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Ants associated with prickly pear cactus crop in Texcoco, State of Mexico

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Abstract. In Mexico, center of domestication of prickly pear cactus species (also called "nopales") few studies exist on insects associated with this crop. The studies are scantier on ants, since the majority are not considered to be pest. For this motive, the population dynamics of the ants was studied in experimental prickly pear crop in the installation of Colegio de Postgraduados, Mexico. The sample was fortnightly performed from February 2013 to March 2014. Ants were gathered with pitfall traps and arboreal traps, all of them with three baits and others without bait. Also recorded raiding, the nests in crop and inside to the cladodes. We collected a total of 10,953 individuals (74 % on ground and 26% on prickly pear cladodes), and seven species were determined: *Hypoponera opacior* (Forel), *Neivamyrmex nigrescens* (Cresson), *Pogonomyrmex barbatus* (Smith), *Linepithema humile* (Mayr), *Camponotus atriceps* (Smith), *Pheidole obtusospinosa* Forel and *Monomorium minimum* (Buckley). The last four were more abundant and frequent. We discuss the presence and nesting of ants in crop and their association with other insects of prickly pear crop.

Keywords: *Opuntia ficus-indica, Formicidae, Dactylopius opuntiae, antagonism, Hyperaspis trifurcata, Laetilia coccidivora, Melitara nephelepasa*

Introduction

The The genus Opuntia (Cactaceae) has a natural distribution from Argentina to Southern Canada (Britton and Rose, 1963). An important area of domestication exists in the Mesoamerica region (Casas and Barrera, 2002; Griffith, 2004), and Mexico is the largest producer and consumer of these plants as a fruit and as a vegetable, with a harvest of 462,209 and 868,956 t per year, respectively (SIAP, 2021). The species consumed as vegetable is the "nopal verdura" *Opuntia ficus-indica* (L.) Miller excelled for its uses in industry and nutritional benefits (Flores-Valdez, 1995; Sáenz *et al.,* 2006), and considered the most important cactus in agriculture worldwide (Kiesling, 1998). Despite the economic importance of these plants, studies about associated insects with their crops are scarce, and limited to lists of local (Ruiz-Machuca *et al.,* 2010; Vanegas-Rico *et al.,* 2010; Rocha-Flores *et al.,* 2017; Palemón-Alberto *et al.,* 2022) or widely distributed pest in the continent (Mann, 1979); often excluding insect fauna, considered less significant in the productive chain of the cacti. Other research includes insects like ants as occasional extra nectaries visitors with botanical structures emphasis (Silva *et al.,* 2020) or conservation proposes (Novoa *et al.,* 2003; Caballero *et al.,* 2013; Rafael-Valdez *et al.,* 2017

Guerra *et al.,* 2022; Tenorio-Escandón *et al.,* 2022).

The importance of ants in the ecological balance of most terrestrial ecosystems is relevant because of their predatory activities, seed dispersion and participation in soil physicochemical processes (Del Toro *et al.,* 2012; Folgarait, 1998). The presence of these insects is beneficial in areas with vegetation of cacti (Miller, 2007; Robbins and Miller, 2009), but it is unknown in cactus agroecosystems. Therefore, the present study aims to know the myrmecofauna taxonomy, richness and abundance as well as its temporal dynamics (in soil and plant), in an experimental nopal verdura crop in Texcoco, State of Mexico.

Material and Methods

Field work

This study was performed in *O. ficus-indica* crop (<2 ha) at Colegio de Postgraduados (Campus Montecillo, Texcoco, State of Mexico (19 ° 27 '33.79 "N; 98 ° 54' 20" W)) through one year (February 2013 to March 2014). To know the abundance and richness of the myrmecofauna in the soil and the plants, ants were sampled with pitfalls and arboreal traps respectively (capacity of 250 mL) with four treatments (baits): tuna, pineapple, honey, and test (without bait). Each treatment had two repetitions (a total of eight traps for strata) with a random distribution and distance at five meters between each trap to ensure minimal dependence. An ethanol-antifreeze-water (5: 65 30) solution was used to preserve the insects, and fortnightly replaced the solution and bait. Additional observations were performed for 1 hour (≈10: 00 to 11:00 am.), including a direct search of ant nests in old cladodes, since young pads are frequently pruned, and collects of any organisms on the cactus that interacting with ants.

