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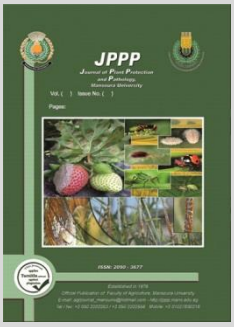
The Seasonal Abundance of Immature Stages of the Cabbage Worm, *Pieris rapae* L. on Cabbage Crop in Beni Suef Governorate, Egypt

Wael, E. A. El-Sheikh*

Department of Plant Protection, Faculty of Agriculture, Beni-Suef University, Egypt.



ABSTRACT

In recent years the number of cabbage worm *Pieris rapae* has increased in Beni Suef Governorate, and they have threatened the vegetative growth of cabbage crop, especially in the newly reclaimed areas. That study was conducted during the 2017/18 – 2018/19 seasons respectively. Results obtained revealed that there are two distinct peaks for each eggs, larvae and pupae stages per year on cabbage plants. The immature stages covered the entire period of sampling from August 2017, till April 2018 on the cabbage plant. The first peak of egg Population was recorded on November 6 2017 and another smaller peak on mid of March 2018. The maximum larval Population (770 larvae) appeared on November 13, 2017 another smaller peak (450 larvae) on beginning April 2018. Pupal population exerted two periods of abundance On the 22 November, 2017 the highest numbers of pupae were recorded and another smaller peak on mid-April 2018. We can point out that the first and second peak of these stages in 2018/19 came about one to two weeks after the previous season 2017/18. The results also showed that there were statistically significant differences between the number of immature stages and the seasons of the year in cabbage fields. The cabbage sown in autumn season was severely attacked by this pest, followed by spring season. Autumn insect population was about 2-3 folds of winter population. Knowledge of the seasonal abundance of the immature stages is of great valuable to help in planning a control program against this target pest.

Keywords: Seasonal abundance, *Pieris rapae*, Cabbage, Field, Reclaimed areas.

INTRODUCTION

Cabbage worm, *P. rapae* has been registered in North America, Australia and New Zealand for a century or more, has spread rapidly across continents and is among the most abundant types of brushes. It is a serious pest for the cabbage crop (Barkat *et al.* 2018 and Shen *et al.* 2017). The imported cabbage worm, *P. rapae* (Lepidoptera: Pieridae), which is a major pest of crucifers throughout Egypt, is an important pest of cabbage crop. Young plants of the autumn-crop are subjected to severe attack and the maturing heads frequently are seriously infested (Ali *et al.* 1984; El-Fakharany and Hendawy 2014).

Cabbage worm is distributed in North Africa through Europe and Asia to the Himalayas in the mountains. Small larvae feed on the leaves of host plants such as cabbage and the larvae sometimes destroy the heads of plants, causing great damage to the crop (Hasan and Ansari 2011). A small white butterfly, *P. rapae* has been reported to cause significant damage to the oilseed brassica crops in India, so timely reporting of this pest is important to avoid crop losses (Kumar 2014 and Layman *et al.* 2015).

Cabbage crop are usually invaded by numerous insect pests causing considerable crop losses. Density estimates for Lepidoptera species in crucifer's fields have done by Lariviere *et al.* 2015 and Itoh *et al.* 2018. The life cycle duration of this insect is 3-6 weeks, depending on the state of temperatures during the seasons. The female lays 300-400 eggs. Adult cabbage worm Pieris rapae are very active during daylight hours, often going from the crop to flowering weeds for feeding. Larvae of this *P. rapae* feed widely on plants of the cruciferous family, such as broccoli, cabbage, cauliflower, radish and turnip (Sikkink *et al.* 2017; Agrawal and Kurashige 2003).

Stoehr *et al.* 2016 found that the population density of egg, larval and pupal stages occurring in fields markedly differs according to locality, kind of host plant, growing season and environmental conditions prevailing during insect activity. Female cabbage worm lays more than 100 eggs on leaves of the plant. The highest fertility rate in June and July, Declines as the season progresses. The most favorable conditions for flying and eggs are medium temperatures coupled with low wind speeds (Langan *et al.* 2001). Differences in climatic temperatures, season length, natural enemies and geographical areas in the seasons of the year can affect the total cabbage worm during the season by Seiter and Kingsolver (2013). During assessment of such injurious insect Population in cabbage fields, it was noticed that Populations varied from the outer to inner portions of the field (Edelson *et al.* 1988 and Jõgar *et al.* 2008).

