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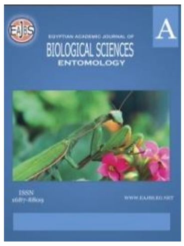


# Biodiversity and Population Dynamics of Natural Enemies in the Western Desert Agro-Ecosystem, Egypt

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**ABSTRACT**

Extension of the newly reclaimed areas for agriculture in Egypt has obviously affected the microclimate of the insect pests, which seriously threatens the cultivated field crops. Besides, the role of the major natural enemies must be carefully understood. Therefore, a field study was conducted in El-Farafra Oasis, Western Desert, Egypt to assess biodiversity and population dynamics of major natural enemies found associated with three field crops (faba bean, cotton, and alfalfa) by sweep-net and beat and shake sampling. The species diversity of natural enemies included 27 species, 23 genera, 14 families belonging to six orders and the total abundance of these species was 5098 individuals sampled during 2018 and 2019. The most common insect order was Coleoptera (composing 42.2% of the total abundance) followed by Hymenoptera (28.1%) and Neuroptera (17.8%), whereas the smallest number of individuals found in Odonata (2.1%). Similar population dynamics of natural enemies in the three crop fields were observed during the two seasons, and most species showed a positive correlation with temperature and negative correlation with relative humidity. The values of species diversity, richness, and evenness indices were higher in the alfalfa field (2.529, 2.623, and 0.846, respectively).

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## INTRODUCTION

The reclamation of desert land in Egypt has increased recently to satisfy the needs of a growing human population. Increasing agricultural activities may have negative results such as biodiversity loss, expand soil disintegration, pollution (Kleijn, *et al.* 2006). The direct impact of variations in agricultural cultivation is pest control with reduced chemical use (El-Sheikh, 2019). Biological control agents like predators, parasitoids, and pathogens play an important role in limiting damages from native and exotic pests (Straub, *et al.* 2008). Therefore, biological pest control could be a key system that is necessary for sustainable crop production (Bianchi, *et al.* 2006). Therefore, biological pest control could be a key system that is necessary for sustainable crop production (Losey and Vaughan, 2006).

Several endeavors are made to value biological pest control as a system service. In most studies, a spread of services from diversity is estimated, with biological control being only one of those. Studies of this sort usually build very broad and challenging assumptions (Waage, 2007). The last decade has seen an incredible increase during this earlier neglected field of biological control (Waage and Reathead, 1988). In distinction, in natural ecosystems, conservation of overall biodiversity is targeted no matter its functions. Indicators of biodiversity are also used for agroecosystem monitoring to evaluate the health of the ecosystem.

Therefore, in agricultural ecosystems, the indications of biodiversity embrace all-natural enemies within the scheme. To maximize the services from biodiversity, species richness ought to be the maximum amount of importance as species abundance (Duelli and Obrist, 2003). The presence of insect pests, global climate change, absence of natural enemies, and the use of pesticides is a serious drawback facing farmers in a new land (El-Husseini, *et al.* 2018). In brief, agriculture includes a tall level of reliance on the complete extends of biological system administrations. It evaluated a noteworthy sum of the world's wild biodiversity found in or around agricultural landscapes. In Egypt, El-Farafra Oasis, the study area, is located at the Western Desert of Egypt within the borders of the New Valley Governorate. El-Farafra is characterized by many types of cultivated crops; mainly cereals, dates, faba bean, alfalfa, cotton, vegetables, and wild plants. All these crops are subject to attack by several insect pest species, causing different levels of damages (Afazal, *et al*. 2003). Surveys conducted by Mabrouk, *et al.* (2017) in Dakhla Oasis, New Valley Governorate, Egypt recorded the presence of many beneficial insects associated with the pests. The results included 46 species belonging to 33 families and 9 orders.

For the first time, a comprehensive study was conducted on the biodiversity of population dynamics of beneficial insects associated with field crops under desert ecosystems in Egypt. Due to the increase in newly reclaimed areas and climate change, the emergence of previously non-existent insect pests seriously threatens field crops, causing economic losses to farmers, and the absence or inefficiency of natural enemies has helped some of these pests reach critical economic limits. In order to preserve the desert environment, the role of natural enemies in the desert ecosystem must be understood, their presence encouraged and their role strengthened to reduce insect pests. It is necessary to know more about the existing natural enemies associated with the major pests in the economic crops representing the agro-ecosystems in Egypt and to benefit from them in the development of integrated control programs. As a result of our interest in sustainable agricultural development in the desert, especially the Farafra Oasis, our attention has been devoted to addressing this issue because of its scientific and economic importance to farmers' problems.

## MATERIALS AND METHODS

**Study Area:**

El-Farafra Oasis, the study area, is located in the Western Desert of Egypt within the borders of New Valley Governorate. Is one hundred seventy kilometers aloof from Al-Bahariya Oasis, 627 kilometers apart from Cairo, and 370 kilometers to the South West of Marsa Matruh. El-Farafra is characterized by many types of cultivated crops and wild plants. Cultivated crops include mainly cereals, dates, faba bean, alfalfa, cotton, and vegetables. The wild plants include desert plants that grow at the edge of the cultivated lands and weeds that grow in cultivated areas. They contribute to compose the particular landscape of the oasis. Desert climatic factors this region is characterized by high temperature in the summer, where the average temperatures are between 25-50 °C and temperatures decrease dramatically during the winter where the temperatures range between 2-25 °C. The rains in El-Farafra

Oasis are non-existent, and the average relative humidity is 35-65% per year (El-Sheikh 2019; Gadallah *et al.* 2015)

**Sampling:**

The present study was conducted at the village of Al-Liwa Subaih, El-Farafra Oasis, New Valley Governorate, Egypt, during two successive seasons for 2017/18-2018/19. Three main field crops were chosen; cotton (*Gossypium hirsutum* L) (represented summer crops) crop is grown from May 16 - September 13 and from May 15 - September 11 in 2018 and 2019 respectively, faba bean (*Vicia faba* L.) represents winter agriculture (November 10 - April 22 and 15 November to April 25), and alfalfa (*Medicage sativa* L.) as a continuous crop grows all over the year (Muammar). These crops are considered major crops and are cultivated in large areas. The survey was conducted in four 4 sites for each crop, with a total of 12 sites/year during the two seasons of study and the area of the site was one Fadden each. Once plants are grown (about 20 days old), a random survey of the predators and parasitoid species was performed at regular intervals (about 14 days) throughout the entire season. Regular conventional agricultural practices were normally performed in all plots. The following sampling methods were used:

**A. Shaking and Beating Vegetation:**

The shaking and beating vegetation sampling method was carried out by placing paper or plastic sheets under the shaken and beaten plants. Fifty plants were chosen randomly and wholly inspected in an axial pattern at regular distances (about 5 m). The dislodged arthropods were collected quickly before escaping. The count was timed to sunrise (about 6:30 am), when arthropods still settled in the plants' canopy. The insects were collected by an aspirator, or into a tray containing a killing solution such as chloroform (Wade, *et al* 2006).

