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Community spiders in lemon crops (*Citrus limon*), conventional and abandoned management, Montevideo, Uruguay

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SUMMARY

Spiders are generalist predators during all stages of their life and effective natural enemies of phytophagous insects in almost all terrestrial ecosystems. However, the number of spiders can drastically reduce in monocultures, due to different farming practices. The citrus crops have an architectural physiognomy favoring the formation of refuges and microhabitats, which determine the diversity of spiders, together with agricultural practices. We analyze the spider's fauna with different agricultural practices in abandoned crop (AC) *vs*. conventional crop (CC). AC was the most abundant (n= 4202, 19 families) with respect to CC (n= 2567, 24 families). During the stages of crop development, in both farming systems increased amount of spiders was observed during the curdling (November), fruit formation-1 (December) and fruit formation-2 (January). The predominance of juveniles over adults in AC was 79.3% (n= 955) and 85.9% (n=600) in CC. The richness in AC was 121 species and 100 species in CC. The Margalef and Shannon-Wiener indices indicated a high diversity in both agricultural systems, being greater CC. The spider´s guild most abundant in AC and CC were the ground hunter's runners (37.38%, 30.34%), the orb web weavers (24.81%, 24.11%) and the wandering irregular sheet web weavers (16.33%, 22.83%). The ground hunters runners guild, showed a greater abundance and species richness in both agricultural systems. The greatest dominance of species according to Simpson indices was represented by the weavers of orb web weaver's guild in AC and CC. The greatest diversity observed according to the Margalef and Shannon-Wiener indices', in AC corresponded to the stalkers hunter guild, while for CC, the ground hunters runners. This type of study attempts to raise awareness among agricultural producers, to reduce the indiscriminate use of pesticides and to promote the incorporation of other plants, such as ground cover and natural shelters for spiders and other natural enemies.

Keywords: Spiders, Lemon Crops (*Citrus Limo n*)**,** Diversity, Agroecosystems, Natural Enemies.

INTRODUCTION

Spiders (Arachnida, Araneae) are arthropods that are generalist predators during all stages of their life, and effective natural enemies of phytophagous insects in almost all terrestrial ecosystems (SPECHT & DONDALE, 1960; TURNBULL, 1973; FOELIX, 2010). The great voracity together with the abundance, dispersal capacity and colonization in different agroecosystems, makes them biological control agents for pest insects (SUNDERLAND, 1999; BENAMÚ, 1999; BENAMÚ & AGUILAR, 2001; SYMONDSON *et al.*, 2002; MALONEY *et al.*, 2003; PEARCE *et al.*, 2004; JACAS *et al.* 2006; CAVE *et al.*, 2008; GHAVAMI, 2008; VIERA & BENAMÚ, 2009; BENAMÚ *et al.*, 2017), being a dominant component among the predatory arthopods (SUNDERLAND & GREENSTONE, 1999).

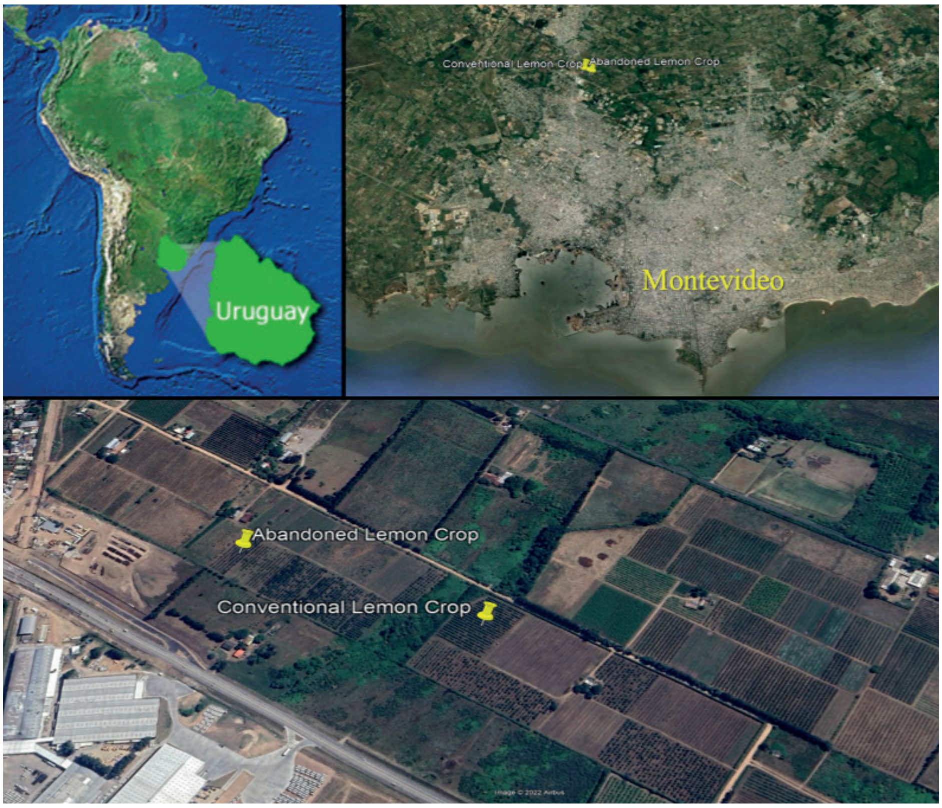
The abundance of specimens and the number of species of spiders would be related to the diversity of vegetation associated with the crop, depending on the type of agricultural system. (FEBER *et al.*, 1998; BENAMÚ, 2001). According to RYPSTRA *et al.* (1999), the diversity and density of the spider community is associated with the structural complexity of the environment, plants associates of different physiognomy, will offer different structures or microhabitats (VIERA *et al.*, 1996; BENAMÚ, 2004). Citrus crops have a physiognomy that favors the formation of shelters and microhabitats, which determine the diversity of spiders (RIECHERT & LOCKLEY, 1984; BREENE *et al.*, 1993); being able to colonize and select habitats, responding positively to greater structural complexity (RINALDI, 1998). The physiognomy changes with the “vigour” and the phonological stage of the plants (BENAMÚ, 1999, 2000, 2004), altering efficiency and relative preference in preys capture (SYMONDSON *et al.*, 2002). In Uruguay the cultivation of citrus has a commercial importance, and it´s usual management could affect potential natural pest controllers, such as spiders; being necessary analyze the spider community in citrus with different agricultural practices. We compare the abundance, diversity and species richness of spiders between a lemon crops with conventional practice, with another abandoned, throughout the different stages of crop development.

MATERIALS AND METHODS

Area of study

Conducted in a crop field lemon (Montevideo, Uruguay), with a total area of 35 ha., a conventional agricultural system predominated, with plants of 16 years old (34°51’53.6” S, 56°16’51.2” W) and another of 2 ha, characterized by the presence of abandoned lemon trees (34°51’52.8”S, 56°17’09.7”W), without management or exploitation of the crop for 5 years, with 19 year-old plants, separated from the rest of the crops (0.3 km) by a vegetable curtain of acacias (*Acacia longifolia*) (Fig. 1)

Figure 1. Location of the study area of lemon crops.



Source: Google Earth (2022).

Collecting spiders

Samples were taken from November 2001 to November 2002, in an area of 1.0 ha with 417 trees per agricultural system: abandoned crop (AC) and conventional crop (CC). The spiders samples were linked to the different stages of the lemon crop went through: manual pruning, sprouting, flowering, curdling (onset of ovarian growth), fruit-1 (15 – 20mm in length), fruit-2 (25-35 mm in length) fruit-3 (45-60 mm in length), fruit ripening, harvest (66 mm in length and upwards). For the manual collection, 10 plants were taken at random for each agricultural system; all samples were fixed in 75° alcohol. The collection of spiders on the plants took place between 9:00h and 15:00h, to minimize the effects of migration to other strata or shelters before sunset (LILJESTHRÖM *et al.*, 2002).

The collection with pitfall traps consisted of 500 ml glasses with a saturated saline solution + detergent, 10 m apart for a period of 15 days. The taxonomic determination of spiders were performed using the identification keys of DONDALE (1990), DIPPENAAR-SCHOEMAN & JOCQUÉ (1997), UBICK *et al.* (2005) and BENAMÚ (2007). The specimens of each sample were deposited in the collection of the Faculty of Sciences of the Universidad de la República

(Montevideo, Uruguay). For the classification at guild level, it was taken into account the following authors UETZ *et al.* (1999), DIAS *et al.* (2010) and CARDOSO *et al.* (2011).

