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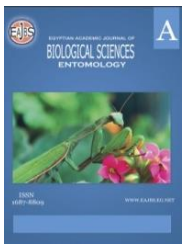

Species Composition of Phytophagous, Entomophagous Insects and Prevalent Aphid Fungi Species Inhabiting Cabbage Plantations

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ABSTRACT

The main goal of this study is to determine the species composition of the major cruciferous insect pests (phytophagous and entomophagous insects) inhabiting cabbage plantations in Assiut, Northern Upper Egypt during the 2017-2018 and 2018-2019 growing seasons. The abundance of the prevalent fungi species associated with the cabbage aphid *Brevicoryne brassicae* L. was calculated. In this study, yellow sticky traps and direct observation sampling methods were used. Twenty arthropod species, belonging to fifteen families and six orders were recorded. Eleven species were captured by the yellow sticky traps, while five only were collected by the direct observation method. Four species were collected by both methods. Ten species appeared as phytophagous species (three could be predacious in part). Four predatory, five parasitic and one hyperparasitoid species were recorded. *Thrips tabaci*¸ *Bemicia tabaci*, *Empoasca* sp. and *Aphis craccivora* were found to be the highest dominant species inhabiting cabbage plantations during both years of study. Predatory species were found to be equal to14.10% and 14.86% of the total arthropod insect species inhabiting cabbage plantations during 2017-2018 and 2018-2019 seasons, respectively. Seventeen fungi species belonging to two divisions, five classes, six orders and eight families, were found to be associated with the cabbage aphid (*B. brassicae*). This study was conducted to shed a light on insect pests and the natural enemies occurring in cabbage. Also, it can be used as a good informative background on the cabbage insect's fauna. More studies are needed for clarifying and improving the roles of those naturally occurring entomophagous species.

INTRODUCTION

Cabbage (*Brassica oleracea* var.*Capitata*) is a member of the Brassica family. It is considered an important source of nutrients. This vegetable crop is rich in necessary minerals and vitamins (Mochiah *et al*., 2011; Sharma and Rao, 2012). Cabbage plantations are subjected to be attacked by serious insect pests causing significant economic damage losses e.g. the aphid *Brevicoryne brassicae* (Linnaeus) (Homoptera: Aphididae) and the

small white butterfly, *Pieris rapae* (Linnaeus) (Lepidoptera: Pieridae) (Embaby and Lotfy 2015b). Aphids damaged cabbage both directly and indirectly. Plants are directly impacted by the feeding habits of adults and nymphs, while indirect consequences occur as a result of honeydew secretion, disease transmission and contamination of the harvested crop (Liu and Sparks, 2001). The small white butterfly, *P. rapae* occurs in temperate regions around the world. It feeds on foliage, and mature plants will be reduced to just stems and large veins if left unmonitored. Larvae fecal materials also, contaminate and stain the yield. The feeding habits of *P. rapae* larvae generate ragged holes in the leaves of the host plant. When the attack is severe, only the veins remain, resulting in huge commercial losses for growers. Less severely afflicted plants become stunted and dirty with dark green pellets (Capinera, 2014). In general, Insects and pests attack host plants, to complete their life cycle they damage and use every part of the plant and ultimately cause high economic loss to the farmers.

Scarce information has been obtained about the natural fauna presented on cabbage fields. Therefore, this investigation was initiated to introduce a beam of light about the species composition of the flight and non-mobile arthropod pests inhabiting cabbage fields. Also, fungi species associated with the cabbage aphid *B. brassicae* were taken into consideration.

MATERIALS AND METHODS

Experiments were carried out at the experimental farm of the Faculty of Agriculture, Assiut University during the 2017-2018 and 2018-2019 cabbage growing seasons at (Ca.1050 m2). Direct observation and yellow sticky traps were used to covering the following points:

1- Species Composition of Phytophagous and Entomophagous Species:

Flying and hovering insect pests around cabbage plantations were collected weekly by using yellow sticky traps. However, non-mobile stages of cabbage insect pests were observed by direct observation on cabbage leaves during both seasons. The captured insects were identified by specialists in Taxonomy Department and Biological Control Research Department, Plant Protection Research Institute, ARS, Egypt.

2-Dominance and Abundance of The Prevalent Phytophagous and Predatory Species:

Dominance and abundance percentages of the prevalent arthropods inhabiting cabbage plantations were estimated using yellow sticky traps (El-Wakeil and Volkmar, 2013). Yellow sticky traps (10 × 22 cm) were hanged on a 100 cm height stand to determine the dominance and abundance of the flight stages during the 2017-2018 and 2018-2019 seasons in Assiut region. The direct observation on sites was conducted using naked eyes. No regular samples were collected. Both methods were done at 47 days post-transplantation until harvesting.