**B. Sweeping Net:**

Sweep netting has important advantages, including low equipment cost and potentially large yield of specimens per unit (Mccravy and Kenneth, 2018). Once plant stalks became more rigid, this technique was applied in both seasons, respectively until harvesting. Fifty double sweep-net strokes were randomly axially taken 14 days intervals. Collected samples were emptied in a labeled collecting glass jars and transferred to the laboratory for examination and identification.

**C. Specimens Identification:**

Adult and immature stages of the predatory and parasitoid species were killed by chloroform, counted, sorted, bagged, and stored at 10°C. Specimens were then deposited at the insect classification Department, Faculty of Agriculture, Beni-Suef University, Egypt and identified using the proper keys (Shoukry, 1980 & Zalat, *et al*., 1992 & Hosny, 2002 & Aufy, 2005 & El-Azab, 2007 & Gadallah, *et al*., 2010 & Abd-Rabou, 2011& Abu Alsood, 2014 & Bedewy, 2015).

**Biodiversity Measures:**

Patterns of insect diversity were assessed, using the Shannon index (H) (Shannon and Weaver, 1949) of species diversity, the Margalef richness index (DM) (Margalef, 1958), and the Pielou evenness index (J) (Pielou, 1966). All indices were computed, using the PAST program version 3.10 (Hammer, *et al*., 2001) and were described as:

$$H = -\sum_{i=1}^{S} Pi \ln Pi \quad DM = \frac{S-1}{\ln N} \quad J = \frac{H}{\ln S}$$

Where: Pi = ni/N is the observed relative abundance of the species, ni is the number of individuals of a species I, N is the size of the entire community, and S is the total number of species.

**Meteorological Data:**

Temperature and relative humidity averages data were obtained from the meteorological station of the Central Climate Laboratory, Agriculture Research Center for the two years

**Data Analysis**:

A student t-test was used for significant differences in average monthly temperatures and relative humidity between the years 2018 and 2019. Correlation analyses between species numbers in all fields were detected, using Spearman's rank correlation (Press, *et al*. 1992). All statistical analyses were conducted by IBM SPSS Statistics Version 22 (IBM Corp. Armonk, NY, USA).

## RESULTS

It seems that this is the first report of the survey of predatory and parasitoid species, collected from a faba bean, alfalfa, and cotton fields at El-Farafra Oasis, Egypt, using the sweeping net and shaking & beating. A total of 5098 individuals belonging to 27 species to 23 genera, 14 families, and 6 orders were obtained during 2018 and 2019 (Table 1). Coleopteran species were the highest order (composing 42.2% of the total number), followed by hymenopterans (28.1%) and neuropterans (17.8%) whereas the lowest number of individuals was found in order Odonata (2.1%). Within order Hymenoptera, the richest family was Ichneumonidae, with 11 species, followed by Aphelinidae, Eumenidae, Pompilidae, and Scoliidae, with one species each. Order Diptera was represented by Tachinidae and Syrphidae with one species each. Tachinidae was the most abundant family, representing (67.2% of the total surveyed) Dipterans (Table 1). Order Coleoptera was represented by 3 species of Coccinellidae (composing 78.3% of the total), followed by Staphylinidae with 2 species. Neuroptera and Mantodea were represented by only one family (Chrysopidae and Empusidae, respectively). Of the 3 families representing order Odonata, Libellulidae was the most dominant, composing (66.7%) of the total order number.

Among the surveyed species, the most abundant ones were: *Coccinella septempunctata* L. (Coleoptera: Coccinellidae) (composing 19.7% of the total species density), *Chrysoperla carnea* (Steph.) (Neuroptera: Chrysopidae) (17.8%), *Aphelinus* sp. (Hymenoptera: Aphelinidae) (16.2%), and *C. undecimpunctata* L. (Coleoptera: Coccinellidae) (12.0%). These 4 species were collected from all the study fields (Table 1). The highest number of beneficial species was sampled from the alfalfa (20 species), followed by cotton (13 species) and faba bean (9 species).

The most abundant host species, found on the cultivated crops, are shown in Table (1). The majority of these species belong to the order Lepidoptera followed by Hemiptera and then Coleoptera. Population dynamics of the predators and parasitoids, in the 3 crop fields (cotton, faba bean, and alfalfa), through the growing seasons of 2018 and 2019 were presented in Figs. (1, 2, and 3).

Similar population trends were observed during the 2 seasons of the study. The total number of *Aphelinus* sp., *C. undecimpunctata*, and *C. carnea* counted in the cotton field throughout the second season 2019 (137, 52, and 137 individuals, respectively), exceeded that recorded in the first season 2018 (96, 36, and 105 individuals, respectively). The total number of *Exorista larvarum* (L.), (Diptera: Tachinidae) and *Hemianax ephippiger* (Burm.) (Odonata: Aeshnidae) counted in the same field throughout the first season 2018 (22 and 14 individuals, respectively) exceeded that recorded in the subsequent season (8 and 9 individuals, respectively). In faba bean and alfalfa fields, total species recorded throughout the second year (2019) exceeded that of the first year (2018). Nevertheless, the total number of *Aphelinus* sp. population (Hymenoptera) collected form the alfalfa field was higher in 2018. In the cotton field, the density of all species exhibited uni-model seasonal patterns with one peak in mid-summer (July) (Fig. 1).

