

REVIEW ARTICLE

Cereal Aphids and their Biological Control Agents in Egypt

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Gramineae (grass family) is one of the largest plant families. All cereal species belong to this family. Cereal species include pests or weeds and also economic plants (wheat, barley, corn, sorghum, oat and ray).

The weeds that belong to family Gramineae harbored the highest number of aphid species among the weed families (Megahed, 2000). Aphids are one of the insect groups whose economic importance increases with the development of agriculture (Stary, 1976). All species of aphids nearly reproduce parthenogenetically (Dixon, 1998). Aphids damage the plants roughly through; loss of sap by sucking, reaction of plant tissues stimulated by aphid's saliva, excreting viscous honeydew on them sooty-molds usually develop and finally transmission of viral diseases to plants.

Cereal aphids are the serious pests attacking cereal crops, particularly wheat, barley and maize (El-Hariry, 1979 and El-Heneidy, 1994). Damages to wheat caused by aphids were estimated by up to 23%, particularly in Upper Egypt, where highest infestation mostly occurs (Tantawi, 1985). Some of the cereal aphids are efficient vectors of different strains (types) of Barley yellow dwarf virus (BYDV). The first reported of this virus in Egypt was in 1962 by (Slykhuis, 1962) to be scattered in the delta area near Cairo. The wild plants, *Bromus catharticus* Vahl, *Hordeum murinum*, and *Panicum* sp. were found to be natural BYDV hosts (Elnagar *et al.*, 1980); the virus was identified as economically important in some parts of Egypt (ICARDA, 1995).

Survey of Cereal Aphid Species on Main Cereal Crops and Weeds in Egypt

Aphid species belong to Order: Homoptera and Family: Aphididae. The survey (available literatures) revealed the record of 11 aphid species; *Rhopalosiphum padi*, *Schizaphis graminum*, *Rhopalosiphum maidis*, *Sitobion (Macrosiphum) avenae*, *Diuraphis noxia*, *Metopolophium dirhodum*, *Anoecia corni*, *Geoica phaseoli*, *G. spatulata*, *Tetranurraegyptiae* and *Rhopalosiphum rufiabdominalis* as major cereal aphid species surveyed on cereal and weed plants in Egypt. Egypt, as a country, can be divided to four different agro-ecosystem regions; Delta (Lower Egypt) (Kafr El-Sheikh, Dakhalia, Behera, Gharbia, Menoufia, Sharkia and Qalubia Governorates), Middle-Egypt (Giza, Fayoum and Beni-Suef Governorates), Upper-Egypt (Menia, Assuit, Sohag and New Valley Governorates) and Sinai (North Sinai Governorate).

1. Bird Cherry-Oat Aphid, *Rhopalosiphum padi* (Linnaeus, 1758)

The first record of *R. padi* in Egypt was on the **cereal weed plants**, *Panicum colonum* and *Phalaris* sp. (Hassan, 1958). It was recorded also on other different cereal weed plants in Giza Governorate (Middle Egypt) by many authors (Megahed *et al.*, 1978, Elnagar *et al.*, 1978, Amin, 1979, Abdel-Wahab, 1998 and El-Fatih, 2006) and in Zagazig Governorate (Delta) by Megahed, 2000 on the weed plants; *Polypogon monspeliensis*, *Setaria* spp., *Avena fatua*, *Cynodon dactylon*, *Panicum coloratum* (first record), *Poa annua*, *Cyperus* spp. (first record), *Anagallis arvensis* (first record), *Coronopus squamatus* (first record), *Lolium perenne*, *Bromus catharticus*, *Ammi majus* (first record) and *Diplachne malabarica*, in Kafer El-Sheikh (Delta) on the three weed plants; *Phalaris paradoxa*, *Brassica nigra* and *Malva praviflora* by Huda, 2006 and in North Sinai Governorate on beard grass and wild oats (Ahmed *et al.*, 2007).

The first record of *R. padi* on **wheat** plants in Egypt was in Cairo (Habib and El-Kady, 1961). Then, it was recorded in different sites in Egypt by (Tantawi *et al.*, 1986), Sharkia (El-Heneidy, 1994, Megahed, 2000, El-Heneidy and Abdel-Samad, 2001), Qalubia (Al-Ansary, 1993, Hafez, 1994), Menofia and Garbia (Abd-El Wahed, 2003), Giza (Ibrahim, 1990 a, El-Fatih, 2000), Fayoum (El-Heneidy and Attia, 1988/89), Beni-Suef (El-Heneidy and Attia, 1988/89, Mohamed, 1992, El-Heneidy, 1994, El-Lathy, 1999, El-Fatih, 2000, El-Heneidy and Abdel-Samad, 2001), Minia (Mohamed, 1992), Assiut (El-Heneidy, 1991, Mohamed, 1992, Slman, 1993 & 1997, Abdel-Rahman, 1997), Sohag (El-Heneidy, 1991, El-Heneidy, 1994, Mohamed, 1992, El-Heneidy and Abdel-Samad, 2001, AbdEl-Awal, 2005), New Valley (Mannaa, 2000), Sinia (Abd El-Salam, 1999) and North Sinai (Rafah and El-Arish) (Ahmed *et al.*, 2007).

