ENTOMOFAUNA DIVERSITY IN SUNFLOWER CROP IN ASSOCIATION WITH ATTRACTANT PLANTS[1]

[DIVERSIDAD DE LA ENTOMOFAUNA EN CULTIVOS DE GIRASOL EN ASOCIACIÓN CON PLANTAS ATRAYENTES]

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SUMMARY

The objective of the research was to determine the effect of the association of the sunflower crop with attractive crops on the diversity and abundance of the entomofauna at the Experimental Farm Querochaca, Facultad de Ciencias Agropecuarias, Universidad Tecncia de Ambato (UTA), Ecuador. Samplings of insects visiting sunflower were made at 8:30; 11:30 and 14:30 h during three months. The insects were separated by morphotypes and posteriorly identified to family or when possible to species level using taxonomic keys. Specimens belonging to Diptera and Hymenoptera were sent to the J.M Osorio-UCOB Entomological Museum (Venezuela) for identification. The different morphotypes were separated by their feeding habit as predators, phytophagous, parasitoids and pollinators. A total of 379, 1065 and 396 insects were collected when the sunflower seeded alone, in association with *Vicia* and Chinese cabbage, respectively. In general, the entomofauna composition was similar in the three cropping systems in which it was found that the highest number of families collected corresponded to insects of predatory habit (11), phytophagous (5), pollinators (4) and parasitoids (2) ($p<0,001$). Diptera showed greatest diversity of families (14), followed by Homoptera (3) and Hymenoptera (3), whereas only two families from Coleoptera and one from Hemiptera were collected. A positive correlation was observed between insect numbers and temperature in sunflower + Vicia ($r = 0.9144$, $p <0.00$), sunflower + Chinese cabbage ($r = 0.9548$, $p <0.00$) and sunflower alone ($r = 0.9204$, $p <0.00$). According using attractive plant species in association to sunflower promoted higher insect diversity, including pollinator and natural enemies species, which could be profited to increase crop productivity, however, more detailed studies are required to establish its impact.

Keywords: diversity, habit, correlation, entomofauna, attractant crops

RESUMEN

El objetivo de la investigación fue determinar el efecto de la asociación del cultivo de girasol con cultivos atrayentes sobre la diversidad y abundancia de la entomofauna en la Granja Experimental Querochaca, Facultad de Ciencias Agropecuarias, Universidad Técnica de Ambato (UTA), Ecuador. Se hicieron muestreos de los insectos visitantes al cultivo de girasol a las 8:30; 11:30 y 14:30 h durante tres meses. Los insectos fueron separados por morfotipos y posteriormente identificados usando claves taxonómicas hasta nivel familia y cuando fue posible hasta el nivel especie. Los especímenes pertenecientes a Diptera e Hymenoptera fueron enviados al Museo Entomológico J.M Osorio-UCOB (Venezuela) para su identificación Los diferentes morfotipos fueron separados por su hábito de alimentación en depredadores, fitófagos, parasitoides y polinizadores. Se colectó un total de 379, 1065 y 396 insectos cuando el girasol de sembró solo, en asociación con *Vicia* y col china, respectivamente. En general, la composición de la entomofauna fue similar en los tres sistemas de cultivo en los cuales se encontró que el mayor número de familias colectadas se corresponden con insectos de hábito depredador (11), fitófagos (5), polinizadores (4) y parasitoide (2) ($p<0,001$). Diptera mostró la mayor diversidad de familias (14), seguido de Homoptera (3) e Hymenoptera (3), mientras que solo fueron colectadas dos familias de Coleoptera y una de Hemiptera. Se observó una correlación positiva entre el número de insectos y la temperatura en las asociaciones de girasol + *Vicia* ($r=0,9144$; $p<0,00$), girasol + Col china ($r=0,9548$; $p< 0,00$) y girasol solo ($r=0,9204$; $p< 0,00$). De acuerdo con los

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resultados, el uso de especies de plantas atrayentes en asociación con el cultivo de girasol promovió mayor diversidad de insectos, incluyendo especies polinizadoras y enemigos naturales, las cuales podrían ser aprovechadas para incrementar la productividad del cultivo, sin embargo se requieren hacer estudios más detallados para establecer su impacto.