Spearman's rank correlation analysis showed significant positive relationships between the number of all species in the cotton field and temperature (r = 0.480–0.821, N = 18, P = 0.04–0.0001). Nevertheless, this analysis showed no correlation between temperature and number of *E. larvarum* and *H. ephippiger* (r = -0.066, N = 18, P = 0.796; r = 0.383, N = 18, P = 0.116, respectively). In contrast, significant inverse correlation was obtained between relative humidity and number of *C. carnea* and *H. ephippiger* (r = -0.636, N = 18, P = 0.005; r = -0.657, N = 18, P = 0.003, respectively). In the faba bean field, coleopteran populations showed uni-model seasonal patterns with one peak in spring. However, *Paederus alfierii* Koch (Coleoptera: Staphylinidae) exhibited a bi-model distribution with 2 peaks of adult number: winter (January) and spring (March).

Populations of Diptera, Neuroptera, Mantodea, and Odonata showed bi-modal seasonal patterns, with one peak in late autumn or early winter (December or January) and the second one in spring (April). *Aphelinus* sp. population peaked in late winter (February) (Fig. 2). Similar to the cotton field, analyses using Spearman's rank correlation revealed positive relationships between insect number in the faba bean field and temperature and inverse relationships between the number and relative humidity. But the correlation was only significant in case of temperature with *C. septempunctata*, *C. undecimpunctata*, and *Blepharopsis mendica* (Fabr.) (Mantodea: Empusidae) (P < 0.05) and in case of relative humidity with *Aphelinus* sp., *C. septempunctata*, *C. undecimpunctata*, *B. mendica*, and *Crocothemis erythraea* (Brullé) (Odonata: Libellulidae) (P < 0.05). In the fall and spring, relatively high numbers of hymenopteran populations were recorded in the alfalfa field and were disappeared or greatly decreased in winter and summer. But the populations of *Aphelinus* sp. and *Sinophorus xanthostomus* (Grav.), (Hymenoptera: Ichneumonidae) were observed during spring and almost disappeared during the other seasons. In contrast, *Dichrogaster aestivalis* (Grav) (Hymenoptera: Ichneumonidae) population was collected only during the fall.

The highest populations of Diptera, Coleoptera, Neuroptera, Mantodea, and Odonata were recorded in spring and summer, while the lowest densities of these orders were recorded in autumn and winter (Fig. 3). The correlation was significantly positive between temperature and populations of *Diplazon laetatorius* (Fabr.) (Hymenoptera: Ichneumonidae), *E. larvarum*, *C. septempunctata*, *C. undecimpunctata*, *P. alfierii*, *C. carnea*, *B. mendica*, and *C. erythraea* and was significantly negative between temperature and populations of *Barylypa pallida* (Grav.), (Hymenoptera: Ichneumonidae) and *D. aestivalis*. In contrast, the correlation showed significant invers relationships between relative humidity and populations of *Aphelinus* sp., *D. laetatorius*, *S. xanthostomus*, *E. larvarum*, *C. undecimpunctata*, *P. alfierii*, *C. carnea*, *B. mendica*, and *C. erythraea* and showed significantly positive relationships between relative humidity and populations of *B. pallida*, *B. rufa* (Holmg.) (Hymenoptera: Ichneumonidae) and *D. aestivalis.*

**Table 1**. Diversity and abundance of Natural Enemies collected from each of the three crops in El-Farafra Oasis during 2017-2018 and 2018-2019

| Species | *Host species | Crop | | | | | | Total (%) | Order |
|---|---|---|---|---|---|---|---|---|---|
| | | Cotton | | Faba bean | | Alfalfa | | | |
| | | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | | |
| **Aphelinidae** | | | | | | | | | |
| *Aphelinus* sp. | a, b | 96 | 137 | 72 | 102 | 213 | 206 | 826 (16.2) | |
| **Eumenidae** | | | | | | | | | |
| *Polistes gallicus* (L.) | u | 13 | 15 | 0 | 0 | 0 | 0 | 28 (0.54) | |
| **Ichneumonidae** | | | | | | | | | |
| *Anomalon cruentatum* (Geoffroy) | h, i | 0 | 0 | 0 | 0 | 36 | 45 | 81 (1.5) | |
| *Anomalon venustulum* (Tosqu.) | u | 0 | 0 | 0 | 0 | 19 | 37 | 56 (1.1) | |
| *Barylypa amabilis* (Tosqu.) | f, h | 0 | 0 | 0 | 0 | 36 | 45 | 81 (1.5) | |
| *Barylypa pallida* (Grav.) | f, i | 0 | 0 | 0 | 0 | 16 | 19 | 35 (0.68) | |
| *Barylypa rufa* (Holmg.) | g | 0 | 0 | 0 | 0 | 11 | 18 | 29 (0.56) | **Hymenoptera 28.1%** |
| *Bathyplectes exiguous* (Grav.) | n | 0 | 0 | 0 | 0 | 19 | 41 | 60 (1.2) | |
| *Casinaria trochanterator* Aubert | u | 0 | 0 | 0 | 0 | 17 | 28 | 45 (0.88) | |
| *Dichrogaster aestivalis* (Grav.) | j, m | 0 | 0 | 0 | 0 | 10 | 23 | 33 (0.64) | |
| *Diplazon laetatorius* (Fabr.) | p | 0 | 0 | 0 | 0 | 23 | 41 | 64 (1.3) | |
| *Pimpla wilchristi* FSG | l | 0 | 0 | 0 | 0 | 10 | 26 | 36 (0.70) | |
| *Sinophorus xanthostomus* (Grav.) | f,g,i,k | 0 | 0 | 0 | 0 | 11 | 21 | 32 (0.62) | |
| **Pompilidae** | | | | | | | | | |
| *Agenioideus melas* (Klug) | u | 8 | 5 | 0 | 0 | 0 | 0 | 13 (0.25) | |
| Scoliidae | | | | | | | | | |
| *Dielis collaris* Fabr. | f,g,i | 4 | 10 | 0 | 0 | 0 | 0 | 14 (0.27) | |
| **Tachinidae** | | | | | | | | | |
| *Exorista larvarum* (L.) | i | 22 | 8 | 8 | 9 | 50 | 75 | 172 (3.4) | **Diptera 5.0%** |
| **Syrphidae** | | | | | | | | | |
| *Eupeodes corollae* Fabr. | a, c | 0 | 0 | 5 | 10 | 24 | 45 | 84 (1.6) | |
| **Coccinellidae** | | | | | | | | | |
| *Coccinella septempunctata* L. | a,b,c,e | 105 | 118 | 109 | 160 | 211 | 302 | 1005 (19.7) | |
| *Coccinella undecimpunctata* L. | a,b,c,d,e | 36 | 52 | 116 | 110 | 148 | 154 | 616 (12.0) | **Coleoptera 42.2%** |
| *Scymnus* sp. | a,b,c,e | 33 | 31 | 0 | 0 | 0 | 0 | 64 (1.3) | |
| **Staphylinidae** | | | | | | | | | |
| *Anotylus nitidulus* (Grav.) | u | 10 | 12 | 0 | 0 | 0 | 0 | 22 (0.43) | |
| *Paederus alfierii* Koch | u | 99 | 83 | 8 | 19 | 112 | 125 | 446 (8.7) | |
| **Chrysopidae** | | | | | | | | | **Neuroptera 17.8%** |
| *Chrysoperla carnea* (Steph.) | q | 105 | 137 | 109 | 142 | 195 | 220 | 908 (17.8) | |
| **Empusidae** | | | | | | | | | **Mantodea 4.3%** |
| *Blepharopsis mendica* (Fabr.) | r | 0 | 0 | 40 | 45 | 48 | 89 | 222 (4.3) | |
| Aeshnidae | | | | | | | | | |
| *Hemianax ephippiger* (Burm.) | r | 14 | 11 | 0 | 0 | 0 | 0 | 25 (0.49) | |
| **Libellulidae** | | | | | | | | | **Odonata 2.1%** |
| *Crocothemis erythraea* (Brullé) | r | 0 | 0 | 10 | 16 | 29 | 29 | 84 (1.6) | |
| **Coenagrionidae** | | | | | | | | | |
| *Ischnura senegalensis* Rambur | r | 9 | 8 | 0 | 0 | 0 | 0 | 17 (0.33) | |
| N[a] | | | | | | | | 5098 (100) | |

