **46**: 241-250.

BUDDLE, C.M. & A.L. RYPSTRA 2003. Factors initiating emigration of two wolf spider species (Araneae: Lycosidae) in an agroecosystem. Environ. Entomol., **32**: 88-95.

CARDOSO, P. 2008. Biodiversity and conservation of Iberian spiders: past, present and future. En: Jornadas sobre Biodiversidad valenciana y Arácnidos. VIII Jornadas G.I.A. 25-28 octubre 2007. Valência. *Boletín Sociedad Entomológica Aragonesa*. **42**: 487–492.

CARDOSO, P. 2010. Portugal spider catalogue (v.2.0). Available online at http://www.ennor.org/catalogue.php

CARDOSO, P., I. SILVA & A.M. SERRANO 2007. Seasonality of spiders (Araneae) in Mediterranean ecosystems and its implications in the optimum sampling period. *Ecol. Entomol.*, **32**: 516–526.

CARDOSO, P., S.S. HENRIQUES, C. GASPAR, L.C. CRESPO, R. CARVALHO, J.B. SCHMIDT, P. SOUSA & T. SZŰTS 2009. Species richness and composition assessment of spiders in a Mediterranean scrubland. *J. Insect. Conserv*., **13**: 45–55.

CHATZAKI, M., A. TRICHAS, G. MARKAKIS & M. MYLONAS 1998. Seasonal activity of the ground spider fauna in a Mediterranean ecosystem (Mt Youchtas, Crete, Grece). En: *Proceedings of the 17th European Colloquium of Arachnology* (ed. by P. A. Selden). European Society of Arachnology, Edinburgh , UK. 235 – 243.

CLARKE, K.R. & R.M. WARWICK 2001. A further biodiversity index applicable to species lists: variation in taxonomic distinctness. *Mar. Ecol. Prog. Ser.*, **216**: 265–278.

JENSER, G., K. BALÁZ., C.S. ERDÉLYI, A. HALTRICH, F. KÁDÁR, F. KOZÁR, V. RÁCZ & F. SAMU 1999. Chances in arthropod population composition in IPM apple orchards under continental climatic conditions in Hungary. *Agr. Ecosyst. Environ.,* **73**: 141-154.

KREBS C., 1989. Ecological Methodology. Harper Collins Publishers. U.S.A.

MACHADO, A.B. 1941. Araignées nouvelles pour la faune portugaise (II). *Mem. Est. Mus. Zool. Univ. Coimbra,* **117:** i-xvi, 1-60.

MALLIS, R.E. & L.E. HURD 2005. Diversity among ground-dwelling spider assemblages: habitat generalists and specialists. *J. Arachnol*., **33**:101–109

MARC, P. & A. CANARD 1997. Maintaining spider biodiversity in agroecosystems as a tool in pest control. *Agr. Ecosyst. Environ.,* **62:** 229-235.

MARC, P., A. CANARD & F. YSNEL 1999. Spiders (Araneae) useful for pest limitation and bioindication. *Agr. Ecosyst. Environ.,* **74:** 229-273.

MARKÓ, V., B. KERESZTES, M.T. FOUNTAIN & J.V. CROSS 2009. Prey availability, pesticides and the abundance of orchard spider communities. Biol. Control., **48:**115-124.

MILICZKY, E.R., C.O. CALKINS & D.R. HORTON 2000. Spider abundance and diversity in apple orchards under three insect pest management programmes in Washington State, USA. *Agr. Forest. Entomol*., **2:** 203-215.

NOBRE, T. & C. MEIERROSE 2000. The Species composition, whitin-plant distribution, and possible predatory role of spiders (Araneae) in a Vineyard in Southern Portugal. Ekol Bratislava, **19**: 193-200.

PEKÁR, S. 1999a. Effect of IPM practices and conventional spraying on spider population dynamics in an apple orchard. *Agr. Ecosyst. Environ*., **73:** 155-176.

PEKÁR, S. 1999b. Side-effect of integrated pest management and conventional spraying on the composition of epigeic spiders and harvestmen in an apple orchard (Araneae, Opiliones). J. Appl. Entomol., **123:** 115-120.

