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IMPACT OF MANGO MANILA MANAGEMENT SYSTEMS ON ARTHROPODS IN FOLIAGE AND WEEDS

[IMPACTO DE SISTEMAS DE MANEJO DE MANGO MANILA SOBRE ARTRÓPODOS EN FOLLAJE Y ARVENSES]

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SUMMARY

In recent years, cultivation of mango Manila in the State of Veracruz, Mexico, has had a tendency of increased technification and continuous substitution by sugarcane. All this is causing a negative impact on the environment and biodiversity. Thus, the impact of mango Manila management systems on arthropods in foliage and weeds was evaluated. Arthropods associated with foliage and weeds were sampled during different seasons of the year on each management system: technified, transitional, minimum traditional, and substituted by sugarcane. Abundance, diversity and richness by substrate, system and season were calculated. Comparisons between the minimum traditional system and each one of the others were made with Student´s t-test ($P \leq 0.05$). The system substituted by sugarcane had a negative impact on abundance, diversity and richness of arthropods in weeds and foliage during the dry season. The effect of management systems were significantly different after pooling seasons, with greater values during the rainy season, and similar in the dry and winter seasons. System substituted by sugarcane showed a negative impact on diversity during the dry and rainy seasons.

Keywords: Insects; abundance; diversity; sugarcane.

RESUMEN

En últimos años, el cultivo de mango Manila en el estado de Veracruz, México, ha tenido una tendencia de tecnificación y sustitución por caña de azúcar, lo cual ha impactado negativamente al ambiente y su biodiversidad asociada. Por ello, se realizó una evaluación del impacto de sistemas de manejo de mango Manila sobre artrópodos en follaje y arvenses. Se muestrearon artrópodos asociados a follaje y arvenses en diferentes épocas del año en los sistemas de manejo: tecnificado, en transición, mínimo tradicional y sustituido por caña de azúcar. Se calculó la abundancia, diversidad y riqueza por sustrato, sistema y época. Se realizaron comparaciones entre el sistema mínimo tradicional y cada uno de los demás sistemas mediante la prueba t de Student ($P \leq 0.05$). El sistema sustituido por caña de azúcar tuvo un impacto negativo sobre la abundancia, diversidad y riqueza de artrópodos en arvenses y follaje en la época seca. El efecto de los sistemas de manejo resultó significativamente diferente al agruparlos por épocas, con valores mayores en época de lluvias, e iguales en época de secas e invierno. El sistema sustituido por caña de azúcar mostró un impacto negativo sobre la diversidad en las épocas seca y de lluvias.

Palabras clave: Insectos; abundancia; diversidad; caña de azúcar.

INTRODUCTION

Since the Green Revolution, transformation of agricultural management systems has put behind the existing relationships between agriculture and environment (Sans, 2007). The ongoing intensification of agriculture has generated a drastic loss in biodiversity (Tscharntke *et al*., 2005). Taxonomic richness has a decreasing trend based on agricultural intensification gradients (Attwood *et al*., 2008); the increment on agricultural practices reduces the heterogeneity of natural resources, with the loss or reduction of appropriate habitats for survival and reproduction of different species (Atauri and Lucio, 2001). This is one of the main causes of extinction of small and isolated populations (Benton *et al*., 2003). Arthropods have a number of roles in the ecosystem; by losing biodiversity the appropriate ecosystem performance is affected, as well as several ecological services (Altieri, 1999). Intensification of agricultural management might alter processes like soil conformation and soil structure (Pimentel *et al.*, 1997), crop pollination (Klein *et al.*, 2003) and pest biological control (Thies and Tscharntke 1999; Donald, 2004).

Gámez-Virués *et al.* (2009) and Mailafiya *et al*. (2010b) studied the impact of agricultural activities on beneficial insects in leaves and weeds; they pointed out that beneficial insects are quite susceptible to the manipulation and perturbation of their habitat, used for feeding, oviposition and refuge. Arthropod abundance and diversity are good indicators of the impact of agricultural practices on biodiversity (Isaía *et al.*, 2006; Bautista *et al*., 2009), and of a disturbed system (Uribe-Hernández *et. al.*, 2010). After crop disturbance, a selective reduction of arthropod diversity may occur (Palacios-Vargas, 2003).

The production capacity of the State of Veracruz, Mexico, has been diminishing since over 50 years ago, along with a decrease in biological diversity. Veracruz has depleted most of its forest cover; original vegetation has been replaced by pastures, cattle ranches and sugarcane areas. Amount of available water has decreased, making superficial runoff water more violent and uncontrolled; its quality has diminished by soil erosion, fertilizers, insecticides, industrial and urban waste (PVD, 2010).

