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Diversity of spiders in an almond *Prunus dulcis* (Mill.) D.A. Webb orchard in the Metropolitan Region of Chile (Central Chile)[1]

Diversidad de arañas (Arthropoda: Araneae) en cultivo de almendros Prunus dulcis *(Mill.) D.A. Webb en la Región Metropolitana de Chile (Chile Central)*

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ABSTRACT

The species of epigeal Araneae from an almond orchard located in the former El Mariscal Ranch (33º36'30.5"S-70º38'30.3"W) in the Metropolitan Region, Chile were investigated. The samples were taken using pitfall traps placed in two parallel transects, one within the orchard and the other in the adjacent uncultivated border, each with 5 traps. The sampling period extended from September to December 2006 and September to December 2007. The collected material was removed approximately every 15 days. The determination of families was made through taxonomic keys (Ramírez, 1999; Aguilera & Casanueva, 2005); the species were distinguished only by morphological differences.
The total number of spiders collected was 2556, including 11 families and 37 species. The most abundant families, in decreasing order, were Linyphiidae, Gnaphosidae, Dysderidae and Anyphaenidae, which together included 72% of the total. Linyphiidae was the most abundant family during the two sampling periods. The families Anyphaenidae, Linyphiidae, Dyctinidae, Gnaphosidae and Salticidae accounted for 70% of the total species richness. Wandering spiders were dominant in the almond orchard, probably related to the disturbances due to agricultural practices. On the other hand, the uncultivated border showed a dominance of web-building spiders, probably due to the greater stability and complexity of the habitat.
Key words: web-building spiders, wandering spiders, almond orchard, edge of culture.

RESUMEN

Se caracteriza la araneofauna epigea de un cultivo de almendros ubicado en el ex fundo El Mariscal (33º36'30,5"S-70º38'30,3"O), Provincia Cordillera, Región Metropolitana, Chile. El muestreo se efectúa mediante trampas de intercepción (Barber) que se disponen en dos transectos paralelos, uno en la zona de cultivo y el otro en el borde adyacente con 5 unidades en cada lugar. Las trampas se renuevan quincenalmente entre septiembre y diciembre del año 2006 y en el mismo periodo del año 2007. Mediante el uso de claves (Ramírez, 1999; Aguilera y Casanueva, 2005) se reconocen familias y sus morfoespecies.
Se colectan 2.556 individuos del orden Araneomorphae, pertenecientes a 11 familias y 37 morfoespecies. Las familias más abundantes, Linyphiidae, Gnaphosidae, Dysderidae y Anyphaenidae, en ese orden de importancia constituyen el 72% de la abundancia de la muestra. Sólo Linyphiidae coincidió en ambos años como la familia más abundante y por ende se reconoce como dominante. En cuanto a la composición, las familias Anyphaenidae, Linyphiidae, Dyctinidae, Gnaphosidae y Salticidae constituyen el 70% de la riqueza registrada en el total de la muestra. En la zona de cultivo se reconoce el predominio de arañas errantes, lo que tendría directa relación con condiciones oscilantes que ofrece el cultivo por las frecuentes perturbaciones que se ejercen en la aplicación de las prácticas de manejo agrícola. En cambio, en el borde se constata el predominio de arañas tejedoras, lo que tendría relación con las condiciones estables y de mayor complejidad de estratos que ofrece este hábitat.
Palabras clave: *arañas tejedoras, arañas errantes, almendro, borde de cultivo.*

Introduction

Spiders are one of the most important animal groups both in species richness and in population abundance, only a few orders of hexapods surpass them in species richness (Parker, 1982; Platnick 2009). Spiders are considered to be the most abundant arthropod predators in terrestrial ecosystems (Ibarra-Núñez & García, 1998); their population dynamics shows that they act as stabilizing agents

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of insect populations and they have sensitive reactions to the abiotic variables of their systems (Reid & Miller, 1989). These traits make spiders one of the most important groups of terrestrial predators; they may play a preponderant role in the biological control of agricultural pests (Nyffeler *et al.* 1992, Comstock, 1995, Sunderland, 1999).

