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Seasonal Activity, Natural Enemies and Life Table Parameters of *Cryptoblabes gnidiella* Mill. on Mango Inflorescences

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ABSTRACT

The population density of the honeydew moth (HM), *Cryptoblabes gnidiella* Mill. (Lepidoptera: Pyralidae) and its associated natural enemies was estimated in neglected (without chemical control treatments) orchard cultivated with mango trees (*Mangifera indica* L.), located at Shirben district, Dakahlia governorate, Egypt. The obtained results showed that this pest was recorded only at the height of 2.5±0.5 meters and was not at the height of 5.5±0.5 meters from the ground. The population of *C. gnidiella* had three peaks of abundance annually. During the two seasons of study, the anthocorid predator, *Orius* sp. was mainly associated with *C. gnidiella* population. In addition, an endo-parasitoid species was firstly observed on *C. gnidiella* larvae**,** namely, *Tachina larvarum* (Order: Diptera, Family: Tachinidae). *Orius* sp. exhibited three peaks of seasonal abundance annually. The total number of collected predator showed high significantly positive correlation with the average population density of the prey in the first and second years (r = 0.51** and 0.63**). The population of *T. larvarum* exhibited four peaks of abundance annually. The percentage of parasitism all over the season averaged 13.2±3.2 and 14.3±5.01% during 2016 and 2017, respectively. Statistical analysis indicated that there were significant positive correlations between populations of *C. gnidiella* and its parasitoid during the first (r = 0.65**) and second (r = 0.79**) seasons. Life and fertility tables of *C. gnidiella* reared on mango inflorescences were conducted under laboratory conditions. The developmental time of the egg, larvae and pupal stages lasted 4.1±1.8, 14.4±0.6 and 10.7±0.9 days respectively. The generation time, the net reproductive rate (R_O) and intrinsic rate of increase (r_m) were 35.97 days, 29.03 females/female and 0.04 female/female/ generation.

INTRODUCTION

The honeydew moth (HM), *Cryptoblabes gnidiella* Mill. is an opportunistic species native to the Mediterranean region (Dawidowicz & Rozwalka, 2016). Nowadays, *C. gnidiella* is recorded all over the world, attacking several hosts mainly pomegranate, grapes, citrus, avocado, figs, mangoes, mulberry, as well as several field and vegetable crops (Ben Yehuda *et al*., 1991; Hashem *et al*., 1997 and Dawidowicz & Rozwalka, 2016). It is considered a serious pest together with accompanying insects such as mealybugs. Bagnoli and Lucchi (2001) stated that larval diet includes sweet matter, dry flower parts, berry juice, berry stalk, and even healthy grapes. Larval populations can be very high, especially if they are close to a large colony of mealybugs. Harari *et al*. (2007) mentioned that damage caused by *C. gnidiella* is twofold, direct damage "caused to clusters when the larvae feed among the berries" and indirect damage "characterized by fungal infestation of injured berries". Wysoki *et al*. (1993) reported that HM caused losses reached 30%.

Chemical control is costly, adversely affect the natural enemies, and pollute the environment. In Brazil, Bisotto-de-Oliveira *et al*. (2007) reported that *C. gnidiella*, is an important pest on grapevine orchards, five parasitoid species of Hymenoptera were found associated with *C. gnidiella*, and parasitoid populations were observed with high abundance in the orchard without application of insecticides. Hashim *et al*. (2017) recommended that control of *C. gnidiella* could be effectively achieved by the safe means. Little attention has been directed towards predatory insects that are believed to make an important contribution to the mortality of lepidopterous species (Bugg and Wilson, 1989; Mansour, 2004; EL-Barbary, 2006 and Abd El-Kareim *et al*., 2008).

Efficient control of economic insects requires detailed investigations of the ecology and biology of these insects as well as the natural enemies were recorded as bio-control agents against lepidopterous insects as HM population. Some criteria are essential for the control of *C. gnidiella* such as adult population dynamics, peak times of population and generation number (Öztürk and Ulusoy, 2012). Therefore, the present investigation deals with some ecological and biological aspects of the honeydew moth under field and laboratory conditions.

