Boletín de la Sociedad Zoológica del Uruguay, 2022
Vol. 31 (1): e31.1.2
ISSN 2393-6940
https://journal.szu.org.uy
DOI: https://doi.org/10.26462/31.1.2

DIVERSITY AND FUNCTIONAL GROUPS OF ANTS IN *Citrus sinensis* CROP FIELD WITH DIFFERENT WATERING REGIME

Dario D. Larrea*, Gilberto Avalos and Ivo Zanone

Universidad Nacional del Nordeste, Facultad de Ciencias Exactas y Naturales y Agrimensura, Departamento de Biología, Laboratorio de Biología de los Artrópodos. Av. Libertad 5470, Corrientes, Argentina.

*Corresponding author: dariolarrea@gmail.com

Fecha de recepción: 24 de marzo de 2021
Fecha de aceptación: 07 de octubre de 2021

ABSTRACT

Ants have an important ecological role and they can help in prevention and pests management. That is why is important to know the species and understand the function they perform in different systems. The main propose of this work was to study the ants diversity on the ground in *Citrus sinensis* crop, with irrigation (IC) and without (NC). Pitfall traps, foliage patterns, manual capture and sifting litter were used to characterize ant assemblages and compare the ant diversity between treatments. In total, 26 species and 13 genera were collected, grouped in 5 families. The irrigated crop presented the higher richness, abundance and diversity index values, although the differences between crops were not significant. Nine ant guilds were recognized, distributed in three groups (epigeas, arboreal and hypogea). The epigeous ant group was the one that presented the most abundance in both crops. In the two treatments the three general groups were found, even though in NC crop, the Specialist predators (Sp) and Agile pseudomyrmicinae (Ap) guilds were not registered, which were exclusives of treatment CR. Sf index showed big functional similarity between both treatments. This study provides four new species records for Corrientes province: *Cephalotes bruchi, Cephalotes minutus, Cyphomyrmex transversus* y *Pheidole jelskii.*

Keywords: Biodiversity, Formicidae, agroecosystems, Argentina.

RESUMEN

DIVERSIDAD Y GRUPOS FUNCIONALES DE HORMIGAS EN CULTIVOS DE *Citrus sinensis* CON DIFERENTE RÉGIMEN DE RIEGO. Las hormigas tienen un papel ecológico importante y pueden ayudar en la prevención y el manejo de plagas. Por eso es importante conocer las especies y comprender la función que desempeñan en los diferentes sistemas. El principal objetivo de este trabajo fue estudiar la diversidad de hormigas en cultivo de *Citrus sinensis*, con riego (IC) y sin (NC). Se utilizaron trampas de caída, golpeteo de follaje y captura manual para caracterizar a los grupos de hormigas y comparar la diversidad de hormigas entre los tratamientos. En total, se recolectaron 26 especies y 13 géneros, agrupados en 5 familias. El cultivo con riego asistido presentó los mayores valores del índice de riqueza, abundancia y diversidad, aunque las diferencias entre cultivos no fueron significativas. Se reconocieron nueve gremios de hormigas, distribuidos en tres grupos (epigeas, arbóreas e hipogeas). El grupo de hormigas epigeas fue el que presentó mayor abundancia en ambos cultivos. En los dos tratamientos se encontraron los tres grupos generales, aunque en el cultivo NC no se registraron los gremios Predadoras especialistas (Sp) y Pseudomyrmex Agiles (Ap), los cuales fueron exclusivos del tratamiento CR. El índice Sf mostró una gran similitud funcional entre ambos tratamientos. Este estudio proporciona cuatro nuevos registros de especies para la provincia de Corrientes: *Cephalotes bruchi*, *Cephalotes minutus*, *Cyphomyrmex transversus* y *Pheidole jelskii*.

Palabras claves: Biodiversidad, Formicidae, agroecosistemas, Argentina.

INTRODUCTION

The integrated pest management (MIP) has the purpose of protecting the harvest as much possible, to the cheapest way and with the less possible damage to mankind, animals, ecosystems and agroecosystems (Romero, 2016).

One of the main objectives of MIP is biological control, which doesn't tend to eradicate the pests, but to reduce their density and prevent economic damages. As it is known, the success of these programs will depend on preliminary studies about biology and ecology of the natural enemies groups of crop pests (Bale, Van Lenteren and Bigler, 2008).

Ants are important predators and they can help to prevent and manage pests, to do so, it is important to study and understand the roles they play on different systems (Philpott and Armbrecht, 2006; Arenas and Armbrecht, 2018). There are studies that demonstrate the significance of ants in the regulation of arthropod populations which is important for biological control (Aldana-De La Torre, Aldana, Calvache and Arias, 1998; Bañol, Barrientos and Piñol, 2015).

Some records are known about ant assemblage structure on agricultural systems, of which some can be mentioned, such as: palm plantations (Aldana-De La Torre et al., 1998); coffee plantation in Colombia (Gallego-Ropero, Montoya-Lerma and Armbrecht, 2009; Arenas and Armbrecht, 2018) and Cuba (Vázquez Moreno, Matienzo Brito, Alfonso Simonetti, Moreno Rodríguez and Álvarez Núñez, 2009); sugar cane plantations (Santos, Carrano-Moreira and Torres, 2012), pine tree plantations (Matos, Yamanaka, Castellani and Lopes, 1994) and oranges crops in Colombia (Lozano, Cardona and Ulloa-Chacon, 2013).

In the province of Corrientes, the citrus production covers 25000 ha approximately, of which 9000 are available for the European Union exportation, for which it has to have the best quality and sanitary requirements. Exported citric fruit to EU and others markets with similar restrictions must have the highest quality standards (Avalos, Bar, Oscherov and González, 2013).