PEKÁR, S. & C.R. HADDAD 2005. Can agrobiont spiders (Araneae) avoid a surface with pesticide residues? *Pest. Manag. Sci.,* **61:** 1179-1185.

PEKÁR, S. 2003. Change in the community of epigeal spiders and harvestmen (Araneae, Opiliones) with the age of an apple orchard. *Plant Soil Environ*., **49:** 81-88.

PLATNICK, N.I. 2010. The world spider catalog, version 11.0. American Museum of Natural History, online at http://research.amnh.org/entomology/spiders/catalog/index.html

RYPSTRA, A., P.E. CARTER, R.A. BALFOUR & S.D. MARSHALL 1999. Architectural features of agricultural habitats and their impact on the spider inhabitants. *J. Arachnol*., **27:** 371-377.

SAMU, F. & CS. SZINETÁR 2002. On the nature of agrobiont spiders. *J. Arachnol*., **30:** 387-402.

SAMU, F., K.D. SUNDERLAND & CS. SZINETÁR 1999. Scale-dependent dispersal and distribution patterns of spiders in agricultural systems: a review. *J. Arachnol*., **27:** 325-332.

SANTOS, S.A.P., J.E. CABANAS & J.A. PEREIRA 2007. Abundance and diversity of soil arthropods in olive grove ecosystem (Portugal): Effect of pitfall trap type. Eur J Soil Biol, **43**: 77-83.

SILVA E.B., J.C. FRANCO, T. VASCONCELOS & M. BRANCO 2010. Effect of ground cover vegetation on the abundance and diversity of beneficial arthropods in citrus orchards. B Entomol Res, **100**: 489–499.

THALER, K., J. BUCHARA & B. KNOFLACH 2000. Notes on Wolf Spiders from Greece (Araneae, Lycosidae). *Linzer biologische Beiträge*, **32**: 1071–1091.

UETZ, G.W. & J. D. UNZICKER 1976. Pitfall trapping in ecological studies of wandering spiders. *J. Arachnol.,* **3:** 101-111.

UETZ, G.W., J. HALAJ & B.C. ALAN 1999. Guild structure of spiders in major crops. *J. Arachnol.*, **27:** 270-280.

UGLAND, K.I., GRAY, J.S. & K.E.ELLINGSEN 2003. The species–accumulation curve and estimation of species richness. J. Anim. Ecol., 27: 888-897.

WYSS, E., U. NIGGLI & W. NETWIG 1995. The impact of spiders on aphid populations in a strip-managed apple orchard. *J. Appl. Entomol.*, **119:** 473 -478.

Table I- Pesticides applied in the orchards surveyed in the Oeste region of Portugal. Pear orchards surveyed: CA1 and CA2 - conventional agriculture, IPM1 and IPM2- integrated pest management, OA1 and OA2 - organic agriculture.

2007	OA1	OA2	IPM1	IPM2	CA1	CA2
10 April	sulphur copper hydroxide	sulphur	flusilazole	captan difenoconazole	captan cyprodinil	cyprodinil
16 April		sulphur	cyprodinil	difenoconazole thiram flusilazole chlorpyrifos	flusilazole captan glyphosate teflubenzuron	difenoconazole mancozeb
1 May	sulphur copper hydroxide	sulphur	flusilazole dodine abamectin mineral oil chlorpyrifos	abamectin mineral oil thiram tebuconazole	fluquinconazole pyrimethanil captan methidathion	difenoconazole captan chlorpyrifos
14 May	sulphur copper hydroxide	sulphur	thiram kresoxim-methyl	fluquinconazole pyrimethanil chlorpyrifos bitertanol dodine	captan flusilazole glyphosate diazinon thiram flusilazole	
29 May			tebuconazole	bitertanol dodine thiacloprid thiram kresoxim-methyl abamectin diazinon	tebuconazole glyphosate	tetraconazole thiram teflubenzuron
11 June	sulphur copper hydroxide	sulphur	kresoxim-methyl	thiram tebuconazole difenoconazole thiacloprid	thiram phosmet	thiram kresoxim-methyl phosmet captan thiacloprid

Table II. Spiders captured in the six orchards surveyed in the Oeste region of Portugal (CA1 and CA2 - conventional agriculture, IPM1 and IPM2 - integrated pest management, OA1 and OA2 - organic agriculture). * New species to Portugal.