R. padi was recorded also on **barley** plants in Giza (El-Fatih, 2006), Fayoum (Tantawi *et al.*,1986), Middle Egypt (El-Hariry, 1979), Beni-Suef (Tantawi *et al.*,1986, Mohamed, 1992), Assiut (Mohamed, 1992), Sohag (Mohamed, 1992, Slman & Ahmed, 2005), Ismailia (Noaman *et al.*, 1992), Marsa Mattrouh (El-Sayed *et al.*, 1995), Sinai (Abd El-Salam, 1999) and North Sinai (Rafah and El-Arish) (Ahmed *et al.*,2007).

It was recorded also on **maize** plants in Qalubia Governorate (Yossef, 1990), Giza (El-Heneidy and Abbas, 1984), Darwish,1989), Sinai (Abd El-Salam, 1999) and North Sinai (Rafah and El-Arish) (Ahmed *et al.*, 2007).

2. Green Bug, *Schizaphis graminum* (Rondani, 1852)

The first record of *S. graminum* in Egypt was on **cereal weed plants**, (Willcocks, 1922). Afterwards, it was recorded on other cereal weeds in Giza (Megahed *et al.*, 1978, Elnagar *et al.*, 1978, Amin, 1979, Abdel-Wahab, 1998 and El-Fatih, 2006), in Zagazig by Mohamed,1984 and on the weed plants; *Bromus catharticus* and *Lolium perenne* by Megahed, 2000 and in Kafer El-Sheikh on the three weeds plants; *P. paradoxa*, *B. nigra* and *M. praviiflora* by Huda, 2006.

S. graminum was recorded on **wheat** plants by El-Hariry, 1979, then in different sites in Egypt by (Tantawi *et al.*,1986) who reported this species as the most predominant in upper Egypt, in Sharkia (El-Heneidy, 1994, Megahed, 2000, El-Heneidy and Abdel-Samad, 2001), Qalubia (Al-Ansary, 1993 and Hafez, 1994), Menofia and Garbia (Abd-El Wahed, 2003), Giza (El-Fatih, 2000), Fayoum(El-Heneidy and Attia,1988/89), Beni-Suef (El-Heneidy and Attia,1988/89, El-Heneidy, 1994, El-Fatih, 2000, El-Heneidy and Abdel-Samad, 2001), Assiut (El-Heneidy, 1991), Upper Egypt (Slman, 1997), Sohag (El-Heneidy, 1991, Mohamed, 1992, El-Heneidy, 1994, El-Heneidy and Abdel-Samad, 2001, AbdEl-Awal, 2005), New Valley (Mannaa, 2000) and North Sinai (Rafah, Elsheikh Zewaid, El-Arish and Ber El-Abed) (Ahmed *et al.*, 2007).

It was also recorded on **barley** plants by Abd El-Salam, 1999 in Sinai, El-Sayed *et al.*, 1995, El-Fatih, 2006 in Giza and North Sinai (Rafah, Elsheikh Zewaid, El-Arish and Ber El-Abed) (Ahmed *et al.*, 2007).

3. Corn Leaf Aphid, *Rhopalosiphum maidis* (Fitch, 1856)

The first record of *R. maidis* in Egypt was on the **cereal weedplants**, *Andropogon halepensis* (Willcocks, 1922). Afterwards, it was recorded on cereal weeds in Kharga and Dakhla Oases (Hassan, 1957), in Giza (Megahed *et al.*, 1978, Elnagar *et al.*, 1978, Amin, 1979, Abdel-Wahab, 1998 and 2004, and El-Fatih, 2006), Zagazig (Mohamed,1984, Abd Alla, 1985 and Megahed, 2000) on the weed plants; *Panicum coloratum* (first record), *Echinochloa colonum*, *Cynodon dactylon*, *Setaria* spp., *Echinocloa crus – galli*, *Arundo donax*, *Avena fatua*, *Bromus catharticus*.

R. maidis was recorded also on **wheat** plants at both of Kharga and Dakhla Oases (Hassan, 1957), in different sites in Egypt by (Tantawi *et al.*,1986), Sharkia (El-Heneidy, 1994, Megahed, 2000, El-Heneidy and Abdel-Samad, 2001), Menofia and Garbia (Abd-El Wahed, 2003), Giza (Ibrahim, 1990a and El-Fatih, 2000), Fayoum (El-Heneidy and Attia,1988/89),Beni-Suef (El-Heneidy and Attia,1988/89, Mohamed, 1992, El-Heneidy, 1994, Abd El-Salam, 1999 and El-Lathy, 1999, El-Fatih, 2000, El-Heneidy and Abdel-Samad, 2001), Assiut (El-Heneidy, 1991, Mohamed, 1992, Slman, 1993 and 1997 and Abdel-Rahman, 1997), Sohag (El-Heneidy, 1991,Mohamed, 1992, El-Heneidy, 1994, El-Heneidy and Abdel-Samad, 2001, AbdEl-Awal, 2005), New Valley (Mannaa, 2000) and North Sinai (Rafah, Elsheikh Zewaid and El-Arish) (Ahmed *et al.*,2007).