[a]Total abundance of pest natural enemies at each crop.* **a:** Aphis gossypii Glover, **b:** Myzus persicae Sulzer, **c:** *Aphis craccivora* Koch, **d**: *Aphis fabae* Scopoli (Hemiptera: Aphididae), **e:** *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), **f:** *Spodoptera exigua* (Hübner), **g:** *Spodoptera littoralis* Boisduval,, **h:** *Helicoverpa armigera* (Hübner), **i:** *Agrotis ipsilon* (Hufnagel) (Lepidoptera: Noctuidae), **j:** *Coleophora hemerobiella* Scopoli (Lepidoptera: Coleophoridae), **k:** *Pieris rapae* (L.) (Lepidoptera: Pieridae), **l:** *Depressaria pastinacella* (Duponchel) (Lepidoptera: Depressariidae), **m:** *Blastophaga spiniperda* (L.), **n:** *Hypera nigrirostis* (Fabricius) (Coleoptera: Curculionidae), **o:** *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), **p:** A large number of insect hosts belonging to the Order Hemiptera, Coleoptera, Lepidoptera, and Diptera, **q:** a large number of insect hosts belonging to the Order Hemiptera and Thysanoptera, **r:** feeding on variety of small arthropods (mainly insects), **s:** feed primarily on invertebrates and small vertebrates, t: **u:** Unknown, *****(Kamal, 1951; Ehrmann, 1992; Yu *et al*., 2012; Gadallah *et al*., 2015).

