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Parasitoid Species Associated with Immature Stages *pieris rapae* (L.) Inhabiting Cabbage Plantations in Assiut Governorate, Upper Egypt

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Abstract: This work was initiated for the first time to identify parasitoid species associated with the immature stages of *Pieris rapae* (L.) inhabiting cabbage plantations in Assiut governorate, Upper Egypt during the 2018 and 2019 cabbage growing seasons. Attacking periods and parasitism percentages (PPs) of the identified parasitoid species were calculated. One solitary parasitoid species, *Hyposoter ebeninus* was found to attack *P. rapae* larvae in the field 110 days after transplantation. However, one hyperparasitoid species *Baryscapus galactopus* was recorded as an internal gregarious hyperparasitoid of *H. ebeninus*. The solitary larval parasitoid *H. ebeninus* strikes were recorded throughout the last five weeks of the season with a marked decline before harvesting. Although *H. ebeninus* revealed 42.00% abundance, it presented 21.69% PP on *P. rapae* larvae during the entire period of study. One solitary, *Brachymeria femorata* and two gregarious parasitoid species [*Pteromalus puparum* (L) and *Tetrastichus* sp. (Haliday) were recorded as *P. rapae* pupae parasitoids on October, 2nd. Parasitism peak was recorded on October, 16th with an average of 56.25%. The first appearance of the gregarious pupal parasitoid *P. puparum* was recorded on October, 9th. Four weeks later, the second gregarious parasitoid (*Tetrastichus* sp.) was recorded on November, 6th. Both pupal gregarious parasitoid species were found to be active until harvesting. The gregarious parasitoid *P. puparum* presented high PP (23.73%) as compared with *Tetrastichus* sp. which exhibited 6.96% PP during the entire period of study. In conclusion, two solitaries, one hyperparasitoid, and two gregarious parasitoid species were identified. Pupal gregarious parasitoid species together reduced *P. rapae* pupae populations by 30.69%. These parasitoids could be used in the IPM programs for this pest in the future. At the same time, the effect of hyperparsitoides must be taken into consideration.

Keywords: Parasitoids Complex, Pieris Rapae, Parasitism Percentages, Abundance

1. Introduction

The white butterfly (WB), *Pieris rapae* (Linnaeus, 1758) (Lepidoptera: Pieridae) occurs in temperate regions around the world. WB larvae feeding habits caused ragged holes in the leaves of the host plant. Under heavy attack, only the veins are left, resulting in considerable losses to commercial growers. Less heavily infested plants become stunted and fouled with dark green pellets [1]. In Egypt, cabbage

plantations have been subjected to attack by sever key insect pests e.g. the WB *P. rapae* [2].

Parasitoid species of *P. rapae* in northern Egypt were surveyed by Kolaib et al. [3]. The recorded parasitoids were the gregarious larval parasitoid, *Apantelus glorneratus* L., (Hymenoptera: Braconidae), the solitary pupal parasitoid, *Brachyrneria femorata* Panz. (Hymenoptera: Chalicididae) and the gregarious pupal parasitoid, *Pteromalus puparum* L. (Hymenoptera: Pteromalidae). In a field study in Kafr El-Sheikh Egypt, Awadalla et al. [4] reported that *P. rapae* attacking cabbage plants was subjected to attack by the pupal parasitoids *B. femorata* and *P. puparum*. Also, El-Husseini et al. [5] found five parasitoid species associated with *P. rapae* when surveyed cabbage plantation in old cropland middle Egypt. The five recorded species were *Trichogramma buesi* V., *Cotesia glomerata* (L.), *Hyposoter ebeninus* Grav., *Brachymeria femorata* Panz, and *Pteromalus puparum* L.

Pesticide massive application and appearance of pest resistance strains, outbreaks of secondary pest, the absence or ineffective presence of natural enemies, and global worming and climate change are all contributing to changes in insect pest problems faced by farmers in Egypt's newly reclaimed land as well as in the old valley [6]. Recording natural biological control agents for plants is becoming increasingly important in order to expand our knowledge. The main objective of this manuscript is to identify parasitoid species attacking *P. rapae* immature stages (larvae and pupae) inhabiting cabbage plantations in the reclaimed areas in Assiut, Upper Egypt. Parasitism percentages and attacking duration were also taken into consideration.