Palabras clave: diversidad, hábito, correlación, entomofauna, cultivos atrayentes

INTRODUCTION

Modern agriculture has promoted simplification of the environment structure, thus replacing natural biodiversity by a minimal cultivated plant species variety (Altieri, 1999). This fact has traditionally erected a conflict between the need to produce food preserving the wild life. In recent decades has surged the tendency to conciliate both point of view, based on a multifunctional approach of use of agricultural lands. This includes diversification of crop systems by increasing space-temporal heterogeneity in agricultural farms as alternative to overcome the negative impact of the modern agriculture (de la Fuente *et al*., 2014) providing habitats for predators and parasitoids of crops pests (Jones and Gillett, 2005), and also for pollinator insect species (Nicholls and Altieri, 2002).

Previous studies have shown that organic farm systems show higher diversity and abundance of different functional groups of insects, including predators, parasitoids and pollinator species, as compared to those conventional farm systems (Paoletti, 2000). Moreover, insect biodiversity is frequently increased by intercropping. In this regard, Lanjar *et al*. (2014), observed increase in number of phytophagous, predatory and pollinator species in association sunflower and mustard. Similarly, more biocontrol agents were found in intercropping with soybean (*Glycine max* (L.) due to increases in refuge sites and food sources providing ideal habitats for predators that controlled phytophagous species (Hernández and Limonte, 2010). Additional benefits from intercropping is related to increases in pollinator diversity, such as some Apidae species, which play a role in increasing yield in various crops, including sunflower (Ali *et al*., 2015; Rasheed *et al*., 2015). Torretta *et al*. (2010) reported *Melissodes tintinnans* (Holmberg), *Melissodes rufithorax* Brèthes, *Melissoptila tandilensis* Holmberg and *Megachile* spp. (Hymenoptera: Apidae) as potential pollinator in sunflower.

Based on previous reports of beneficial effects of the plant species diversification on insect diversity, the aim of this work was evaluate the effect of the association of the sunflower (*Helianthus annuus* L.) with attractive crops (Chinese cabbage and lupine) on the diversity and abundance of the entomofauna in Querochaca, Tungurahua, Ecuador.

MATERIAL AND METHODS

This research was carried out in the Experimental Teaching Farm ¨Querochaca¨, Faculty of Agricultural Sciences, Technical University of Ambato (UTA), Province of Tungurahua, Ecuador (01°21' S; 78°36' W; altitude 2865 masl), mean temperature 14.5 °C, relative humidity 77.25% during the study time (March-May 2016).

The abundance of the different functional groups of insects (phytophagous, parasitoids, predators or pollinators) was determined in three crop systems: sunflower alone (T0), sunflower + *Vicia sativa* (T1) and sunflower + *Brassica oleraceae* var. *pekinensis* (T2).

Trials were carried out in field plots (0.9 x 23 m) separated at 3.3 m each and the subdivided into four sub-plots (0.9 x 3.5 m) separated each other at 3.0 m, each representing a replication. Twenty days-old sunflower seedlings were supplied by Nursery Israel (Montalvo, Province of Tungurahua) and transplanted (0.25 x 0.30 m). Thirty days after sunflower being planted, both seeds of *Vicia sativa* (T2) were sprayed in a continuous flow (at 0.3 between rows) and *Brassica rapa* var. *pekinensis* seedlings were planted (0.40 x 0.30 m) (T3). Weekly drip irrigation was applied (flow rate 2.3 L/h per emitter) and manual control of weeds was made at 30, 60 and 90 days after the transplant.

Before sampling, collecting of insects was made every two hours from 8:00 to 14:00 to determine the time of day in which the greatest abundance of insects occurred using an entomological net. Based on this, three sampling times were established (8:30, 11:30 and 14:30) and samplings were made at 8-days interval from first floral bud was observed until seed maturation.

Entomological specimens were taken to the Plant Health Laboratory (Faculty of Agricultural Sciences), separated by morphotypes and pin mounted according to conventional techniques. The identification was made by taxonomic keys available for each insect order or family. Identifications was corroborated by Dr. Neicy Valera (Hymenoptera) and Dr. Evelin Arcaya (Diptera) from the Entomological Museum "J.M. Osorio-UCOB", Universidad Centroccidental "Lisandro Alvarado", Venezuela.