Laboratory work

Morphospecies were separated and counted using a stereomicroscope at the personal laboratory. Preserving the organisms in vials with 70% ethanol and determined with genera (Mackay and Mackay, 1989), and specific keys (Mackay *et al.,* 1985; Longino, 1999; Wilson, 2003; Snelling, 2007, Wild, 2007; Mackay and Mackay, 2014). Then, deposited voucher specimens in the entomological collection of FES-Iztacala and the private collection of the correspond author of this paper.

Data analysis

To compare ant abundance trapped between stratum (ground and arboreal) and baits, a Mann-U tests and Kruskal-Wallis respectively were performed, both with p = 0.05 (IBM SPSS Ver. 24).

Results and Discussion

Species richness and abundance

Trapping 10,953 individuals in the prickly pear crop, which 8,125 collected on the ground and 2,828 on the cacti. Grouping the ants into five subfamilies, seven genera and seven species: *Hypoponera opacior* (Forel), *Neivamyrmex nigrescens* (Cresson), *Pogonomyrmex barbatus* (Smith), *Linepithema humile* (Mayr), *Camponotus atriceps* (Smith), *Pheidole obtusospinosa* Pergande and *Monomorium minimum* (Buckley). The last four species occurred more often and together accounted for 97% (10,600 ants) of the total abundance (Table 1). 55% of the individuals surveyed between May and September, recording in July the highest abundance of the species *C. atriceps*, *L. humile*, and *M. minimum* (Fig. 1). In contrast, the lowest abundance (12% of the total) occurred between November and February. The abundance of ants was similar in both strata (soil and cacti) in the species C. atriceps (U, 111= 5840, p= 0.37) and L. humile (U, 111= 6107, p= 0.72), and differing in *M*. *minimum* (U 111= 5008, p= 0.009) and *P*. *obtusospinosa* (U, 111= 1421, p=0.000). This latter species was mainly collected in ground traps (97% of individuals), recording populations peaks in April and September (Fig. 1). Baits that attracted more ants were tuna (41%) and honey (30% of individuals), mostly exploited in ground and prickly pear, respectively (Table 1).

Table 1. Ant abundance by strain in prickly pear crop, sampled from February 2013 to March 2014 in Texcoco, Estate of Mexico

	Ground					Prickly pear					Abundance
Subfamily/Species	**Ph**	**Pp**	**Pt**	**Pw**	**total**	**Ah**	**Ap**	**At**	**Aw**	**total**	**Total (relative)**
Dolichoderinae											
Linepithema humile§	635	30	1	166	832	404	51	32	2	489	1321 (12.06)
Dorylinae											
Neivamyrmex nigrescens§	108	0	0		108	0	0	0	0	0	108 (0.98)
Formicinae											
Camponotus atriceps§	272	203	213	255	943	290	475	102	10	877	1820 (16.61)
Myrmecinae											
Monomorium minimum §	334	348	1122	610	2414	846	334	158	21	1359	3773(34.45)
Pheidole obtusospinosa	335	272	2620	374		20	25	58	0	103	3704 (33.83)
Pogonomyrmex barbatus	226	0	0	0	226	0	0	0	0	0	226 (2.06)
Ponerinae											
Hypoponera opacior *§	0	0	0	1	1	0	0	0	0	0	1 (0.01)
Total					8125					2828	10953 (100)

Ground traps (baited with): Ph (honey), Pp (pineapple), Pt (tuna), Pw (test without bait). Arboreal traps (baited with): Ah (honey), Ap (pineapple), At (tuna), Aw (test without bait). §New record for the State of Mexico. *Queen collected.