Family	Species /Morphospecies	OA1	OA2	IPM1	IPM2	CA1	CA2
Agelenidae	*Lycosoides coarctata* Lehtinen, 1967	0	0	1	0	0	0
	Malthonica lusitanica Simon, 1898	2	0	1	0	9	0
	Tegenaria atrica C. L. Koch, 1843	1	0	0	0	0	0
	Tegenaria feminea Simon, 1870	13	2	19	4	6	0
	Tegenaria montigena Simon, 1937	0	1	10	1	4	0
	Tegenaria incognita Bolzern, 2009	0	0	0	0	0	1
Corinnidae	*Liophrurillus flavitarsis* (Lucas, 1846)	0	0	0	0	3	0
	Phrurolithus minimus C. L. Koch, 1839	0	0	1	0	0	0
	Phrurolithus sp.1	0	1	0	0	0	0
Dictynidae	*Dictyna civica* (Lucas, 1850)	0	0	0	1	1	0
	Dictynidae sp.1	0	0	0	0	1	0
Dysderidae	*Dysdera crocata* C. L. Koch, 1838	6	3	2	2	9	1
	Dysdera fuscipes Simon, 1882	7	0	0	2	2	0
	Dysdera lusitanica Kulczyn'ski, 1915	0	0	3	1	0	0
	Harpactea sp.1	4	0	6	2	9	0
	Rhode scutiventris Simon, 1882	0	0	0	0	0	2
Gnaphosidae	*Drassodes lapidosus* (Walckenaer, 1802)	1	0	0	1	2	0
	Drassodes luteomicans (Simon, 1878)	0	0	1	2	2	0
	Gnaphosa alacris Simon, 1878	2	4	0	0	2	0
	Haplodrassus dalmatensis (L. Koch, 1866)	0	0	6	1	1	0
	Haplodrassus macellinus (Thorell, 1871)	9	0	3	2	2	0
	Micaria pallipes (Lucas, 1846)	1	3	4	0	2	1
	Setaphis carmeli (O. P.-Cambridge, 1872)	0	1	2	1	2	0
	Trachyzelotes fuscipes L. Koch, 1866	3	12	30	3	10	13
	Trachyzelotes holosericeus (Simon, 1878)	0	0	1	0	0	0
	Zelotes civicus (Simon, 1878)	0	0	3	0	1	0
	Zelotes electus (C. L. Koch, 1839) *	0	0	1	0	0	0
	Zelotes ruscinensis Simon, 1914	0	1	0	1	2	0
	Zelotes sp.1	18	13	165	22	36	166
	Zelotes tenuis (L. Koch, 1866)	30	30	77	21	32	4
Linyphiidae	*Canariphantes zonatus* (Simon, 1884)	0	0	0	0	1	0
	Centromerus phoceorum Simon, 1929	3	0	1	4	1	0
	Erig. sp.1	1	0	0	0	2	0
	Erig. sp.2	0	0	0	0	0	1
	Gongylidiellum vivum (O. P.-Cambridge, 1875)	0	0	0	1	0	0
	Lessertia dentichelis (Simon, 1884)	0	0	0	9	0	0
	Linyph.sp.1	1	0	0	0	0	0
	Meioneta sp. 1	3	0	2	0	0	0
	Meioneta sp. 2	0	0	3	1	0	0
	Microctenonyx subitaneus (O.P.-Cambridge, 1875)	0	0	0	5	1	0