The data referring to insect order/family and its frequency were tabulated and plotted to illustrate both abundance and the time of greatest activity in each cropping system (sunflower alone or in association). Correlation between climatic parameters and abundance of insects associated with each crop system was determined.

The trial was conducted in a completely randomized design. The data were subjected to analysis of variance and to mean test according to Tukey (p <0.001) using Statistix software version 10.0.

RESULTS AND DISCUSSION

Insect diversity in sunflower cultivation alone and associated with attractant plants

A total of 379, 396 and 1065 specimens were collected when the sunflower was sown alone, or in association with Chinese cabbage and lupino, respectively (Figure 1). Although greater insect abundance was found in the association sunflower + *V. sativa*, no differences were observed in the familial composition between the three cropping systems, of which the largest number of family insects showed predatory habit (11), followed by phytophagous insects (5), while a smaller number of insects with pollinating habits (4) and parasitoids (2) were collected (p <0.001). According to the Jaccard index, similarity in the insect composition between the systems sunflower alone in relation to the associated systems was 0.28 with only five families in common: Apidae, Cicadellidae, Culicidae, Syrphidae and Therevidae.

On the other hand, similarity between associated systems (sunflower grown in association with *V. sativa* or *B. oleraceae* var. *pekinensis*) was 0.41 since both systems shared seven families (Chrysopidae, Coccinellidae, Lauxanidae, Sarcophagidae, Syrphidae, Tephritidae and Therevidae). Ali *et al*. (2015) observed that Hymenoptera showed the higher abundance represented by 15 species belonging to three families (91% of insect visitors to sunflower crop), followed by Lepidoptera with three families and four species (6%) and Diptera with two families and two species (3%). Jadhav *et al*. (2011) also found insects belonging to Coccinellidae and Curculionidae (Coleoptera), in both cases they were reported feeding on nectar. Additionally, Lanjar *et al*. (2014) found greater insect abundance when sunflower was sown in association with mustard (a total of 32 species belonging to the orders Homoptera, Thysanoptera, Lepidoptera, Isoptera, Neuroptera, Odonata, Coleoptera, Orthoptera, Hymenoptera and Diptera), of which 23 species were phytophagous and only 4 predators and 5 pollinators. Similarly, de la Fuente *et al*. (2014) also observed that the association sunflower + soybean resulted in higher insect abundance (mainly phytophagous) than in sunflower growing alone. Conversely, Jones and Gilleti (2005) stated that the use of crops in association with sunflower results in higher occurrence of beneficial insects. These authors observed a greater number of predatory insects almost immediately after crop establishment, while parasitoids and pollinators species were attracted when the plants started to bloom. These variations in diversity and abundance of insect composition could be explained by variations in the plant community composition, the canopy structure, and crop management practices (de la Fuente *et al*., 2014).

Probably, low number of phytophagous species found in association with sunflower in this study could be due to the greater number of predatory species, suggesting that there could be natural biological control in the area. However, more detailed studies should be addressed to determine the impact of natural enemies on populations of herbivorous species associated to sunflower in this region. In addition, variation in insect number due to the sampling time was observed (Table 1).

Table 1. Diversity of insects occurring in three sunflower association systems at different sampling times

Insect Order	Sampling time								
	8.30			**11:30**			**14:30**		
	S	S+V	S+ChC	S	S+V	S+ChC	S	S+V	S+ChC
Diptera	60	189	33	39	223	30	45	229	49
Hemiptera	12	18	8	11	23	10	8	22	2
Homoptera	49	117	20	34	75	12	32	103	35
Coleoptera	9	18	8	13	7	2	7	5	7
Hymenoptera	17	13	55	26	14	65	13	6	58
Neuroptera	2	1	0	0	2	2	2	0	0
Total	149	356	124	123	344	121	107	365	151

S= sunflower; S+V = sunflower + *Vicia sativa*; S+ChC = sunflower+chinese cabbage

During the three sampling times, the largest number of insects was collected in the sunflower + *Vicia* association, with 356 individuals collected at 08:30, which was 58.5 and 65.5% higher than when the sunflower was grown only and in association with Chinese cabbage, respectively. This difference was even greater during the following sampling times, since the number of insects attracted in the sunflower + *Vicia* association was 63.6 or 71.0% % higher when compared with the crop alone at 12:30 or 14:30 h. Similarly, Ali *et al*. (2015) observed that the abundance of visiting species in a sunflower crop varied along the day, with the highest bee's density peaks being recorded between 12:00 and 14:00 pm, while the minimum were recorded at 08:00 a.m. and after 16:00 p.m. In addition to the effect of sampling time, the association with other crops also influences the number of insects attracted. Thus, de la Fuente *et al*. (2014) found greater diversity of morpho-species when the sunflower was grown in association with soybean.