To determine dominance and abundance percentages of the collected species, an equation was used as follows Facylate (1971):

D = Dominance percentage

$D = t / T \times 100,$

Where

t= Total number of each species during the collecting period.

T= Total number of all species collected during the collecting period.

A = Abundance percentage

$$A = \frac{n}{N} \times 100,$$

Where

n = Total number of samples in which each species appeared.

N = Total number of samples taken all over the season.

3- Abundance of the Prevalent Fungi Associated with Cabbage Aphid:

Individuals of cabbage aphid *Brevicoryne brassicae* L. were incubated in a moist chamber for 24 hrs by using a camel hair brush onto an agar plate. Sabouraud dextrose agar medium (SDAY) of the following components (gm/L): glucose or maltose 40 gm; peptone, 10 gm; yeast extract, 10 gm; and tween 80, 1 ml; and agar, 15 gm was employed for the isolation and counting of fungi as described by (Moubasher, et al., 2010). Fungus identification was based on external symptoms and the morphology of spores and sporulating structures according to (Humber, 1989) and checked in Assiut University Mycological Center (AUMC). Identified fungi were considered to be the cause of the death. The abundance percentages of the collected species were estimated by equation Facylate (1971).

RESULTS AND DISCUSSION

1- Species Composition of Phytophagous and Entomophagous Species:

Twenty arthropod species, belonging to fifteen families and six orders, were presented in cabbage plantations in Assiut, Upper Egypt (Table 1). Eleven species were captured by the yellow sticky traps, while five only were collected by the direct observation method. Four species were collected by both methods. Ten species are categorized as phytophagous species (three could be predacious in part). Four predatory, five parasitic and one hyperparasitoid species were recorded. Two species were high frequent (HF), however, frequent (F) and the rare (R) species were presented by eight and eleven species, respectively. The highest frequent and harmful species inhabiting cabbage plantations were the cabbage aphid *B. brassicae* and the white cabbage butterfly *P. rapae.*

In India, using three different collecting methods, sticky trap, plant sampling and pitfall trap in cabbage plantation; *Lygus lineolaris, Stenolophus comma* and *Coleomegilla maculatalengi* were recorded (Schmaedick and Shelton, 2000). They were the most abundant insects in both collecting years. Climate and the biodiversity in both India and Egypt could be responsible for these differences in species composition.

In Giza, Northern Egypt, specific surveying of the natural enemies associated with cabbage aphids in cabbage, revealed the presence of three braconid parasitoids i.e. *Aphidius colemani* (Viereck), *Diaeretiella rapae* (Mc'Intoch) and *Praon* sp. in addition to two predators *Coccinella undecimpunctata* L. and *Chrysoperla carnea* (Steph) (Abdel-Samad 2010). In agreement with Embaby and Lotfy (2015a) results, two harmful insect pests (under two families and two orders) were found to attack cabbage crops. The pests were the imported cabbageworm, (*P. rapae*) and the cabbage aphid (*B. brassicae*).

2-Dominance and Abundance of The Prevalent Phytophagous and Predatory Species:

Dominance and abundance percentages were calculated in (Table 2). Results indicated that *Thrips tabaci*¸ *Bemicia tabaci, Empoasca* sp. and *Aphis craccivora* collected by the yellow sticky traps were found to be the highest dominant species inhabiting cabbage plantations during both years of the study with an average of 14.06, 29.72, 32.48, 23.55% during the 2017-2018 and 13.15, 27.33, 28.87, 30.16% during 2018-2019, respectively. The aforementioned species were recorded in high abundance percentages during both years of the study. During this investigation, no data and scarce information were obtained about the dominance and abundance of the non-mobile stages of cabbage insect pests. Predatory species were found to be equal to 14.10 and 14.86% of the total arthropod insect species inhabiting cabbage plantations during the 2017-2018 and 2018-2019 seasons, respectively. The most common insect pests infesting cabbage plants recorded during this

work was previously recorded by Embaby and Lotfy (2015a) on cabbage fields with (17.9 %) for *P. rapae* and (7.59 %) for cabbage aphid *B. brassicae.* In the light of these data, it can be stated that species with the most collected specimens may have dense populations, and species with fewer collected specimens may have sparse populations in nature. The seasonal abundance of the white butterfly *P. rapae* on several local and imported cabbage cultivars was evaluated in the same area of study by Abdel-Galil *et al.*, (2021). This finding was dependent on the fact that arthropods are often captured by traps to assess the functional biodiversity of the targeted taxa.