Statistical Analysis

A estimate of species richness was performed using nonparametric estimators (first order Jackknife, second order Jackknife, Chao-1 and Chao-2) using Stimates v.8.0 (COLWELL, 2010). The choice of the estimator that best represents the species richness was based on the observation of the curve with the best yield and a greater tendency to stability. (TOTI *et al.*, 2000). The diversity of each system was determinate by applying the Shannon-Wiener diversity index (H'), based on the proportion of species abundance, based on the ratio of abundance of species, of the uniformity index Pielou (J'), expressed by the relationship between observed diversity and maximium expected diversity, and the Margalef´s index, based on the numerical distribution of the individuals of the different species as a function of the number of individuals existing in the analyzed sample (MAGURRAN, 1988). To assess whether there are significant differences between agricultural systems, it was calculated through the *t* test *Hutcheson* (MAGURRAN, 1988). To evaluated patterns in araneofauna composition among agricultural systems, we used the Sørensen similarity coefficient with PAST 3.5 (ØYVIND, 2019).

RESULTS

Composition of spider communities

6769 spiders divided into 24 families and 137 species were collected in both agricultural systems. AC presented the highest number of spiders (n = 4202, 19 families) compared to CC (n = 2567, 24 families) (Table 1). Manual spider collection in AC was higher (1205 individuals) than CC (698 individuals). A greater abundance was observed in both agricultural systems during the months of November (curdling), December (fruit-1) and January (fruit-2), with the most abundant shared species: *Achaearanea hirta* (Theridiidae), *Parawixia* sp., *Araneus lathyrinus* (Araneae), *Clubiona* sp. (Clubionidae), *Xiruana* sp.1, *Xiruana* sp.2, *Aysha* sp. 1 (Anyphaenidae), *Misumenops* sp.1 (Thomisidae), *Metaltella* sp.1 (Amphinectidae). The predominance of juveniles over adults in the AC was 79.3% (n=955) and 85.9% (n=600). In adults the proportion of females and males was higher in the AC (14% and 6.8%) than in CC (11% and 3.3%), while the proportion of juveniles was increased from March to July, observing its highest peak in October for both agricultural systems compared to adults (Fig. 2).

Table 1. Composition of guilds, families and species of spiders in the lemon crop (*Citrus limon*) in Montevideo, Uruguay. CA: abandoned crop, CC: conventional crop.

Guilds	Families	Species / Morphospecies	CA Manual (%)	CC Traps (%)	Total (%)	Manual (%)	Traps (%)	Total (%)
Orb web weavers	Araneidae	*Araneus lathyrinus*	62.74	0.10	18.06	60.60	0.21	16.63
	Araneidae	*Araneus* sp.1				0.43		0.12
	Araneidae	*Araneus sp.2*				0.14		0.04
	Araneidae	*Argiope* sp.					0.05	0.04
	Araneidae	*Cyclosa* sp.				0.14		0.04
	Araneidae	*Micrathena ucayali*	0.25		0.07			
	Araneidae	*Parawixia audax*	0.75	0.07	0.26	2.15	0.05	0.62
	Araneidae	*Parawixia* sp.		0.03	0.02			
	Araneidae	Morfo sp.1	0.17		0.05	0.14		0.04
	Araneidae	Morfo sp.2	0.08		0.02	0.14		0.04
	Tetragnathidae	*Glenognatha lacteovittata*		9.68	6.90		8.99	6.54
	Tetragnathidae	*Leucauge* sp.	0.08		0.02			
Irregular web weavers	Pholcidae	*Physocyclus* sp.		0.03	0.02		0.05	0.04
	Scytodidae	*Scytodes thoracica*				0.29	0.11	0.16
	Theridiidae	*Achaearanea hirta*	0.83	0.20	0.38	3.58	0.21	1.13
	Theridiidae	*Achaearanea* sp.1	2.49		0.71			
	Theridiidae	*Achaeatanea* sp.2	0.33		0.10	0.43		0.12
	Theridiidae	*Achaeranea* sp.3	1.24		0.36	0.43	0.05	0.16
	Theridiidae	*Achaeranea* sp.4	0.17		0.05			
	Theridiidae	*Anelosimus ethicus*	1.24		0.36			
	Theridiidae	*Anelosimus studiosus*	2.57		0.74	0.57		0.16
	Theridiidae	*Argyrodes nephilae*	0.33		0.10	1.72	0.05	0.51
	Theridiidae	*Dipoena cordiformis*		0.80	0.57		0.11	0.08
	Theridiidae	*Euryopis pumicata*		2.77	1.98		0.43	0.31
	Theridiidae	*Euryopis* sp.1		0.03	0.02			
	Theridiidae	*Euryopis* sp.2		1.17	0.83		0.05	0.04
	Theridiidae	*Theridion calcynatum*	0.91		0.26	0.57		0.16
	Theridiidae	*Theridion frondeum*	0.50		0.14	0.43		0.12
	Theridiidae	*Theridion* sp.1	0.08	0.03	0.05	0.14		0.04
	Theridiidae	*Theridion* sp.2	0.08		0.02	0.14		0.04
	Theridiidae	*Theridion* sp.3	0.08		0.02			
	Theridiidae	*Pholcomma* sp.		0.03	0.02		0.11	0.08
	Theridiidae	Morfo sp.1					0.05	0.04
	Titanoecidae	*Goeldia* sp.		1.23	0.88	0.14	6.90	5.06

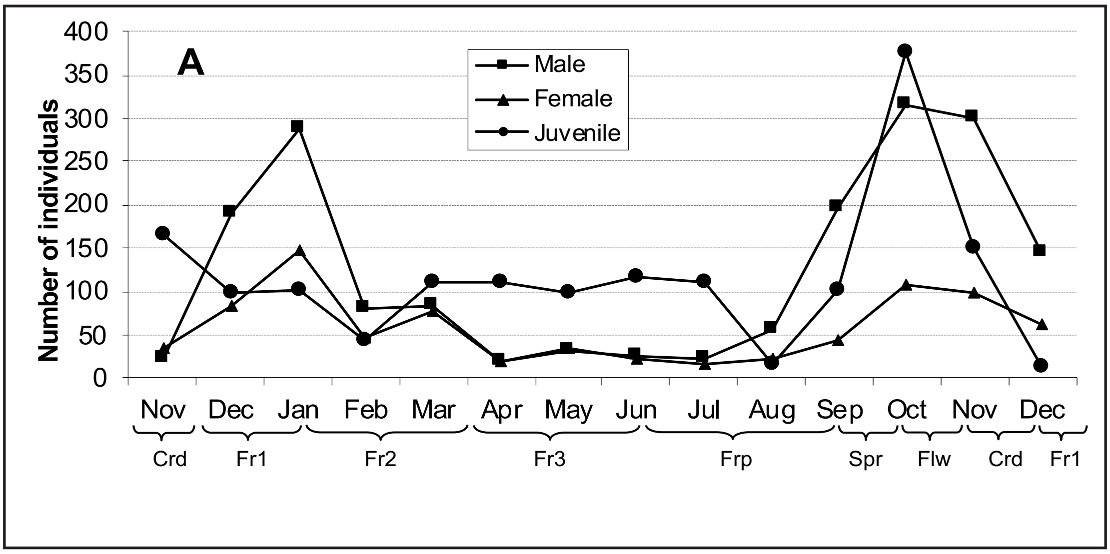
Guilds	Families	Species / Morphospecies	CA Manual (%)	CC Traps (%)	Total (%)	Manual (%)	Traps (%)	Total (%)
Wandering irregular sheet web weavers	Linyphiidae	*Drapetisca alteranda*	0.33	11.08	8.00	0.14	5.46	4.01
	Linyphiidae	*Erigone* sp.1		0.03	0.02		0.11	0.08
	Linyphiidae	*Erigone* sp.2		1.10	0.79		3.58	2.61
	Linyphiidae	*Erigone* sp.3					0.37	0.27
	Linyphiidae	*Erigone* sp.4		7.91	5.64		16.53	12.04
	Linyphiidae	*Lepthyphantes* sp.1		0.03	0.02		0.59	0.43
	Linyphiidae	*Lepthyphantes* sp.2					0.05	0.04
	Linyphiidae	*Lepthyphantes* sp.3		0.03	0.02		0.11	0.08
	Linyphiidae	*Linyphia* sp.1		0.03	0.02			
	Linyphiidae	*Meioneta* sp.1		0.03	0.02		0.43	0.31
	Linyphiidae	Morfo sp.1	0.17	2.14	1.57	0.14	3.48	2.57
	Linyphiidae	Morfo sp.2		0.07	0.05		0.05	0.04
	Linyphiidae	Morfo sp.3		0.13	0.10		0.48	0.35
	Linyphiidae	Morfo sp.4	0.08		0.02			
	Linyphiidae	Morfo sp.5		0.03	0.02			
	Linyphiidae	Morfo sp.6		0.03	0.02			
Sheet web weavers	Amaurobiidae	*Amaurobius* sp.1		0.27	0.19	0.57	1.93	1.56
	Amaurobiidae	*Amaurobius* sp.2	0.08	0.07	0.07	0.14	0.43	0.35
	Amphinectidae	*Metaltella* sp.1	1.99	0.20	0.71	7.02	0.96	2.61
	Amphinectidae	*Metaltella* sp.2					0.05	0.04
	Hahniidae	*Antistea* sp.	0.08	3.50	2.52		0.86	0.62
	Hahniidae	*Neoantistea* sp.		0.43	0.31		0.11	0.08
Trap door	Actinopodidae	*Actinopus* sp.		0.03	0.02		0.16	0.12
Ambush hunters	Philodromidae	*Thanatus* sp.1					0.16	0.12
	Thomisidae	*Misumena vatia*	0.08		0.02			
	Thomisidae	*Misumena* sp.	0.08		0.02			
	Thomisidae	*Misumenoides* sp.1		0.43	0.31		0.21	0.16
	Thomisidae	*Misumenoides* sp.2		0.67	0.48		0.21	0.16
	Thomisidae	*Misumenoides* sp.3	0.25		0.07			
	Thomisidae	*Misumenops* sp.1	0.58	0.03	0.19	1.00		0.27
	Thomisidae	*Misumenops* sp.2		0.03	0.02		0.05	0.04
	Thomisidae	*Misumenops* sp.3		0.10	0.07			
	Thomisidae	*Misumenops* sp.4	1.99		0.57	0.14		0.04
	Thomisidae	*Misumenops* sp.5		0.03	0.02			