MATERIALS AND METHODS

1. Estimation the population density of the honeydew moth (HM), *Cryptoblabes gnidiella* Mill. and its natural enemies:

1. Experimental orchards:

The experiments were conducted in a neglected (without chemical control treatments) orchard of about 2 feddans (a feddan = 4200 m^2) cultivated with mango trees (*Mangifera indica* L.), located at Shirben district, Dakahlia governorate, Egypt.

2. Sampling procedure:

To estimate the population density of *C. gnidiella* and its associated natural enemies, five homogenous mango trees (in size and age) were randomly chosen. Samples were started from the 8th of February (in 2016 and 2017) and continued till the 24th and 25th of October (2016 and 2017). Samples were weekly collected at two height levels (2.5±0.5 and 5.0±0.5 meters) above the ground from the trees. Each sample consisted of 20 inflorescences/level (4 inflorescences/tree) that collected from different sides (north, south, east and west) of the tree. The collected samples were kept in paper bags and then they were pulled up and taken to the laboratory for inspection by using a binocular microscope. Number of HM larvae and pupae were counted and recorded.

The collected *C. gnidiella* larvae and pupae of each sample were maintained in Petri-dishes (10 cm in diameter) containing pieces of moistened cotton wools till emergence of the parasitoids. The emerged parasitoids were counted, recorded and identified in Plant Protection Research Institute, Agricultural Research Center. The average percentages of parasitism were calculated during the two successive years (2016 and 2017). The predators in the collected samples were also counted and recorded.

3. Statistical analysis:

The obtained data were statistically analysed using the computer program of CoHort Software (2004), where correlation and regression analysis were done. In addition, Duncan's Multiple Range Test was also done by using one way ANOVA to estimate the Least Significant Difference (LSD) with the same computer program.

2. Life and fertility tables:

Life and fertility table parameters of *C. gnidiella* were evaluated on floral clusters of mango under laboratory conditions (26±2°C and 65±5% RH).

1. Rearing technique:

The HM individuals were obtained as pupal stage from the Experimental orchard. These pupae were collected in late June. Pairs of male and female pupae were deposited in 9 cm diameter Petri-dishes, with a piece of moistened cotton wool on a filter paper in the dish bottom, and kept until emergence.

To have an initial population of HM eggs homogenous in age, newly emerged adults were collected from the stock culture and caged in transparent plastic boxes (15 × 20 × 10 cm). Each box was provided with a piece of moistened cotton wool soaked in a 10% honey solution as a source of food for the moths, in addition, flowers of mango inflorescences for oviposition. The eggs laid on the inflorescences were daily removed with a soft camel hair brush and placed in clean Petri-dishes. The flowers daily were replaced and honey solution was also changed.

2. Life and fertility tables for *Cryptoblabes gnidiella*:

An initial population of 150 newly deposited eggs (collected from the stock culture) was placed in other three transparent plastic boxes. When the eggs developed to the larval stage, the resulting larvae were daily provided with fresh flowers of mango infested with the mealybug, *Planococcus citri* until pupation. The daily numbers of dead individuals of each stage were recorded and the duration of each stage was calculated. The number of emerged adults were sexed and counted.

To study the fecundity table, newly emerged twenty pairs of moths were caged in glass jars; each pair in a cage containing mango inflorescences for oviposition. The daily number of eggs laid per female was recorded. The experiment was conducted during June (2017) in the laboratory where the average temperature and relative humidity were daily recorded. Each glass jar was provided with a piece of moistened cotton wool soaked in a 10% honey solution as a source of food for the moths. The old flowers were daily replaced and honey solution was also changed for each pair of moths.