For an effective integrated pest management, it is important to know the structure of the community to encourage the maintenance of beneficial organisms. Therefore, it is important to know the composition of ant communities in *Citrus* crops.

The objective of this work was to describe ant communities in *Citrus sinensis* crops (L) Osbeck (Valencia Late variety) and evaluate if they differ according to the irrigation regime on the plantations. This study represents a contribution to the diversity, richness and structure for Formicidae.

To achieve these standards, SENASA (National Sanity and Quality Agribusiness Service) requires Good Agricultural Practices (BPA) which implies the reduction of agrochemical use to ensure safety on primary production.

MATERIAL AND METHODS

Study Area

The investigation was placed in orange crops located in the experimental station of INTA in Bella Vista department, province of Corrientes, Argentina (28°26' S 58°55' W). This department is 70 m above sea level. The ground is sandy loam and it rains about 1200 mm annually. The absolute maximum temperature is 33ºC, the absolute minimum is 8.5ºC and average temperature is 20.5ºC (Giménez, Goldfarb and Casco, 2001). The study area belongs to the Humid Eastern District of the Phytogeographical Province of Chaco, Subregion of Chaco (Morrone, 2000).

Samples were taken during a year in two *Citrus sinensis* crops plots of 0.82 ha and 392 plants each. The sample plot one (IC) had a crop with irrigation management and was frequently fertilized, and plot two (NC) was treated without additional water and with a limited fertilization level.

In IC treatment, fertilization is carried out with Ammonium Nitrate, Phosphoric Acid and Dolomite. All compounds are applied to the soil twice per week, using 4 sprayers per plant. Fertilization is carried out during 2 hours with a total of 32 liters of water. First, during 5-10 minutes, only water is poured, then water with fertilizer during 90 minutes and finally only water within 20-25 minutes.

Sampling methodology

Every month, in each studied plot, orange plants (20 trees) were randomly selected based on systematic sampling. In all of them, four harvesting techniques were performed; each technique was repeated three times per plant, totaling 1440 samples per year for every single plot.

All methods applied to trees during each month are considered as a sampling unit. Where every unit represents a complementary set of different methods employed during a concrete period.

We use foliage beating technique and manual capture to collect ground ants on higher canopy, pit-fall traps were installed and sifting litter made. Foliage beating technique consisted in shaking vigorously one sector three times on the top above an entomologic umbrella of 0.70 m length by 0.60 m wide. Three pit-fall traps were installed at the foot of every sample tree, making a triangle around it, at a 1.50 m distance. Plastic recipients of 900 ml were used, with an opening of 11 cm diameter. Inside each recipient, ethylene glycol was diluted in water in a 1:10 proportion with detergent drops, then these recipients were buried to the ground level without cover and left there during 48 hs. A 0.50 m^2 surface of litter was sifted on a 3m^2 white canvas. The sieve with a 10x15 mm mesh aperture on three places around each selected tree. On each crop, 120 samples were obtained monthly. The manual collection is carried out in an area of 4m^2, with a collection effort of 3 hours/man for treatment.

The samples were analyzed in the lab and classified using taxonomical keys (de Andrade and Baroni Urbani, 1999; Palacio and Fernández, 2003; Quiran, 2007; Olivero-G., Guerrero and Escárraga-F., 2009). All samples were identified to species level; those that were not, were grouped using a morphospecies criteria, differentiating them according

Table 1. Adjusted abundance (AA) of species/morphospecies of Formicidae found in *Citrus sinensis* crop with two types of treatments. Bella Vista, Corrientes, Argentina.

Reference	Subfamily *Especies*	Ic[a]	Nc[b]	Functional groups [c]
	Dolichoderinae			
1	*Dorymyrmex thoracicus* Gallardo, 1916	7,02	4,77	Op
2	*Dorymyrmex pyramicus* (Roger, 1863)	2,82	0,69	Op
3	*Dorymyrmex* sp 1	0,1	0,06	Op
	Formicinae			
4	*Camponotus punctulatus* Mayr, 1868	37,29	27,3	Sc
5	*Camponotus rufipes* (Fabricius, 1775)	0,15	0,51	Sc
6	*Camponotus blandus* (Smith, 1858)	0,26	0,3	Sc
7	*Camponotus cordiceps* Santschi, 1939	0,2	0	Sc
8	*Brachymyrmex* sp 1	1,35	1,4	Lvs
9	*Brachymyrmex* sp 2	0,01	0	Lvs
10	*Nylanderia fulva* (Mayr, 1862)	0,88	0,06	Op
11	*Nylanderia silvestrii* (Emery, 1906)	0,06	0,1	Op
	Myrmicinae			
12	*Cephalotes bruchi* (Forel, 1912)*	2,97	1,71	Ce
13	*Cephalotes minutus* (Fabricius, 1804)*	0,2	0	Ce
14	*Crematogaster* sp 1	4,02	0	Msla
15	*Crematogaster* sp 2	0,06	0	Msla
16	*Cyphomyrmex rimosus* (Spinola, 1851)	0,36	0	CA
17	*Cyphomyrmex transversus* Emery, 1894*	0,21	0,11	CA
18	*Pheidole oscurithorax* Naves, 1985	8,81	0,56	Gd
19	*Pheidole radoszkowskii* Mayr, 1884	0,3	0,14	Gd
20	*Pheidole jelskii* Mayr, 1884*	0,18	0,03	Gd
21	*Pheidole* sp 2	0,07	0,05	Gd
22	*Solenopsis invicta* Buren, 1972	5,3	5,1	Gd
23	*Trachymyrmex* sp	0,02	0	CA
24	*Wasmannia auropunctata* (Roger, 1863)	0,88	7,21	Msla
	Pseudomyrmicinae			
25	*Pseudomyrmex gracilis* (Fabricius, 1804)	0,06	0	Ap
	Ponerinae			
26	*Odontomachus haematodus* (Linnaeus, 1758)	0,12	0	Sp
Adjusted Abundance Total		73,69	60,1	

[a]IC Irrigated crop.