Mango trees are planted as a production system in 22,000 ha, being of high importance in the State of Veracruz (SIAP, 2009). Mango habitat maintains a broad diversity of organisms, but this has not been properly documented (Plan Veracruzano de Desarrollo, 2010). Mango agroecosystems might be a good example of arthropod biodiversity reduction, due to the application of different levels of technology in the same area. It is possible to find a gradient in agricultural practices intensification: from orchards with a minimum traditional management, to those in transition, the technified ones and also orchards that have been substituted by sugarcane, a more intensive agroecosystem. Thus, we evaluated the impact of mango Manila management systems with different management levels, on arthropod presence in mango and sugarcane leaves, and in associated weeds.

MATERIALS AND METHODS

Study area and production systems

This study was carried out at the municipality of Tierra Blanca (Lat. 18° 27’ N, Long. 96° 21’ W, 60 m of altitude), in the Central area of the State of Veracruz, Mexico. The systems S1, S2 and S3 were present in the property “Rancho el Pantano”, and the system S4 in the locality Huixcolotla. Climate is Aw”$_2$(w)(e)g, the most humid of the warm and subhumid class, with summer rains, extreme thermal oscillation, with the highest temperature occurring during the first semester of the year (García, 1987). Tropical deciduous forest is the predominant natural vegetation (INEGI, 2010).

Mango Manila orchards 50 years old or more were selected for the study. One of the following agricultural management systems were in place: Technified System (S1), characterized by the intensive use of agricultural machinery, as well as fertilizers, insecticides, fungicides, herbicides, flowering inductors, among other inputs; Transitional System (S2), with a scarce or null use of machinery and agricultural inputs; Minimum Traditional System (S3), which avoids the use of machinery and other agricultural inputs; Recently Substituted by sugarcane System (S4), was an old mango Manila orchard, recently cut and substituted by sugarcane.

Sampling design

This non-experimental trial was intended to obtain information from pre-existing agricultural systems. Because several uncontrolled environmental conditions are in place, we chose to make simple comparisons between each mango Manila (and sugarcane) management system and the minimum traditional system, considered as our control because it resembles a natural ecosystem. Information obtained on nearer weeds and crop foliage was analyzed separately. Thus, the setting was considered as a completely randomized design, for each one of the three sampling periods: dry season (March - May), rainy season (July - September) and winter season (November - February). Response variables were abundance, diversity and richness of sampled arthropod morphospecies. Sampling was made during the year 2008. A D-Vac® Model 122 entomological aspirator was used. A 2 min aspiration per tree was considered the sampling unit. For crop foliage arthropods aspirations were performed in two randomly assigned trees per orchard or system, also considered as replicates. In sugarcane, sampling was made from the basal part to the top of the plant, in two plot areas with approximately 10 plants each. Aspirations in weeds and their replicates were made from the base to the top of weed stems, in the surrounding area of each tree. Sampling was performed during two consecutive months on each season. Samples were carried to the laboratory in tagged plastic bags.

Sample processing

Samples were placed in 70 % alcohol vials. Organisms were counted and separated by class, order, family and morphospecies. A morphospecies was defined as a taxonomic unit beneath the class level, presenting conspicuous morphological differences in relation to others (Villalobos *et al*., 2000). Arthropod separation by class, order and family was made with the aide of Triplehorn and Johnson (2005) taxonomic keys.

Data analysis

Abundance was calculated with the number of organisms of each morphospecies, diversity with the Shannon-Wiener Index (Spellerberg and Fedor, 2003), and richness with the number of morphospecies, for each management system, season and sample. Means of the minimum traditional system were compared with the other systems means, for each season and sampling substrate (crop leaves and weeds), with the Student´s t-test ($P \leq 0.05$), using the SAS v 9.1 statistical software.