R. maidis was recorded also on **barley** plants in Middle Egypt (El-Hariry, 1979), Giza (El-Fatih, 2006) and Sohag (Slman and Ahmed, 2005), Sinai (Abd El-Salam,1999), North Sinai (Rafah, Elsheikh Zewaid and El-Arish) (Ahmed *et al.*, 2007), Ismailia (Noaman *et al.*, 1992), both of Nubaria, Borg El-Arab and Marsa Mattrouh (El-Sayed *et al.*, 1995).

It was recorded also on **maize** plants (Willcocks, 1922 and Hall, 1926). Afterwards, it was recorded in Kharga and Dakhla Oases (Hassan, 1957), (Tawfik *et al.*,1974a), Gharbiah (El-Khouly *et al.*, 1994), Zagazig (Megahed, 2000), Qalubia (Yossef, 1990), Giza (El-Heneidy and Abbas,1984, Darwish,1989), Sohag (El-Gapaly,2007) and Sinai (Abd El-Salam, 1999).

4. English Grain Aphid *Sitobion* (*Macrosiphum*) *avenae* (Fabricius, 1775)

The first record of *S. avenae* in Egypt was recorded on **barley** plants by Willcocks, 1922. Afterwards, it was recorded by Hall, 1926, in Giza region by El-Hariry, 1979 and El-Fatih, 2006, in Sinai by Abd El-Salam, 1999 and North Sinai (Rafah, Elsheikh Zewaid, El-Arish and Ber El-Abed) (Ahmed *et al.*,2007).

S. avenae was recorded also on different **cereal weed plants** in Giza Governorate by many authors (Hall, 1926, Megahed *et al.*, 1978, Elnagar *et al.*, 1978, Amin, 1979, El-Heneidy, 1991 and El-Fatih, 2006) and in Zagazig, by Mohamed, 1984 and Megahed, 2000 and in Kafer El-Sheikh on three weeds plants; *P. paradoxa*, *B. nigra* and *M. praviiflora* by Huda, 2006.

The first record of *S. avenae* on **wheat** plants was in Cairo (Habib and El-Kady, 1961). Afterwards, it was recorded in different sites in Egypt by (Tantawi *et al.*, 1986), Sharkia (El-Heneidy, 1994, Megahed, 2000, El-Heneidy and Abdel-Samad, 2001), Qalubia (Hafez, 1994), Menofia and Garbia (Abd-El Wahed, 2003), Giza (El-Fatih, 2000), Fayoum (El-Heneidy and Attia, 1988/89), Beni-Suef (El-Heneidy and Attia, 1988/89, Mohamed, 1992, El-Heneidy, 1994, Abd El-Salam, 1999 and El-Lathy, 1999, El-Fatih, 2000, El-Heneidy and Abdel-Samad, 2001), Assiut (Mohamed, 1992, Slman, 1993 & 1997, Abdel-Rahman, 1997), Sohag (Mohamed, 1992, El-Heneidy, 1994, El-Heneidy and Abdel-Samad, 2001, AbdEl-Awal, 2005), and North Sinai (Rafah, Elsheikh Zewaid, El-Arish and Ber El-Abed) (Ahmed *et al.*, 2007).

It was also recorded on **maize** plants in Giza (El-Heneidy and Abbas, 1984), (Darwish, 1989) and Qalubia (Yossef, 1990).

5. Russian Wheat Aphid, *Diuraphis noxia* (Mordvilko, 1914)

The first record of *D. noxia* in **wheat** fields in Egypt was done by (Attia and El-Kady, 1988). Afterwards, it was recorded by many authors on wheat and **barley** plants in Giza (El-Fatih, 2000 and 2006), Fayoum (El-Heneidy and Attia, 1988/89), Beni-Suef (El-Heneidy and Attia, 1988/89, El-Lathy, 1999), Ismailia (Noaman *et al.*, 1992), Sinai (Abd El-Salam, 1999), North Sinai (Rafah, Elsheikh Zewaid and El-Arish) (Ahmed *et al.*, 2007). Also, it was recorded on the **cereal weed plants**; *Avena fatua* and *Bromus catharticus* by El-Fatih, 2006.

6. Rose-grass / Rose-grain Aphid, *Metopolophium dirhodum* (Walker, 1849)

M. dirhodum was recorded first time in Egypt on **wheat** plants in Beni-Suef Governorate (El-Lathy, 1999), Giza and Beni-Suef (El-Fatih, 2000), and on **barley** and different **cereal weed plants** in Giza Governorate (El-Fatih, 2006).

7. Dog Wood Aphid, *Anoecia corni* (Fabricius)

The first record of *A. corni* in Egypt was by Theobald, 1922 on the **cereal weed species** *Cyperus longus*. It was recorded also on different cereal weed plants in Giza (Elnagar *et al.*, 1978 and Amin, 1979) and on *Avena fatua* and *Bromus catharticus* in Zagazig by (Megahed, 2000). *A. corni* was recorded on **wheat** plants by Habib and El-Kady, 1961 in Cairo, El-Fatih, 2000 in Giza and Megahed, 2000 in Zagazig.