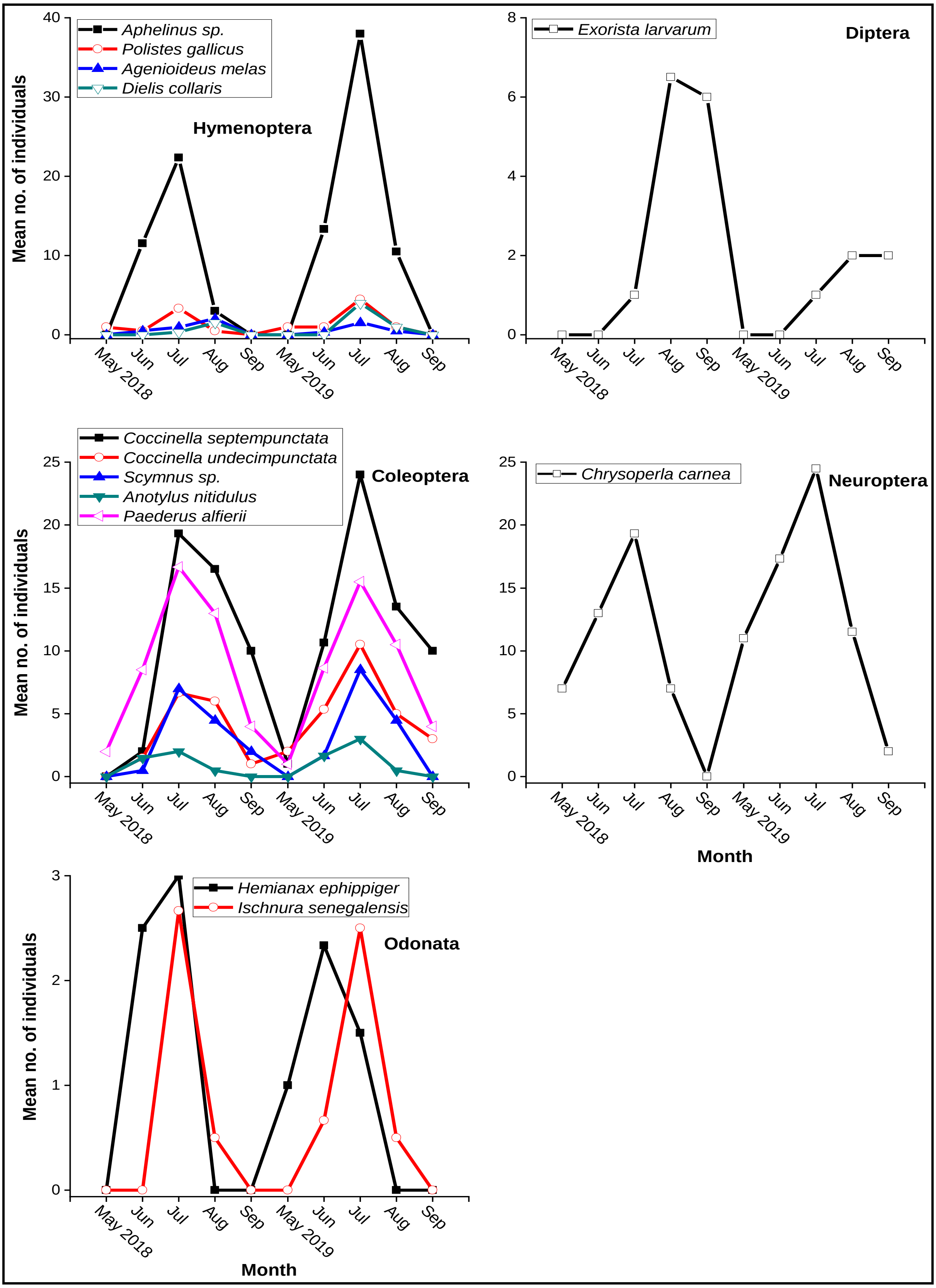



**Fig. 1.** Seasonal abundance of the most dominant parasitoid and predator species from cotton