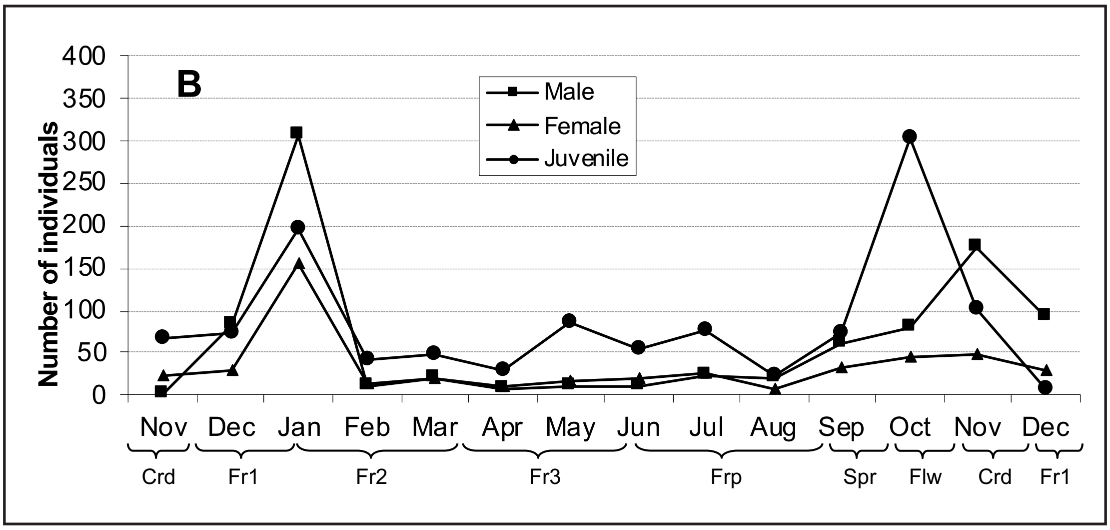
Guilds	Families	Species / Morphospecies	CA Manual (%)	CC Traps (%)	Total (%)	Manual (%)	Traps (%)	Total (%)
Stalker hunter	Oxyopidae	*Oxyopes* sp.	0.08	0.17	0.14		0.05	0.04
	Salticidae	*Evophris* sp.		0.03	0.02	0.43	0.05	0.16
	Salticidae	*Lyssomanes* sp.	0.58	0.07	0.21			
	Salticidae	*Peckhania* sp.		0.17	0.12		0.11	0.08
	Salticidae	*Phlegra* sp.1					0.27	0.19
	Salticidae	*Plexipus* sp.1	0.33		0.10	0.14		0.04
	Salticidae	*Plexipus* sp.2		0.03	0.02	0.29	0.05	0.12
	Salticidae	*Plexipus* sp.3	0.08	0.10	0.10	0.14	0.05	0.08
	Salticidae	Morfo sp.1					0.11	0.08
	Salticidae	Morfo sp.2	0.08	0.30	0.24	2.44	0.86	1.29
	Salticidae	Morfo sp.3		0.17	0.12		0.11	0.08
	Salticidae	Morfo sp.4		0.07	0.05			
	Salticidae	Morfo sp.5	0.17		0.05	0.14		0.04
	Salticidae	Morfo sp.6		0.03	0.02			
	Salticidae	Morfo sp.7		0.10	0.07		0.11	0.08
	Salticidae	Morfo sp.8		0.13	0.10			
	Salticidae	Morfo sp.9	0.08	0.03	0.05			
	Salticidae	Morfo sp.10	0.08	0.03	0.05			
	Salticidae	Morfo sp.11	0.08		0.02			
	Salticidae	Morfo sp.12	0.25		0.07	0.14	0.05	0.08
	Salticidae	Morfo sp.13		0.03	0.02			
	Salticidae	Morfo sp.14		0.03	0.02			
	Salticidae	Morfo sp.15		0.03	0.02		0.05	0.04
Foliage hunter runners	Anyphaenidae	*Anyphaena* sp.1	0.33	0.07	0.14		0.96	0.70
	Anyphaenidae	*Anyphaena* sp.2	0.17	0.03	0.07	0.14	0.05	0.08
	Anyphaenidae	*Aysha prospera*	2.07	0.33	0.83	2.58	0.54	1.09
	Anyphaenidae	*Aysha* sp.1	1.08	0.13	0.40	1.72	0.48	0.82
	Anyphaenidae	*Aysha* sp.2		0.03	0.02			
	Anyphaenidae	*Xiruana* sp.1	4.90	0.17	1.52	5.30	0.05	1.48
	Anyphaenidae	*Xiruana* sp.2	4.56	0.03	1.33	3.44	0.05	0.97
	Anyphaenidae	*Wulfila* sp.	2.49	0.13	0.81		0.11	0.08
	Anyphaenidae	*Morfo* sp.1		0.07	0.05			
	Anyphaenidae	*Morfo* sp.2		0.03	0.02			
	Anyphaenidae	*Morfo* sp.3	0.00	0.10	0.07			
	Anyphaenidae	*Morfo* sp.4	0.08		0.02			
	Clubionidae	*Agroeca* sp.1		0.03	0.02			
	Clubionidae	*Clubiona* sp.1	1.83		0.52	1.29	0.21	0.51
	Clubionidae	Morfo sp.1					0.16	0.12
	Clubionidae	Morfo sp.2		0.07	0.05		0.05	0.04
	Clubionidae	Morfo sp.3		0.17	0.12			
	Segestridae	*Segestria* sp.1				0.14		0.04
	Sparassidae	*Heteropoda* sp.1				0.14		0.04