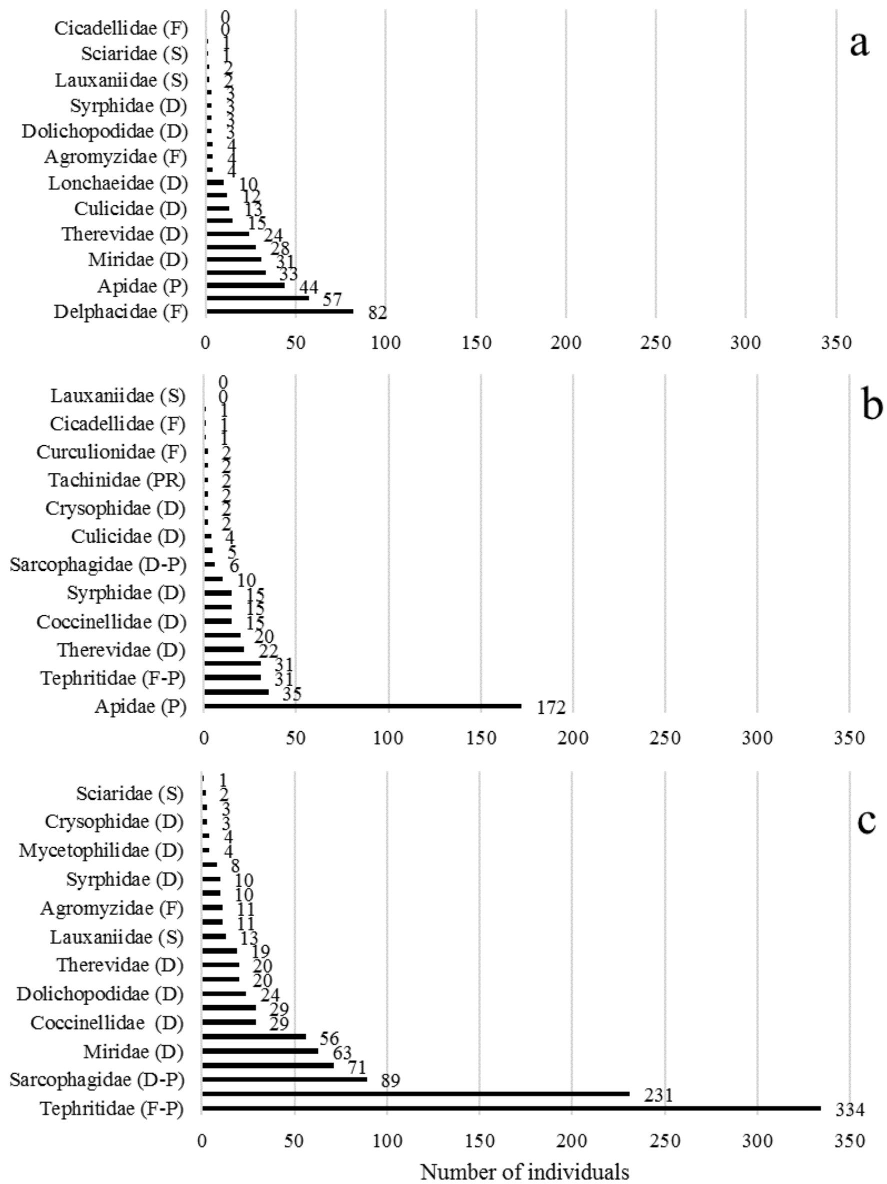

Figure 1. Number of individuals per insect family collected in the sunflower crop sown alone (a) and in association with Chinese cabbage (b) and Vicia (c) [D = predator; F = phytophagous; P = pollinator; PR = parasitoid; S: saprophage]