2. Materials and Methods

2.1. Experimental Design

Experiments were conducted at a reclaimed area at the border of the eastern desert of Assiut governorate (private farm at El-Fath province) during the 2018 and 2019 cabbage growing seasons. Area of about 1050 m^2 divided into plots (10.50 m^2/plot). Cabbage seeds were planted in the greenhouse on 17th June during both seasons. One month later cabbage seedlings were transplanted at a 50 cm distance at the sustainable farm. Regular agricultural practices were used. Chemical treatments were completely prevented.

The natural parasitism rates on *P. rapae* larvae were estimated weekly in the field by counting parasitized and non-parasitized larvae/plant (4 plants/ plot). However, parasitism rates on *P. rapae* pupae were estimate

d weekly by picking up *P. rapae* pupae inhabiting the outer and/or the middle leaves of randomly selected cabbage plants. The collected larvae and pupae were transferred to the laboratory and kept individually in moistened test tubes (10 replicates) at the laboratory conditions (22± 3 °C and 60± 5 R. H. %). The test tubes were carefully labeled and covered with a piece of cotton to provide aeration. Emerged parasitoids were killed by chloroform and preserved at –5 °C in a freezer for later identification by the specialists in the biological control and taxonomy Departments in the Plant Protection Research Institute, Ministry of Agriculture.

Parasitism percentages (PP) on larvae and pupae were estimated by the equations used by Puneeth, & Vijayan [7], Bhat [8] as follows:

$$PP = \frac{\text{Number of parasitized larvae/pupae}}{\text{Total number of parasitized and non-parasitized larvae/pupae}} \times 100$$

2.2. Abbreviations

WB=The White butterfly, PPs=Parasitism percentages, *H. ebeninus=Hyposoter ebeninus*, *P. rapae=Pieris rapae*, *B. galactopus=Baryscapus galactopus*, *B. femorata=Brachymeria femorata*, *P. puparum=Pteromalus puparum*, (SWB)=The small white butterfly, R. H.=Relative Humidity, H=Highest L=Lowest, IPM=Integrated Pest Management, A%=Abundance %, GPP=General Parasitism Percentage.

3. Results

3.1. Larval Parasitoids

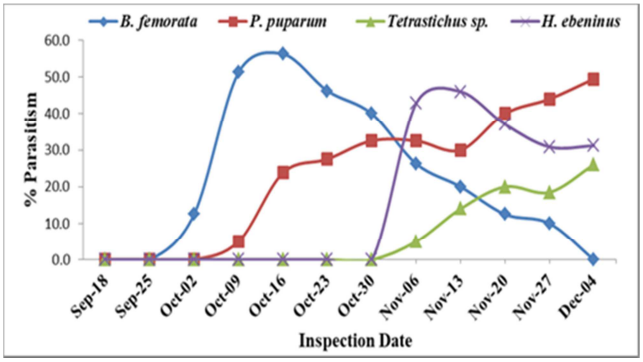

Figure 1. *Mean parasitism percentages of the identified parasitoids attacking the cabbage white butterfly Pieris rapae larvae and pupae in cabbage fields in Assiut (El-Fath province) during 2018 and 2019 growing seasons.*

One solitary parasitoid species, [*Hyposoter ebeninus* (Gravenhorst) (Hymenoptera: Ichneumonidae)] was recorded attacking *P. rapae* larvae in the field 110 days after transplantation. However, one hyperparasitoid species [*Baryscapus galactopus* (Ratzeburg) (Hymenoptera: Eulophidae)] was recorded as an internal gregarious hyperparasitoid of *H. ebeninus*. Data illustrated in Figure 1 revealed that the larval parasitoid *Hyposoter ebeninus* (Gravenhorst, 1829) attacking *P. rapae* larvae in cabbage fields during 2018 and 2019 growing seasons, 110 days after transplantation. The first attack of *H. ebeninus* on *P. rapae* larvae recorded 42.81% PP on November 6th. Although *H. ebeninus* showed its highest attack in mid-November, its parasitism percentages declined gradually. Although *H. ebeninus* revealed 42.00% abundance percentage, it presented 21.69% PP on *P. rapae* larvae throughout the entire period of study (Table 1). Data collected during this investigation can be helpful in future studies for devising pest

management strategies, especially against the cabbage white butterfly *P. rapae*.