RESULTS

Abundance and richness of taxonomic groups

A total of 14,755 organisms were collected, including adults, nymphs, pupae and larvae; 2248 were obtained from mango leaves and 12,507 from weeds. By season, 995 organisms were collected in winter, 2444 in the dry and 11,316 in the rainy season. A total of 661 arthropod morphospecies were separated, corresponding to four taxonomic classes: Insecta, Arachnida, Diplopoda and Malacostraca, in 21 orders. Majority of immature stadia were only identified at the Order level. Orders with greater number of morphospecies of Insecta class were Hymenoptera (178 morphospecies from 22 families, 30.7 % captured organisms); Hemiptera (129 from 24 families, 22.3 %); Coleoptera (107 from 27 families, 18.5 %) and Diptera (81 from 22 families, 14 %); in addition, another ten orders with lower number of families and morphospecies were captured (Figure 1). Other groups of arthropods found in lower proportion were Isopoda and Polydesmida; these groups play an important role in several agroecosystems. Among arachnids, in number of morphospecies the Araneae and Acari orders (65 and 32 % of class Arachnida captured organisms, respectively) stood out (Figure 1). The greatest number of insect families in some orders had phytophagous habits, mainly in Hemiptera, Lepidoptera, Coleoptera and Diptera. Other abundant insect families were Hymenoptera parasitoids. Some members of insect families found in samples were recognized as mango pests: aphids (Hemiptera: Aphididae), other hemipterans, thrips and coleopterans. Dipterans and hymenopterans that participate in pollination were also found, as well as vinegar flies (Diptera: Drosophilidae). Predatory insects such as ladybeetles (Coleoptera: Coccinellidae) and green lacewings (Neuroptera: Chrysopidae) were present, along with several families of micro-hymenopteran and dipteran parasitoids.

Morphospecies abundance

Oribatida-1, a soil mite, was the most abundant morphospecies (26.1 % individuals); it was collected mainly when plant parts were in contact with the soil, by aspirating the basal part of plants, meaning that these arthropods were not associated directly with weeds or leaves. When excluding Oribatida-1 from the analysis, two species of Entomobryidae (springtail) were the most abundant (29 and 23 %), followed by one Cicadellidae (leafhopper, 26 %) and one Thripidae (thrips, 22 %). There were in total 665 less abundant morphospecies, representing < 5 % of collected individuals (Figure 2).

Abundance in substrates studied

Weeds had the greatest arthropod abundance. This substrate is considered of great importance based on a number of roles played in several agroecosystems. The greatest arthropod abundance on weeds was registered in the technified (3877 individuals) and minimum traditional system (2854 individuals) (Figure 3). In crop leaves, the system substituted by sugarcane had the greatest arthropod abundance (638 individuals), in contrast with mango leaves of other systems, probably due to the increased accessibility and less selectivity of sugarcane leaves for several species of insects, in contrast with mango Manila leaves. When comparing only the mango systems, the minimum traditional had the greatest abundance of arthropods (342 individuals), whereas the technified system had the lowest (276 individuals), probably due to the management level effect (Figure 4). Overall, weeds had the greatest amount of morphospecies (587), compared with leaves (356) (Figures 3 and 4).