Lanjar *et al*. (2014) showed that the diversity of insects can vary according to the cultivation system, being higher (H'= 1.78) in sunflower + mustard association, whereas the value of H' was lower when sunflower or mustard grown alone (1.62 and 1.30, respectively). In addition, the environment can also influence insect diversity (Chowdhury *et al*., 2014). Thus, these authors found agricultural environment showed a higher diversity index as compared to anthropic areas, due to the effect of contamination, human interference and changes in the environment. In this study, a greater number of families belonging to Diptera was found, followed by Homoptera and Hymenoptera, while only two families from Coleoptera, one from Hemiptera and one from Neuroptera were collected, both in sunflower cultivation alone as in association (Figure 2).

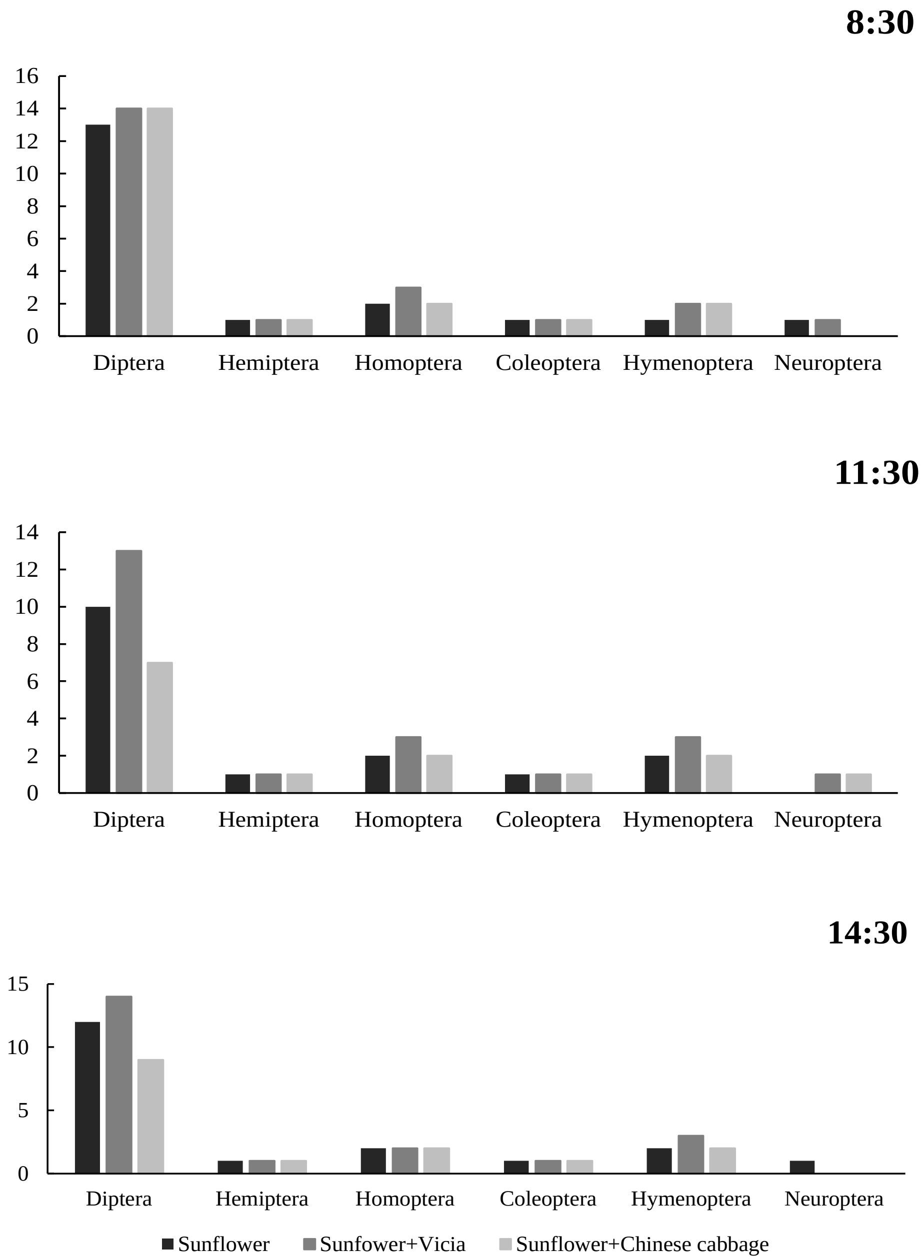

Figure 2. Total number of insect families collected in different sunflower association (sunflower; sunflower + *Vicia sativa* and sunflower + *B. oleraceae* var. *pekinensis*)