[b]NC Non.irrigated crop

[c] CA Criptic Atini, Msla: Massive recruitment little arboreal, Ce: Cephalotini, SC: Subordinate camponotini, Sp: Specialist predators, Gd: Ground dominant, Lvs: Litter and vegetation specialists, Op: Opportunistic, Ap: Agile pseudomyrmicinae.

*New record to Corrientes province.

to their morphological characteristics (Krell, 2004; Majka and Bondrup-Nielsen, 2006). To define the ecological role of the species, the samples were classified according to functional groups (Andersen, 1995; Silvestre, Roberto, Brandão and Rosa, 2003). Species were classified into three general groups considering collecting method and nesting habits in epigeas, arboreal and hypogea species containers with alcohol 70.

The specimens were preserved in alcohol 70%, with the following data: species name, country, province, department, locality and date of collection and collector and were deposited in the Cátedra de Biología de los Artrópodos, Universidad Nacional del Nordeste, Corrientes, Argentina (CARTROUNNE).

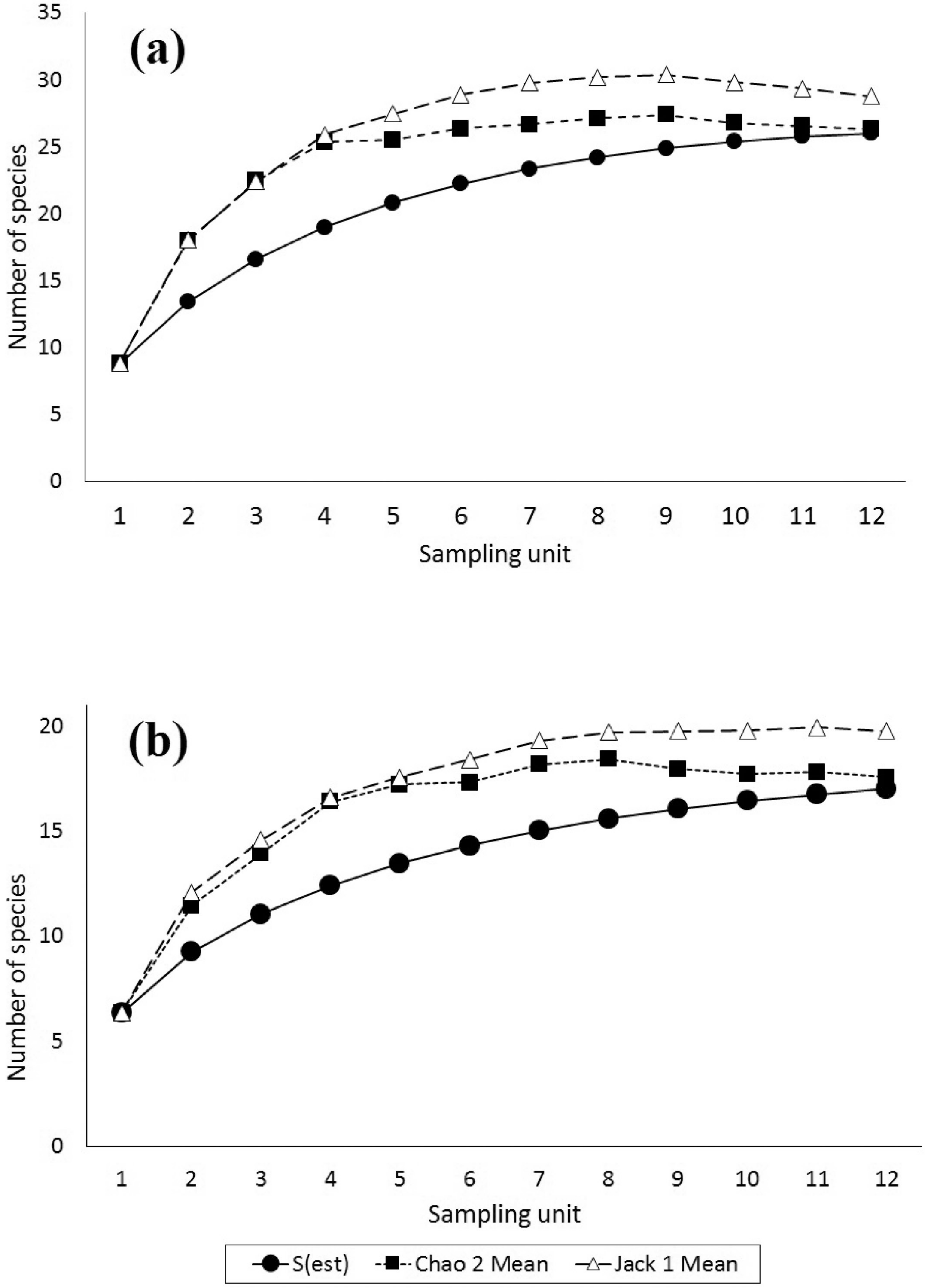

Fig. 1. Accumulation curves of observed (S) and estimated (Chao 2 and Jack 1) ant species in crops of *Citrus sinensis* with two types of treatments. Bella Vista, Corrientes, Argentina. **a.** Irrigated Crop **b.** Non-irrigated crop.