Table 1: Species composition of arthropods collected from and around cabbage plantations by using yellow sticky traps and direct observation during 2017-2018 and 2018-2019 growing seasons at Assiut.

Taxon: Order; family & Scientific name	Status & Frequency	Sampling method
Thysanoptera		
Thripidae (Cotton/Onion thrips) *Thrips tabaci* Lindeman, 1889	Phytophagous (F)	Yellow sticky traps
Hemiptera-Heteroptera		
Anthocoridae (Minute pirate bugs) *Orius* spp. (Say, 1832)	Predator (R)	Yellow sticky traps
Miridae (Plant bugs or leaf bugs) *Campylomma unicolor* Poppius, 1914) *Creontiades pallidus* (Rambur,1839) *Nesidiocoris tenuis* (Reuter, 1895)	Phytophagous (R) (Predator in part) Phytophagous (R) (Predator in part) Phytophagous (R) (Predator in part)	Yellow sticky traps Yellow sticky traps Yellow sticky traps
Homoptera		
Aleyrodidae (Whiteflies) *Bemicia tabaci* (Gennadius, 1889)	Phytophagous (F)	Yellow sticky traps
Cicadellidae (Leaf hoppers) *Empoasca* spp. Walsh, 1862	Phytophagous (F)	Yellow sticky traps
Aphididae (Aphids) *Aphis crassivora* Koch,1854 *Brevicoryne brassicae* (Linnaeus,1758)	Phytophagous (F) Phytophagous (HF)	Yellow sticky traps Direct observation and Yellow sticky traps
Coleoptera		
Staphylinidae (Horseshoe crab beetles) *Paederus alfierii* Fabricius, 1775	Predator (R)	Yellow sticky traps
Coccinellidae (ladybird beetles) *Scymnus interruptus* (Goeze,1777) *Stethorus punctillum* (Weise,1891)	Predator (R) Predator (R)	Yellow sticky traps Yellow sticky traps
Lepidoptera		
Plutellidae (Diamondback moths) *Plutella xylostella* (Linnaeus, 1758)	Phytophagous (R)	Direct observation and Yellow sticky traps
Pieridae (White butterflies) *Pieris rapae* (Linnaeus, 1758)	Phytophagous (F)	Direct observation and yellow sticky traps
Hymenoptera		
Ichneumonidae (Parasitoid wasps) *Hyposoter ebeninus* (Gravenhorst, 1829)	Parasitoid (F)	Direct observation
Pteromalidae (Parasitoid wasps) *Pteromalus puparum* (Linnaeus, 1758)	Parasitoid (F)	Direct observation
Chalcididae (Parasitoid wasps) *Brachymeria femorata* (Panzer, 1801)	Parasitoid (F)	Direct observation
Braconidae, Aphidiinae (Parasitoid wasps) *Diaeretiella rapae* (McIntoch,1855)	Parasitoid (HF)	Direct observation and yellow sticky traps
Eulophidae (Parasitoid wasps) *Tetrastichus* sp. (Haliday, 1844) *Baryscapus galactopus* (Ratzeburg, 1844)	Parasitoid (R) Hyperparasitoid (R) On: *H. ebeninus*	Direct observation Direct observation

(F) =Frequent (HF) = High Frequent (R) =Rare

Table 2: Dominance and abundance percentages of the major insect pests and their associated natural enemies inhabiting and hovering around cabbage plantations by using yellow sticky traps* at Assiut during 2017-2018 and 2018-2019 growing seasons.

Taxon	2017-2018				2018-2019			
	Total numbers	Dominance %	Presence	Abundance %	Total numbers	Dominance %	Presence	Abundance %
Phytophagous species								
Thrips tabaci	740	14.06	10	63	510	13.15	10	63
Bemicia tabaci	1565	29.72	16	100	1060	27.33	16	100
Empoasca spp.	1710	32.48	15	94	1120	28.87	15	94
Aphis crassivora	1240	23.55	11	69	1170	30.16	11	69
Pieris rapae	10	0.19	5	31	19	0.49	7	44
Total	5265	85.90	-----	-----	3879	85.14	-----	-----
Predatory species								
Campylomma unicolor	770	89.12	9	56	625	92.32	9	56
Creontiades pallidus	37	4.28	8	50	5	0.74	5	31
Coccinella undecimpunctata	57	6.60	14	88	47	6.94	11	69
Total	864	14.10	-----	-----	677	14.86	-----	-----
Grand total	6129	-----	-----	-----	4556	-----	-----	-----