8. *Geoica phaseoli* (Passerini)

This aphid species was recorded for the first time in Egypt by (Willcocks, 1922) and then by (Hall, 1926) on **barley** plants. It was recorded on **weed** plants Sedge and *Portulaca* sp. by Habib and El-Kady, 1961.

9. *Geoica spatulata* Theobald

This aphid species was recorded for the first time in Egypt by Willcocks, 1922) and then by (Hall, 1926) in **barley** plant field.

10. Root Aphid, *Tetranrura aegyptiaca* (Theobald)

This aphid species was recorded for the first time in Egypt on **weed plant** *Panicum* sp. by Habib and El-Kady, 1961. Afterwards, it was recorded on different weed plants in Giza by (El-Fatih, 2000). It was also recorded on **barley** fields in Giza by El-Fatih (2000).

11. Rice Root Aphid, *Rhopalosiphum rufiabdominalis* (Sasaki)

This aphid species was recorded for the first time in Egypt by (Theobald, 1915) on **barley** in Giza. It was also recorded on the **weed plant** *Arundo* sp. by Hall, 1926 and on *Cynodon dactylon* in Giza by Hassan, 1958.

Survey of Aphid Species Infest Cereal Weed Plants in Egypt

Available literatures revealed the record of 12 aphid species; *Asiphonella dactylonii*, *Hyalapterus pruni*, *Melanaphis phyllostachia*, *Pemphigus napaesus*, *Saltusaphis scirpus*, *Schizaphis minuta*, *Schizaphis rotundiventris*, *Sipha (Rungia) maydis*, *Smynthuroides betae*, *Tetraneura africana*, *Tetranruracynodontis* and *Tetranrurahirsuta* as aphid species that infest only cereal weed plants in Egypt.

1. *Asiphonella dactylonii* Theobald

First record of *A. Dactylonii* in Egypt was on the **cereal weed plant**, *Cynodon dactylon* in Delta and Middle Egypt by (Hassan, 1958).

2. Mealy Plum Aphid, *Hyalapterus pruni* (Geoffroy, 1762)

H. pruni was recorded for the first time in Egypt by Willcocks, 1916 on two **weed plant** species; *Arundo donax* and *Phragmites communis* and then it was recorded by Elnagar *et al.*, 1978 and Amin, 1979 in Middle Egypt and by Megahed, 2000 on *Phragmites communis* in Delta.

3. *Melanaphis phyllostachia* (Soliman)

This aphid species was recorded first time in Egypt by Habib and El-Kady, 1961 on two **weed plant** species; *Phyllostachus mytis* and *Phragmites* sp. in Middle Egypt and then it was recorded in Delta on *Arundo donax* by Megahed, 2000.

4. *Pemphigus napaeus* Buck

First record of the species in Egypt was on the **weed plant**, *Cynodon dactylon* in Middle Egypt by Hassan, 1958.

5. *Saltusaphis scirpus* Theobald, 1915

It was recorded on **weed plant** on Sedge "*Scirpus* sp." by Theobald, 1915 and then on *Cyperus* sp. It was caught on light trap in Middle Egypt by Habib and El-Kady, 1961. Afterwards, it was recorded on *Cyperus* sp. in Delta (Megahed, 2000) and in Middle Egypt on *Cyperus rotundus*, *Cynodon dactylon* and *Echinochloa colonum* by El-Fatih 2006.

6. *Cyperus* Aphid, *Schizaphis minuta* (Van der Goot, 1917)

The species was recorded for the first time in Egypt on **weed plants** by Habib and El-Kady, 1961 using a light trap. There wasn't any record about it until it was observed after 39 years on *Cyperus rotundus* by El-Fatih, 2000 and 2006.

7. Oil Pulm Aphid, *Schizaphis rotundiventrif* Signoret, 1860

The species was recorded for the first time in Egypt by Theobald, 1922, as a new species under the name of *Aphis acori* on the **weed plant** Sedge, *Cyperus longus*. Then, it was recorded by Hall, 1926 under the name of *Toxoptera acori*. After approximately 78 years, it was observed in Middle Egypt on different cereal weed plants by Abdel-Wahab, 2004 and El-Fatih 2006 under the name of *Schizaphis cyperi*. Börner and Heinze (1957) stated that *Schizaphis cyperi* (Van der Goot) (Ainslie) is a junior synonym of *S. rotundiventrif* Börner and Heinze list (Ainslie) after Van der Goot as the describer, evidently synonymized the two species.

8. *Sipha (Rungia) maydis* Passerini, 1860

First record of the species in Egypt was in Middle Egypt on *Aegilops* sp. (El-Hariry, 1991). Then, it was recorded on the cereal weed plants; *Bromus catharticus* Vahl and *Sorghum virgatum* (Hack.) Stapf. (El-Fatih 2000).