Data analysis

The number of species (S) was considered as a diversity measure. The Shannon-Wienner index ($H´=\Sigma pi\ lnpi$) was also used, considering the number of appearance of each species, as it is recommended for social insects (Leponce, Theunis, Delabie and Rosin, 2004). Equitability of Pielou ($J'= H'/ H'max$) and Simpson ($\lambda=\Sigma\ (n^2/N^2) = \Sigma pi^2$) were also estimated. All analysis was made by the statistical software PAST (Hammer, Harper and Ryan, 2001). The abundance was standardized according to the proposal of Lindsey and Skinner (2001) by adjusted abundance (AA), where AA= A (O/100): A= total number of individuals of each species, O= capture frequency. The use of AA values minimizes the problems associated to overcollection bias generated by nests or foraging trails near the traps (Lindsey and Skinner, 2001).

The ants abundance of both treatments was compared by one-way variance analysis (ANOVA). The ANOVA assumptions were corroborated with a Shapiro-Wilk test to evaluate the normal distribution of the data and a Levene test to evaluate the homogeneity of variance (Hammer et al., 2001).

Whittaker rank-abundance curves were made for each site, representing AA values on logarithmic scale (Feinsinger, 2001).

For the ants richness analysis, accumulation curves were made based on sample units for each plot, together with the richness estimators of first-order Jacknife (JK1) and second-order Chao (Chao 2) included in the statistic package EstimateS version 9.1 (Colwell, 2015). These estimators allow predicting the richness of a specific plot, based on the incident data (Colwell, Mao and Chang, 2004). The calculations were made with 100 random occurrences considering only incidences data (presence-absence) because of the limitations imposed for the use of ant abundance on richness estimations (Bestelmeyer, 2000). For this analysis, each month of the collection year was used as the sampling unit.

The ant fauna composition was compared between sites with Jaccard qualitative similarity index (Moreno, 2001). All analysis was made on the statistical program PAST (Hammer et al., 2001).

In order to evaluate the fauna in a different scale than taxonomic, all species were assigned to different guilds according to the classification of Perez-Sanchez, Lattke and Viloria (2012)). The guild composition was compared between sites with the functional similarity index (Sf) proposed by Silvestre et al. (2003). The functional similarity index, adapted by Silvestre, is defined as:

$$Sf = \frac{2 \times Gc \times Nc}{Ga \times Na + Gb\ Nb} \times 100$$

That is:

Ga = number of guilds in locality 1

Gb = number of guilds in locality 2

Gc = number of guilds in common in the two localities

Na = number of species registered in locality 1

Nb = number of species registered in locality 2

Nc = number of species shared within the guilds

RESULTS

A total of 1683 ants were registered, five families, 13 genera and 26 species (Table 1). The Myrmicinae subfamily presented the highest richness values of genera (7) and species (13), representing the 36% of AA total. The Formicinae subfamily registered eight species distributed in three genera, representing 69.87% of AA total. The three subfamilies Dolichoderinae, Pseudomyrmicinae and Ponerinae presented less than 16% of AA with the lowest richness values of species (3, 1 and 1 respectively). This work adds four new records to the list of species in Corrientes province: *Cephalotes bruchi, Cephalotes minutus, Cyphomyrmex transversus* y *Pheidole jelskii* (Table 1).

With pit-fall traps, 20 species were collected on which the best represented were *Dorymyrmex thoracicus* and *Camponotus punctulatus*. With foliage beating technique, four species were captured: *Cephalotes bruchi*, *Cephalotes minutus*, *Pseudomyrmex gracilis* and *Crematogaster* sp 1 and with sifting litter only two additional species were collected: *Cyphomyrmex rimosus* and *Trachymyrmex* sp.

A total of 13 genera and el 100% de species (26 species) were registered for IC treatment, while for NC treatment 9 genera and 17 species (Table 1). Accumulation curves of species for treatment IC reached close to saturation points at the time it gained nine samples units, meanwhile the saturation point of species for treatment NC was reached with much more sampling effort (Figure 1). In NC treatment, the sampling efficiency varied between 86% and 97% (first-order Jackknife and second-order Chao respectively). On the other hand, this index varied between 90% and 98% (first-order Jackknife and second-order Chao respectively) in treatment IC. These values indicated that the sampling effort was sufficient to estimate species richness. Jacknife 1 estimator indicates at least 4 and 3 non collected species for IC and NC plot respectively (Fig. 1).

The highest ant adjusted abundance was registered in the IC crop (73.69). The NC treatment registered less adjusted abundance (60.1), but two of its species (*Wasmannia auropunctata* and *Pheidole oscurithorax*) presented higher abundance values in this treatment. The IC treatment presented the highest species richness, with nine exclusive species. The ant abundance did not present significant differences between treatments (ANOVA $F = 0.08$; $p = 0.78$; $df = 51$).

Table 2. Diversity index of ant assembly found in *Citrus sinensis* crop with two types of treatments. Bella vista, Corrientes, Argentina.

Indexel	C[a]	NC[b]
Richness (S)	26	17
Simpson (D)	0,94	0,91
Shannon-Wiener (H')	3,03	2,57
Equitability of Pielou (J')	0,93	0,91

[a] IC Irrigated crop.

[b] NC Non-irrigated crop

All alpha diversity measures expressed higher values in the irrigated crops (Table 2).

Whittaker curves for treatment IC showed more aggrupation between points, which describes a more equitative distribution among species. At the same time, it describes a better distribution in the number of individuals per species (Fig. 2). The curve of the NC crop presents a higher slope and separation between points, indicating higher dominance of one or more species (Fig. 2). The numerically dominant species were *Camponotus punctulatus* and *Solenopsis invicta* (Table 1; Fig. 2).