Age-specific survival table constructed with the following columns:

X: The pivotal age for the age class in days.
l_x: The number of surviving at the beginning of age class x.
d_x: The number of dying during the age interval x.
q_x: The mortality rate per age interval as the rate per thousand.

Age-specific fertility table constructed with the following:

X: Actual female age (time from egg stage).
m_x: The number of living females born per female in each age.
L_x: Represents the fraction surviving of females of an initial population of one.

To estimate the stage-specific survival (Ix) and the intrinsic rate of natural increase (r_m), life and age-specific fertility tables were constructed as follows (Southwood, 1978):

$$R_o = \sum L_x m_x$$
$$T = \sum x (L_x m_x)/R_o$$
$$r_m = \ln (R_o)/T$$

Sex ratio of *C. genidiella* (as males: females) was considered according to Bhadauriya *et al.* (2011)

RESULTS AND DISCUSSION

1. Population density of *Cryptoblabes gnidiella* in mango orchards:

To follow up the changes in the population of *C. gnidiella* infesting mango inflorescences, mean numbers of immature stages (larvae and pupae)/ inflorescence were weekly counted during 2016 and 2017 years in mango orchards. The obtained data are graphically illustrated in Figure (1). During the period of study this pest was recorded only at the height of 2.5±0.5 meters and was not at the height of 5.5±0.5 meters from the ground.

In the first year, during the period lasted from the 1st of March till the 18th of October, the population of *C. gnidiella* had three peaks of abundance. The first peak was recorded on the 18th of April, the second on the 13th of June (the highest) and the third one on the 15th of August. These peaks represented by 9.1, 15.9 and 11 individuals/ inflorescences (Figure, 1).

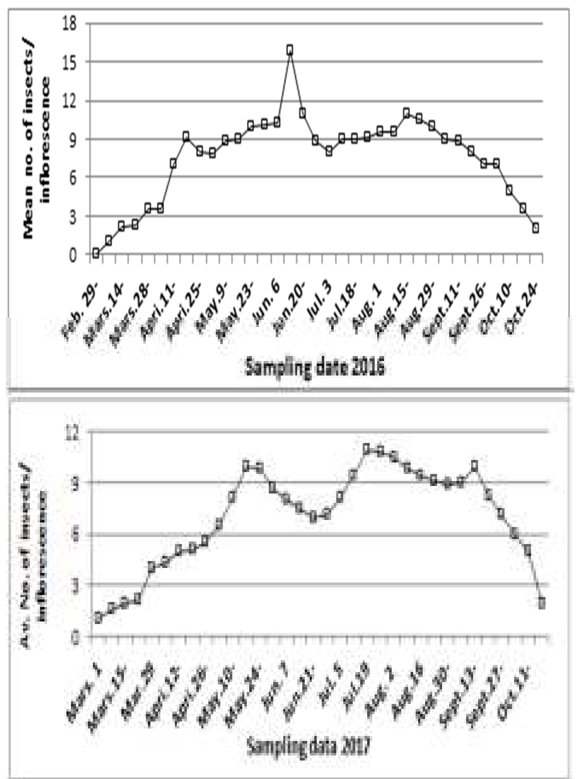

Figure 1. Population density of *C. gnidiella* larval and pupal stages infesting mango inflorescences at Shirben district during 2016 and 2017 years.

In the second year, changes of *C. gnidiella* population showed that the same trend to those of the first year. The honeydew moth population exhibited three peaks of seasonal abundance. The peaks occurred on the 17th of

May, 19th of July and 13th of September, which represented by 10, 11 and 10 individuals / inflorescence (Figure, 1).

2. Seasonal activity of the natural enemies associated with the *C. gnidiella*:

The obtained data during the two seasons of study revealed that the anthocorid predator, *Orius* sp. was mainly associated with *C. gnidiella* individuals. In addition, an endo-parasitoid species, which was firstly observed on *C. gnidiella* larvae, namely, *Tachina larvarum* (Order: Diptera, Family: Tachinidae).