Draney and Crossley (1999) indicated that the Linyphiidae respond efficiently to environmental pressures, although they reproduce only when conditions are favorable, while other groups such as the Gnaphosidae, Lycosidae, Anyphaenidae, Dyctinidae and Salticidae move rapidly, using the soil environment as a temporary refuge (Comstock, 1965; Gertsch, 1979; Maes, 1992; Liljesthrom *et al.*, 2002). These strategies of movement and life cycle may be interpreted as characteristics which allow them to prosper in ecosystems with climatic oscillations such as central Chile (Di Castri, 1968; Di Castri & Hajek, 1976) and in cultivation conditions in which treatments for the control or management of pests may be regular perturbations of their habitat (Castro *et al.*, 1996).

Some authors have considered spiders to be regulators of phytophagous insects in half-year crops such as cotton, rice, sorghum, wheat and sunflower, and in annual or perennial plantations such as citrus species, African palm and grasslands (Saavedra *et al.,* 2005; Aguilar 1965, 1968). In agricultural zones agrochemicals and physical modifications of the soil are used to enrich the substrate, which affects the agroecosystem (Kajak, 1978; Seetle *et al.,* 1996). The strips of vegetation which border or separate cultivated areas are those which usually have the greatest plant species richness and are not disturbed; thus they also have the greatest insect diversity, due the environmental diversity of the border or because it is a refuge (Ries & Sisk 2004, Olson & Andow, 2008). Thus it is expected that the spider community in the border will be more diverse than that within the cultivated area, assuming that insects respond similarly to the conditions of cultivation and borders.

Materials and Methods

The study area is an almond orchard in the former EL Mariscal Ranch (33º36'30.5"S-70º38'30.3"W) in the community of San Bernardo, Cordillera Province, Metropolitan Region, Chile. The orchard was approximately 50 years old; fertilizer is used and weeds are controlled with herbicides. The border is composed of a number of grasses and *Eucalyptus globulus* Labill trees along with blackberry vines (*Rubus ulmifolius* Schott), and is not disturbed.

Five Barber-type pit traps were installed in the orchard and 5 in the adjacent border, separated by 10 m, following a zigzag trajectory. Samples were collected at about two-week intervals from September to December of 2006 and 2007. The individuals obtained were washed, separated, counted and preserved in 70% ethanol. Families were determined using keys (Ramírez, 1999; Aguilera & Casanueva, 2005). We distinguished morphospecies using characters of the genitalia and external morphology, since there are no keys to species or collections identified by specialists.

To determine the composition and community structure of the epigeal arachnid fauna we analyzed the data of abundance and richness with the methods of Jaccard and Winer as described by Sáiz (1980), the diversity with Shannon's formula and evenness according to Pielou (Peet, 1978) using the software Multivariate Statistical Package 3.0. We used analysis of variance to corroborate abundance and richness by situation and by family, with Tukey's *a posteriori* test to distinguish significant differences among groups, using SPSS 15.0. Spider families were grouped in two guilds, wandering and web-building spiders, according to the classification of Uetz *et al.* (1999) and Giraldo *et al.* (2004). To compare the abundance of the guilds we calculated the proportion W/WB, wandering/web building. The proportions were transformed to logarithms, so that positive values indicate more wandering spiders and negative values indicate more web builders.

Results and Discussion

We collected a total of 1556 individuals of the order Araneae, all belonging to the suborder Araneomorphae, of 37 morphospecies and 11 families (Annex I), which represent 22% of the families of Araneomorphae known from Chile (Platnick, 2009). The Linyphiidae were the most common group, with 40% of the total relative abundance. Together with the Gnaphosidae (14%) and Dysderidae (10%) they composed about 64% of the total. About 30% were of the families Dyctinidae, Anyphaenidae, Salticidae and Amaurobiidae in order of abundance, while the remaining groups composed 6% of the total sample (Table 1, Annex I). The high incidence of

Table 1: Richness and abundance of families of Araneae in orchard and border. N: number of individuals; S: number of species.