Diptera was represented by 14 families with the largest number of specimens found in Tephritidae, Neriidae and Sarcophagidae during the three sampling times. On the other hand, three families were collected in Homoptera and Hymenoptera, respectively (Figures 2). Contrary to our results, in studies conducted in sunflower in Pakistan greater diversity corresponded to Hymenopteran species (91%), mainly bees (*A. mellifera*), followed by Lepidoptera (6%) and Diptera (3%) (Ali *et al*., 2015), although predominance of Hymenoptera could be explained by the proximity of the study to commercial apiaries, so it is logical that bees took advantage of this resource as a source of pollen. When the abundance of insects in each of the crop systems was considered, it was found that the highest percentage of dipterous collected belonged to the family Tephritidae in all of the crop systems and sampling times (Figure 3).

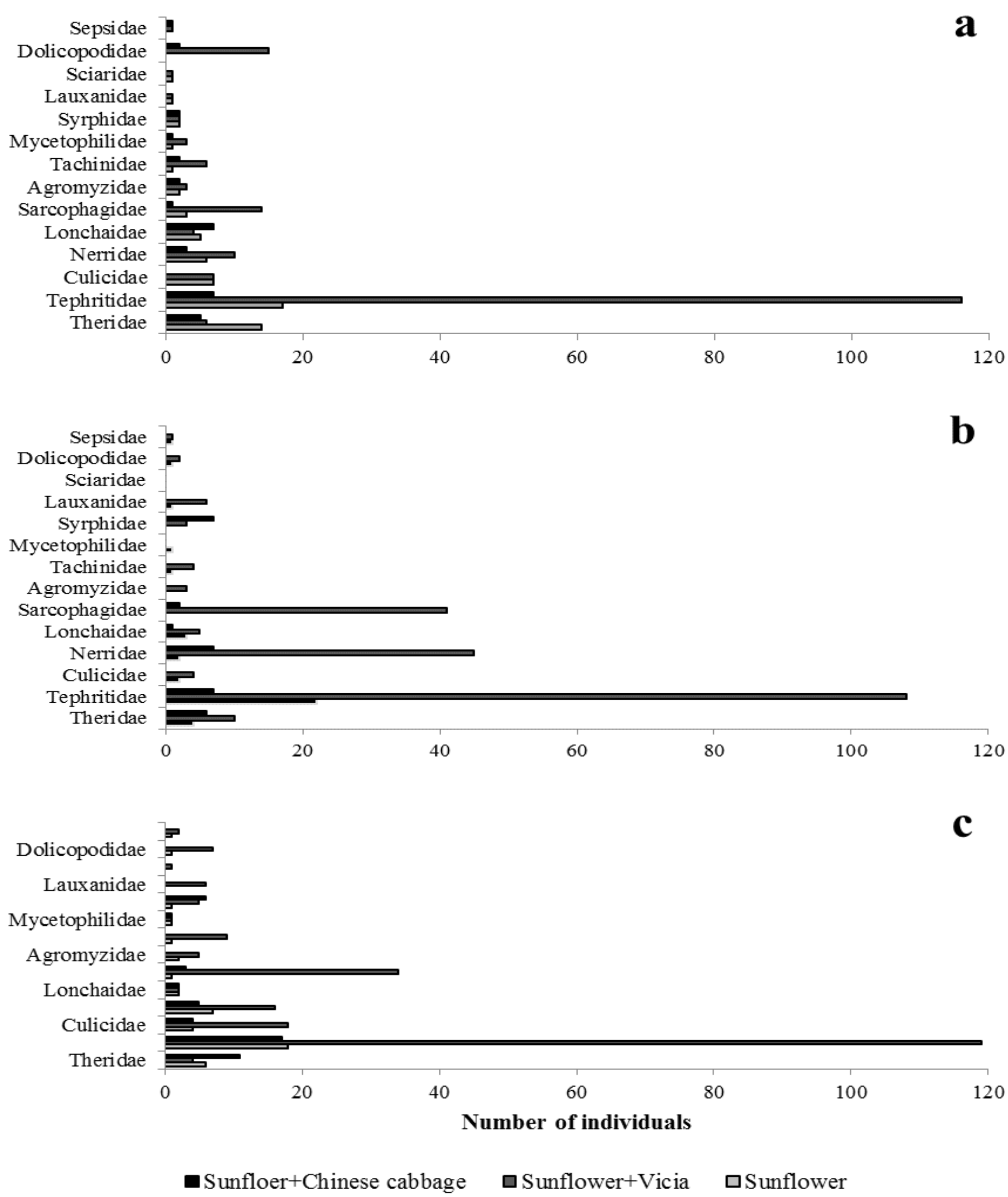

Figure 3. Variation in the composition of Dipteran families in different sunflower associations in the three sampling times: 08:30 (a), 11:30 (b) and 14:30 (c).

At 8:30 a.m., insect composition showed percentage of tephritids 28, 61 and 21% in sunflower alone, sunflower + *V. sativa* and sunflower + *B. oleraceae* var. *pekinensis*, indicating that more than 50% of insect abundance was represented by fruit flies in association with *V. sativa*, while