The present study was carried out to explore the seasonal abundance of immature stages of the cabbage worm, *P. rapae* on cabbage plants. These facts attracted the author attention to studying the immature stages of the cabbage worm in a new desert environment. This available data will aid in determining the density of immature stages of the pest and thus achieving successful control.

MATERIALS AND METHODS

Study Area:

The current study was conducted in about one feddan were cultivated with seedling of cabbage (*Brassica oleracea*) during two successive seasons (2017/18 & 2018/2019) in Beni Suef Center - Beni Suef governorate, which are lands located between Beni Suef Governorate and Fayoum governorate, an extension of modern agricultural reclamation lands. The usual agricultural methods were used and no pesticides were used for the experiment field. From the perspective of pest adaptation to agriculture, this desert area is truly unique as it has been newly reclaimed, and the cabbage crop is grown in large areas.

* **Corresponding author.**
E-mail address: wael.elzaher@agr.bsu.edu.eg
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Sampling:

The cabbage is planted in the nursery and transferred in the ground during August, November and February, when the plant reaches a height of 15-20 cm. Samples were taken for the imperfect phases from August to April during the two seasons of the study (Ali *et al.* 1984 and El-Sheikh and El-Kenway 2020). Samples of 100 plants from cabbage crop were chosen randomly and wholly inspected in an axial pattern at regular distances were chosen weekly in the field where they were carefully inspected for the presence of the insect immature stages (egg, larva and pupa). The numbers of eggs, larvae and pupae were counted and recorded on the leaves of the plant by direct count investigation. Samples were taken at 10 am throughout the study period.

Meteorological data:

Records of temperature and relative humidity were obtained from Giza Meteorological Station, A.R.C to find the relationship between plants, immature stages and weather factors.

Statistical analysis:

Partial correlation (r) and regression coefficient (B) values were calculated and the relationship between these climatic factors and *P. rapae* and Population fluctuations were estimated according to Analysis of variance (ANOVA) applied using Holm-sidak method to refuse the null hypnosis and confirm the presence of significant variance between different levels of factors.

RESULTS AND DISCUSSION

Results

Population abundance of immature stages:

a) Eggs:

Female cabbage worm P. rapae laid eggs singly, on the lower surface of the outer leaves of cabbage plants. Data depicted in Fig. 1 A and B, show that eggs were first observed on the first week of August with Mean numbers of 65 and 72 egg/100 plants of cabbage during two study seasons respectively. In subsequent samples, the number of eggs proportionally increased and exerted the first peak 510 egg/ plants, occurred in the first week of November during the first year 2017/18. It came after a week with a total number of 630 eggs / plants in the second year 2018/19. Egg Population showed sharp decrement through January and February. By raising the temperature throughout February and March, a remarkable increase of egg numbers was denoted. In mid-March, the second peak of eggs (340 egg / plants) was shown on cabbage during 2017/18. While the second peak in 2018/19 recorded the highest density of eggs (386 eggs) on the cabbage plant in last week of March (Fig.1). These results reveal that eggs of P. rapae occur with considerable numbers on cabbage plant during the period extending from August to the end of next April. Adult cabbage worm P. rapae, fly great distances in search of egg-laying sites. The butterfly puts only one egg on the plant leaf and continues to fly in search of a new plant, and if there are many suitable plants for laying eggs, it remains in the same area for a long time. Butterfly eggs contain a deterrent pheromone that prevents other butterflies from laying eggs on the same leaf of the plant.

b) Larvae:

The larvae of *P. rapae* appeared in cabbage field on second week of August during the study two seasons of 2017 / 18 - 2018 / 19 with few individuals, Mean numbers of 54 and 62 larvae per 100 plants of, respectively. The consecutive weekly numbers revealed gradual increase of larval Population which reached the maximum density (770 larvae / 100 plants) on November 13, and on November 25 (805 larvae / 100 plants) in the seasons 2017 / 18 - 2018 / 19. Another peak of larvae was formed in beginning of April 2018 on cabbage (450 larvae), while this peak appeared a week later (522 larvae) in 2019 (Fig. 1 A and B). Cabbage worm larvae occupy the outer leaves of the cabbage plant for feeding. Older larvae move to the inner cabbage leaves and head of cabbage, eat the inner leaves and destroy the cabbage head. Aside from direct destruction, the areas between the leaves and the inflorescences are dirty with feces as a result of which they rot easily.

c) Pupae:

The pupa stage was first detected on the Cabbage in late August however the Population remained low during August-September. The highest number was recorded on cabbage (147 pupae / 100 plants) on November 22, and after a week (168 pupae) for the second consecutive season. The period extending from late October to the beginning of January was characterized by the remarkable increase of pupae Population. There was a gradual increase in pupae in the cabbage fields, showing another peak on April 8 for cabbage (98 pupae) for the 2018 season, and a week later for the second season 2019 (112 pupae) Fig. 1 A and B.