(*) 16 samples

3- Abundance of the Prevalent Fungi Associated with Cabbage Aphid:

A partial taxonomic list of fungi species associated with cabbage aphid *B. brassicae* inhabiting cabbage plantations during 2017-2018 growing season at Assiut, was presented in (Table 3). Data revealed that seventeen fungi species belonging to two divisions, five classes, six orders and eight families were found. The isolated fungi species are divided into three groups. The first group contained the highly abundant species i.e. *Acremoni umhyalinulum* which revealed 33.33% abundance. The second group contained less abundant species with an average of 10.26% for both *Cladosporium aphidius* and *Cladosporium cladosporiodes* and 7.69% for both *Cladosporium sphaerospermum* and *Fusarium semitectum.* The remaining fungi species were presented by 2.56% abundance/each and constituted the 3rd group. Nine fungi species were recorded as plant pathogens. However, three species were recorded as saprophytic. The remaining fungi species revealed variable behavior.

Entomopathogenic species were hoped but not found. However, most of the fungi collected were either plant pathogens or saprophytic. Representatives of the genera *Aspergillus* and *Fusarium*, on the other hand, can be attributed conditionally to saprotrophic fungi that normally develop on dead insects. Although the fungi *Aspergillus* and *Fusarium* have been shown to be particularly deadly for insects in some situations, it is now known that the fungi in question primarily develop on insects that died due to mechanical injury to the cuticle (Embay and Lotfy, 2016). In a different study by Embaby and Lotfy, (2016), *Metarhizium anisopliae* was the naturally occurring entomopathogenic fungi isolated from adult cabbage aphid collected from cabbage field in Qalubia, Egypt. Also, they found the genera *Aspergillus*, *Mucor*, and *Rhizopus*.

Effect of conidial concentration of entomopathogenic fungi (e.g. *Beauveria bassiana; Verticillium lecanii*; *Paecilomy cesfumosoroseus* and *Metarhizium anisopliae*) on mortality of cabbage aphid, *B. brassicae* was previously studied in Pakistan Asi *et al*., (2009), in Egypt Embaby and Lotfy (2015a) and in Saudi Arabia (Al-Keridis 2016).

Natural insect pest population regulation is efficiently accomplished by broad disease-causing pathogenic fungi, which have the potential to be the most adaptable biological control agents due to their vast host range in various insects. Insect pathogenic fungi are effective at reducing the prevalence of specific populations of soil pests with varying modes of action and severity. Fungi have evolved methods for adhesion and

recognition of host surface cues, which aid indirect adaptive response, such as the generation of hydrolytic, assimilatory, and detoxifying enzymes, as well as other metabolites that aid in insect pest infection. Some fungi, such as Aspergilli, may alter their activity reviewed by (Pfliegler *et al.*, 2020). In conclusion, the data presented here provide an overview of the most common major and economically important insect pests and their associated natural enemies of cabbage. These will undoubtedly contribute to the formulation of an integrated pest management strategy for significant commercial crops.

Table 3: A partial taxonomic list of fungi species associated with cabbage aphid *Bevicoryne brassicae* on cabbage plantations during 2017-2018 growing season at Assiut.