The Jaccard index showed a 65% similarity between both treatments, indicating the composition of species in both plots is similar.

Nine ant guilds were recognized within three general groups (Table 3). From three general groups (epigeas, arboreal and hypogea), epigeal ants represent close to 90% of total AA, where the subordinate Camponotini (Sc) guild was the most important (Table 3). Tree ants represent about 20%, whereas the hypogeous ants group represents only 0.5% of total AA with just one guild (Table 3). In both treatments the three general groups were found. However, large epigeal Predators (Sp) and agile Pseudomirmecins (Pa) guilds were not registered in NC crop, which were exclusive to IC treatment. The Sf index showed a great functional similarity (72%) between both treatments.

DISCUSSION

This study represents the first contribution to knowledge of the composition and structure of formicids in Citrus sinensis crops in the Argentinian northeast. For this reason, it is important to highlight that most of the studies based on the composition and structural characteristics of the region's myrmecofauna focus on natural environments. Among these studies, we can find the works by Arbino and Godoy (2001); Calcaterra, Cuezzo, Cabrera and Briano (2010); Gomez Lutz and Godoy (2010); Leponce et al. (2004).

The number of species registered on this work is low comparing to others carried out in natural environments by Calcaterra et al. (2010) on the natural reserve of Ibera marshland, which collected 94 species. Also, Leponce et al. (2004) recorded 66 species in the Pilcomayo National Park in Formosa. This particularity of species richness in natural environments and specially forests could be attributed to the complexity of those environments as Gerez (1988) assures, who argues that all arthropods in general are associated to a plant formation, depending on the specialization degree they present. From this perspective, many microhabitats of these systems provide refuge to feed, nesting, mating and protection of the climatic adverse effects (Lawton, 1983).

On both experimental units where the investigation took place, no agrochemicals were used to eliminate pests; this explains the abundance and richness found, probably because of particular characteristics of the crop. Halaj Ross and Moldenke (2000) argues that agricultural systems, especially perennial crops such as sweet orange (*Citrus sinensis*) deploy a tree structure of important dimensions and are very stable with a rich entomofauna.

On the other hand, the number of species registered on this work is intermediate, compared to other crops. On this matter, Vázquez Moreno etal. (2009) in Cuba, registered five species in coffee polycultures without pest treatments or fertilization. In orange crops in Colombia (Lozano et al., 2013), 119 species / morphospecies were identified, within eight subfamilies, values much higher than those recorded in the present study. These values exceed the findings here mentioned. The best-represented families in Colombia (Lozano et al. 2013) were Myrmicinae (64) and Formicinae (23) and among the least represented were Pseudomyrmecinae (7) and Dolichoderinae (7). This pattern is also observed in our study, which does not show an overall pattern of constant dominance in the Citrus sinensis crops of the region. Also Samways (1983), in environments associated with citric crops in South Africa, registered 23 genera and 49 species. Almeida, Queiroz and Mayhe-Nunes (2007) found 39

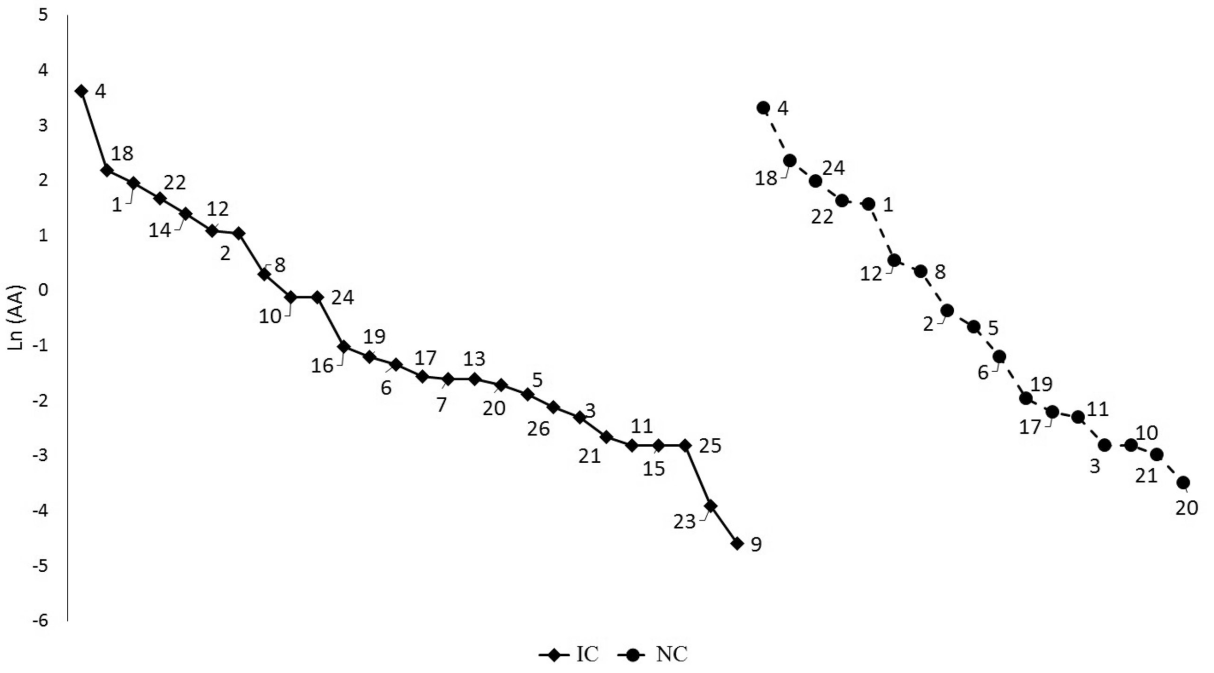

Fig. 2. Whittaker curves of ant species in crops of *Citrus sinensis* with two types of treatments. Bella Vista, Corrientes, Argentina. The numbers represent the identity of each species (Table 1). IC: Irrigated crop. NC: Non-irrigated crop.

species in agroecological crops in Brazil, while in Colombia, in mono and polycultures of coffee with different levels of agrochemical use, Gallego-Ropero (2005) quote 48 and 18 species respectively.