9. *Smynthuroides betae* Westwood

This species was recorded on the weed plant, *Cyperus rotundus* in Middle Egypt by Hassan, 1958.

10. *Tetraneura africana* Van der Goot, 1912

This aphid species was recorded for the first time in Egypt on the roots of the **weed plant** species *Cynodon dactylon* by Theobald, 1922. Afterwards, it was recorded in Delta and Middle Egypt (Hassan, 1958, Habib & El-Kady, 1961; Elnagar *et al.* 1978 and Amin, 1979).

11. *Tetranuracynodontis* (Theobald)

It was recorded on the **weed plant** *Cynodon dactylon* in Delta and Middle Egypt by Willcocks, 1925, Hassan, 1958, Habib and El-Kady, 1961, Elnagar *et al.*, 1978 and Amin, 1979.

12. *Tetranurahirsuta* (Baker)

It was recorded on the **weed plants**; *Cynodon dactylon*, *Panicum colonum* and *Setaria viridis* in Middle Egypt by Hassan, 1958 and on *Echinochloa colonum* in Delta by Megahed, 2000.

Description and Identification of Aphididae in Egypt

Habib and El-Kady (1961) constructed a key to the Egyptian Aphididae (80 species) with biometric data and drawing most of the species. This taxonomical study revealed a revolutionary change in the

nomenclature of the Egyptian Aphididae (78 species given by Hall, 1926) and additional records were made by the authors.

Fathi and El Fatih (2009) used morphological characters to make a key to identify apterous viviparous of cereal aphids in Egypt. Helmi, (2011), surveyed, described and illustrated thirteen cereal aphid species represent five subfamilies from different cereal plants in different localities of Egypt. Dichotomous and pictorial keys for apterous viviparous females of these aphid species were included to assist the personnel charged with detection, identification and control of aphids associated with cereals in Egypt. Helmi *et al.* (2011) reported that classical morphological criteria for aphid species identification may be affected by **environmental factors** such as; climatic conditions and physiological status of the host plant. So, they used two modern molecular techniques; Random Amplified Polymorphic DNA (RAPD) and Inter Simple Sequence Repeats (ISSRs) to find diagnostic markers for fingerprinting eleven cereal aphid species, those collected from different cereal plants and from different localities in Egypt. Eight RAPD and five ISSRs primers were successfully produced 97 and 69 markers that could be used to differentiate the eleven different cereal aphid species (*A. corni*, *T. africana*, *R. maidis*, *R. padi*, *S. graminum*, *S. rotundiventris*, *S. minuta*, *S. avenae*, *M. dirhodum*, *H. pruni* and *S. scirpus*). Also, these molecular techniques, with 23 diagnostic morphological characters, were used to find the phylogenetic relationship among the different collected species; that divided into two clusters with similarity matrix percentages of 73 and 82%. From these results, it could conclude that these techniques could be successfully used successively to fingerprint and identify these aphid species and differentiate among them.

Seasonal Abundance of Cereal Aphid Species

On wheat

As reported in the literatures and in the previous survey, the most important and economic cereal aphid species in Egypt are; *R. padi*, *S. graminum*, *R. maidis* and *S. avenae*. Highest population of *R. padi* was recorded on the lower level of wheat plants, while the highest population of *R. maidis* and *S. graminum* was presented on the upper level of the wheat plants. Both *D. noxia* and *S. avenae* were in the upper and middle levels of the plants but in relatively low numbers. *M. dirhodum* was found infested both middle and lower levels of the plant (El-Fatih, 2000).

El-Hariry, (1979) and Abdel-Rahman *et al.* (2000) reported that fluctuations in cereal aphid populations were affected by weather factors. El-Heneidy (1998) stated that relative abundance of different aphid species varied not only from one region to another, but also from one season to another, at the same area, while Ibrahim and Afifi, (1991) and Ali, *et al.* (1997b) suggested that the fluctuations depended on the activity of natural enemies.

The active period of cereal aphids usually starts from the late-tillering growth stage (mostly during January) and continued through the stem elongation, booting, heading and ends during the ripening (mostly during April) (El-Heneidy and Abdel-Samad, 2001). *R. padi* starts its occurrence by late December, *S. graminum* by early January, *R. maidis* by early February and *S. avenae* by early March and all of them usually continue until April (El-Hariry, 1979, Tantawi, 1985, El-Heneidy and Attia, 1988/89, Ibrahim, 1990 a, b El-Heneidy, 1991, 1994, Hafez, 1994, El-Serafy, 1999, Abdel-Rahman *et al.*, 2000, El-Heneidy and Abdel-Samad, 2001, Abd-El Wahed, 2003, AbdEl-Awal, 2005 and Slman, 2006).

On barley

El-Hariry (1979) and Tantawi (1985) mentioned that *R. padi* and *R. maidis* were the dominant aphid species on barley plants in Middle Egypt. Noaman *et al.* (1992) recorded that *R. maidis* was the most abundant aphid species in Northern and North Western coast. Bishara *et al.*, (1997) stated that the weather conditions greatly affected the peak activity of aphids. Marzouk and El-Bawab, (1999) reported that the peak of *R. maidis* occurred at the weather conditions of 10-11°C and 63-73% RH.