Division, Class, Order & Family	Scientific name	Presence©	Abundance%	Status
Division: Ascomycota Class: Sordariomycetes Order: Hypocreales Family: Hypocreaceae	*Acremonium hyalinulum* Link (1809)	13	33.33	Plant Pathogen
	Acremonium rutilum Link (1809)	1	2.56	Saprophytic (Opportunistic pathogens of man and animals)
	Acremonium strictum W. Gams (1971)	1	2.56	Saprophytic
Division: Ascomycota Class: Eurotiomycetes Order: Eurotiales Family:Trichocomaceae	*Aspergillus fumigatus* Fresenius 1863	1	2.56	Saprophytic (Plays an essential role in carbon and nitrogen recycling)
Division: Ascomycota Class: Dothideomycetes Order: Capnodiales Family: Davidiellaceae	*Cladosporium aphidius*	4	10.26	Plant Pathogen
	Cladosporium cladosporioides (Fresen.) G.A. de Vries, (1952)	4	10.26	Plant Pathogen (Rarely causes invasive disease in animals)
	Cladosporium herbarum (Pers.) Link (1816)	1	2.56	Found worldwide in organic and inorganic matter (It is an important exacerbant of asthma and hay fever)
	Cladosporium sphaerospermum Penz. (1882)	3	7.69	from the decaying leaves and branches of Citrus
Division: Ascomycota Class: Dothideomycetes Order: Pleosporales Family: Didymellaceae	*Epicoccum nigrum* Link	1	2.56	Plant Pathogen (Can be used as antifungal agents against other pathogenic fungi)
Division: Ascomycota Class: Sordariomycetes Order: Hypocreales Family: Nectriaceae	*Fusarium scirpi*	1	2.56	Plant Pathogen
	Fusarium semitectum Berk. & Ravenel, (1875)	3	7.69	Plant Pathogen
Division, Class, Order & Family	Scientific name	Presence©	Abundance%	Status
Division: Zygomycota Class: Zygomycetes Order: Mucorales Family: Mucoraceae	*Mucor hiemalis* Wehmer, (1903)	1	2.56	----------
Division: Ascomycota Class: Eurotiomycetes Order: Eurotiales Family: Trichocomaceae	*Penicillium* sp. Link (1809)	1	2.56	Used as an antibiotic, which kills or stops the growth of certain kinds of bacteria (Others are used in cheese aking)
Division: Ascomycota Class: Leotiomycetes Order: Helotiales Family: Incertaesedis	*Scytalidium dimidiatum* Pesante	1	2.56	Causes onychomycosis in tea leaf pluckers
Division: Ascomycota Class: Sordariomycetes Order: Hypocreales Family: Incertaesedis	*Verticillium dhaliae* Kleb., (1913)	1	2.56	Plant Pathogen (It may cause death in some plants)
	Verticillium nubilum	1	2.56	Plant Pathogen
	Verticillium nigrescens	1	2.56	Plant Pathogen

© based on 39 samples

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ARABIC SUMMARY

التركيب النوعي للحشرات آكلة النباتات و آكلة الحشرات و أنواع الفطريات المصاحبة لحشرة المن التي تقطن زراعات الكرنب

فاروق عبد القوى عبدالجليل[1] ، محمد عبد الرحمن عمرو[2] ، مرفت أحمد بدوي محمود[3]
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الهدف الرئيسي من هذا البحث هو تحديد التكوين النوعى للحشرات آكلة النباتات و آكلة الحشرات التي تقطن نباتات الكرنب في أسيوط -شمال الصعيد- بمصر خلال مواسم النمو 2017- 2018 و 2018- 2019. كذلك تم حساب درجات السيادة للفطريات المصاحبة لحشرة من الكرنب .L. *Brevicoryne brassicae* و ذلك بأستخدام طريقتي المصائد الصفراء اللاصقة والملاحظة المباشرة. أظهرت الدراسة وجود عشرين نوعًا من مفصليات الأرجل تنتمي إلى خمسة عشر عائلة وستة رتب. ولقد جمع أحد عشر نوعًا بواسطة المصائد الصفراء اللاصقة ، بينما تم ملاحظة خمسة أنواع فقط بطريقة الملاحظة المباشرة. تم تعريف أربعة أنواع بكلتا الطريقتين. ظهرت عشرة أنواع من الحشرات آكلة النباتات (ثلاثة يمكن أن تكون مفترسة جزئيًا). وكذا تسجيل أربعة أنواع مفترسة وخمسة طفيلات ونوع واحد مفرط التطفل. أيضا سجلت الأنواع الأتيه:

Thrips tabaci, Bemicia tabaci , Empoasca sp. and *Aphis craccivora*

لتكون أعلى الأنواع السائدة التي تعيش في .زراعات الكرنب خلال عامي الدراسة. وأظهرت النتائج أن الأنواع المفترسة تساوي 14.10% و 86.14٪ من مجموع أنواع الحشرات من مفصليات الأرجل التي تعيش في زراعات الكرنب خلال موسمي 2017-2018 و 2018-2019 على التوالي. أمكن عزل علىى سبعة عشر نوعًا من الفطريات المصاحبة لحشرة من الكرنب *Brevicoryne brassicae* والتي تنتمي إلى قسمين وخمس فصائل وستة رتب و ثماني عائلات. ولقد أجريت هذه الدراسة" لإلقاء الضوء على الآفات الحشرية والأعداء الحيوية المصاحبة لها علي زراعات الكرنب والاعداء الحيوية الموجودة في الكرنب. كما أن هذه الدراسة يمكن أعتبارها قاعدة معلومات هامة عن المجاميع الحشرية التي تتواجد علي الكرنب. هناك حاجة إلى مزيد من الدراسات لتوضيح وتحسين أدوار الحشرات آكلة الحشرات التي تتواجد بشكل طبيعي.