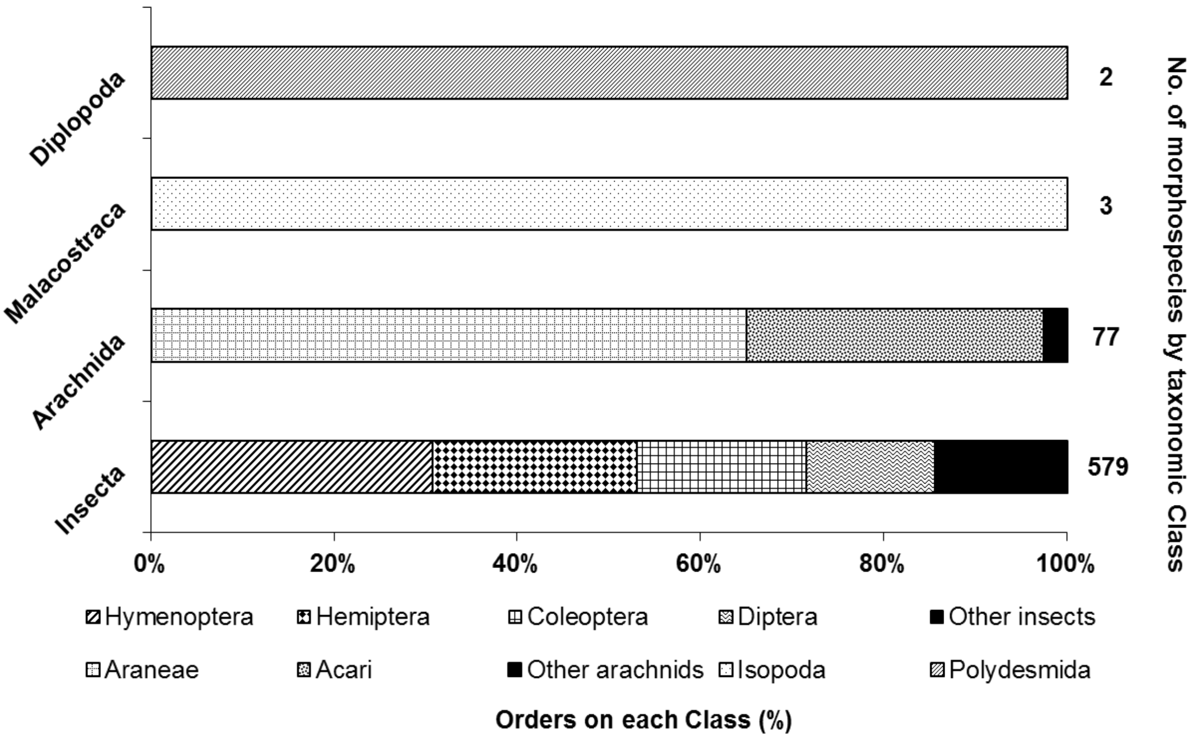

Figure 1. Abundance and richness of taxonomic groups collected in mango leaves and weeds in mango Manila management systems. Municipality of Tierra Blanca, Veracruz, Mexico.

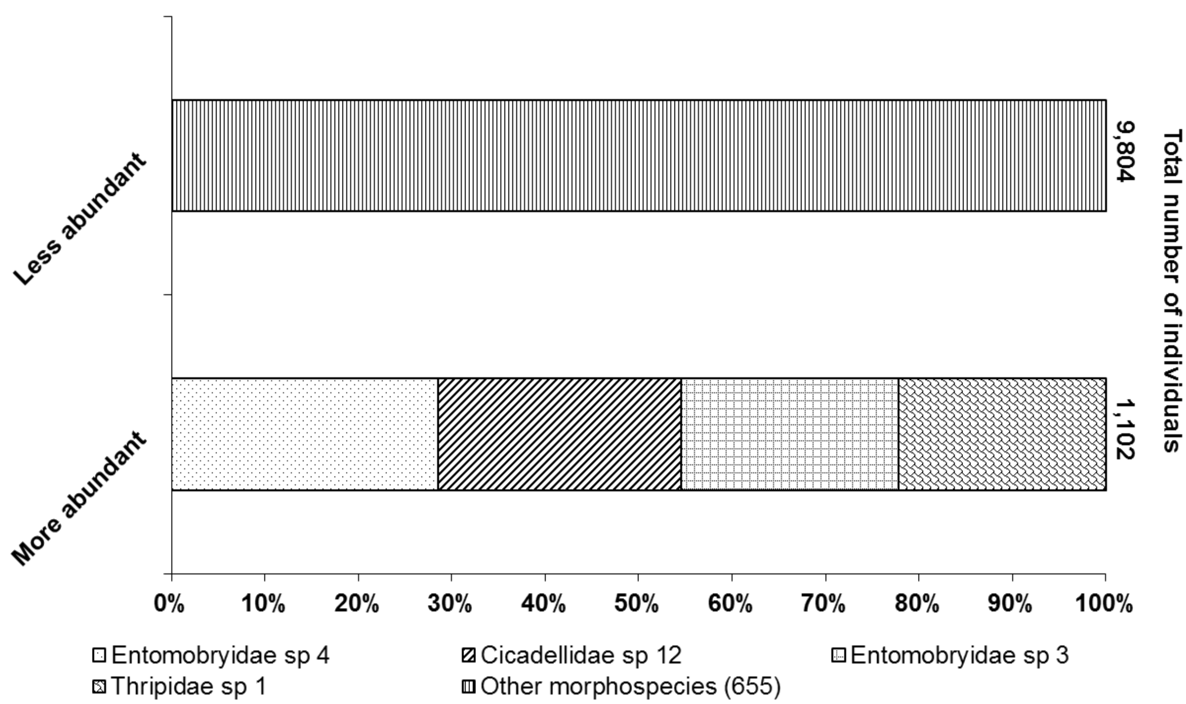

Figure 2. Abundance of arthropod morphospecies collected in leaves and weeds in mango Manila management systems (excluding the Oribatida-1 morphospecies). Municipality of Tierra Blanca, Veracruz, Mexico.

Excluding Oribatida 1, a Cicadellidae species had the greatest total abundance in weeds (3 %). Two species of Entomobryidae, one species of Acari, one of Chironomidae and one of Formicidae were recorded in lower percentages. Technified system and the system substituted by sugarcane had the greatest percentage of abundance of one Cicadellidae species (5 and 2 %), compared to the minimum traditional system that registered greater abundance of one Formicidae species (4.3 %). A total of 581 morphospecies with abundance lower than 2 % were recorded, which in total represented 85.2 % of organisms captured; this group of morphospecies was more abundant in sugarcane, with 91 % (Figure 3).