	Orchard		Border	
	N	S	N	S
Lycosidae	52	2	21	2
Salticidae	154	3	22	4
Dysderidae	111	2	161	1
Linyphiidae	219	5	811	6
Anyphaenidae	5	1	191	8
Amaurobiidae	143	3	12	2
Dyctinidae	56	4	172	4
Gnaphosidae	191	4	169	4
Theridiidae	18	1	43	1
Thomisidae	0	0	2	1
Mimetidae	0	0	3	1

the Linyphiidae in the sample may be due to their association with the environments on the soil surface, under thickets and between shrubs where they spin their webs and have their feeding and reproductive activities (Alayón, 2004). The Anyphaenidae had the greatest species richness (24.3%) (Table 1, Annex 1); they are the most diverse group in South America (Ramírez *et al.*, 2004). The families Linyphiidae (16.2%), Gnaphosidae (10.8%), Salticidae (10.8%) and Dyctinidae (10.8%), which are importantly diverse groups in the world (Platnick, 2009) were also important in the sample (48.6%); together with the Anyphaenidae they had 72.9% of the species richness. It is worth noting that the Anyphaenidae are important both in species richness and moderate relative abundance, similar to what has been found in the spider fauna of protected environments (Ávila & Suazo, 2007), while in epigeal insects the groups with greatest species richness do not have high relative abundance (Solervicens & Elgueta 1989; Solervicens *et al.,* 1991; Solervicens & Estrada 2002).

There was a significant difference in the relative abundance between the orchard and border ($p < 0.005$), and also in the interaction between these factors (families and sampling areas), which indicates that both were important in the abundance of individuals. Tukey tests showed that the abundance of Linyphiidae was greater ($p < 0.005$) than that of the other 10 families, which reflects the high relative abundance of certain species which were dominant in both sampling sites, although their representation was different in the two communities (Annex I). This may be due to their capacity for aerostatic displacement and also to their amplitude of diet, since they feed on colembola, which are important components of environments with greater humidity such as the border, and on Lepidoptera and aphids which are frequent in the orchard, thus they would have a greater probability of survival than species of the other families of spiders (Riechert & Lockley, 1984; Covarrubias, 1991; Nyffeler, 1999; Suter, 1999; Thomas & Jepson, 1999; Alayón, 2004; Harwood *et al.,* 2004; Hoffman, 2004).

With respect to the community parameters, both overall and in each year the values of the Shannon index were similar (Table 2). The diversity values were lower in the border even though species richness was higher, which clearly responds to the high abundance of a few species (Linyphiidae sp.1, Dictynidae sp.4 and Gnaphosidae sp.4), which also reduced the evenness of the sample (Table 2, Annex 1). Although in the second year the observed diversity decreased, the overall tendency was maintained, showing that the border community is more homogeneous than the orchard community (Table 2, Annex 1). The indexes of ecological similarity of both areas in both years show that both the composition and the distribution of abundances of the populations were similar (Table 2). The border samples were richer

Table 2. Number of individuals (N), morphospecies (S), Shannon's ecological diversity (H') and evenness of Pielou (J), overall and for each site and each year.

	Orchard			Border		
	2006	2007	Total	2006	2007	Total
N	425	524	949	642	965	1607
S	16	25	25	17	30	34
H`	2.24	2.68	2.66	1.14	2.62	2.33
J	0.80	0.70	0.83	0.42	0.65	0.66
Sj			0.60			
Sw			0.45			

in species than the orchard samples, and included almost all the species recorded in the orchard, thus the differences are due to those species only found in the border, accentuated by the effect of the abundance of the Linyphiidae (Table 1, Annex 1).

The temporal dynamics of a few species determined the global tendency of the samples in both years, both in the orchard and in the border (Fig. 1). In the border two Linyphiidae and one Gnaphosidae were mainly responsible for the total observed abundances, while in the orchard the general tendency was produced by different increases and decreases in abundance over the sampling period, which were affected to some degree by the soil disturbances associated with the application of fertilizer in both years (see Fig. 1).

The composition of the guilds in the two situations shows that in both years wandering spiders were predominant in the orchard (Fig. 2), which is related to the open spaces which make foraging for prey easier (Giraldo *et al.*, 2004). The predominance of web spiders in the border (Fig. 2) is explained by the greater availability of substrate for webs on branches and in the leaf litter, in which a microclimate is generated with some regularity in humidity, which favors groups such as the Linyphiidae (Rypstra *et al.,* 1999).

As a consequence, in the orchard the conditions result in a constant renewal of the community, dominance of wandering spiders and a greater number of dominant species with various population fluctuations over time, which explains the greater heterogeneity of species observed during the sampling period. The community variables of the border samples were strongly influenced by a number of more stable and abundant elements such as web-building spiders, as well as the wandering spiders with greater vagility and fluctuation in their populations, which made it a community rich in species and with a diversity of spider species which can optionally occupy the orchard, in which the continual re-colonization after the usual perturbations of the management of the orchard generate the observed effect of greater diversity.