Guilds	Families	Species / Morphospecies	CA Manual (%)	CC Traps (%)	Total (%)	Manual (%)	Traps (%)	Total (%)
Ground hunter runners	Corinnidae	*Castianeira* sp.1		1.97	1.40		0.37	0.27
	Corinnidae	*Castianeira* sp.2		1.60	1.14		0.27	0.19
	Corinnidae	*Castianeira* sp.3		5.11	3.64		1.28	0.93
	Corinnidae	*Falconina* sp.1		5.01	3.57		4.55	3.31
	Corinnidae	*Falconina* sp.2		0.23	0.17		0.11	0.08
	Corinnidae	Morfo sp.1		0.27	0.19		0.27	0.19
	Corinnidae	Morfo sp.2		0.03	0.02			
	Ctenidae	*Asthenoctenus* sp.		0.77	0.55		1.07	0.78
	Ctenidae	*Ctenus ctenіatus*		0.20	0.14		0.16	0.12
	Ctenidae	Morfo sp.1		0.23	0.17		0.05	0.04
	Ctenidae	Morfo sp.2		0.13	0.10		0.05	0.04
	Dysderidae	*Dysdera crocata*		0.13	0.10		0.54	0.39
	Gnaphosidae	*Drassodes* sp.		0.03	0.02		0.05	0.04
	Gnaphosidae	*Drassyllus frigidus*		0.47	0.33		0.86	0.62
	Gnaphosidae	*Drassyllus* sp.1		0.27	0.19		0.05	0.04
	Gnaphosidae	*Drassyllus* sp.2		1.40	1.00	0.14	3.69	2.73
	Gnaphosidae	*Eilica* sp.		0.23	0.17		0.16	0.12
	Lycosidae	*Aulonia* sp.		0.07	0.05		4.71	3.43
	Lycosidae	*Diapontia* sp.		0.10	0.07			
	Lycosidae	*Lycosa carbonelli*		0.47	0.33		0.11	0.08
	Lycosidae	*Lycosa poliostoma*		0.10	0.07			
	Lycosidae	*Lycosa thorelli*		2.87	2.05		10.11	7.36
	Lycosidae	*Lycosa* sp.		1.03	0.74		0.91	0.66
	Lycosidae	*Schizocosa mallitiosa*		0.50	0.36		7.76	5.65
	Lycosidae	Morfo sp.1		28.90	20.61		4.44	3.23
	Lycosidae	Morfo sp.2		0.30	0.21			
	Lycosidae	Morfo sp.3					0.05	0.04

Source: Author (2022).

Figure 2. Total individuals collected by sex and stage of development in the months and phenological stages of lemon crop (*Citrus limon*) in Montevideo, Uruguay. A: abandoned crop, B: conventional crop.





Br: sprouting, Fl: flowering, Qj: curdling, Fr1: fruit formation-1, Fr2: fruit formation-2, Fr3: fruit formation-3, Md: fruit ripening.

Source: Author (2022).

The collection of spiders with pitfall traps in AC was more abundant (2997 individuals) that CC (1869 individuals), with a greater number during November (curdling), December (fruit-1), and January-February (fruit-2). The species shared by both were: *Drapetisca alteranda*, *Erigone* sp.4, *Erigone* sp.2, Morfo sp.3, (Linyphiidae); *Glenognatha lacteovittata* (Tetragnathidae); *Lycosa thorelli*, *Pardosa* sp.1 (Lycosidae); *Drassyllus* sp.2 (Gnaphosidae); *Clubiona* sp.1 (Clubionidae); *Falconina* sp.1 (Corinnidae); *Asthenoctenus* sp. (Ctenidae); *Goeldia* sp. (Titanoecidae). Adult's spiders predominated in AC with 78% (2337 individuals) than CC with 68% (1277 individuals). The highest proportion of males was notable (56.5% AC, 47% CC) with respect to juveniles (22% AC, 32% CC), as in females (21.5% in both agricultural systems).

The predominant families in both agricultural systems were Lycosidae, Araneidae and Linyphiidae. Araneidae was abundant in manual collection and rare in pitfall traps, with a predominance of juvenile instar. In pitfall traps, the Lycosidae, Linyphiidae and Tetragnathidae were predominant, being mostly male individuals. The family Actinopodidae (Mygalomorphae) was captured only in pitfall traps, mostly in CC, with males registered. In the collection with pitfall traps, a greater number of adult individuals were captured in both agriculture systems, reaching 78% for AC and 68.3% in CC. Males predominated in this type of sampling.

Richness, diversity of species and similarities

The richness in AC was 121 species and in CC 100 species. During manual collection in AC 49 species (40.5% of the total species) were captured, while in CC 41 species (41%).

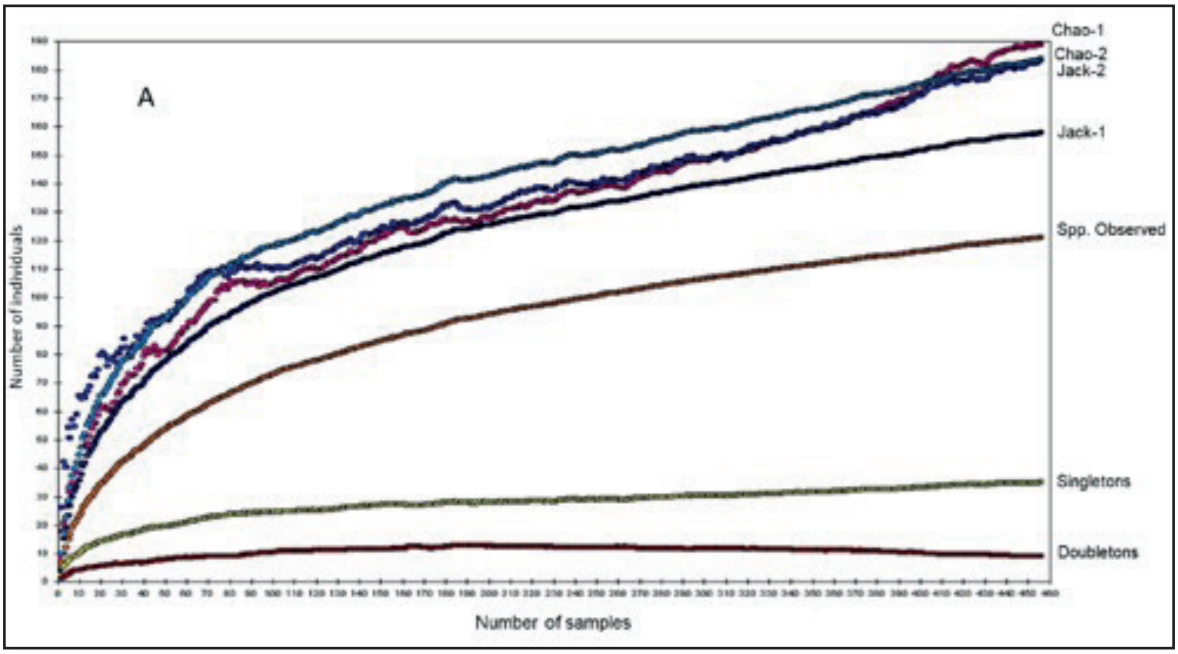
With pitfall traps in AC 95 species were captured (78.5% of the total number of species) and 83 species (83%) in CC.

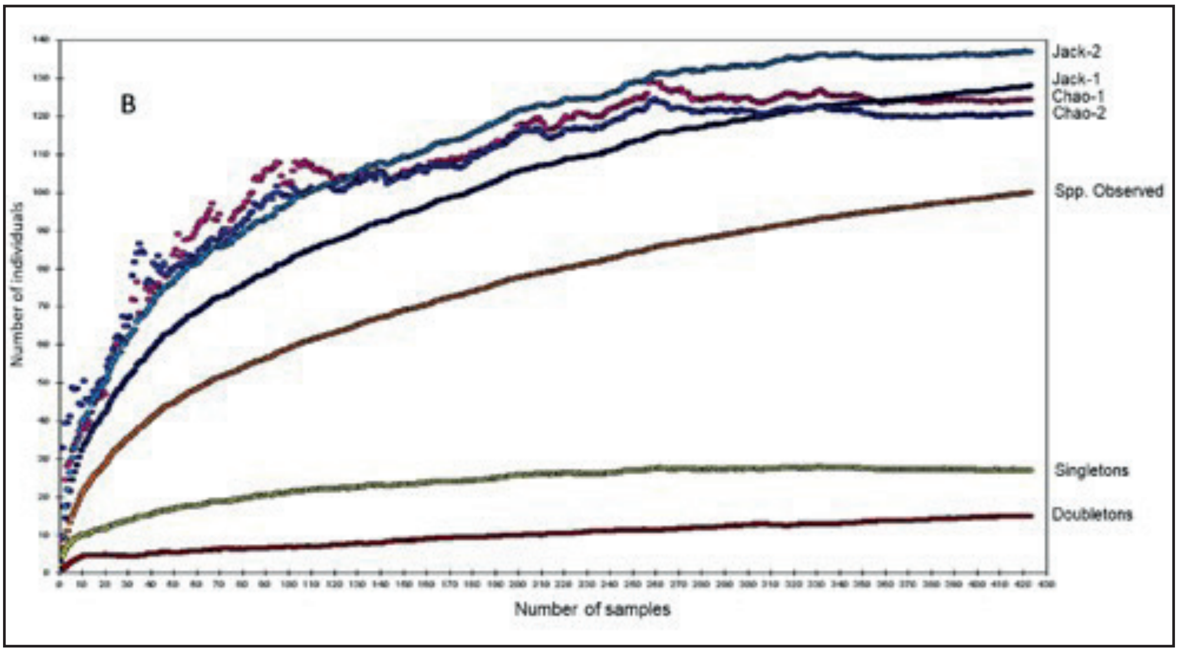
The curves corresponding to the indices of nonparametric richness (Chao 2, Jacknife-1, Jacknife-2 and Chao-1) were not asymptotic for CC and AC (Fig. 3), indicating that even a larger number of species need to register to complete the inventory of spiders. The observed species curve seems to reach the asymptote with a lower sampling effort in CC than AC. Fewer singletons and doubletons were recorded in CC than in AC. The singletons in CC, from sample 330 remained asymptotic while the doubletons increased, in AC the singletons increased and the doubletons decreased (Fig. 3).