field in El-Farafra Oasis during 2017-2018 and 2018-2019

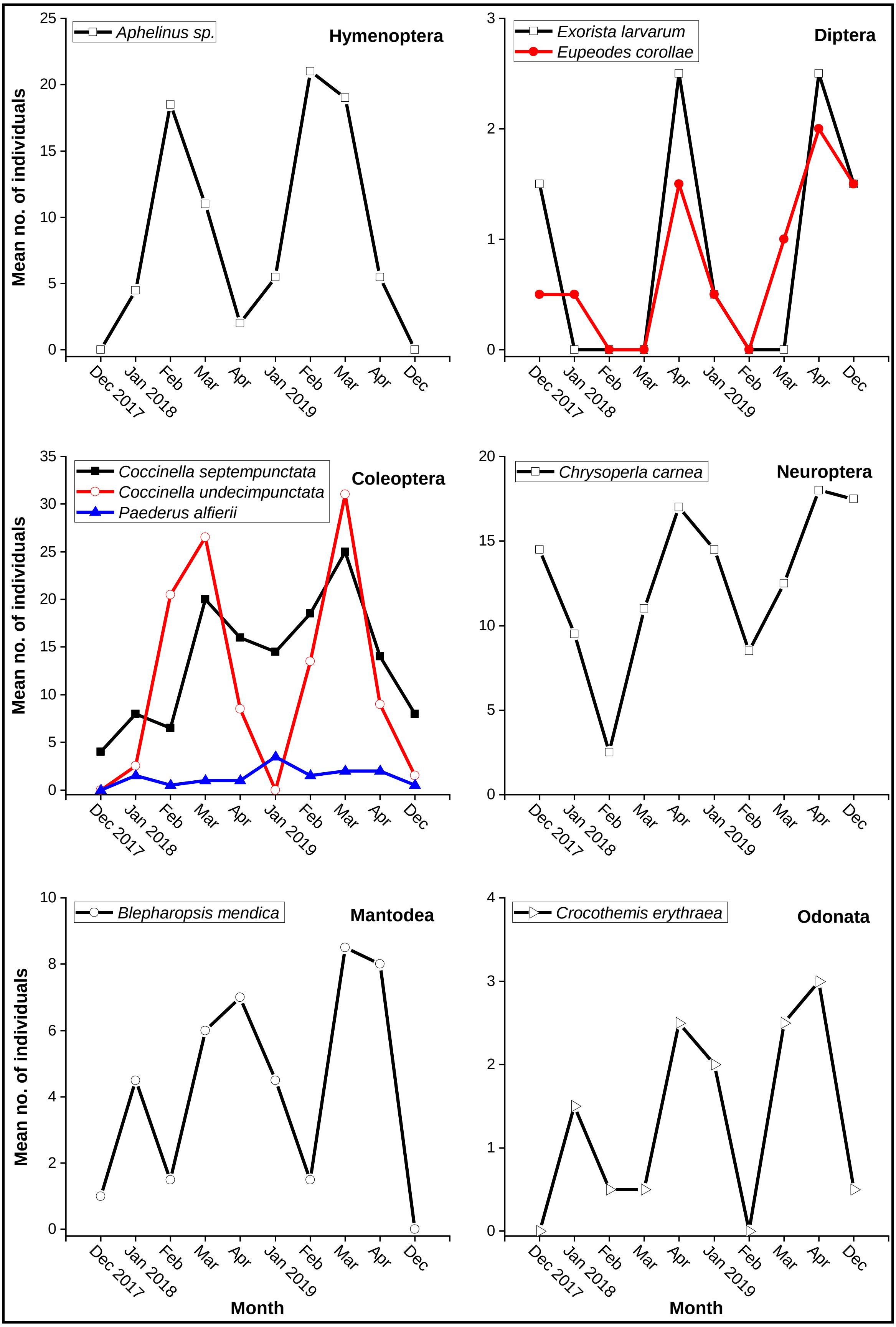
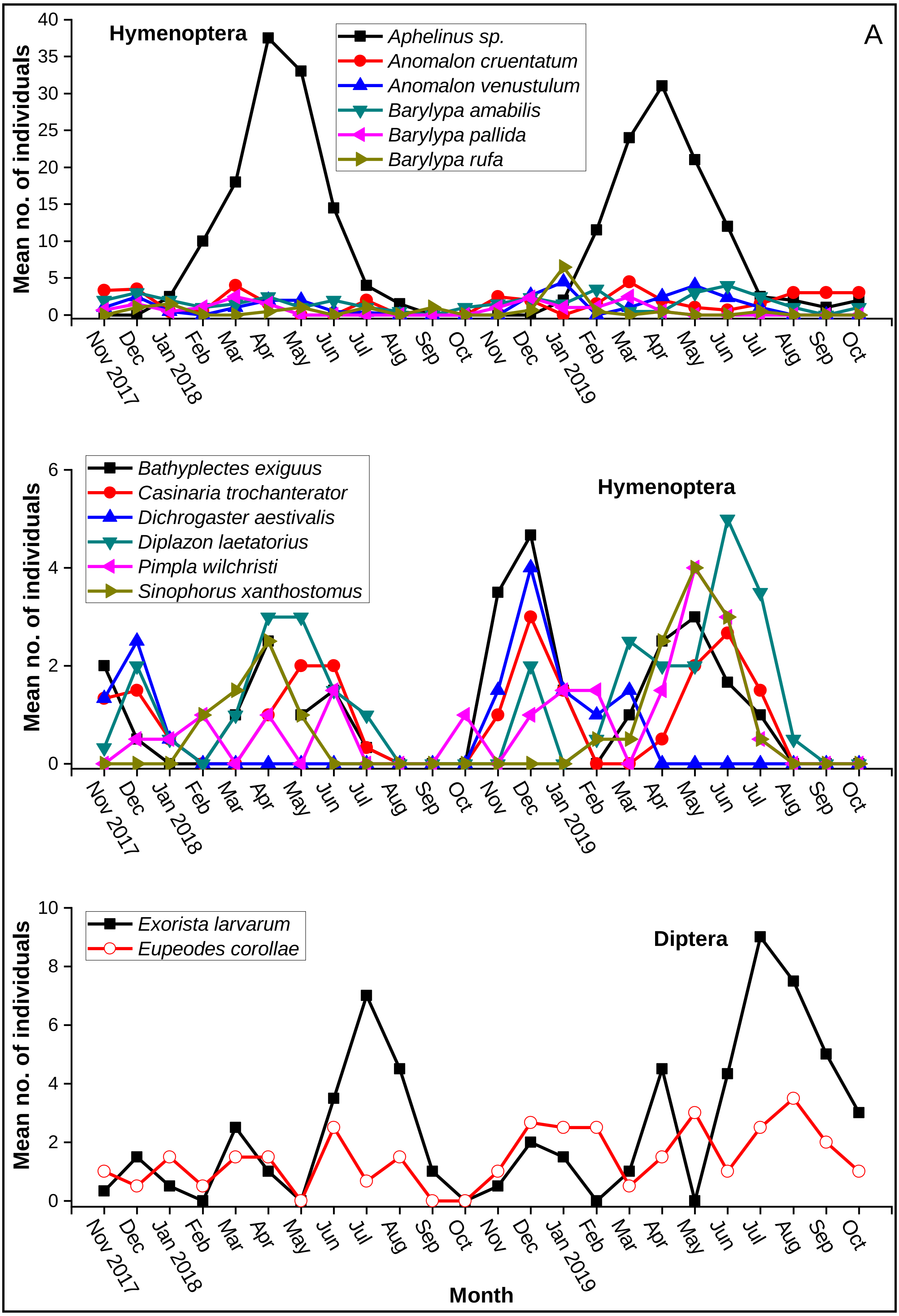