For many families, knowing the specific taxonomic level is still incipient to South America. Also, in many cases the lack of specialists in the field makes the determination job too tricky. That is why specific taxonomic units were used (morphospecies), as it has been proven useful for a quick estimate of biodiversity (Oliver and Beattie, 1993).

Four new records of Formicidae to the Mesopotamian region are important due to the limited investigation carried out. According to Vittar (2008), provinces like Entre Ríos and Corrientes present an underestimated value of species due to the reduced number of works executed in both provinces.

Shannon-Weaver and Equitability index obtained in this work are high values compared to the results obtained in sugar cane crops by Santos et al. (2012). This feature could be explained by the diversity of niches present in citric crops (such as litter and canopy).

Rivera and Armbrecht (2005), studying coffee crops with different degrees of plant cover, found Shannon values between 1.12 and 2.87. All these results are lower than those found in this study, indicating that despite being a cropping system, it allows the occurrence of an interesting number of ant species.

The number of groups in *Citrus sinensis* was closer to functional groups or guilds in semiarid zones of South America (Bestelmeyer and Wiens, 1996; Pérez-Sanchez et al., 2012) and guilds in Ibera marshlands (Calcaterra et al., 2010). The most abundant functional groups were Camponotini patrol, Ground dominant and Opportunists. These groups have the following ecological characteristics in common: 1) high abundance; 2) active foraging; 3) great variety of alimentary items (Bestelmeyer and Wiens, 1996; Silvestre et al., 2003). The number of guilds found in this study (9) is lower than the records for Cerrado (15) (Silvestre et al., 2003). The main difference found with Bestelmeyer and Wiens (1996) was the absence of Ecitoninae species (army ants). In studies made by Pérez-Sánchez et al. (2012) in semiarid plant formations in Venezuela, between captured guilds, Big Dolicoderini, Cutters and Nomads, were found, which were not registered in studied crops. In Ibera (Calcaterra et al., 2010) the most abundant guilds, in the four studied environmental units, were the opportunistic and generalists Myrmicinae, while in this study, the predominant were the soil Dominant and Cosmopolitan patrols. In the studied crops, omnivorous groups are predominant. This indicates a low functional complexity system within the ensemble, as well as a poor food quality system (Silvestre et al., 2003). The functional groups that are not found in this study represent groups of ants with highly

Table 3. Formicidae guilds percentage in *Cistrus sinensis* crop Bella Vista, Corrientes, Argentina.

Groups		Guilds	IC %[a]	NC %[b]
Arboreals		Massive recruitment little arboreal (Msla)	6,73	12
		Cephalotini (Ce)	4,3	2,85
		Group pseudomyrmicinae (Gp)	0,08	0
Epigeous	Micophagous	Criptic Attini. (CA)	0,8	0,18
	Omnivorous	Ground dominant (Gd)	19,88	26,42
		Camponotini patrol (Cp)	51,43	46,77
		Opportunists; (Op)	14,76	9,45
	Depredators	Specialist predators (Sp)	0,16	0
Hypogeous		Litter and vegetation specialists (Lvs)	1,85	2,33

[a] IC% Guild percentage in irrigated crop.

[b]NC% Guild percentage in non-irrigated crop.

speciesalized habitats such as cryptic Attinis. These functional groups disappear due to the loss of niches produced in the crops by the homogenization of the environment. This trend could be explained by the habitat heterogeneity hypothesis (Tews et al., 2004) as a determinant factor of ant assemblage structure since naturals environments have more niches and/or microhabitats to be exploited by ants.

Although the crop was located within the bounds of humid Chaco, this ant community expressed a structure similar to that of semiarid South American communities (Bestelmeyer and Wiens, 1996; Pérez-Sánchez et al., 2012). This could be explained by the homogeneity of the crop which would allow a limited number of niches to exploit.

According to Kaspari et al. (2000), diversity of ants would not be explained only by the high net primary productivity but also due to the heterogeneity of the habitat. Likewise, humidity, temperature, dispersion, competition and/or disturbance would also affect diversity values in ants. Therefore, the greater richness in the crop with irrigation could be explained by the greater of humidity.

Many of the species collected have ecological characteristics that make them important species for the productive point of view. *Camponotus punctulatus* in agricultural systems of Argentinian northeast present a great activity as ground ecosystem engineer. *Wasmannia aurapunctata* is plague for cacao, coffee and ornamentals, by protecting Homoptera against parasites and predators which promotes an ecological imbalance in favor of phytophagous insects. Furthermore, the aggressiveness of these ants and there painful sting make more difficult the crop management practice. *Nylanderia fulvia* represent another aggressive specie, considered an important coffee crop plague in Colombia, by defending Homoptera from there natural enemies, favoring the increase population of phytophagous. All these make *W. aurupunctata* and *N. fulvia* important species to *Citrus sinensis* studied crops. *Odontomachus haematodus*, is a general predator species that usually feeds on caterpillars, flies, beetles, small Hemiptera among other resources. They patrol solitary way with underground nests. Those characteristics made of *O. hamatodus* an interesting specie to be use as biological control.