Table 1. *Mean parasitism percentages and abundance of the parasitoids attacking Pieris rapae larvae and pupae in cabbage fields in Assiut (El-Fath province) during 2018 and 2019 growing seasons.*

Parasitoid species	Mean parasitism percentage						A%©	GPP
	2018		2019		Mean (2018+2019)			
	H	L	H	L	H	L		
Hyposoter ebeninus (Gravenhorst, 1829) (Hymenoptera: Ichneumonidae)	48.56	30.56	43.93	29.03	46.25	29.80	42.00	21.69
Brachymeria femorata (Panzer, 1801) (Hymenoptera: Chalcididae)	60.00	10.00	52.00	10.00	56.00	10.00	75.00	22.92
Pteromalus puparum (L, 1758) (Hymenoptera: Pteromalidae)	43.00	22.00	56.00	10.00	49.50	16.00	75.00	23.73
Tetrastichus sp. (Haliday, 1844) (Hymenoptera: Eulophidae)	37.00	15.00	15.00	10.00	26.00	12.50	42.00	6.96

H=Highest, L=Lowes, A%=Abundance %, © Based on 12 samples**,** GPP=General Parasitism Percentage

3.2. Pupae Parasitoids

Data illustrated in Figure 1 revealed that the first appearance of the solitary parasitoid *Brachyrneria femorata* (Panzer, 1801) was recorded on October, 2nd (75 days after transplantation) with an average of 12.50% PP. Two weeks later PP of *B. femorata* multiplied and showed 51.25%. The highest PP (peak) of *B. femorata* on *P. rapae* pupae was recorded on October 16th with an average of 56.25%. A gradual decrease in *B. femorata* PPs was recorded. The general PP of *B. femorata* during the entire period of the study recorded 22.92% (Table 1). On the other hand, *B. femorata* showed the highest abundance percentage (75.00%) and the absolutely highest PPs on *P. rapae* pupae (56.00%).

Data illustrated in Figure 1 revealed that two gregarious parasitoid species were recorded as parasitoids of *P. rapae* pupae in cabbage fields, vs. *Pteromalus puparum* (L., 1758) and *Tetrastichus* sp. (Haliday, 1844). The first appearance of *P. puparum* was recorded 82 days after transplantation (October, 9th). Four weeks later, the second parasitoid, (*Tetrastichus* sp.) was recorded in cabbage fields (November, 6th). It is important to point herein that both gregarious parasitoid species was found to be active until harvesting. Data revealed that *P. puparum* ranked the first and presented the highest PPs with an average of 23.73% compared with *Tetrastichus* sp which exhibited 6.96% PP during the entire period of study. Gregarious parasitoid species together reduced *P. rapae* pupae populations by 30.69% (Table 1). Concerning the gregarious parasitoids parasitism and abundance percentages, data presented in Table 1 showed that *P. puparum* ranked the first and parasitized *P. rapae* pupae by the highest PP (ranged between 49.50 and 16.00%). This parasitoid abundance percentage (75.00%) was found to be equal to 1.71 fold of that presented by the second gregarious parasitoid (*Tetrastichus* sp.). Although, *Tetrastichus* sp. presented throughout 5 weeks only in the field, its PP (ranged between 26.00 and 12.50%). This finding reflects the importance of this pupal parasitoid as an effective biological control agent against (WB) in cabbage fields.