**Fig. 2**. Seasonal abundance of the most dominant parasitoid and predator species collected from Faba bean field in El-Farafra Oasis during 2017-2018 and 2018-2019.


A
Hymenoptera
Aphelinus sp.
Anomalon cruentatum
Anomalon venustulum
Barylypa amabilis
Barylypa pallida
Barylypa rufa
Mean no. of individuals
Hymenoptera
Bathyplectes exiguus
Casinaria trochanterator
Dichrogaster aestivalis
Diplazon laetatorius
Pimpla wilchristi
Sinophorus xanthostomus
Mean no. of individuals
Diptera
Exorista larvarum
Eupeodes corollae
Mean no. of individuals
Nov 2017
Dec
Jan 2018
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2019
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Month

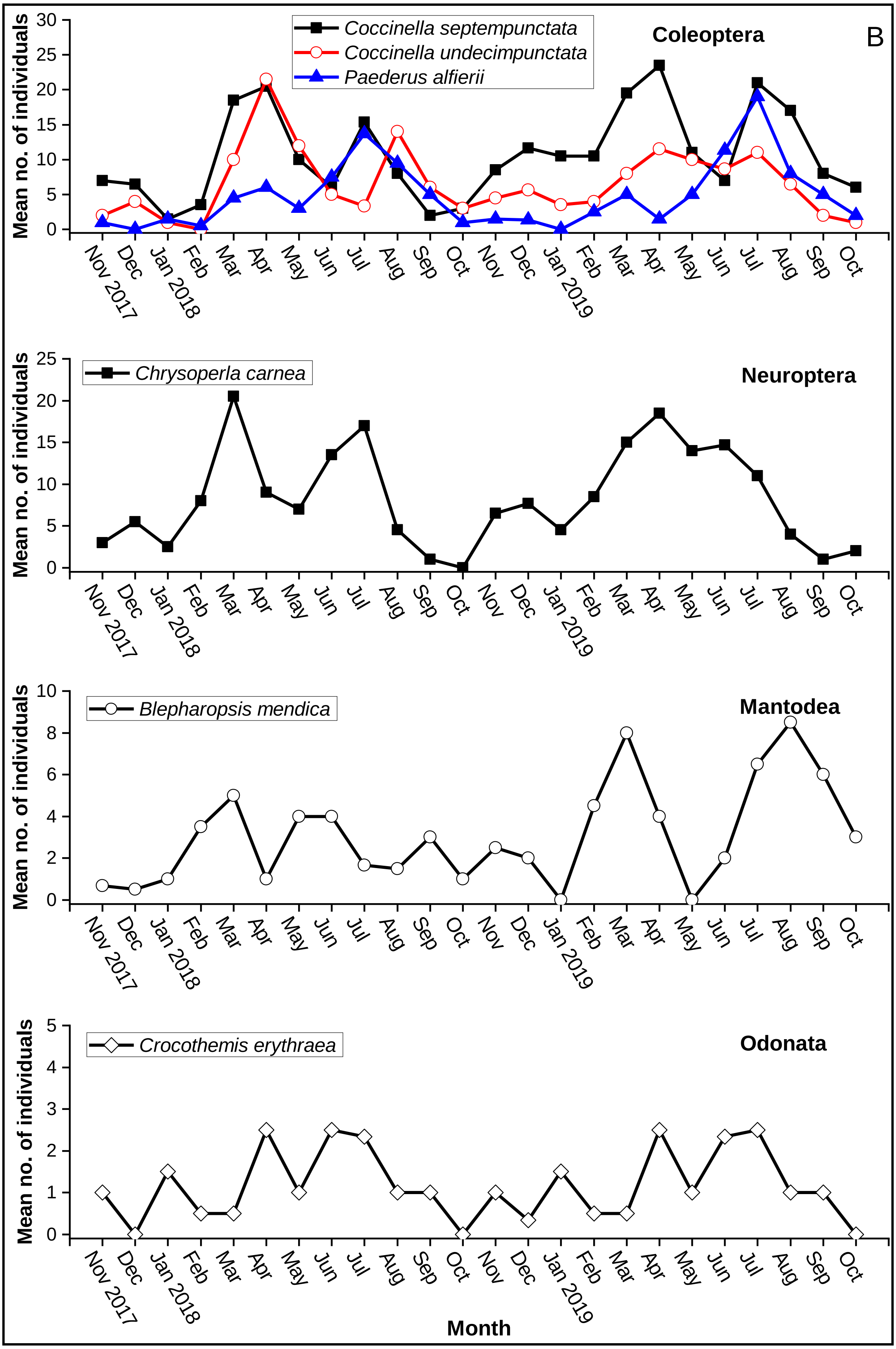



**Fig. 3**. Seasonal abundance of the most dominant natural enemies of insect pests collected from an alfalfa field in El-Farafra Oasis during 2017-2018 and 2018-2019; (A) Hymenoptera, Diptera; (B) Coleoptera, Neuroptera, Mantodea, Odonata.

Fig. 4, shows meteorological data recorded at El-Farafra Oasis show that the mean monthly temperatures ranged from 11.2 to 32.5 ˚C in 2018 and from 12.9 to 33.6 ˚C in 2019, with mean temperatures records above 25 ˚C from May to September. The monthly average of relative humidity ranged from 23 to 55% in 2018 and from 21 to 54.5% in 2019. However, the differences were only significant for temperatures in March ($t = -3.493$, $df = 6$, $P = 0.013$) and for relative humidity in April ($t = 6.012$, $df = 6$, $P = 0.001$). Table 2 shows the species richness, diversity, and evenness calculated for natural enemies during 2018 and 2019 in cotton, faba bean, and alfalfa fields. The values of Margalef index were higher in the alfalfa field (2.623) followed by cotton (1.881) and faba bean fields (1.271). The Shannon diversity index confirms these results, where the highest value (2.529) was recorded at the alfalfa field and the lowest value (1.799) was reported at the faba bean field. Similarly, the highest value of the evenness index was recorded at the alfalfa field, but the lowest value was detected for the cotton field. This result highlights that little is known about the natural enemies' species in El-Farafra Oasis and no accurate information is published. Moreover, this sequence of experiments is very useful knowledge to highlight and provide a direct assessment of the seasonal importance of different predators and parasitoid species attacking insect pests at El-Farafra Oasis.

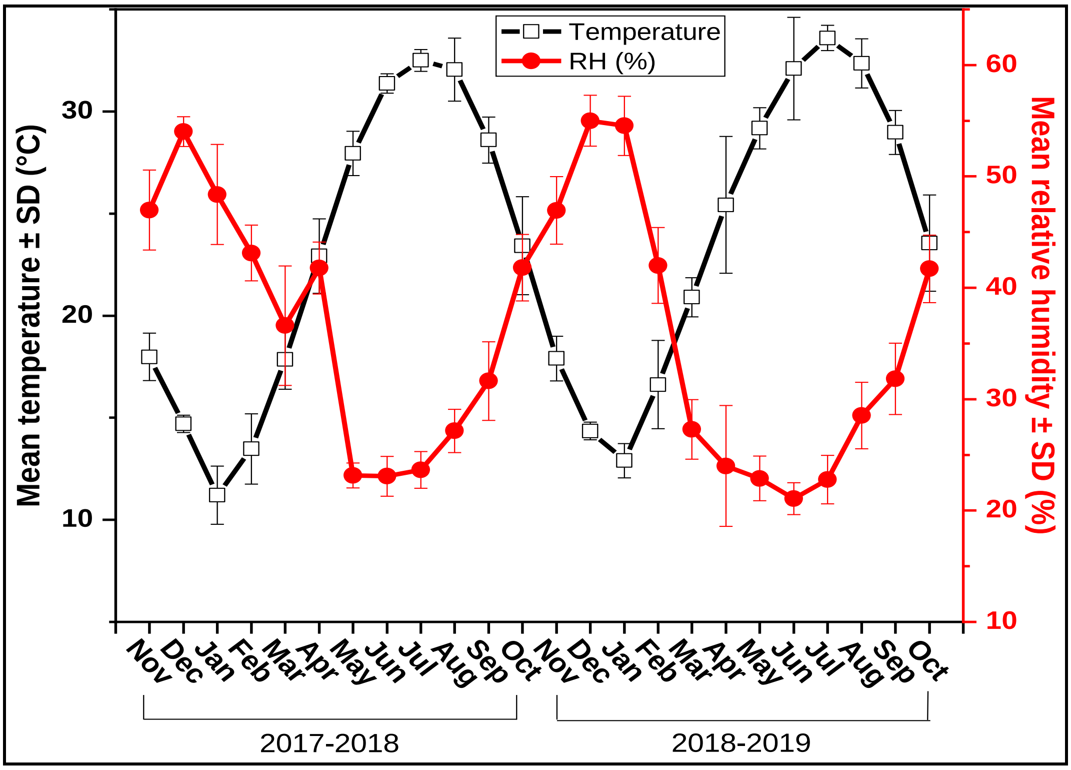



**Fig. 4**. Seasonal fluctuations in the mean monthly temperature and relative humidity in El-Farafra Oasis during 2017-2018 and 2018-2019