	Palliduphantes stygius (Simon, 1884)	35	3	5	5	19	
	Pelecopsis inedita (O. P.-Cambridge, 1875)	0	6	1	0	0	0
	Prinerigone vagans (Audouin, 1826)	0	0	0	5	0	0
	Tenuiphantes tenuis (Blackwall, 1852)	22	24	32	17	26	16
	Microlinyphia pusilla (Sundevall, 1830)	0	0	1	0	0	0
Liocranidae	*Agraecina lineata* (Simon, 1878)	1	7	11	5	2	1
	Agroeca brunnea (Blackwall, 1833)	0	0	1	0	0	0
Lycosidae	*Alopecosa albofasciata* (Brullé, 1832)	41	34	23	8	62	7
	Arctosa personata (L. Koch, 1872)	0	0	0	4	0	0
	Pardosa hortensis (Thorell, 1872)	1	5	0	0	3	0
	Pardosa proxima (C. L. Koch, 1847)	3	15	71	2	5	3
	Pardosa sp.1	0	0	0	0	1	0
	Trochosa ruricola (De Geer, 1778)	0	1	0	0	0	0
	Hogna radiata (Latreille, 1817)	0	1	0	0	5	0
Nemesiidae	*Nemesia bacelarae* Decae, Cardoso & Selden, 2007	0	0	0	0	41	0
Philodremidae	*Thanatus vulgaris* Simon, 1870	0	0	0	0	1	0
Pisauridae	*Pisaura mirabilis* (Clerck, 1757)	4	0	0	0	0	0
Salticidae	*Chalcoscirtus infimus* (Simon, 1868)	0	1	0	0	0	0
	Euophrys herbigrada (Simon, 1871)	1	0	0	0	1	0
	Euophrys sulphurea (L. Koch, 1867)	1	0	3	0	0	0
	Evarcha jucunda (Lucas, 1846)	0	0	1	0	0	0
	Phlegra fasciata (Hahn, 1826)	1	1	1	0	1	0
	Talavera aequipes (O. P.-Cambridge, 1871)	0	0	0	0	1	0
	Pseudeuophrys erratica (Walckenaer, 1826)	0	0	0	1	0	0
Theridiidae	*Robertus arundineti* (O. P.-Cambridge, 1871)	1	0	0	0	0	2
	Theridiidae sp.1	0	0	1	1	1	0
	Theridion sp.2	0	0	1	0	1	0
Thomisidae	*Ozyptila bicuspis* Simon, 1932	1	0	1	3	3	20
	Ozyptila pauxilla (Simon, 1870)	7	2	8	3	13	10
	Xysticus kochi Thorell, 1872	0	0	0	1	1	0
	Xysticus nubilus Simon, 1887	1	0	0	0	0	0
Titanoecidae	*Nurscia albomaculata* (Lucas, 1846).	0	3	8	1	1	1
Zodariidae	*Zodarion atlanticum* Pekár & Cardoso, 2005	0	1	33	1	3	1

Table III. Estimates of spider species' richness and abundance, captured in the six orchards surveyed in the Oeste region of Portugal (CA1 and CA2 - conventional agriculture, IPM1 and IPM2 - integrated pest management, OA1 and OA2 - organic agriculture).

Orchards	6
Individuals	1672
Species	73
Species/Samples	12.17
Estimates	
Sobs	73
Chao1 + SD	121 ± 30.7
Chao2 + SD	103 ± 15
Jacknife1	97
Jacknife2	109
Bootstrap	84
MM	71
UGE	73

Table IV. Spider species' richness and abundance, Shannon-diversity index (H') and Pielou's evenness index (J') per orchard surveyed in the Oeste region of Portugal (CA1 and CA2 - conventional agriculture, IPM1 and IPM2 - integrated pest management, OA1 and OA2 - organic agriculture).

Orchads	OA1	OA2	IMP1	IMP2	CA1	CA2	Total
Samples/Data	17	17	17	17	17	13	98
Individuals	225	175	544	144	334	250	1672
Individuals/Sample	13.2	10.3	32.0	8.5	19.6	19.2	17.1
morphospecies	31	25	39	35	45	17	73
Unique species	13	9	15	14	16	7	22
Species/Sample	1.82	1.47	2.29	2.06	2.65	1.31	0.74
H' ($\log_e$)	2.67	2.56	2.49	3.00	2.93	1.38	2.90
J'	0.78	0.80	0.68	0.84	0.77	0.49	0.68