CONCLUSIONS

Our results show the ant diversity is not significantly affected by irrigation regime applied to *Citrus sinensis* crops studied. Although the irrigated crop presented slightly higher diversity index values.

Although the studies were carried out in a humid region, the union structure is more similar to the ant communities of dry region of Argentina. That difference in the structure of the guilds can be explained by the reduction niches, common in homogeneous environments as *Citrus sinensis* crop. This study highlights the need to conduct insect inventories in crop groups to know their role in systems. This could define better integrated pest management plans.

ACKNOWLEDGMENT

We are grateful to our colleagues of GIBA (Grupo Investigación Biología de los Artrópodos) for the assistance in the field and logistic.

REFERENCES

Aldana-De La Torre, R.C., Aldana, J., Calvache, H. and Arias, D. (1998). Papel de la hormiga *Crematogaster* spp. en el control natural de

Leptopharsa gibbicarina en una plantación de palma de aceite de la Zona Central. *Palmas (Colombia), 19*, 25–32.

Almeida, F.S., Queiroz, J.M. and Mayhe-Nunes, A.J. (2007). Distribuição e abundância de ninhos de Solenopsis invicta Buren (Hymenoptera: Formicidae) em um agroecossistema diversificado sob manejo orgânico. *Brazilian Journal of Forestry and Enviroment, 14*, 34–44.

Andersen, A.N. (1995). A Classification of Australian Ant Communities, Based on Functional Groups Which Parallel Plant Life-Forms in Relation to Stress and Disturbance. *Journal of Biogeography, 22*, 15.

de Andrade, M. and Baroni Urbani, C. (1999). Diversity and adaptation in the ant genus Cephalotes, past and present. *Stuttgarter Beiträge zur Naturkunde Serie B (Geologie und Paläontologie), 271*, 1–889.

Arbino, M.O. and Godoy, M.C. (2001). Relaciones biológicas entre hormigas (Insecta: Hymenoptera, Formicidae) y termites (Insecta : Isoptera) en el macrosistema Iberá. *Universidad Nacional Del Nordeste. Comunicaciones Científicas y Tecnológicas 2002.*

Arenas, A. and Armbrecht, I. (2018). Guilds and diversity of ants in three land uses from a coffee landscape at Cauca -Colombia. [Gremios y diversidad de hormigas (Hymenoptera: formicidae) en tres usos del suelo de un paisaje cafetero del Cauca-colombia.]. *Revista de Biologia Tropical*, *66*, 48–57.

Avalos, G., Bar, M.E., Oscherov, E.B. and González, A. (2013). Diversidad de Araneae en cultivos de Citrus sinensis (Rutaceae) de la Provincia de Corrientes, Argentina. *Revista de Biología Tropical*, *61*, 1243–1260.

Bale, J.S., Van Lenteren, J.C. and Bigler, F. (2008). Biological control and sustainable food production. *Philosophical Transactions of the Royal Society B: Biological Sciences, 363*, 761–776.

Bañol, C., Barrientos, J.A. and Piñol, J. (2015). Efecto de la exclusión de hormigas sobre la abundancia y diversidad de Hymenoptera Parasitica en un cultivo ecológico de mandarinos (La Selva del Camp, Tarragona, España). *Orsis, 29*, 119.

Bestelmeyer, B.T. (2000). The trade-off between thermal tolerance and behavioural dominance in a subtropical south american ant community. *Journal of Animal Ecology, 69*, 998–1009.

Bestelmeyer, B.T. and Wiens, J.A. (1996). The Effects of Land Use on the Structure of Ground-Foraging Ant Communities in the Argentine Chaco. *Ecological Applications, 6*, 1225–1240.

Calcaterra, L.A., Cuezzo, F., Cabrera, S.M. and Briano, J.A. (2010). Ground Ant Diversity (Hymenoptera : Formicidae) in the Iberá Nature Reserve, the Largest Wetland of Argentina. *Annals of the Entomological Society of America, 103*, 71–83.

Colwell, R. (2015). Estimates: Statistical Estimation of Species Richness and Shared Species from Samples. Version 9.

Colwell, R., Mao, C. and Chang, J. (2004). Interpolating, extrapolating, and comparing incidence-based species accumulation curves. *Ecology, 85*, 2717–2727.

Feinsinger, P. (2001). *Designing Field Studies for Biodiversity Conservation*. Island Press. Washington, USA., 212 pp.

Gallego-Ropero, M.C. (2005). Intensidad de manejo del agroecosistema de café (coffea arabiga l.) (monocultivo y policultivo) y riqueza de especies de hormigas generalistas. *Boletín del Museo de Entomología de la Universidad del Valle, 6*, 16–29.

Gallego-Ropero, M.C., Montoya-Lerma, J. and Armbrecht, I. (2009). ¿Es la sombra benéfica para la diversidad de hormigas y peso del café? una experiencia en pescador, Cauca, Colombia. *Boletin Cientifico Centro de Museos. Museo de Historia Natural, 13*, 106–116.

Gerez, A. (1988). *Procalus lenzi* y *Procalus malaisei* (Coleoptera: Chrysomelidae): Dos especialistas del matorral. *Revista Chilena de Entomología, 16*, 65–67.

Giménez, L., Goldfarb, M. and Casco, J. (2001). *Comportamiento regional de precipitaciones mensuales en la Provincia de Corrientes.* Corrientes, Argentina.

Gomez Lutz, M.C. and Godoy, M.C. (2010). Diversidad y grupos funcionales de Formicidae (Insecta, Hymenoptera) de la reserva natural educativa Colonia Benítez (Provincia del Chaco, Argentina). *Revista FABICIB, 14*, 180–195.