in the other two systems this family was only present <30%. At 11:30 a.m., the proportion of fruit flies increased from 28 to 56% when sunflower sown alone, while a slight decrease (61 to 44%) in the association with *V. sativa*. In the sunflower + *B. rapa* association no substantial variation in this group was observed, remaining around 21 and 23% at 8:30 and 11:30 am, respectively. Finally, during the sampling carried out at 2:30 p.m., changes in the composition were observed again, with a decrease of up to 40% in the sunflower alone, whereas in the association sunflower + *V. sativa* an increase up to 52% was observed again, while in sunflower + *B. rapa* increased up to 35%. Most of Tephritidae larvae feed on soft fruits of tropical trees, shrubs, vines and mainly of horticultural species (Clarke *et al*., 2002). Other observations have shown evidence that adults could act as pollinators when visiting flowers of some plant species (Tan and Nishida, 2000), although there is no conclusive evidence so far. However, the presence of pollen from orchid flowers suggests that tephritids could function as potential non-specialized pollinators. Pisciotta *et al*. (2011) found nine Dipteran families acting as pollinators on two Apocynaceae species, including Tephritidae, Milichiidae, Trixoscelididae, Scathophagidae, Antho-myiidae, Muscidae, Calliphoridae, Sarcophagidae and Rhinophoridae.