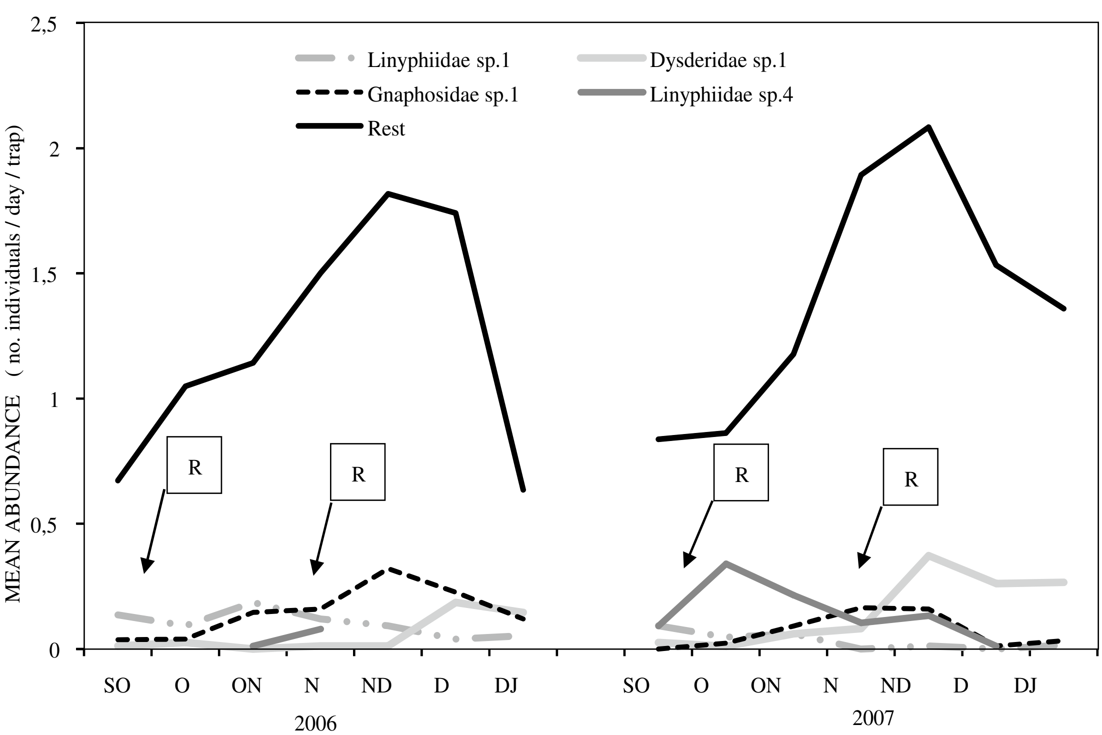

Figure 1. Variation in mean abundance during the sampling period in two collecting years. R: Event of soil surface disturbance.