Bishara *et al.* (1997) and Slman and Ahmed (2005) stated that *R. maidis* infested barley by late February and early March at Middle and Southern Egypt, respectively. El-Fatih (2006) stated that *R. maidis* was the most abundant aphid species while the other cereal aphid species were found in few numbers over two seasons at Middle Egypt. Highest records of aphids' population were found at the plant age of 70 days.

On maize

The maize aphid, *R. maidis*, the key aphid species on maize, occurs all the year round and its distribution is not limited. It damages a wide range of host plants (mainly maize, sorghum, barley and wheat). It is also a carrier of virus diseases (Hassan, 1957). The infestation with the aphid starts high, on the new tassels and

cobs, then decreases gradually during the plant senescence and followed by migration of aphids to younger plants. Occurrence of *R. maidis* usually starts early in July (at flowering stage), its population increases gradually reaching its peak in August and then decreases to reach its minimum in October (El-Heneidy and Abbas, 1984, Darwish, 1991 and El-Gapaly, 2007). El-Gapaly (2007) observed *R. padi* and *S. graminum* on the corners of different cultivated corn plots but *R. maidis* was the most dominant.

On weeds

In agro-ecosystems, weeds are very important hosts (source) of insects and pathogens as they usually disperse from them to economic crops (Van Emden and Wearing, 1965). Hassan (1957) studied the movement of *R. maidis* throughout the year and noticed that *R. maidis* migrated from the weeds; *Panicum colonum*, *Digitaria* sp., *Cynodon dactylon*, *Setaria* sp. and *Polygonum* sp. to early grown barley by end of December and early January. By mid-January, the aphids migrated to wheat and the infestation remained until March or April. Aphids moved again to gramineous weeds for a short time. *R. maidis* migrated during May and early June to the sorghum and summer maize plantations. During June and July, the weeds grew on the sides of canals such as; *P. colonum* were the most favorite host plants for *R. maidis*. Aphids attacked maize and sorghum at Nile plantations heavily from the end of August until the end of October. The infestation of the Nile maize starts first in the Delta, later in Middle Egypt and ends in Upper Egypt.

Megahed *et al.* (1978) recorded *R. maidis* as the most abundant species on wild plants and associated mainly with the plant species, *Panicum* sp. throughout the year. Three aphid species; *R. padi*, *S. graminum* and *S. avenae* occurred on the wild plants only in March and April. Amin (1979) found that *R. padi* and *S. graminum* occurred on their wild host plants from mid-February to late April. *R. maidis* occurred all the year round on its wild host plants. Tantawi (1985) surveyed a wide range of gramineous weeds attacked by *R. padi* and *R. maidis* and concluded that these weed species may play a major role in the ecosystem for the aphid species. Megahed (2000) reported that the total number of surveyed aphids on weed plants was greatly higher (three folds) than recorded on economic crops.

El-Fatih (2000) mentioned that highest population density of cereal aphids on the cereal weed plant, *S. cyperi* was found by mid-December. *D. noxia* reached the highest population by early May, while *R. padi* occurred by early January. The same author in (2006) recorded highest average number of *S. cyperi* on *E. colonum* and *C. dactylon*, during late December and early January. Highest average numbers of *R. padi*, *R. maidis* and *M. dirhodum* were recorded on *A. fatua*, both *R. maidis* and *M. dirhodum* in early April and *R. padi* in early March. The highest average number of *S. avenae* was recorded on *L. temulentum* by early March. *D. noxia* was recorded on two cereal weed plant species but in remarkably very low numbers. The highest peak was by mid-February. The highest average of *S. graminum* was recorded on *A. fatua*, followed by *C. dactylon*, whereas *B. catharticus* harbored the lowest numbers. The average numbers of *S. minuta* and *S. scirpus* were found by mid-February and early March, respectively.

Biological Studies on Cereal Aphid Species

Biological and life table studies on different cereal aphid species under laboratory conditions were carried out. Only *R. padi* and *S. graminum* are considered here as examples.

R. padi:

Life cycle, longevity and fecundity of *R. padi* on wheat were studied under laboratory conditions by many authors; Mohamed (1992), El-Fatih (2000), Abdel-Rahman, *et al.* (2002), Agamy, *et al.* (2003) and El-Heneidy, *et al.* (2004). They found that the optimum temperature for the development and reproduction of *R. padi* was 24°C. The life table of *R. padi* was studied by El-Fatih (2000), Abdel-Rahman, *et al.* (2002) and El-Heneidy, *et al.* (2004). The intrinsic rate of increase (r_m) ranged (0.241- 0.37) and the net reproductive rate (R_0) ranged (11.77-58.32 at 20-28°C on wheat. Thermal requirement of *R. padi* was studied by Abdel-Rahman, *et al.* (2002), who reported that the thermal requirement needed to develop one generation was about 92032 day-degrees, using 8.89°C and El-Heneidy, *et al.* (2003c) reported that the thermal unit requirements for the time to adult was estimated by 96.15 and 86.2 degree-days for *R. padi* on wheat and barley. Life cycle, longevity and fecundity of *R. padi* on barley were also studied by Agamy, *et al.* (2003) and El-Heneidy, *et al.* (2004). Its life table was studied by El-Heneidy, *et al.* (2004) who estimated the intrinsic rate of increase (r_m) and the net reproductive rate (R_0) as 0.43 and 63.83, respectively.