The Simpson index indicated a greater dominance in AC, which was consistent with the lower equity indicated by the Pielou index, indicating a more uniform distribution of the abundance of the different species. The Margalef and Shannon-Wiener index indicated a high diversity in both agricultural systems, being more noticeable in CC (Table 2), with significant differences between both agricultural systems, with the *Hutcheson t* test ($t_{H'} = 4.66$; $df = 6134, 5$; $P < 0.005$).

The value of the similarity index was high between the two agricultural systems (Sørensen = 78.2%). Both agricultural systems shared 84 species, the most abundant being: *Araneus lathyrinus* (Araneidae); *Pardosa* sp.1, *Lycosa thorelli* (Lycosidae); *Drapetisca alteranda*, *Erigone montevidensis* (Linyphiidae); *Glenognatha lacteovittata* (Tetragnathidae); *Castianeira* sp3, *Falconina* sp.1 (Corinnidae); *Antistea* sp. (Hahniidae); *Euryopis pumicata* (Theridiidae).

Figure 3. Species accumulation curves of the observed richness and estimated by non-parametric estimators, singletons and doubletons curves in lemon crops (*Citrus limon*). A: abandoned crop, B: conventional crop.





Source: Author (2022).

Table 2. Diversity estimators in two agricultural systems of lemon crop (*Citrus limon*) in Montevideo, Uruguay. CA: abandoned crop, CC: conventional crop.

	AC	CC
Specie´s richness	121	100
CHAO 1	183 ± 28	120 ± 10
CHAO 2	189 ± 33	124 ± 12
Jacknife 1	157 ± 6	127 ± 6
Jacknife 2	183 ± 0	136 ± 0
Singletons	34	27
Doubletons	10	15
Simpson	0.095	0.066
Pielou	0.647	0.709
Margalef	12.611	14.383
Shannon-Wiener	3.101	3.267

Source: Author (2022).

The greatest species richness was collected through pitfall traps, with a greater number of species in AC. The greatest species dominance, according to Simpson index, was found with manual sampling in AC. The greatest species equity was obtained with pitfall traps in CC, as well as the greatest diversity according to Margalef and Shannon-Wiener index (Table 3).

The similarity index Sørensen with pitfall traps from both agricultural systems reached 76.4%, while the manual sampling was lower (Sørensen = 67.4%).

Table 3. Diversity estimators with two types of samplings, in two agricultural systems of the lemon crop (*Citrus limon*) in Montevideo, Uruguay. CA: abandoned crop, CC: conventional crop.

	AC			
	Manual	**Traps**	**Manual**	**Traps**
Specie´s richness	49	95	41	83
Simpson	0.402	0.121	0.379	0.07
Pielou	0.469	0.621	0.487	0.705
Margalef	6.766	10.885	6.108	11.866
Shannon-Wiener	1.825	2.836	1.808	3.117

Source: Author (2022).

- Guild composition

The spider families present in both agricultural systems of lemon crops were grouped into nine guilds according to their functional attributes (Table 1). The most abundant guilds in AC and CC were the ground hunter's runners (37.38%, 30.34%), the orb web weavers (24.81%, 24.11%) and the wandering irregular sheet web weavers (16.33%, 22.83%) (Fig. 4).

In both agricultural systems, the orb web weaver's guilds were abundant, highlighting the species *Araneus lathyrinus* (Araneidae) and *Glenognatha lacteovittata* (Tetragnathidae). The irregular web weavers, presented similar proportion in both agricultural systems (Fig. 4), with a higher representation in AC of *Euryopis pumicata* (Theridiidae), while for CC it was *Goeldia* sp. (Titanoecidae).

The wandering irregular sheet web weaver's guild, in both agricultural systems was represented by family Linyphiidae (14 species in AC and 12 in CC).

The sheet web weaver's guild represented by Amphinectidae y Hahniidae in both agricultural systems. In AC, the most abundant species was *Antistea* sp. (Hahniidae), while CC it was *Metaltella* sp.1 (Amphinectidae).

Trap door spider's guild, the only representative species *Actinopus* sp. (Mygalomorphae, Actinopodidae) presented low abundance in both agricultural systems (Fig. 4).

The ambush hunter spiders, the most abundant species were *Misumenops* sp.4 (Thomisidae) in AC and *Misumenops* sp.1 in CC; the Philodromidae family was only present in CC with the *Thanatus* sp.

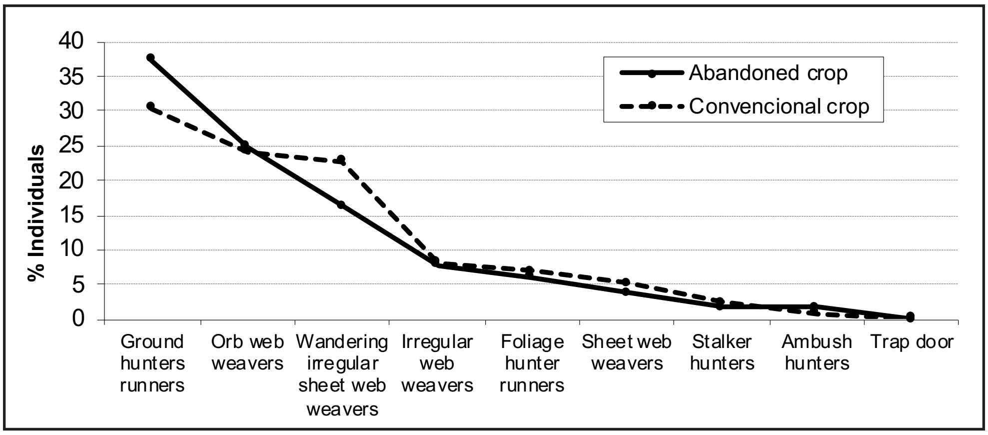
The stalker hunter spiders showed a low proportion in AC while in CC it was high; Salticidae was the most representative family, being higher in CC.

The foliage hunter runner, Anyphaenidae was the dominant family of this guild for both agricultural systems, notable for its abundance *Xiruana* sp.1 and *Xiruana* sp.2.

The spider´s guild, with the highest percentage of individuals and also the highest number of representative families were the ground hunters runners, where the most numerous family in both agricultural systems was Lycosidae, *Pardosa* sp.1 in AC and *Schizocosa mallitiosa* in CC.

The ground hunters runners guild where showed a greater abundance and species richness in both agricultural systems. The greatest dominance of species according to Simpson index was represented by the orb web weaver's guild in AC and CC. The greatest diversity observed according to the Margalef and Shannon-Wiener index, AC corresponded to the stalkers hunters' guild, while for CC, the ground hunter's runners. According to the statistical analysis of comparative diversity between the two agricultural systems, guilds unique spiders no significant differences were ambushed hunters and foliage hunter runners (Table 4).

Figure 4. Proportion of relative abundance in the different spider guilds, in two agricultural systems of lemon crop (*Citrus lemon*) in Montevideo, Uruguay.



Source: Author (2022).

Table 4. Diversity estimators for spider guilds in two agricultural systems of lemon crop (*Citrus limon*) in Montevideo, Uruguay. AC: abandoned crop, CC: conventional crop.