Halaj, J., Ross, D. and Moldenke, A. (2000). Importance of habitat structure to the arthropod food-web in Douglas-fir canopies. *Oikos, 90*, 139–152.

Hammer, Ø., Harper, D.A.T. and Ryan, P.D. (2001). PalaeontologiaElectronica *PAST: Paleontologicalstatistics software package for education and data analysis.*

Kaspari, M., O'Donnell, S. and Kercher, J. R. (2000). Energy, density, and constraints to species richness: ant assemblages along a productivity gradient. *The American Naturalist, 155*, 280Ð293

Krell, F. (2004). Parataxonomy versus taxonomy in biodiversity studies-pitfalls and applicability of 'morphospecies' sorting. Biodiversity & Conservation, *13*, 795–812.

Lawton, J.H. (1983). Plant architecture and the diversity of phytophagous insects. *Annual*

Review of Entomology, 28, 23–29.

Leponce, M., Theunis, L., Delabie, J.H.C. and Roisin, Y. (2004). Scale dependence of diversity measures in a leaf-litter ant assemblage. *Ecography, 27*, 253–267.

Lozano, J.C., Cardona, A.M.A. and Ulloa-Chacon, P. (2013). Hormigas en cultivos de naranja (Citrus sinensis L. Osbeck) de la costa Caribe de Colombia. *Biota Colombiana, 8*, 13–19.

Majka, C. and Bondrup-Nielsen, S. (2006). Parataxonomy: a test case using beetles. *Biodiversity Animal Conservation, 29*, 149-156.

Matos, J., Yamanaka, C., Castellani, T. and Lopes, B. (1994). Comparação da fauna de formigas de solo em áreas de plantio de *Pinus elliottii*, com diferentes graus de complexidade estrutural (Florianópolis, SC). *Biotemas, 7*, 57–64.

Moreno, C.E. (2001). 1 MandT–Manuales y Tesis SEA *Métodos para medir la biodiversidad*. Zaragoza, 84 pp.

Morrone, J.J. (2000). What is the Chacoan subregion? *Neotropica, 46*, 51–68.

Oliver, I. and Beattie, J. (1993). A possible method for the rapid assessment of biodiversity. *Conservation Biology, 7*, 562–568.

Olivero-G., D., Guerrero, R. and Escárraga-F., M. (2009). Claves taxonómicas para las hormigas cazadoras (Hymenoptera: Formicidae: Ponerinae S. Str., Ectatomminae, Heteroponerinae) de la Sierra Nevada de Santa Marta, Colombia. *Intropica, 4*, 17–28.

Palacio, E.E. and Fernández, F. (2003). Claves para las subfamilias y géneros. In: F. Fernández (Ed), *Introducción a las hormigas de la región neotropical* (pp. 233–260). Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Bogota, Colombia,

Pérez-Sanchez, A.J., Lattke, J.E. and Viloria, A.L. (2012). Composición y Estructura de la Fauna de Hormigas en tres formaciones de vegetacións semiarida de la Peninsula de Paraguaná, Venezuela. *Interciencia, 37*, 506–514.

Philpott, S.M. and Armbrecht, I. (2006). Biodiversity in tropical agroforests and the ecological role of ants and ant diversity in predatory function. *Ecological Entomology, 31*, 369–377.

Quiran, E.M. (2007). The neotropical genus Brachymyrmex Mayr (Hymenoptera: Formicidae) in Argentina. III. redescription of species: B. aphidicola Forel, B. australis Forel and B. constrictus Santschi. *Neotropical Entomology, 26(5)*, 699–706.

Rivera, L. and Armbrecht, I. (2005). Diversidad de tres gremios de hormigas en cafetales de sombra, de sol y bosques de Risaralda. *Revista Colombiana de Entomología, 31*, 84–96.

Romero, F. (2016). Manejo integrado de plagas: las bases, los conceptos, su mercantilización. *Universidad Autónoma de Chapingo*, *109*.

Samways, M.J. (1983). Community Structure of Ants (Hymenoptera: Formicidae) in a Series of Habitats Associatedwith Citrus. *Journal of Applied Ecology, 20*, 833–847.

Santos, M.P.C.J., Carrano-Moreira, A.F. and Torres, J.B. (2012). Diversidade de formigas epigeicas (Hymenoptera: Formicidae) em floresta ombrófila densa e em cultivo de cana-de-açúcar, no município de Igarassu, PE. *Revista Brasileirade Ciencias Agrarias, 7*, 648–656.

Silvestre, R., Roberto, C., Brandão, F. and Rosa, R. (2003). Grupos funcionales de hormigas: El caso de los gremios del Cerrado. In: F. Fernández (Ed.), *Introducción a las hormigas de la región neotropical* (pp. 113–148). Bogota, Colombia.

Tews, J., Brose, U., Grimm, V., Tielbörger, K., Wichmann, M.C., Schwager, M. and Jeltsch, F. (2004). Animal species diversity driven by habitat heterogeneity/diversity: The importance of keystone structures. *Journal of Biogeography*, *31*, 79–92.

Vázquez Moreno, L., Matienzo Brito, Y., Alfonso Simonetti, J., Moreno Rodríguez, D. and Álvarez Núñez, A. (2009). Diversidad de especies de hormigas (Hymenoptera: Formicidae) en cafetales afectados por Hypothenemus hampei Ferrari (Coleoptera: Curculionidae: Scolytinae). *Fitosanidad, 13*, 163–168.

Vittar, F. (2008). Hormigas (Hymenoptera: Formicidae) de la Mesopotamia Argentina. In: F. G. Aceñolaza (Ed.), *Temas de la Biodiversidad del Litoral III (*pp. 447–466). Tucuman.

Editor de Sección: Miguel Simó