1. The anthocorid predator, *Orius* sp.:

As shown in Figure (2), *Orius* sp. started to visit mango inflorescences in the first season, at the first week of March 2016. It exhibited three peaks of seasonal abundance. The first peak (1.6 individuals / inflorescence) was recorded on the first week of May, the second peak was occurred on the first week of July (4.2 individuals / inflorescence) whereas, last one was shown on the second week of September (3.0 individuals / inflorescence).

During the second season (2017), changes of *Orius* sp. population showed that similar trend to those of the first year. However, *Orius* sp. population exhibited three peaks of seasonal abundance. The first peak was recorded on the 10th of May, the second on the 12th of July (the highest) and the third on the 27th of September. These peaks represented by 3.0, 5.3 and 2.4 individuals / inflorescence (Figure, 2).

From the statistical point of view, the total number of collected predator (*Orius* sp.) showed high significantly positive correlation with the average population density of the prey in the first and second years. The correlation coefficient values were (0.51** and 0.63**) in the first and the second years (Table, 1). The simple regression for the effect of prey density on *Orius* sp. population revealed that a highly significant positive effect during the two seasons (b= 0.14 and 0.25). This means that, each increase of the honey dew moth population by one larva/ inflorescence increased the population of *Orius* sp. by 0.14 and 0.25 individuals/ inflorescence during the first and second seasons (Table, 1).

2. The endo-parasitoid, *Tachina larvarum*:

The obtained data summarized in Figure (2) revealed that, the population of *T. larvarum* exhibited four peaks of abundance. The first peak was recorded on the 25th of April, the second on the 13th of June, the third on the 15th of August (the highest) and the fourth one on the 3rd of October (Figure, 2). These peaks represented by 1.2, 1.7, 2.3 and 2.0 individuals / inflorescence (Figure, 2).

As shown in Figure (2), there was a visual synchronization between *T. larvarum* and *C. gnidiella* populations during the first season; whereas, changes of the parasitoid population approximately coincided with those of its host population.

During the second season, changes of *T. larvarum* population showed similar trend to those of the first year, where *T. larvarum* population exhibited four peaks of seasonal abundance. The first peak was recorded on the 3rd of May, the second on the 21th of June, the third on the 19th of July (the highest) and the fourth one on the 20th of September (Figure, 2). These peaks represented by 1.2, 2.2, 2.9 and 2.5 individuals / inflorescence (Figure, 2).

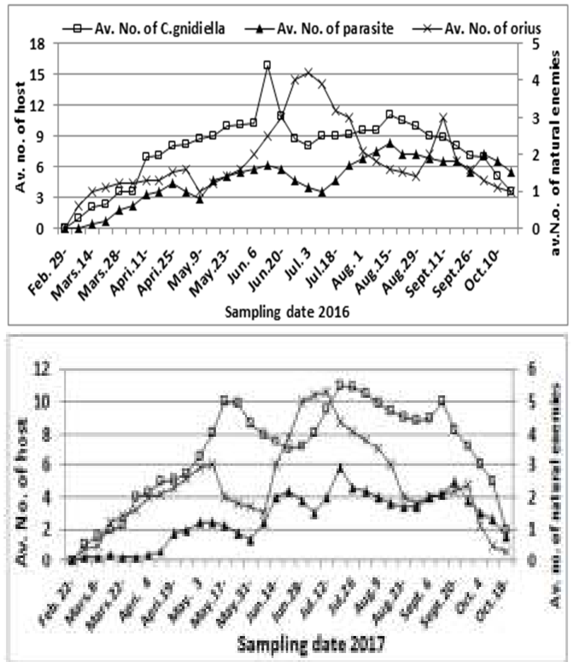

Figure 2. Seasonal activity of the predator, *Oruis* sp. and the endoparasitoid *Tachina larvarum* in response to the density of *C. gnidiella* population on mango orchard at Shirben district during 2016 and 2017 years.