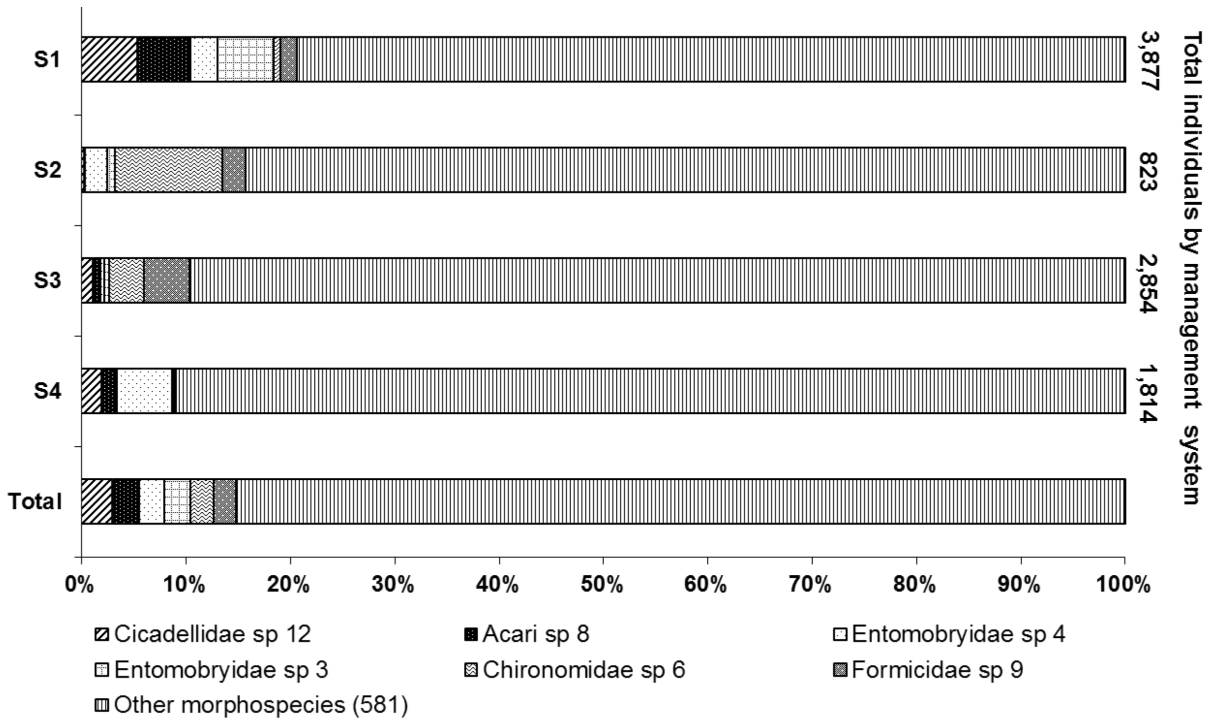

Figure 3. Abundance of arthropod morphospecies in weeds according to the mango Manila management system (excluding the Oribatida-1 morphospecies). S1 = Technified System, S2 = Transitional System, S3 = Minimum Traditional System, S4 = Technified System. Municipality of Tierra Blanca, Veracruz, Mexico.

In mango leaves, one morphospecies of Entomobryidae (Collembola) outstanded (5.5 % total abundance by substrate), followed by one Formicidae (2.9 %), one Scatopsidae (2.8 %), and one Thripidae (2.6 %). In the system substituted by sugarcane the greatest abundance registered was one Entomobryidae (12.9 %), in the transitional system morphospecies of greater abundance was one Scatopsidae (14 %), one Thripidae (11 %), and one Chironomidae (10 %). A total of 350 morphospecies were registered, with less than 2 % abundance, which in total represented 81.6 % of organisms captured, although in the minimum traditional system 90 % of the abundance was present (Figure 4).

When analyzing the mango Manila management systems by substrate and season of the year, weeds had the greatest arthropod abundance (614) compared with leaves (381), during winter. In weeds, the greatest abundance, diversity and richness were registered in the technified, followed by the minimum traditional system. In leaves, the greatest abundance was registered in the transitional (127 individuals), compared to the technified (41) system, that had the lowest abundance; major diversity was registered in the minimum traditional system, and major richness in the system substituted by sugarcane (Table 1).

Ecological indices in mango Manila management systems

During the dry season, weeds had a high arthropod abundance (2097 individuals) compared to that in leaves (347 individuals). In weeds, greater arthropod abundance and richness were present in the technified system, followed by the minimum traditional, and the greatest diversity in the transitional system; meanwhile, the system substituted by sugarcane had the lowest arthropod abundance, diversity and richness, compared to the minimum traditional and technified systems. In leaves, the greatest arthropod abundance, diversity and richness were found in the technified system, followed by the minimum traditional system, and the lowest values in the system substituted by sugarcane (Table 1).