4. Discussion

The present study was conducted for the first time in this area of northern Egypt. Results demonstrated the finding of just one solitary *p. rapea* larval parasitoid *H. ebeninus* and one hyperparasitoid *B galactopus*. These results of the current investigations are in agreement with those obtained by the earliest, Abbas and Hassanein (1989) [9] who recorded the absolutely first parasitism in Egypt on *P. rapae* larvae in cabbage fields. Also, Deen & Bhagat [10] found three parasitoids, *C. glomerata*, *H. ebeninus* and *B. femorata* from larvae and pupae of *P. rapae* as a first parasitism of this pest in India. Notable gradual decline of *H. ebeninus* abundance through the time, this finding could be attributed to the appearance of its eolophid hyperparasioid *B. galactopus* which appeared at the same period. Results of Settele et al. [11] confirmed the complementary need for parasitoid based knowledge. Their article explained that parasitoid complexes are not closed systems, and there is no a prior way of assessing whether a parasitoid reared from a particular species also uses related hosts, or perhaps unrelated ones occurring in similar environments. Therefore, researchers need to establish comprehensive knowledge not only of which species attack butterflies, but also of the host associations of each one. This is gradually accruing, at least for common parasitoid species, especially through small-scale rearing's involving a large number of host species.

Results further exhibited documentation of three parasitoid species conjugated with *P. rapea* paupae; One solitary, [*Brachymeria femorata* (Panzer) (Hymenoptera: Chalicididae)] and two gregarious parasitoid species [*Pteromalus puparum* (L) (Hymenoptera: Pteromalidae) and *Tetrastichus* sp. (Haliday) (Hymenoptera: Eulophidae)]. North Egypt, parasitoid species of *P. rapae* were surveyed by [3] during the two successive years of 2006 and 2007. The recorded parasitoids were the gregarious larval parasitoid, *Apantelus glorneratus* L.; the solitary pupal parasitoid, *B. femorata* and the gregarious pupal parasitoid, *Pteromalus puparum* L. Total parasitism percentages ranged between 5.70 -16.20, 7.80 - 20.00 and 10.00 - 23.00% for *A. glomeratus*, *B. femorata* and *P. puparum*, respectively. In the same approach, Bhat & Bhagat [12] reported that the solitary pupal parasitoid *B. femorata* was considered to be one of the most abundant parasitoids causing the highest extent of 18.5% parasitism on *P. rapae* pupae. They considered their finding as to the first report on *P. rapae* parasitism in India.

In a comparison between cruciferous host plants, Awadalla et al. [4] reported that cabbage plants harbored the highest average percentage of *P. puparum* during 2011/12 and

2012/13 seasons and represented by 30.8 and 31.5% followed by cauliflower plants 24.4 and 26.6% while, canola plants recorded the last category and represented by 19.6% and 14.7%, respectively. Five primary parasitoids vs. (*Trichogramma buesi Voegel*; *Hyposoter* sp.; *Cotesia glomerata* (L); *Pteromalus puparum* and *Brachymeria femorata* (Panzer) were found to associated with developmental stages of *pieries rapea* in field study conducted by El-Fakharany & Hendawy [13].

On the other hand, several investigators proved that *Tetrastichus* species took an important role to manage pupae of some lepidopteran insect pests e.g. Baitha et al. [14] on the spotted stalk borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae); Baitha & Sinha [15] on the gold-fringed rice stem borer *Chilo auricillius* Dudgeon; [16-18] on the sugarcane borer *Diatraea saccharalis* (Fabr.) (Lepidoptera: Crambidae); [19] on *Diatraea* sp. and [20] on the ello sphinx *Erinnyis ello* (Linnaeus) (Lepidoptera: Sphingidae).

These parasitoid species could be efficient in the IPM field. In this approach, [21] results revealed that, *Tetrastichus howardi* parasitized on the larvae, pupae and adults of the sugarcane borer *D. saccharalis*, and therefore seems to be a suitable candidate for the biological control of this insect pest in commercial sugarcane. Parasitism and the emergence of *T. howardi* from the fifth instar larvae, pupae and adults of *D. saccharalis* revealed the ability of this natural enemy to establish itself in culture, even in the absence of host pupae.

5. Conclusion

Results showed that no egg parasitoid species were recorded, but for larvae, one solitary parasitoid species, *H. ebeninus* and one hyperparasitoid species *B. galactopus* was recorded as an internal gregarious hyperparasitoid of *H. ebeninus*. Regarding the pupae parasitoids, one solitary *B. femorata* and two gregarious parasitoid species *P. puparum* and *Tetrastichus* sp. were recorded. These results are important and could be used for the control of the pest in IPM programs in the future.

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