Dynamics and abundance of the prickly pear myrmecofauna suggest that *P. obtusospinosa* and *M. minimum* are the most active species in the crop's soil and exploit the resource efficiently. Moreover, some authors recorded that *M. minimum* competes for the control of baits against invasive species such as *Solenopsis invicta* Buren (Urbani and Kannowski, 1974) or *L. humile* (Alder and Silverman, 2005). While *P. obtusospinosa* is a dominant species in different environments of Jalisco State, Mexico (Villalvazo-Palacios *et al.,* 2014). In contrast, *L. humile* controls baits by recruiting many organisms (Alder and Silverman, 2005); therefore, it is likely that nest of *M. minimum* and *P. obtusospinosa* inside the crop could be useful to have numerical superiority on *L. humile* and control the resource. This might explain its scanty presence in the periods of high abundance of *P. obtusospinosa* in the ground traps (Figure 1) (Table 1).

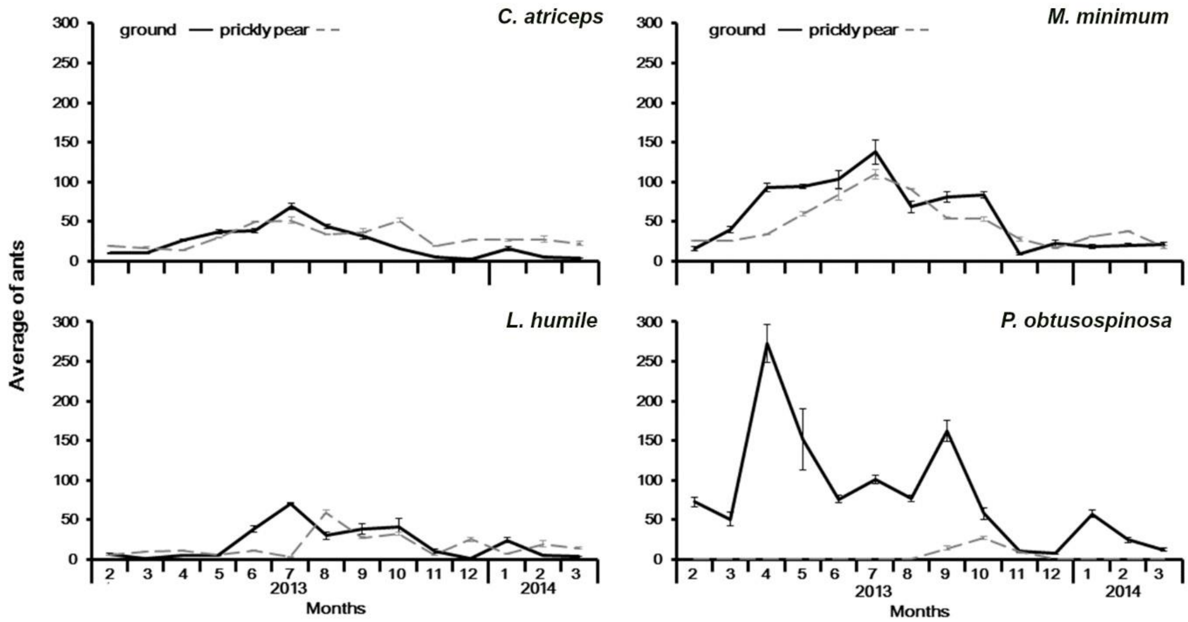

Figure 1. Dynamics of monthly trapped ants (mean ± standard error) on *O*. *ficus*-*indica* crop in Texcoco, State of Mexico

Association with cladodes and pest

Camponotus atriceps and *P. obtusospinosa* were uncommon on cladodes in the fortnightly records (3/26 observations); while L. humile (9/26) and *M. minimum* (16/26 observations) were more frequent and used the glochids as a food source, seen as an enlargement of the abdomen and its amber colour. M. minimum occasionally visited the colonies of the soft scale pest *Dactylopius opuntiae* (Cockerell) (Hemiptera: Dactylopiidae) without visible interactions. In other cladodes, *M. minimum* predated dipterans and micro-wasp, apparently associated with decaying cladodes, remain deposited in the crop's soil.