**Table 2**. Diversity parameters of parasitoids and predators in each of the three crops during two successive seasons (2018 and 2019)

| Diversity index | Cotton field | | | Faba bean field | | | Alfalfa field | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | Average | 2018 | 2019 | Average | 2018 | 2019 | Average |
| Shannon index | 2.133 | 2.054 | 2.089 | 1.778 | 1.820 | 1.799 | 2.472 | 2.587 | 2.529 |
| Margalef index | 1.90 | 1.863 | 1.881 | 1.297 | 1.246 | 1.271 | 2.668 | 2.578 | 2.623 |
| Pielou index | 0.831 | 0.800 | 0.815 | 0.809 | 0.828 | 0.818 | 0.825 | 0.867 | 0.846 |

## DISCUSSION

According to our results, the populations of natural enemies, that would ultimately suppress the increasing numbers of pests, should be conserved by avoiding insecticide application. Moreover, this sequence of experiments is very useful knowledge to highlight and provide a direct assessment of the seasonal importance of different natural enemy groups attacking insect pests in El-Farafra Oasis. A similar pattern of results was obtained by El-Husseini, *et al.* (2018) who reported that many predatory species exist in cotton fields, where they play an important role against most of the pests attacking this crop. El-Ghiet, *et al.* (2014) studied the distribution and fluctuation of *C. carnea* and *C. septempunctata* in Baharyia and El-Farafra Oases.

In accordance with our observation, these species were collected in high numbers from alfalfa and peaked in spring. However, they showed a different seasonal pattern in fall and summer. In an earlier study carried out by Gadallah, *et al*. (2015) in the same areas (Baharyia and El-Farafra Oases), a faunal work of ichneumonid parasitoid in alfalfa fields, showed 6 of the parasitoid species mentioned in the present study (*Anomalon venustulum* (Tosqu.), *B. pallida*, *Bathyplectes exiguous* (Grav.), *Casinaria trochanterator* Aubert, *D. aestivalis*, *Pimpla wilchristi* FSG). Simmons and Abd-Rabou, (2007) conducted a survey of parasitoid and predatory species associated with the Whitefly, *Bemisia tabaci* (Genn.) (Hemiptera: Aleyrodidae) in 10 common cultivated crops in Egypt. They have reported that, among 5 predators, *C. septempunctata* was the most abundant one. Diversity and the seasonal number of terrestrial insects were monitored in Saluga and Ghazal protectorate, Aswan (Abdel-wahab, *et al*. 2019). The results of this study showed that Hymenoptera and Coleoptera were the most abundant orders.

Our findings coincide to some extent with the results of these studies. A similar conclusion was reached by Tawfik, *et al.* (1976) in a survey of the insect fauna of alfalfa crop carried out at Giza, Egypt, 35 species of parasitoids, and predators were recorded. Our results were broadly in line with Kolaib, *et al*. (1980) who recorded the parasitoids, *Barlypa* spp., and *Strobliomyia aegyptia* (Vill) (Diptera: Tachinidae) and two unidentified tachinids on the cotton leafworm in alfalfa fields at Alexandria.

## CONCLUSION

According to our results, this article survey for the first time the most abundant of natural enemies associated with cotton, faba bean, and alfalfa in El-Farafra Oasis. The total abundance of these species was 5098 individuals sampled during 2018 and 2019, included 27 species, 23 genera, 14 families belonging to six orders. The highest number of beneficial species was sampled from the alfalfa field (20 species) followed by the cotton field (13species) and faba bean field (nine species). The most common beneficial species were *Coccinella septempunctata*, *Chrysoperla carnea*, *Aphelinus sp*, and *Coccinella undecimpunctata* .it is necessary to know more about the existing natural enemies associated with the major pests in the economic crops representing the agroecosystems in Egypt and to benefit from them in the development of integrated control programs. Thus, our future work will untangle how management strategies influence the composition and functional roles of native natural enemies in El-Farafra Oasis agroecosystems.

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## ARABIC SUMMARY

**التنوع البيولوجي وديناميكية التعداد للأعداء الحيوية في النظام البيئي الزراعي الصحراوي بالصحراء الغربية – مصر**

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نظرًا لزيادة التوسع في المناطق المستصلحة حديثًا للزراعة في مصر قد أثر ذلك على المناخ المحلي للآفات الحشرية ، مما يهدد بشكل كبير المحاصيل الحقلية المزروعة. إلى جانب ذلك ، يجب فهم دور الأعداء الطبيعيين الرئيسيين بعناية. لذلك ، تم إجراء دراسة ميدانية في واحة الفرافرة ، لتقييم التنوع البيولوجي وديناميكية التعداد للأعداء الحيوية التي تم العثور عليها في ثلاث محاصيل حقلية (الفول البلدي والقطن والبرسيم الحجازي) و لقد استخدام طرق مختلفة لرصد (Beating vegetation - Sweeping net) الحشرات. ولقد تم حصر 27 نوعًا ، و 23 جنسًا ، و 14 عائلة تنتمي إلى ستة رتب ، وبلغت الوفرة العددية لهذه الأنواع 5098 فردًا خلال عامي الدراسة 2018 و 2019. ومن خلال ديناميكية التعداد كانت رتبة Coleoptera الأكثر وفرة بنسبة ٪ 42.2 ، تليها Hymenoptera بنسبة ٪28.1 ، ثم رتبة Neuroptera بنسبة (% 17.8) ، بينما كان اقلهم في عدد الأفراد رتبة Odonata ٪ 2.1 خلال الموسمين ، وأظهرت معظم الأنواع ارتباطًا إيجابيًا بدرجة الحرارة وارتباطًا سلبيًا بالرطوبة النسبية، بينما كانت قيم تنوع الأنواع ، وثرائها من خلال ومؤشرات التكافؤ كانت أعلى في حقل البرسيم الحجازي (2.529 ، 2.623 ، 0.846) على التوالي.