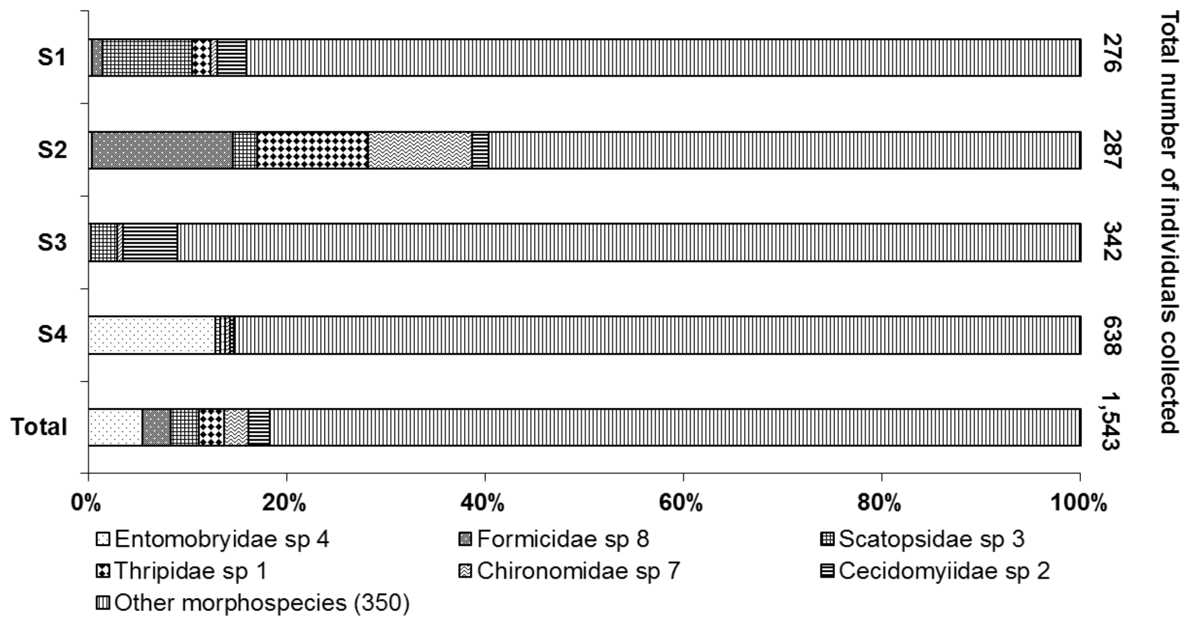

Figure 4. Abundance of arthopod morphospecies in leaves, in different mango Manila management systems (excluding the Oribatida-1 morphospecies). S1 = Technified System, S2 = Transitional System, S3 = Minimum Traditional System, S4 = Technified System.

During the rainy season, weeds were again very superior in abundance (9796 individuals) than leaves (1520). Likewise, in weeds, the technified system had the greatest arthropod abundance and richness. The greatest diversity was found in the minimum traditional system, in contrast with the system substituted by sugarcane, which had the lowest diversity of arthropods. In leaves, the system substituted by sugarcane presented the greatest abundance and richness, but the lowest diversity; the technified and minimum traditional systems registered the greatest arthropod diversity (Table 1).

Statistical analysis

When the arthropod abundance was compared by season of the year, the rainy season had an average of 364 individuals, significantly greater than those in winter, with 71 individuals ($P = 0.005$), and those during the dry season with 81 ($P = 0.004$). The winter and dry seasons were not significantly different ($P = 0.6221$). Regarding the arthropod diversity by season, no significant differences were recorded ($P \geq 0.05$). However, when comparing arthropod richness, the rainy season was superior (55 morphospecies on average) than the winter season with 29 ($P < 0.05$), and also than the dry season with 26 morphospecies in average ($P = 0.0042$).

In relation with the substrates studied, weeds were superior in arthropod abundance with an average of 495 individuals, compared to mango and sugarcane leaves that only registered an average of 79 individuals ($P = 0.0035$); likewise, weeds were superior in arthropod diversity and richness ($P = 0.0001$).

In relation with mango Manila management systems, the most intensive ones (substituted by sugarcane and technified systems) were not different ($P \geq 0.05$) in arthropod abundance than the most stable, which was the minimum traditional system; only the system substituted by sugarcane was different ($P < 0.05$) in abundance (320 individuals in average) than the transitional system (59 individuals). In relation with arthropod diversity, only the system substituted by sugarcane was significantly lower than the minimum traditional system ($P = 0.0038$). Only the transitional system, with an average 24 morphospecies, was different than the technified system, with an average 48 morphospecies ($P = 0.04$).