S. graminum:

Abdel-Rahman (1997), El-Gantiry *et al.* (1999), Agamy, *et al.* (2003) and El-Heneidy, *et al.* (2004) studied the biology of *S. graminum* on wheat at different temperatures. El-Ibrashy *et al.* (1972) showed that the bionomics of *R. maidis* were considerably influenced by the temperature, food-plant and physiological

age of the later. Optimum temperature for rearing was 30°C. At this temperature, nymphal development was accelerated, complete life-cycle lasted half as long as at 15°C, and the number of progeny produced/female was high and nymphal mortality was negligible. Barley was more favorable for development of nymphs than great millet (*Sorghum vulgare*), broad bean (*Vicia faba*) or maize and young plants 3-5 days old appeared to be the best. In the laboratory, 50 generations could be reared in a year, when the aphid was provided continuously with barley seedlings five days old. Abd-El Wahed, (2003) estimated durations of different nymphal instars and life span of *R. padi* on barley under the laboratory conditions (23±1°C and 60±5% R.H.) by 1±0, 1.17±0.38, 1±0, 1.36±0.49 and 23.82 days, respectively. The net reproductive rate R_0 and the intrinsic rate of increase r_m of *R. padi* were 63.83 and 0.43, respectively. Agamy *et al.* (2003) studied the developmental time, longevity and fecundity of *R. padi* and *S. graminum* under the laboratory conditions of 20 ±1°C, 50-70 % R.H. and 16: 8 L: D on barley. Longevity and life cycle of *R. padi* were (12.2 ± 4.85 and 16.2 ± 4.4 days) and for *S. graminum* they were (19.13 ± 4.3 and 24.33 ± 4.4 days), respectively. Fecundity of *R. padi* and *S. graminum* were estimated by (40.33 ± 14.41) and (59.77 ± 13.16), respectively. El-Heneidy *et al.* (2004) studied the life table of *R. padi* and *S. graminum* on barley under laboratory conditions (23±1°C and 60±5% R.H.). The intrinsic rate of increase (r_m) and generation doubling time were 0.43 and 1.61 for *R. padi* and 0.32 and 2.2 for *S. graminum*, respectively. El-Fatih (2006) studied the biological parameters of different cereal aphid species; *R. maidis*, *R. padi*, *M. dirhodum* and *D. noxia* at 15, 20, 25 and 29 °C. Highest fecundity rate was 47.18 progeny/ female for *R. maidis* at 20°C while the lowest was 5.34 progeny/ female for *D. noxia* at 25°C. Longest life span for *M. dirhodum* was 19.1± 2.8 days at 25°C, followed by *R. padi* 15.65 ± 2.47 days. Life table parameters were studied. *R. maidis* recorded the highest value of r_m (0.32), followed by *R. padi* (0.23) and then *M. dirhodum* (0.21). Lowest r_m value (0.09) was recorded for *D. noxia*. The thermal requirement (k) of *R. maidis*, reared on barley seedlings for each nymphal instar, life cycle and generation time, were 15.167, 20.47, 17.05, 25.53, 87.31 and 88.11 degree-days, respectively.

Economic Threshold (ETL) and Economic Injury Levels (EIL) of Cereal Aphids in Egypt

Use of economic threshold as a basis for decision making is a fundamental component in integrated pest management (IPM). Stern *et al.* (1959) proposed the concepts of an economic injury level (EIL) and economic threshold (ETL) as a rational comparison of the economic costs and benefits of pesticide use. EIL is defined as the lowest population density (number) that will cause economic damage, where economic damage is the amount of damage that equals the cost of control (Stern *et al.* 1959 and Pedigo *et al.* 1986). Implicit in the EIL concept is that not all damage is economically significant and that in many instances a certain level of insect injury may be tolerated. It is also useful to maintain a distinction between injury and damage. Injury can be defined as the effect of insect activities on host physiology, damage as the measurable loss of host utility, which is usually measured by reductions in the commodity yield or quality. Consequently, not all injury causes damage, and damage threshold, or boundary, defines the level of injury where damage occurs (Bardner and Fletcher 1974 and Pedigo *et al.* 1986).

The EIL and ETL concepts have been successfully and widely applied to generate management guidelines for insect pests in many cropping systems. Also, aphids have been the subjects of much research on ecological relationships and population management. Many workers have contributed to the understanding of host-aphid relationships, and much has been done towards developing economic action levels for cereal aphids' infestation (Wratten, 1978, Robert *et al.*, 1985, Kurppa, 1989, Hole *et al.*, 1994, Li-Jiping *et al.*, 1995 and Wetzal, 1995). However, in Egypt few studies have concerned with development of EIL and ETL recommendations for cereal aphids in Egyptian wheat fields (Ghanem and El-Adl, 1987, El-Serafy *et al.*, 1997 and Ali *et al.*, 1997a).