Statistical analysis indicated that there was significantly positive correlation between populations of *C. gnidiella* and its parasitoid during the first (r = 0.65**) and second (r = 0.79**) seasons. On another hand, the simple regression values (b) revealed direct relationship between populations of both the host (Larvae of *C. gnidiella*) and the parasitoid where, each increase of *C. gnidiella* population by one larva/ inflorescence increased the population of *T. larvarum* by 0.12 and 0.22 larvae/ inflorescence during the first and second seasons. Also, statistical analysis showed that *C. gnidiella* larval population affected parasitoid population by 0.42 and 0.62 (as R^2-values) during the first and second seasons (Table, 1).

Table 1. Simple correlation and regression between the host, *Cryptoblabes gnidiella* and its natural enemies (*Orius* sp. and *Tachina larvarum* populations in mango orchards at Shirben district during 2016 and 2017.

Natural enemies	Year	Correlation and simple regression			
		R	b	P	R^2
Orius sp.	2016	0.51	0.14	0.0017	0.27
	2017	0.63	0.25	0.0000	0.40
Tachina larvarum	2016	0.65	0.12	0.0004	0.42
	2017	0.79	0.21	0.0000	0.62

The monthly means of parasitism percentage caused by the parasitoid, *T. larvarum* on *C. gnidiella* individuals was estimated and illustrated in Figure (3) for the first and second seasons. The highest activity of *T. larvarum* was recorded during September, represented by 17.5 and 19.9%, while, the lowest one was recorded during March (8.3 and 6.0%) in 2016 and 2017, respectively. The percentage of parasitism all over the season averaged 13.2±3.2 and 14.3±5.01% during 2016 and 2017, respectively.

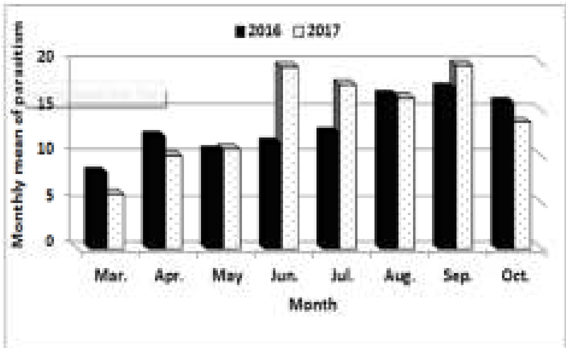

Figure 3. Monthly means of parasitism caused by endo-parasitoid, *T. larvarum* on *C. gnidiella* larvae infesting mango inflorescence during 2016 and 2017 seasons.

3. Life and fertility tables for *Cryptoblabes gnidiella* reared on mango inflorescences:

1. Life table:

Life table analysis were conducted for *C. gnidiella* reared on mango inflorescences based on an initial cohort of 150 eggs under laboratory conditions of 26±3.5°C and 66±5.5 R.H.%. The age-specific survival tables for HM reared under previously mentioned laboratory conditions represented in Table (2).

Data in Table (2) indicate that the egg stage lasted 4.1±1.8 days. The 1st, 2nd, 3rd, 4th and 5th larval instars durated 2.7±0.5, 2.3±0.5, 3.3±0.8, 3.7±0.5 and 2.5±0.5 days, respectively. The developmental period of the pupal stage lasted 10.7±0.9 days.

The egg stage and the 1st instar larval mortalities (q_x) were the highest among all stages and instars. They were 0.187 and 0.156, respectively. The total developmental duration lasted 29.5 days (Table, 2).

Generally, age-specific survival of HM cleared that eggs and first instar larvae appear to be the key stage mortalities.

Table 2. Life tables of *Cryptoblabes gnidiella* reared on mango inflorescences under laboratory conditions (26±3.5°C and 66±5.5 R.H.%).