Table 1. Abundance, diversity and richness of arthropods according to the mango Manila management system in different seasons of the year and substrates studied.

Collected on:	Weeds				Leaves			
	S1	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**
				Winter season				
Abundance	266	158	190		41	127	93	120
Diversity	3.7	3.1	3.4		2.6	2.5	3.8	3.5
Richness	85	55	66		20	30	55	60
				Dry season				
Abundance	782	360	363	217	165	73	80	29
Diversity	3.9	4	3.7	2.5	3.6	3.4	3.6	2.2
Richness	156	109	133	53	63	40	46	14
				Rainy season				
Abundance	3916	311	2091	3478	70	91	176	1183
Diversity	3.9	4.2	4.5	2.9	4.9	3.5	4.9	3.0
Richness	295	114	255	229	145	69	176	248

Systems: S1 = Technified, S2 = Transitional, S3 = Minimum traditional, S4 = Substituted by sugarcane.

DISCUSSION

This study made clear the importance of crop weeds as the habitat of several arthropods, being the substrate with greater abundance of organisms, compared to mango Manila and sugarcane leaves. The difference in arthropod abundance among the substratesstudied could have been related with the heterogeneity of weeds, in accordance to Sans (2007), who stated that weed heterogeneity favors habitat differentiation, and increases opportunities of coexistence and interaction among species, leading to a greater resource efficacy. This substrate was more attractive to several arthropods, mainly insects. Other important aspect of weeds, that resulted less important in crop foliage, is the interaction plant-arthropod, which might be very diverse. Even more, coevolution of plant-arthropod interactions has been indicated, developing interactions in different forms, like mutualistic, antagonistic, amensalistic, etc. (Dirzo *et al.*, 2004). Weed heterogeneity generates abundance and richness of arthropods, however it may vary according to the agricultural practices in place; this also impacts those arthropods that inhabit in this substrate.

In crops with deficient or no weed control, most weeds are opportunistic species; under those circumstances, heterogeneity of plant species is the rule and benefits the diversity of arthropods. On the other hand, intensive, constant and complete coverage of agricultural practices promotes homogeneity of plant species, mostly annuals capable to develop in disturbed systems, affecting negatively arthropod diversity (Cerazo and Conticello, 2008). Arthropods associated to the substrates studied were mostly insects and spiders. Ants and wasps, mostly beneficial insects, had the greatest morphospecies richness in Hymenoptera, followed by mostly phytophagous morphospecies of Hemiptera: planthoppers, bugs, scales and whiteflies. However, in weeds beneficial insects such as parasitoid wasps, predatory bugs and beetles, as well as predatory spiders were the most abundant and diverse, which might potentiate the use of this substrate in an agroecological management system. Traditional agriculture utilizes selective weed control, even promoting weed presence for its beneficial role in the crop or additional utility for the grower (Altieri, 1999). Most of the time it is easier to try to manage the weeds than completely eliminating them; they can be useful in preventing soil erosion or helping in reduction of pest populations. In mango agroecosystems, weeds might serve as an appropriate habitat for predatory ants, as well as Staphylinidae and Histeridae beetles; those act directly on *Anastrepha* fruit fly larvae that jump to the soil ready to pupate. Mango surrounding vegetation might serve as refuge or feeding source for wasps that are parasitoid of pests, such as scales (Hemiptera: Coccoidea y Diaspididae), and *Anastrepha* fruit flies. However, the action of natural enemies can be diminished by the intensification of the agricultural management system, similar to what was found in several trials with natural enemies in disturbed systems (Platt *et al.,* 1999; Gámez-Virués *et al.,* 2009; Mailafiya *et al.,* 2010).