	N		**S**		**Simpson**		**Margalef**		**H'**		
Guild	**CA**	**CC**	**CA**	**CC**	**CA**	**CC**	**CA**	**CC**	**CA**	**CC**	***t Hutcheson***
I. Orb web weavers	1069	620	9	9	0.578	0.549	1.147	1.244	0.698	0.791	t= -2.13; g.l.=1176 P<0.05
II. Irregular web weavers	320	213	20	18	0.125	0.398	3.294	3.171	2.374	1.543	t= -7.29; g.l= 319 P<0.05
III. Wandering irregular sheet web weavers	686	586	14	12	0.371	0.336	1.991	1.726	1.211	1.448	t= -4.13; gl=1183 P<0.05
IV. Sheet web weavers	160	135	5	6	0.483	0.353	0.788	1.019	1.015	1.240	t= -2.23; g.l= 294 P<0.05
V. Trap-door	1	3	1	1	------	------	------	------	------	------	------
VI. Ambush huenters	75	20	10	6	0.219	0.230	2.085	1.669	1.747	1.595	t= 0.84; g.l= 41 P=0.403
VII. Stalkers hunters	68	61	21	14	0.077	0.314	4.740	3.162	2.772	1.806	t= 4.79; gl=95 P<0.05
VIII. Foliage hunter runners	253	153	16	12	0.164	0.163	2.711	2.187	2.054	1.976	t= 0.93; g.l= 370 P=0.349
IX. Ground hunters runners	1571	779	26	23	0.329	0.141	3.397	3.304	1.782	2.243	t= -8.98; gl= 2189 P<0.05

Source: Author (2022).

DISCUSSION

The family of species registered in this study represents 58.9% (CC) and 48.7% (AC) of all spider families reported for Uruguay (SIMÓ *et al.*, 2011). These percentages are considered important for the Uruguayan spider's community; if it is taken into consideration that specific areas of anthropic environments were surveyed.

It was striking the greater number of spider families in the conventional lemon crop than the abandoned crop. However, the differences of abundances varied individual or specific levels. According to JACAS *et al.* (2006), the citrus agroecosystem is known to support a large number of pests and natural enemies; the latter have different polyphagous habits and play an important role in the regulation of pets (MONZÓ *et al.*, 2009).

The largest proportion of adults spiders observed in both agricultural systems occurred during the months of December 2001- January 2002 and September 2002- November 2002, months that correspond to reproductive seasons and key stages in the phenology of the crop, such as the fruit-1 formation, sprouting, flowering, curdling and also a greater supply of prey.

According to MONZÓ *et al.* (2011**),** this year-round presence ensures the continued presence of predators even when it has not yet reached a pest, which helps prevents outbreaks of these. According to CAVE *et al.* (2008) y THAIR *et al.* (2011, 2015), biological control may be the most promising measure against citrus insect pests, being the spiders used in different parts of the world as natural predators of pests (MORRIS *et al.*, 1999; GHAVAMI, 2008; ZRUBECZ *et al.*, 2008).

The presence of males during manual sampling coincided with the phenological stages present in spring 2001- summer 2002, which would correspond to the sexual activity and mating of most spiders. The abundance of females and males, it would be related to the mating season. The presence of juveniles was constant in both agricultural systems, being abundant in the development of the lemon crop corresponding to spring (sprouting, flowering, curdling), capturing small prey; the dominance of juveniles on adults in manual sampling was notorious, which had already been reported by COSTA *et al.* (1991) and PÉREZ-MILES *et al.* (1999), in non-cultivated fields. Generally the spider fauna in cultivated fields, the juveniles are numerically dominant throughout the year (DEAN & STERLING, 1990; NYFFELER, 1999; NYFFELER *et al.*, 1994). According to SUTER (1999) and TOPPING (1999), this may represent a dispersion strategy, being very common at this stage of spider development (PEARCE *et al.*, 2005).

The abundance of adult spiders coincides with the periods of greatest abundance of phytophagous insects that can damage citrus crop (CACERES, 2006); such abundance and richness of spiders observed will suggest that during these seasons there are favorable environmental conditions of foraging and reproductive capacity.

In the collection with pitfall traps, higher species richness obtained than the manual collection for AC and CC, reaching almost double (96 and 83 *versus* 49 and 41 species, respectively). It should be considered that the richness depends on the number of individuals captured, which was 2.5 times higher in pitfall traps than manually. Despite this, it is clear that there was more diversity at the ground level; Margalef index values greater than 5.0 would indicate a high specific diversity (MAGURRAN, 1988).

The predominant species in manual collection included spiders that live on lemon plants and whose passage through the soil is limited or accidental (*Araneus lathyrinus (Araneidae)*, *Achaearanea hirta* (Theridiidae)) or spiders of low displacement *(Scytodes thoracica* (Scytodidae).

The abundance of spiders observed in abandoned crops may be due to the structural increase of the plants, which is consistent with FEBER *et al.*, (1998), as well as the variety of existing weeds; according to DUFFEY (1975), these contribute to the formation and structure of new habitats, regulate microclimates, and variety of biotopes. Thus, semi-natural habitats with host plant diversity and prey availability have shown to be an important factor in the conservation of spider species (BOGYA & MARKO, 1999; PFIFFNER & LUKA, 2003; SCHMIDT *et al.*, 2005; MONZO *et al.*, 2009, 2011). These new habitats change as the crop grows, modifying the preference and efficiency of prey capture of the different spider guilds (YSNEL & CANARD, 2000; BENAMÚ, 2001, 2010; SYMONDSON *et al.*, 2002; LILJESTHTRÖM *et al.*, 2002; ARMENDANO 2008). According to HALAJ *et al.*, (2000), there would be an association between weeds and the abundance of predators, being used as natural refuges, and collaborating with the diversity of spiders, thus favoring the survival, dispersal and colonization of the crop (BENAMÚ, 2001).

It is believed that the lower abundance and species richness in conventional farming may be due to the usually ongoing agricultural work in this crop field. Insecticide´s application, herbicides and mechanical alterations (pruning, defoliation, mowing, spraying, etc.), both of the lemon trees themselves and of the soil grasses, would represent direct sources of mortality for spider populations, as well as indirect ones, through modification of microhabitats, destruction of shelters, nests and egg-sacs (RIECHERT & LOCKLEY, 1984). In the short and medium term, it also represents a drastic impoverishment of the prey´s supplies.

The herbicide often used in traditional fields is glyphosate, and spiders can be directly affected (BENAMU *et al.*, 2010), or indirectly, by habitat modification, microclimatic conditions and available prey (HAUGHTON *et al.*, 1999). In this study, the harmful effects of glyphosate will be reflect in the low abundance of spiders in conventional cultivation, such as the weavers at ground level (Linyphiidae) and some hunters on the ground (Lycosidae, corinnidae), compared to abandoned fields. In general, and consisting with SYMONSON *et al.*, (2002), this herbicide appears to affect the structure of the vegetation, as well as the spider's mobility, dispersal, hiding or combining the location of the fabric and the accessibility of its prey. Studies related to the ecotoxicological effects of the herbicide glyphosate in weaver spiders would confirm the damage it produces directly and indirectly, on web building, prey capture, oviposition, fecundity, fertility, and postembryonic development (BENAMÚ *et al.*, 2010).

It was considered that the lower abundances and species richness in CC could be due to continuous agricultural work. The applications of insecticides, herbicides and mechanical alterations (pruning, defoliation, mowing, spraying fumigation, etc.), of the lemon trees and of weeds, would be direct and indirect sources of mortality for spider populations, due to modification of microhabitats (SYMONDSON *et al.*, 2002), microclimatic conditions, available prey (HAUGHTON *et al.*, 1999), destruction of shelters, nests and egg sacs (RIECHERT & LOCKLEY, 1984; BENAMÚ *et al.*, 2007, 2010, 2013).

The abundance of spiders in CC at pitfall traps during the month of January and February 2002 compared to AC would reflect disturbances in conventional cultivation. These disturbances are related to the application of different pesticides produced during this period, a characteristic of agricultural management that helps spiders fall into traps. If so, only at this time did the species of the herbaceous layer fall into the traps, making it difficult to recover in the following months.