Stage	X	I_X	d_X	Q_X
Egg stage	4.1±1.8	150	28	0.187
Larval stage:				
1st instar	2.7 ± 0.5	122	19	0.156
2nd instar	2.3 ± 0.5	103	9	0.087
3rd instar	3.3 ± 0.8	94	5	0.053
4th instar	3.7 ± 0.5	89	4	0.045
5th instar	2.5 ± 0.5	85	4	0.047
Pupal stage	10.7±0.9	79	3	0.038
Total immature stage	29.5±2.3	76	2	0.026

2. Age specific fecundity table:

The age-specific fertility table is represented in Table (3) for *C. gnidiella* reared under laboratory conditions. From Table (3), the net reproductive rate (R_o), the intrinsic rate of natural increase (r_m) and the generation time (T) of *C. gnidiella* were calculated.

The duration of a generation of HM as shown in Table (3) lasted about 34.15 days on mango inflorescences. The net reproductive rate (R_O) was 29.03 females/ female and the calculated value of intrinsic rate of increase (r_m) which expresses the relationship between fecundity, generation time and its survival was 0.04.

Table 3. Life table parameters as survival (L_X) and fecundity rate (M_X) of HM moths reared on mango inflorescences for one generation under laboratory conditions (26±3.5°C and 66±5.5 R.H.%).

X	L_X	M_X	$L_X.M_X$	$\sum X\ (L_X.M_X)$
29.5	0.509	0	0	0
30.5	0.509	0	0	0
31.5	0.5.09	1.86	0.94674	29.82231
32.5	0.5.09	5.92	3.01328	97.9316
33.5	0.497	6.74	3.34978	112.2176
34.5	0.497	6.74	3.34978	115.5674
35.5	0.484	7.97	3.85748	136.9405
36.5	0.484	8.03	3.88652	141.858
37.5	0.459	8.03	3.68577	138.2164
38.5	0.459	7.77	3.54312	136.4101
39.5	0.382	5.77	2.20414	87.06353
40.5	0.254	4.68	1.18872	48.14316
41.5	0.254	0	29.02533	1044.171

The calculated parameters were as follow: Ro = 29.03, T = 35.97 and r_m = 0.04

Discussion

The honeydew moth (HM), *C. gnidiella* started to appear on mango inflorescences at the beginning of March to the last week of October with the highest occurrence during June-July. The obtained results agree with Ben Yehuda *et al*. (1991) and Harari *et al*. (2007); who found that HM population began to appear in early spring and greatly increased from June to October. Similar results were obtained in Portugal by Silva and Mexia (1999); they mentioned that the highest abundant of HM population was recorded from June until late August. Also, Yildirım and Başpinar (2015) reported that the population of *C. gnidiella* peaked between mid-August and end of September. In the present investigation, *C. gnidiella* population exhibited 2-3 peaks annually. While, in Adana, Mersin and Osmaniye provinces of the Eastern Mediterranean Region *C. gnidiella* population gave 4–5 generations per year (Öztürk and Ulusoy, 2011). The difference between the present results and others may be attributed to the host plant species and/or the different environmental factors.

The obtained data during the two seasons of study revealed that the anthocorid predator, *Orius* sp. was mainly associated with *C. gnidiella* population. Similar conclusion was obtained by Yildirım and Başpinar (2015); they recorded that *Orius* sp. (Hemiptera: Anthocoridae) was among the main predators associated with *C. gnidiella* population in pomegranate orchard. In addition, the endo-parasitoid, *Tachina larvarum* species, was firstly investigated on *C. gnidiella* larvae infesting mango inflorescences. In pomegranate orchard in Aydın Turkey, the parasitoid *Pachycrepoideus vindemmiae* (Hymenoptera: Pteromalidae) was found to be reared on the pest. While, in the grapevine orchards in Brazil, five species of Hymenoptera were found associated with *C. gnidiella*: *Apanteles* sp. (Braconidae), Perilampidae, *Pimpla croceiventris* (Cresson) (Ichneumonidae), *Venturia* sp. (Ichneumonidae) and *Macrocentrus* sp. (Braconidae). *Venturia* sp. was the most abundant parasitoid. (Bisotto-de-Oliveira *et al*. 2007). These different may attributed to the host plant or the climatic factors.