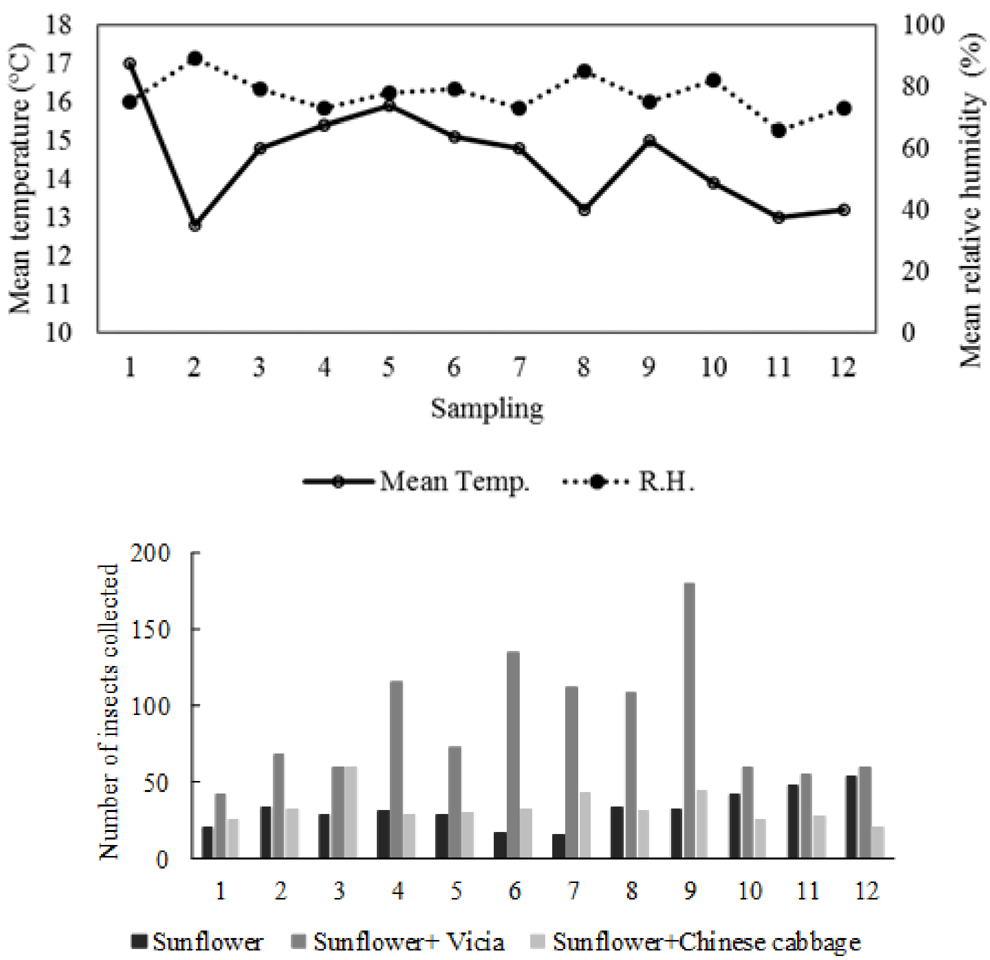

Figure 4. Variation in insect abundance in the different associations of sunflower in relation to temperature (ºC) and relative humidity (%)

Although lower family diversity was found in sunflower + *B. rapa* association, it was noticeable occurrence of higher number of bees (*A. mellifera*) in this association, which could be beneficial for sunflower pollination. Similarly, Ali *et al*. (2015) observed four *Apis* species (*A. mellifera*, *A. dorsata*, *A. cerana* and *A. florea*) to be most abundant pollinating species in sunflower however, *A. mellifera*

was the most predominant species, probably due to the proximity with commercial apiaries.
On the other hand, Delphacidae (Homoptera) was most frequently collected in sunflower + *V. sativa* during the three sampling times.

Correlation between climatic parameters and insect diversity

A positive correlation between the number of insects and temperature was observed in sunflower alone (r= 0.9204, p<0.00), and sunflower + *V. sativa* (r= 0.9144, p<0.00) or sunflower + *B. rapa* (r= 0.9548, p<0.00) association. Similarly, a positive correlation was detected between the number of insects and the relative humidity in the associations of sunflower + *V. sativa* (r = 0.9107, p <0.00), sunflower + *B. rapa* (r = 0.9541; <0.00) and sunflower alone (r = 0.9361; p <0.00) (Figure 4).

Contrarily, the values of correlation between abundance and relative humidity were low. Previous studies have documented that temperature and humidity represent the most determinant abiotic factor in the abundance and distribution of insects, since they affect their survival, development and reproduction (Savopoulou-Soultani *et al*., 2012). Thus, Azevedo and Kruguer (2013) indicated that both species richness and abundance could be influenced by both the mean temperature and relative humidity, with greater richness and abundance observed at the end of spring and early summer.

Probably, the observed increase in insect abundance in the two sunflower association systems (*V. sativa* or *B. rapa*) could be due to the fact that these offered refuge sites when the environmental conditions were not favorable for some groups of insects. Accordingly, Rebaudo *et al*. (2016) observed that the microclimate data (air temperature of plant canopy) allowed to better predict the abundance of the insects when it was evaluated at small and medium scales.

CONCLUSION

Based on our results, the use of attractive plants associated with sunflower crops could be a viable alternative to increase insect diversity that visit the crop, including beneficial species such as pollinating insects and natural enemies. These species could represent a benefit for the crop because, on the one hand, pollinating species could increase productivity and on the other, natural enemies can exert natural control of phytophagous species occurring in sunflower. However, it is necessary to carry out more detailed studies including the most frequent and abundant species in order to establish their impact.

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