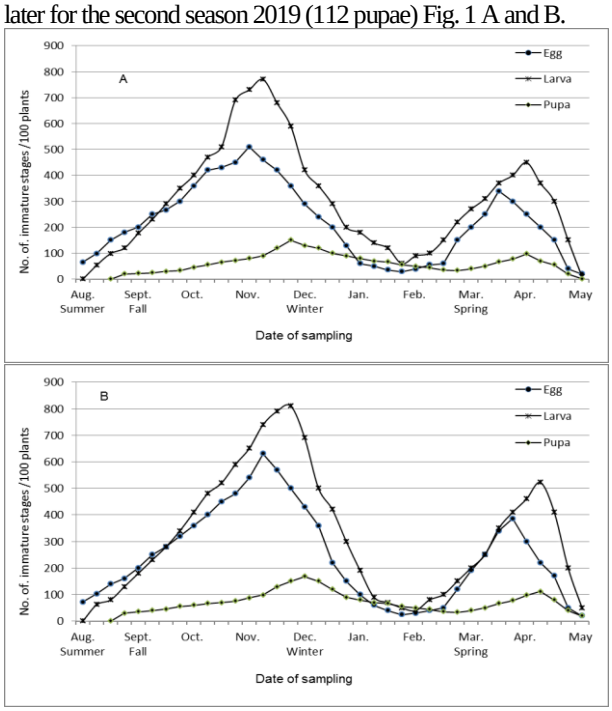

Fig. 1. Population abundance of immature stages *P. rapae* in cabbage crop (A) the first year 2017/18 and (B) the second year2018/19 seasons

Seasonal abundance of immature stages:

The results in Table 1 clarify that the population of the immatures varied from season to another one being the highest through autumn a total number (7415-7942 immature stages), followed by spring (3156 - 4390), winter (2055 - 2333) and the lowest in summer (815 - 918 immature stages) respectively in the study seasons 2017 / 18 - 2018 / 19. This population trend is closely similar on eggs, larval and pupae which are expressed as seasonal averages or as mean numbers of the immatures population of the two years of study (Table 1). The mean numbers of eggs, larval and pupae in the first season of the study in the cabbage fields were lower than the equivalent numbers in the second season.

Nevertheless, there are significant differences between the presence of the three stages of the cabbage worm and the average density of their numbers during the different four seasons of the year, where the largest mean of the immature stages was in the autumn season (2471.6 ±2.5a - 2647.3 ±3.5a), with a population ratio of 55-51%, respectively in two years of study (Table 1). This is followed by the spring season,

with a population ratio of 24-28%, with an mean of (1052 ±2.6 b - 1463.3 ±1.7 b) immature stages during the two seasons 2017/ 18-2018/19. Summer and winter were at their lowest levels, at 7-14% population, with a mean of (306 ±2.1 d -777.6 ±2.4 c) of the immature stage during second year (Table 1).

Statistical analysis of the obtained data revealed no significant differences of the various immature staged prevailed in the first and second seasons. On the other hand, the population of these stages significantly differed in spring, summer, autumn and winter with statistically significant differences between the four seasons in the first and second seasons. At the same time, in general, the total population on *P. rapae* (immature stages) in the cabbage field was Larger in the second season than in the first season (Table 1).

Table 1. Seasonal abundance of immature stages of *P. rapae* existing on cabbage in 2017 /2018 and 2018 /2019 seasons.

Year	Season	No. of. immature stages /100 plants					
		Egg	Larva	Pupa	Total	Mean ± S.E.	% population
2017-18	Summer	394	319	102	815	271.6 ± 3.2 d	6%
	Autumn	2757	3821	837	7415	2471.6 ±2.5 a	55%
	Winter	828	936	291	2055	685 ±4.3 c	15%
	Spring	1261	1412	483	3156	1052 ±2.6 b	24%
2018-19	Summer	412	370	136	918	306 ±2.1 d	7%
	Autumn	3020	4031	891	7942	2647.3 ±3.5 a	51%
	Winter	960	1008	365	2333	777.6 ±2.4 c	14%
	Spring	1840	2010	540	4390	1463.3 ±1.7 b	28%

Number followed by the same letter are, not significantly different (ANOVA)

The prevailing temperature during autumn and spring seasons ranged between 16 and 24 ℃ and between 15.3 and 26.2 °C, respectively, which seem to be more favourable for build-up of the insect population (Fig.2).