Linepithema humile visited cladodes infested by *D. opuntiae* and removed up to 60% of these adult females. In such plants, the workers of *L. humile* fed on secretions that were spurted out through the remains of *D. opuntiae*'s stilettoes trapped in the cladode tissue. Sometimes watch *L. humile* attacking larvae of *Hyperaspis trifurcata* Schaeffer (Coleoptera: Coccinellidae) and *Laetilia coccidivora* (Comstock) (Lepidoptera: Pyralidae), both recognized as natural enemies of *Dactylopius* spp. in Mexico (Vanegas-Rico *et al.,* 2010; Vanegas-Rico *et al.,* 2016) and USA (Gilreath and Smith, 1988). The association between *L. humile* and the prickly pear crop was ambiguous, since this ant affected the population of *D. opuntiae*, as well as its natural enemies. Literature shows ambivalence of this ant regarding the cactus *Ferocactus viridescens* (Torr. & A. Gray) Britton and Rose, since it affects the pollination and the seeds development (Le Van *et al.,* 2014). In contrast, this ant reduces the incidence of phytophagous hemipterans on the plant mentioned above (Ludka *et al.,* 2015).

Four species of ants developed their nests in the prickly pear crop: one (*Po. barbatus*) in soil, and other (*P. obtusospinosa*) under decaying cladodes; while *C. atriceps* nesting inside of dead lignified cladodes fixed in the soil, whereas *M. minimum* nesting in the cavities left by the "zebra worm" *Melitara nephelepasa* (Dyar) (Lepidoptera: Pyralidae), and other nests inside lignified live cladodes that did not present damages by other insects. These nesting characteristics of *M. minimum* are not previously described in ants.

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The observations recorded for one hour did not provide elements to discern whether interspecific competition existed in the cladodes, since the activity periods varied among the species studied in this research. *M. minimum* has diurnal habits, *C. atriceps* nocturnal, *L. humile* can be active in both diurnal and nocturnal (Alder and Silverman, 2005; Dáttilo *et al.,* 2015; Díaz-Castelazo and Rico-Gray, 2004), whereas *P. obtusospinosa* is active in the twilight (Vázquez-Franco *et al.,* 2013).

The harvester ant *Po. barbatus* is well distributed in Mexico (Vásquez-Bolaños, 2011); in arid areas, this species gathers *Opuntia* seeds of fallen fruits (Quintana-Ascencio and Gonzalez-Espinoza, 1990) and thus is the main disseminator of the *Opuntia pilifera* Weber seeds (García-Chávez *et al.,* 2010). Even though *Po. barbatus* nests stay inside the study area, was not observed forage on prickly pears. Therefore, its presence in the traps of soil is incidental, and it might have been promoted by the activities of pruning of the crop, since cladodes remain blocked and changed foraging paths of these ants (pers. obs.). For the remaining species, there is no information regarding their association with cactus.

Conclusion

This research is the first approach to understand the diversity and dynamics of ants on prickly pear crops in the Valley of Mexico. It is an agroecosystem not widely studied in the country, from the insects' interactions point of view, since most of the research focused in combat the phytophagous present in the field or study ants like part of the hymenopterans visitors of *Opuntia* and other cacti (e.g. Díaz-Castelazo *et al*., 2004; Le Van *et al*., 2014; Dáttilo *et al*., 2015). Despite that populations of ants may promote the establishment of hemipterans primary pest; in this case, the interaction of formicids on *D*. *opuntiae*, a key pest of crops and wild *Opuntia*, had an influence upon its colonies, preying to their natural enemies; and otherwise, removing the cochineal individuals to feed on broken stilettoes. Finally, to improve the management of *O*. *ficus-indica* crop, it is necessary to incorporate more knowledge about the arthropods present, including ants, to understand their role in this system and the possible implications for pest control.

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Ethics statement

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Consent to publication

The authors give their consent for the publication of the manuscript

Data availability

The data sets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Author contributions

Jesús Acuña-Soto and Fabian Grifaldo-Alcántara methodology; Ana Lilia Muñoz Viveros and Juan Manuel Vanegas-Rico analysis; Juan Manuel Vanegas-Rico writing; Jesús Acuña-Soto, Fabian Grifaldo and Ana Lilia Muñoz Viveros review and editing.

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