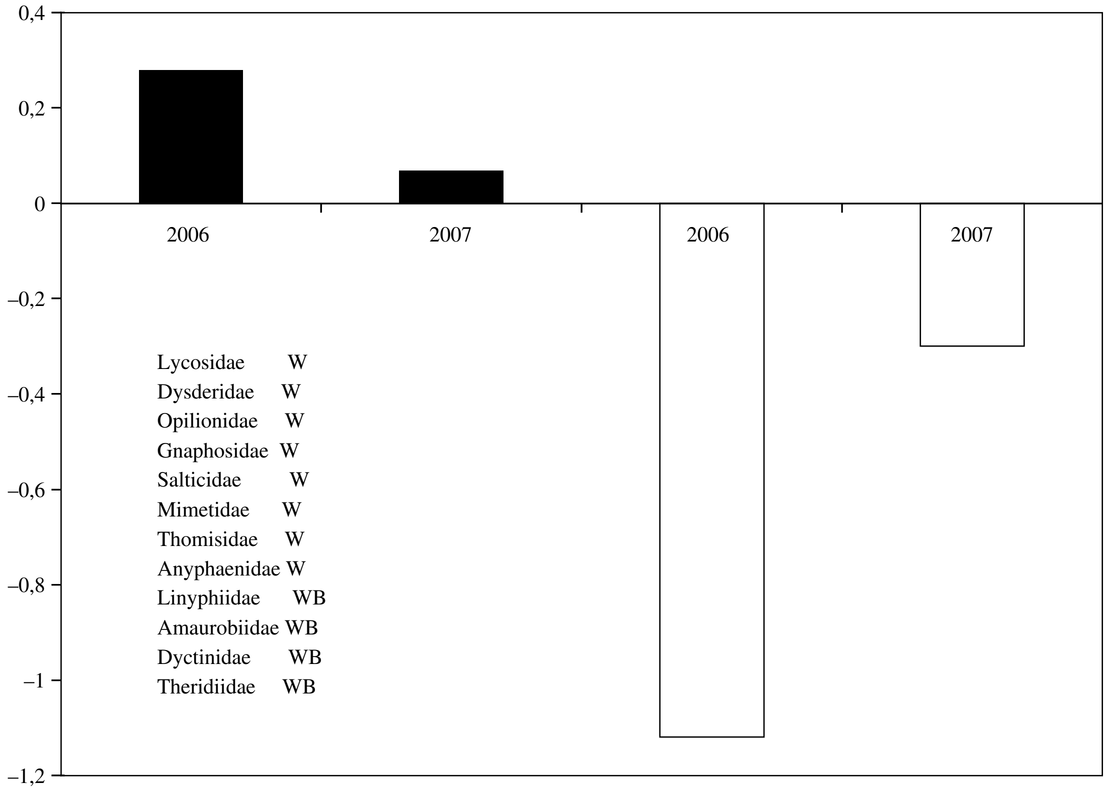

Figure 2. Log W/WB (wandering/web building) in orchard ■ and border □ in the two sampling periods.

Conclusions

Linyphiidae, Gnaphosidae, Dysderidae and Anyphaenidae, in that order of importance, composed almost 73% of the total simple; these characterize the epigeal spider fauna of the samples.

Anypahenidae, Linyphiidae, Gnaphosidae, Dyctinidae and Salticidae were the most important families in the samples, together including about 70% of the relative richness.

The family Linyphiidae was significantly more abundant than the other families, both in the border and in the orchard.

No se encontraron diferencias significativas para las situaciones de borde y cultivo lo que podría llevar a suponer que este factor no influye sobre la abundancia relativa de las diferentes familias.

The community of the border was richer in morphospecies but less diverse, which was caused by a reduced number of dominant species.

The larger total number of wandering spiders collected in the orchard and larger number of web builders in the border is directly related to the oscillating conditions of the orchard and the stable conditions of the border.

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Annex I: List of morphospecies, families and number of individuals collected in orchard and border in the two years of sampling.

	Orchard		Border		Total
	2006	2007	2006	2007	
Lycosidae					
sp.1	4	1	0	1	6
sp.2	31	16	9	11	67
Salticidae					
sp.1	93	35	12	1	141
sp.2	1	24	1	3	29
sp.3	0	1	1	0	2
sp.4	0	0	0	4	4
Dysderidae					
sp.1	30	79	120	41	270
sp.2	0	2	0	0	2
Linyphiidae					
sp.1	55	17	440	172	684
sp.2	0	2	11	10	23
sp.3	12	52	18	70	152
sp.4	10	70	8	76	164
sp.5	0	1	2	2	5
sp.6	0	0	0	2	2
Anyphaenidae					
sp.1	4	1	0	0	5
sp.2	0	0	0	33	33
sp.3	0	0	0	73	73
sp.4	0	0	0	61	61
sp.5	0	0	0	3	3
sp.6	0	0	0	2	2
sp.7	0	0	0	5	5
sp.8	0	0	0	2	2
sp.9	0	0	0	12	12
Amaurobiidae					
sp.1	64	56	3	5	128
sp.2	0	17	0	0	17
sp.3	0	6	0	4	10
Dyctinidae					
sp.1	15	4	0	3	22
sp.2	9	7	0	13	29
sp.3	5	6	0	10	21
sp.4	4	6	0	146	156
Gnaphosidae					
sp.1	79	37	6	4	126
sp.2	0	14	2	11	27
sp.3	0	15	0	19	34
sp.4	0	46	0	127	173
Theridiidae					
sp.1	9	9	2	41	61
Thomisidae					
sp.1	0	0	2	0	2
Mimetidae					
sp.1	0	0	3	0	3
Total	425	524	640	967	2556

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