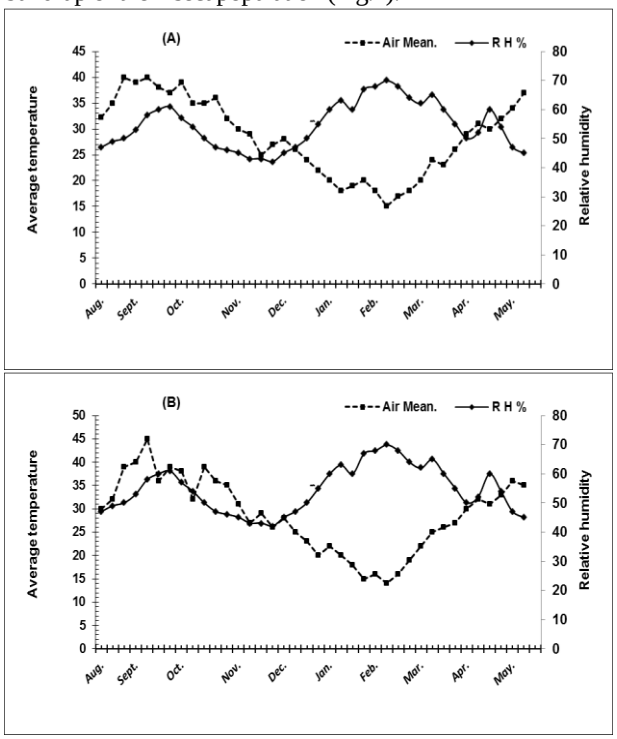

Fig. 2. Effect of mean temperatures and relative humidity on density of immature stages (*P. rapae*) in cabbage crop (A) 2017/18 and (B) 2018/19.

The considerable decline of the insect population through summer months could be regarded to high temperature 28-37 ℃, which is not in favour of population growth even the temperature range 29-45 °C is appropriate for adult activity and immature stages. On the other hand, the autumn of temperature during winter to 12- 14.2 °C, and an increase in the relative humidity of 50-65% results in very low population (Fig.2). One of the most interesting phenomenon's in the present study is the outnumbering of larval population to egg population which could be due to the absence of egg-parasitism under Egyptian desert climatic conditions on one hand and the high fertility of deposited eggs on the other hand. The influence of weather conditions such as temperature and relative humidity, monitoring and dates of the immature stages of cabbage worm that show a positive relationship with temperature and relative humidity. However, climate change during the seasons of the year directly or indirectly affects population dynamics and is the most important variable for year-to-year population fluctuations and incidence levels.

Discussion

The immature stages covered the entire period of sampling from August 2017, till April 2018 on the cabbage plant. On cabbage, the first peak of egg Population (510 eggs) was recorded on November 6 2017, the second peak occurred on March 15, 2018. The maximum larval Population (770 larvae) appeared on November 13, 2017 another smaller peak on beginning April 2018. These results are inconsistent with Edelson *et al.* (1988) in a study conducted in California that the density of immature stages of the cabbage worm was low in the month of August and the average number of them was 25.5 larvae / plant, and a large increase occurred during the month of March and April. This difference can be explained by the change in climatic factors from one area to another (Agrawal and Kurashige 2003 and Stoehr *et al*. 2016).

Comparing the dates of the maximum densities of eggs, larvae and pupae on cabbage plants in the two seasons, it could state that the first peak of these stages came in 2017-18 about one week later than in the first season 2018-19, while the second peak appeared one to two weeks later than the preceding season. At the same time, (eggs, larval and pupal) counts in the second season of study was evidently more than those of the first season. Kumar (2014), proved during the first and third week, the number of larvae ranged from 1.7-3.3 for every 10 plants in November. This number of larvae can destroy cabbage in India. Climatic conditions vary during the seasons of the year, and this difference affects the density of cabbage worm (Harcourt, 1962; Sikkink *et al*. 2017and Barkat, *et al*. 2018).