Spiders found in CC as a unique species, could be considered as indicators of altered environments by certain agricultural managements (CLAUSEN, 1986). Thus, some spiders may be tolerant or resistant to certain pesticides used in commercial crops (OLSZAK *et al.*, 1992; MALONEY *et al.*, 2003). The spiders that could be tolerant to conventional practices were *Erigone* sp. 4 (Linyphiidae), *Goeldia* sp. (Titanoecidae), Amphinectidae and some Lycosidae such as *Schizocosa malitiosa*, *Lycosa thorelli* and *Aulonia* sp.1. *S. malitiosa* and *L. thorelli* are well known for their synanthropic adaptation, abundant in populated areas of southern Uruguay (COSTA & CAPOCASALE, 1984; COSTA, 1991). The most affected were Hahniidae; Thomisidae; *Drapetisca alteranda* (Linyphiidae); the species of *Castianeira* (Corinnidae); *Euryopis pumicata*, *Achaearanea* sp.1 and *Anelosimus studiosus* (Theridiidae), *Wulfila* sp., (Anyphaenidae) and *Pardosa* sp.1 (Lycosidae).

The ground hunter's runner spider's guild was the ones that contributed the greatest number of individuals to the total abundance. NYFFELER & SUNDERLAND (2003) suggest that this particularity could be due to the extensive diet observed in these spiders. In this guild, families with abundant individuals were verified, with Lycosidae being the one with the highest abundance within it and of the total of families determined in this study. The web spiders, represented mainly by the family Araneidae, were place in the second place of importance in comparison to the rest of the guilds present in both agricultural systems, being the most dominant. According to YOUNG & EDWARDS (1990), most of these families are found mainly at the level of the middle and upper strata of the plant. Its appearance was late in crop according to the season and the greater supply of prey, increasing in number and diversity. According to the eating habits of spiders, mainly insects, it could be said that these are the most abundant predators found in citrus crops, so it is essential to highlight their importance (AVALOS *et al.*, 2013). The attributes of spiders as indicators of ecological changes, studied by CHURCHILL (1997), conclude that they are ideal for these types of study and that they deserve to be considered in evaluations.

The presence of spiders as natural enemies in cultivable agroecosystems could be consuming prey in relation to their number, diversity and size, significantly reducing the number of phytophagous insects. This type of study attempts to raise awareness among agricultural producers, to reduce the indiscriminate use of pesticides and to promote the incorporation of other plants, such as ground cover and natural shelters for spiders and other natural enemies, which would benefit the health of their crops, its economy and the quality of the soil in the medium and long term.

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REFERENCES

ARMENDANO, A. 2008. Ecología y rol depredador de la araneofauna presente en agroecosistemas de importancia económica (trigo y alfalfa). Tesis doctoral. Facultad de Ciencias Naturales y Museo. Universidad Nacional de La Plata. Argentina.

AVALOS, G.; BAR, M.; OSCHEROV, E. & GONZÁLEZ, A. 2013. Diversidad de Araneae en cultivos de *Citrus sinensis* (Rutaceae) de la Provincia de Corrientes, Argentina. Rev. Biol. Trop. 61 (3): 1243 – 1260.

BENAMÚ, M. 1999. Estudio preliminar de la araneofauna presente en mandarina cultivada en Vitarte, Lima, Perú. Rev. Per. Ent. 41: 154-157.

BENAMÚ, M. 2000. La Influencia de dos sistemas agrícolas (Ecológico y Convencional) en la diversidad de arañas. Agrobiodiversidad en la Región Andina y Amazónica. Pp.: 305-319.

BENAMÚ, M. 2001. Observaciones sobre “crianza”, liberación y distribución de arañas en un huerto de manzano del valle de Mala, Lima, Perú. Rev. Per. Ent. 42: 211-217.

BENAMÚ, M. 2004. Estudio comparativo de la diversidad de arañas de un campo en abandono y un cultivo convencional de limonero (*Citrus limon* [L.] Burm.) en Rincón del Cerro, Montevideo, Uruguay. Dissertation, Universidad de la República, Facultad de Ciencias, Montevideo, Uruguay

BENAMÚ, M. 2007. Clave para la determinación de algunas familias de arañas (Araneae, Araneomorphae) del Uruguay. Bol. Soc. Zool. Uruguay, 16(2): 1-19.

BENAMÚ, M. & AGUILAR, P. 2001. Araneofauna presente en huertos de manzano del Valle de Mala, Lima, Perú. Rev. Per. Ent. 42: 199-210.

BENAMÚ, M. 2010. Composición y estructura de la comunidad de arañas en el sistema de cultivo de soja transgénica. Dissertation, Universidad Nacional de La Plata, Facultad de Ciencias Naturales y Museo, La Plata, Argentina

BENAMÚ, M.; SCHNEIDER, M. & SÁNCHEZ, N. 2010. Effects of the herbicide glyphosate on biological attributes of *Alpaida veniliae* (Araneae, Araneidae), in laboratory. Chemosphere 78: 871-876.

BENAMÚ, M.; SCHNEIDER, M.; GONZÁLEZ, A. & SÁNCHEZ, N. 2013. Short and long--term effects of three neurotoxic insecticides on biological and behavioural attributes of the orb-web spider *Alpaida veniliae* (Araneae, Araneidae): implications for IPM programs. Ecotoxicology 22:1155–1164

BENAMÚ, M.; LACAVA, M.; GARCÍA, L.; SANTANA, M. & VIERA, C. 2017. Spiders associated with agroecosystems: roles and perspectives. En: Behaviour and Ecology of Spiders. Contributios from the Neotropical Region. Ed.: Springer. Pp: 275 – 302.

BOGYA, S. & MARKO, V. 1999. Effect of pest management systems on ground-dwelling spider assemblages in an apple orchard in Hungary. Agric Ecosyst Environ 73:7–18

BREENE, R.; DEAN, D. & MEAGHER, R. 1993. Spiders and ants of Texas citrus groves. Florida entomologist 76(1): 168-70.

CÁCERES, S. 2006. Guía Práctica para la Identificación y el Manejo de las Plagas de Citrus. Programa de Reposicionamiento de la Citricultura Correntina, EEA INTA Bella Vista, Corrientes, Argentina.

CARDOSO, P.; PEKÁR, S.; JOCQUÉ, R. & CODDINGTON, J. 2011. Global Patterns of Guild Composition and Functional Diversity of Spiders. PLoS ONE 6(6): e21710. doi:10.1371/journal.pone.0021710.

CAVE, R.; FRANK, J.; COOPER, T. & BURTON, M. 2008. Mexican bromeliad weevil report. Flor. Coun. Bromel. Soc., Newsl., 28: 26-27.

CHURCHILL, T. 1997. Spiders as ecological indicators: an overview for Australia. Mem. Mus. Victoria 56: 331-337.

CLAUSEN, I. 1986. The use of spiders (Araneae) as ecological indicators. Bull. Br. Arachnol. Soc. 7: 83-86.

COLWELL, R. 2010. EstimateS: Statistical estimation of species richness and shared species from samples. Version 8.2. University of Connecticut, Connecticut, EE.UU (Disponible en línea: http://viceroy.eeb. uconn.edu/EstimateS).

COSTA, F. 1991. Fenología de *Lycosa malitiosa* Tullgren (Aranea, Lycosidae) como componente del criptozoos en Marindia, localidad costera del sur del Uruguay. Bol. Soc. Zoll. Uruguay, 2a época. 6: 8-21.

COSTA, F & CAPOCASALE, R. 1984*.* *Lycosa carbonelli* sp. nov., una etoespecie gemela, simpátrida de *Lycosa thorelli* (Keyserling) (Araneae, Lycosidae). J. Arachnol. 11(3): 423-431.

COSTA, F.; PÉREZ – MILES, F.; GUDYNAS, E.; PRANDI, L. & CAPOCASALE, R. 1991. Ecología de los arácnidos criptozoicos, excepto ácaros, de Sierra de las Animas (Uruguay). Ordenes y familias. Aracnol. 13/15: 1-41.

DEAN, D. & STERLING, W. 1990. Seasonal patterns of spiders captured in suction traps in eastern Texas. Southwestern Entomologist. 15(4): 399-412.

DIAS, S.; CARVALHO, L.; BONALDO, A. & BRESCOVIT, A. 2010. Refining the establishment of guilds in Neotropical spiders (Arachnida: Araneae). J. Nat. Hist. 44(3–4): 219-239.

DIPPENAAR-SCHOEMAN, A. & JOCQUÉ, R. 1997. African Spiders. An identification Manual. Plant Protection research Institute Handbook, nº 9. South Africa. 392 pp.