As a substrate, leaves registered several insects capable of causing problems to the crop, such as leafhoppers, scales, ants and thrips; however, they can be naturally regulated. Recently in Central Veracruz, severe problems with the mango scale *Aulacaspis tubercularis* has been registered, which means that there is a risk of emergence of new pests, mainly due to the alteration of agricultural systems. Arthropods collected in the systems studied played different roles; they were not just beneficial or phytophagous insects, but the majority of them were arthropods playing ecological functions associated with the agroecosystems, having different abundance, diversity and richness of morphospecies, depending on the agricultural management system used. Total arthropod abundance in weeds was apparently not affected by technification in mango agroecosystems (technified system); it resulted in greater abundance compared to the less technified system (minimum traditional). However, it was not the case with the system substituted by sugarcane, considered as another highly technified system, where the abundance of arthropods was lower than in the minimum traditional system; the difference among morphospecies registered in these two systems was also lower, with a noticeable dominance of Entomobryidae and Cicadellidae morphospecies in weeds associated with sugarcane, insects probably better adapted to crop homogeneity. In contrast, weeds in the minimum traditional system registered a lower morphospecies dominance, standing out those from Formicidae and Chironomidae families, whit habits more related to heterogeneous and less disturbed systems (Cerdá *et al.,* 2009). As a substrate, sugarcane leaves registered the greatest abundance of arthropods, compared to mango leaves, outnumbering the less technified system (minimum traditional); however, it was evident the impact of the system substituted by sugarcane on morphospecies diversity, with a clear dominance of one Entomobryidae, probably closely related to the soil, and the lower part of weeds and crop foliage.

Not many studies can relate seasonal conditions with the impact of agricultural management on hosted organisms. Our results demonstrated the importance of seasonality as a factor increasing or decreasing the impact of such agricultural systems. As an example, the system substituted by sugarcane had a negative impact on arthropod abundance in leaves and weeds during the dry season; however, during the rainy season the impact of this system decreased to a level similar or slightly higher than less technified systems; this demonstrates that rain plays an important role as a factor associated with biological abundance, which attenuates the impact of agricultural management on arthropod populations. However, organism abundance by itself is not a disturbance parameter of agricultural systems, because systems disturbance affects directly biodiversity and not necessarily abundance (Altieri, 1999; Benton *et al.,* 2003; Sans, 2007; Bautista *et al.,* 2009). Biological diversity is more sensitive to the impact of agricultural systems, thus environmental conditions are unlikely to allow the recovery of the affected diversity; this can be demonstrated with the impact of the system substituted by sugarcane on the diversity and richness of arthropods in all seasons sampled, since this is a disturbed system that does not allow the recovery of the system stability. On the contrary, besides recording lower abundance compared with the technified systems (i.e. substituted by sugar cane), the less technified system (minimum traditional) always maintained higher diversity and richness, independently of the season of the year.

According to the statistical analysis, environmental conditions (season) and substrates (weeds and leaves), had a greater effect on arthropod abundance unlike the mango management systems, which indicates that the most technified systems (technified and substituted by sugarcane) have not reached yet to levels that completely affect the survival resources of the arthropods. On the contrary, the dry and winter seasons affected drastically arthropod abundance, explained by the scarcity of living resources compared with those in the rainy season, where there was greater richness, abundance and biomass of plant species. All this allows the establishment and survival of arthropods with different habits, leading to a greater abundance of organisms.

For arthropod diversity, the system substituted by sugarcane had a negative impact on the ecological balance, a characteristic of a disturbed system. This is opposite to the minimum traditional system, which is a system characterized for better protecting biological diversity, mainly in weeds during the rainy season.

System impact by season

The system substituted by sugarcane affected constantly arthropod diversity, independently of the environmental conditions (season). Apparently, the technified and transitional systems did not have a clear effect on arthropods associated with leaves and weeds. It is clear that intensification of agricultural systems had an impact on biodiversity, demonstrated when comparing the sugarcane system with all mango systems. Likewise, the technified system in mango apparently did not have an impact on arthropods in leaves and weeds. However, it would be necessary to study arthropods in other substrates of the agroecosystem, such as soil, as it might indicate a different situation in relation with the technified mango systems, mainly because arthropods associated with soil are more sensitive to changes or disturbances affecting their system (Villalobos *et al*., 2000; Bautista *et al*., 2009; Uribe-Hernández *et al.,* 2010). This type of studies might complete the evaluation of the technified mango system, and would allow to determine whether those systems can have diversity levels similar to less technified systems (minimum traditional and transitional), to benefit from the increase in stability associated with a greater diversity.

CONCLUSION

The most intensive mango Manila management system, and even the system substituted by sugarcane, decreased their parameters of arthropod presence during the rainy season, both in mango and sugarcane leaves, as well as in associated weeds, in comparison to the minimum traditional system, which is less perturbed by agricultural management. In all the mango Manila management systems studied, weeds were the sampled substrate with greater arthropod population. Also in all systems, insects with the greatest richness were from Hymenoptera, Hemiptera, Coleoptera and Diptera, compared to several arthropod orders. Foliage favored dipterans and thysanopterans; weeds did it for coleopteran curculionids and hemipteran cicadellids, mainly during the winter and dry seasons. During the rainy season, oribatids and collembolans were favored. Phytophagous insects were more abundant and entomophagous were only important by their richness. Mites of the Oribatida group were abundant in all the systems studied.

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