Generally, it could be concluded that the natural enemies, especially the endoparasitoid, *T. larvarum* have played a considerable role in eminently successful biological control projects directed against HM populations. They have some of the important attributes of effective natural enemies {i.e. number of generation for the parasitoid is considerably more than the host, usually capable of inflicting high mortality in host population, in addition the anthocorid predator, *Orius* sp. have an excellent good correlation with the prey}. Therefore, *T.*

larvarum and *Orius* sp. proved to be good biological control agents against HM on mango orchards.

Data obtained under laboratory condition cleared that the mean duration period of the different developmental stages of *C. gnidiella* (eggs, larvae and pupae) was 4.1±1.8, 14.4±0.6 and 10.7±0.9 days, respectively. These results agree with those obtained by Bhadauriya *et al*. (2011); they found that the mean incubation period was 3 days, larval period lasted between 8.80-15.40 days; while, the pupal period was 4.40 to 11.00 days. In the present study, mortality of eggs and first instars' larvae proved to be key stage mortalities. Also, Bhadauriya *et al*. (2011) reported that hatchability percentage was 65.03%.

The net reproductive rate and generation time of *C. gnidiella* reared on mango inflorescences were 29.03 females/female and 35.97 days. According to Wysoki *et al*. (1993), the average fecundity of *C. gnidiella* reared on grape was 105 eggs /female; while, when the pest reared on hybrid sorghum, female laid an average of 31.0 egg (Bhadauriya *et al*., 2011).

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النشاط الموسمي، الأعداء الحيوية وجداول الحياة لفراشة الندوة العسلية على شماريخ المانجو الزهرية

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أجريت الدراسة الحالية بمزرعة مانجو مهمله (خالية من المعاملات الكيميائية) بمنطقة شربين – محافظة الدقهلية .لدراسة التذبذبات العددية لفراشة الندوة العسلية والأعداء الحيوية المرتبطة بها. وقد أوضحت النتائج أن هذه الآفة متواجدة على ارتفاع ٢.٥±٠.٥ متر من سطح الأرض ولا تتواجد على ارتفاع ٥.٥±٠.٥ متر. وقد أظهر تعداد الآفة ثلاث ذروات للنشاط سنوياً. كما تم تسجيل مفترس ال *Orius* sp. التابع لرتبة نصفية الأجنحة مرتبط بهذه الآفة وكذلك الطفيل الداخلي *Tachina larvarum* التابع لرتبة ذات الجناحين (لاول مرة على الافة). وقد أظهر تعداد المفترس ثلاثة ذروات للنشاط سنوياً بتزامن جيد مع تعداد الآفة (حيث كان الارتباط بينهما عالي المعنوية). أما تعداد الطفيل فقد أظهر اربعة ذروات للنشاط سنوياً بارتباط عالي المعنوية أيضاً مع تعداد الآفة. وقد بلغ متوسط نسبة التطفل ١٣.٢±٣.٢ و ١٤.٣±٥.٠١% خلال عامي ٢٠١٦ و ٢٠١٧. كما تم دراسة جداول الحياة والخصوبة تحت الظروف المعملية لهذه الآفة المرباه على الشماريخ الزهرية للمانجو، وقد بلغت فترات النمو لكل من طور البيضة واليرقة والعذراء ٤.١±١.٨، ١٤.٤±٠.٦ و ١٠.٧±٠.٩ يوم علي التوالي. كما تم تقدير مدة الجيل ،وصافي معدل الخصوبة (Ro) ، و معدل التزايد الحقيقي (r_m) فكانت كالتالي٣٥.٩٧ يوم ، ٢٩.٠٣ اناث/أنثى ، ٠.٠٤ أنثى/أنثى/ جيل.