We observe the behavior of laying eggs for the cabbage worm on the plant, where the females resort to laying eggs individually on the leaves of the plant (Langan *et al*. 2001and Hasan and Ansari 2011). The life cycle of a cabbage worm is three to six weeks, depending on climatic factors. The number of generations reported annually is two to three in Canada, and three to five are in California, and the insect is present throughout the year in Florida. These results are consistent with Jõgar, *et al*. 2008, as it has been proven that a single female can lay 300-400 eggs, however, the number of eggs may also reach 1,000. A female butterfly may live an average of 20 days, forage on nectar, and lay an average of 356 eggs. Butterflies tend to fly upwind. When searching for host plants, females fly close to vegetation, stopping every few meters to test the plants' suitability for laying eggs by Seiter and Kingsolver (2013).

Feeding the cabbage worm larvae can destroy the crop, pollute the field with excreta, and be unmarketable. The results also showed that only about 37% of larval population found in the field could successfully develop to pupae. The causes of this feature could be regarded to environmental mortality factors as unfavourable temperature during winter and summer seasons, the spread of parasitism and a high contagious larval disease which oppose the build-up of pupal and adult population each year. These results are coincident with those obtained by Shen *et al.* (2017); El-Fakharany and Hendawy (2014) and Lariviere *et al.* (2015). On the other hand, Layman *et al.* 2015 and Itoh *et al.* 2018 reported that its population was highest from July to December, but lowest in the first half of the year in southern California. Monitor the density of immature stages of the cabbage worm during different seasons. We can easily create effective control programs under farming systems in newly reclaimed desert areas.

CONCLUSION

Thus, producers must be on constant alert from the sudden increase in the immature stages of the cabbage worm, *P. rapae*. Temperature and relative humidity are important in determining the total number of immature stages cabbage worms during the different seasons of the year. This research represents an important step in determining the evolution of white cabbage butterflies as a case study to contribute to our understanding of adaptation to desert agricultural environments. The current results are consistent with the idea that adaptation to a new desert agricultural environment has occurred through a change in weather factors. The upgrading step to study the seasonal abundance of immature stages of the cabbage worm was urgently important to record the pest counts and determine the exact time to implement control programs on a biological basis in order to get maximum net return of the crop.

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الوفرة الموسمية للأطوار غير الكاملة لدودة الكرنب .Pieris rapae L علي محصول الكرنب في محافظة بني سويف – مصر

وائل الظاهر عبدالحفيظ الشيخ*

قسم وقاية النبات ، كلية الزراعة ، جامعة بني سويف - مصر

في السنوات الأخيرة ازداد عدد دودة الكرنب *Pieris rapae* في محافظة بني سويف ، مما هدد النمو الخضري لمحصول الكرنب ، خاصة في المناطق المستصلحة حديثًا للزراعة. أجريت تلك الدراسة خلال موسمي 18/2017 - 19/2018 على التوالي. أوضحت النتائج أن هناك ذروتين متميزتين لكل من البيض واليرقات والعذاري في السنة على نبات الكرنب. غطت الاطوار غير الكاملة فترة أخذ العينات من أغسطس 2017 حتى أبريل 2018 في حقول الكرنب. تم تسجيل الذروة العددية الأولى لتعداد البيض في 6 نوفمبر 2017 وذروة عددية أخرى أصغر في منتصف مارس 2018. ظهر الحد الأقصى لتعداد اليرقات (770 يرقة) في 13 نوفمبر 2017 وذروة عددية أخرى أصغر (450 يرقة) في بداية أبريل 2018. اظهرت العذاري فترتين من الوفرة العددية في 22 نوفمبر 2017 تم تسجيل أعلى عدد من العذاري وقمة عددية أخرى اقل في منتصف أبريل 2018. يمكن أن نشير إلى أن الذروة العددية الأولى والثانية من هذه الاطوار خلال عام 19/2018 جاءت بعد اسبوع الي اسبوعين من الموسم السابق 18/2017. كما أظهرت النتائج وجود فروق ذات دلالة إحصائية بين عدد الأطوار غير الكاملة وفصول السنة في حقول الكرنب. تعرض الكرنب الذي تم زرعة في فصل الخريف لهجوم شديد من هذه الآفة ، تلاه موسم الربيع. وكان عدد حشرات الخريف حوالي 2-3 أضعاف تعداد الشتاء. تعتبر المعرفة بالوفرة الموسمية للمراحل غير الكاملة ذات قيمة كبيرة للمساعدة في التخطيط لبرنامج مكافحة هذه الآفة المستهدفة.