DONDALE, C. 1990. Soil Biology Guide. Litter Araneae (Araneida). Wiley-Interscience Publication. Chap. 17: 177-502.

DUFFEY, E. 1975. Habitat selection by spiders in man-made environments. Proc. 6th Int. Arachn. Congr. Pp.: 53-67.

FEBER, R.; BELL, J.; JOHNSON, P.; FIRBANK, L. & MACDONALD, D. 1998. The effects of organic farming on surface-active spider (Araneae) assemblages in wheat in southern England, UK. J. Arachnol.. 26: 190-202.

FOELIX, R. 2010. Biology of spiders. (Third Edition). Oxford University Press. 330pp.

Ghavami, S. 2008. The potential of predatory spiders as biological control agents of cotton pests in Tehran provinces of Iran. Asian J Expl Sci 22(3): 303-306

HALAJ, J.; CADY, A. & UETZ, G. 2000. Modular habitat refugia enhance generalist predators and lower plant damage in soybeans. Environ. Entomol. 29 (2): 383-393.

HAUGHTON, A.; BELL, J.; BOATMAN, N. & WILCOX, A. 1999. The effects of different rates of the herbicide glyphosate on spiders in arable field margins. J. Arachnol. 27:249-254.

JACAS, J.; URBANEJA, A. & VINUELA, E. 2006. History and future of introduction of exotic arthropod biological control agents in Spain: a dilemma? BioControl. 51:1–30.

LILJESTHRÖM, G.; MINERVINO, E.; CASTRO, D. & GONZÁLEZ, A. 2002. La comunidad de arañas del cultivo de soja en la provincia de Buenos Aires, Argentina. Neotropical Entomology 31 (2): 197-210.

MAGURRAN, A.1988. Ecological diversity and its measurement. Princeton UniversityPress. New Jersey, 179 pp.

MALONEY, D.; DRUMMOND, F. & ALFORD, R. 2003. Spider predation in agroecosystems: can spiders effectively control pest populations?. Maine agricultural and forest experiment station, the University of Maine. Technical bulletin 190, 32Pp.

MONZÓ, C.; MOLLA, O.; CASTAÑERA, P. & URBANEJA, A. 2009: Activity-density of *Pardosa cribata* in Spanish citrus orchards and its predatory capacity on *Ceratitis capitata* and *Myzus persicae*. BioControl 54: 393–402

MONZÓ, C.; MOLLÁ, O.; VANACLOCHA, P.; MONTÓN, H.; MELIC, A.; CASTAÑERA, P. & URBANEJA, A. 2011. Citrus-orchard ground harbours a diverse, well-established and abundant ground-dwelling spider fauna. Span. J. Agric. Res. 9(2): 606-616

MORRIS, T.; SYMONDSON, W.; KIDD, N. & CAMPOS, M. 1999. Las arañas y su incidencia sobre *Prays oleae* en el olivar. Bol. San. Veg. Plagas 25(4): 475-489

NYFFELER, M. 1999. Prey selection of spiders in the field. J. Arachnol. 27: 317-324.

NYFFELER, M.; STERLING, W. & DEAN, D. 1994. Insectivorous activities of spiders in United States field crops. J. Appl. Ent. 118: 113-128.

NYFFELER, M. & SUNDERLAND, K. 2003. Composition, abundance and pest control potential of spider communities in agroecosystems: a comparison of European and US studies. Agro. Ecosyst. Environ. 95: 579-612.

OLSZAK, R.; LUCZAK, J.; NIEMCZYK, E. & ZAJAC R. 1992. The spider community associated with apple trees under different pressure of pesticides. Ekol. Pol. 40(2): 265-286.

ØYVIND, H. 2019. PAST 3.25. Natural History Museum, University of Oslo, Noruega

PEARCE, S.; HEBRON, W.; RAVEN, R.; ZALUCKI, M. & HASSAN, E. 2004. Spider fauna of soybean crops in south-east Queensland and their potential as predators of *Helicoverpa* spp. (Lepidoptera: Noctuidae). Aust. J. Entomol. 43: 57-65.

PEARCE, S.; ZALUCKI; M. & HASSAN, E. 2005. Spider ballooning in soybean and non-crop areas of southeast Queensland. Agr. Ecosyst. Environ. 105: 273-281.

PÉREZ – MILES, F.; SIMÓ, M.; TOSCAZO, C. & USETA, G. 1999. La comunidad de Araneae criptozoicas del Cerro de Montevideo, Uruguay: un ambiente rodeado por urbanización. PHYSIS, Secc. C, 57-(132-133): 73-87.

PFIFFNER, L. & LUKA, H. 2003. Effects of low-input farming systems on carabids and epigeal spiders a paired farm approach. Basic Appl Ecol 4:117–127

RIECHERT, S. & LOCKLEY, T. 1984. Spiders as biological control agents. Ann. Rev. Entomol. 29: 299-320.

RYPSTRA, A.; Carter, P.; Balfour, R. & Marshall, S. 1999. Architectural features of agricultural habitats and their impact on the spider inhabitants. J. Arachnol. 27: 371-377.

SCHMIDT, M.; ROSCHEWITZ, I.; THIES, C. & TSCHARNTKE, T. 2005. Differential effects of landscape and management on diversity and density of ground-dwelling farmland spiders. J Appl Ecol 42:281–287

SPECHT, H. & DONDALE, C. 1960. Spider populations in New Jersey apple orchards. Jour. Econ. Ent. 53(5): 810-814.

SUNDERLAND, K. 1999. Mechanism underlying the effects of spiders on pest populations. J. Arachnol. 27: 308-316.

SUNDERLAND, K. & GREENSTONE, M. 1999. Summary and future directions for research on spiders in agroecosystems J. Arachnol. 27: 397-400.

SUTER, B. 1999. An aerial lottery: the physics of ballooning in chaotic atmosphere. J. Arachnol. 27: 281-293.

SYMONDSON, W.; SUNDERLAND, K. & GREENSTONE, M. 2002. Can generalist predators be effective biocontrol agents?. Annu. Rev. Entomol. 47: 561-594.

TAHIR, H.; BUTT, A.; NAHEED, R.; BILAL, M. & ALAM, I. 2011: Activity Density of Spiders Inhabiting the Citrus Field in Lahore, Pakistan. Pakistan J. Zool. 43(4): 683-688.

TAHIR, H.; NAZARAT, I.; NASEEM, S.; BUTT, A.; YAQOOB, R.; MUKHTAR, M. & SAMIULLAH, K. 2015. Seasonal dynamics of spiders and insect pests in citrus orchards of district Sargodha, Pakistan. Pakistan J. Zool. 47(6): 1673-1681

TOPPING, C. 1999. An individual – based model for dispersive spiders in agroecosystems: simulations of the effects of landscape structure. J. Arachnol. 27: 378-386.

TOTI, D.; COYLE, F. & MILLER, J. 2000. A structured inventory of Appalachian grass bald and heath bald spider assemblages and a test of species richness estimator performance. J. Arachnol. 28: 329-345.

TURNBULL, A. 1973. Ecology of the true spiders (Araneomorphae). Ann. Rev. Ent. 18: 305-348.

UBICK, D.; PAQUIN, P.; CUSHING, P. & ROTH, V. 2005. Spiders of North America: an identification manual. Amer. Arachn. Soc. 377 pp.

UETZ, G., HALAJ, J. & CADY, A. 1999. Guild structure of spiders in major crops. J. Arachnol. 27: 270-280.

VIERA, C., SIMÓ, M. & PÉREZ-MILES, F. 1996. La comunidad de arañas epígeas de una huerta orgánica de Montevideo, Uruguay. Resultados preliminares. Actas de las IV Jornadas de Zoología del Uruguay: 43.

VIERA, C. & BENAMÚ, M. 2009: Arañas: pesticidas naturales. Uruguay Ciencia, 7: 16-18.

YOUNG, O. & EDWARDS, G. 1990.

Spiders in United States field crops and their potential effect on crop pest. J. Arachnol. 18: 1-29.

YSNEL, F. & CANARD, A. 2000. Spider biodiversity in connection with the vegetation structure and the foliage orientation of hedges. J. Arachnol. 28: 107-114.

ZRUBECZ, P.; TOTH, F. & NAGY, A. 2008. Is *Xysticus kochi* (Araneae: Thomisidae) an efficient indigenous biocontrol agent of *Frankliniella occidentalis* (Thysanoptera: Thripidae)?. BioControl 53(4): 615-624