El- Heneidy *et al.* (2003b) estimated economic injury (EIL) and threshold (ETL) levels for the key cereal aphid species; *R. padi* and *S. graminum* in different wheat locations in Egypt. Tested parameters were: wheat plant growth stage, density and species of aphids and location. The study was carried out in three wheat locations; Sohag, Beni-Suef and Sharkia Governorates, represented Upper-, Middle-Egypt and the Delta, respectively during the wheat growing seasons 2000/01 and 2001/02. Infested plants were divided into two groups; the first was marked for weekly sampling for aphid numbers and the second was left for yield and yield component determinations. ETLs and EILs values fluctuated significantly according to different seasons, sites, growth stages, and aphid species. Respective highest ETLs and EILs values were estimated at Sohag in the growth stages; stem elongation (6.23 and 10.47) and booting (5.38 and 8.52) and at Sharkia in the heading stage (6.13 and 7.17 aphids/plant). Highest EILs were recorded for *R. padi* during the stem elongation growth stage and decreased in booting and heading stages. An opposite trend was found in ETLs values of the same species. EILs values for *S. graminum* were almost equal in all locations, where they ranged between 5.7 - 5.9 aphids/plant, while ETLs values increased (3.96 - 4.16 - 4.41 aphids/plant) toward

the heading stage. Opposite to the trend of ETLs values in case of *R. padi*, a negative correlation was found between the grain yields and increase of aphids' numbers/plant in all cases. In all growth stages, the impact of the stress of cumulated aphids' infestation (reduction in grain yields) caused by *R. padi* alone was always the lowest, it ranged (21.2 - 75%) compared with (21.3 - 80.8%) by *S. graminum* alone and/or to (22.2 - 84.2%) by the two species together. A recommendation for monitoring cereal aphids' infestation during the stem elongation growth stage (mostly around late January to mid- February) should be considered to take the right decision for the pest control.

Chemical Control and Side Effects

The only control tactic against cereal aphids in cereal field crops available to farmers has been mostly depending upon insecticides. Controlling aphids with insecticides has many risks, including destruction of native natural enemies and accelerated development of insecticide resistance in aphid species. In Egypt, the crop receives an average of 1-2 insecticidal applications during the growing season.

Effect of two mineral oils and five organophosphorous insecticides were tested individually against adults of the cereal aphid *R. padi*. The most effective combination was pirimiphose-methyl/star oil with a factor of synergism 4.54, while the least was dimethoate/star oil (El-Deeb, 1993). Timing and number of the insecticidal application (Malathion 57%) was very important for control aphids' population. One spray in the infested spots early in the season decreased aphid population throughout the season and on the other hand, maintained relatively high population of natural enemies (El-Heneidy, 1994). In Delta, the phenomenon of increasing aphid infestation than before in wheat fields required wide use of insecticides that created more problems through disturbing the natural balance between aphids and their natural enemies, which already exist in many wheat fields of the Delta (El-Heneidy, 1994).

El-Heneidy *et al.* (1991) evaluated the effect of chemical treatments on aphids and their natural enemies in wheat fields during 1990-91 planting season at Sohag Governorate (Upper Egypt). The multiple treatments of insecticides badly affected number of natural enemies. Accordingly, sharp decline in the number of predators (40-48%) and in the percentage of parasitism (66%). The timing of insecticidal application plays a critical role in disturbing the natural balance between aphids and their natural enemies in wheat fields. Early infestation of aphids should be chemically treated only in the infested spots, so less influence on the natural enemies will be occurred. IPM program for aphids control depending on the positive role of predators and parasitoids is always needed to reduce dependence on currently used programs of chemical insecticides.

Biological Control of Cereal Aphids in Egypt

Generally, aphids tend to have three groups of natural enemies; parasitoids, predators, and fungal diseases (Hagen and Van Den Bosch, 1968).

a- Parasitoids

Parasitoid species are mostly specific on a single or certain group of insect hosts. Aphid parasitoids are one of the groups of which utilization in biological control has given significant results in many countries of the world. Aphidiids form the major part of the primary parasitoid spectrum of aphids. As well, the aphelinids form another small group of the primary parasitoids of aphids (Stary, 1976). Eggs of the aphid parasitoids are laid directly into the aphid and the parasitoid may suspend development while the aphid grows and increases in size. As the parasitoid kills the host, it attaches the aphid to subtract by silk, the skin of the aphid drying and becoming a mummy within which the parasitoid pupates. The color and shape of the mummy frequently are characteristic of the genus of parasitoid, (Hafez, 1965 and El-Heneidy and Adly, 2009).

On the biology and morphology of aphid parasitoids

Several studies included biology, life tables and thermal requirements of most common aphid parasitoids in Egypt; *Aphelinus asychis* (El- Gantiry 1997), *Lysiphlebus fabarum* (Rezq *et al.*, 2000), *Aphidius matricariae* (Agamy *et al.*, 2003 and El-Heneidy *et al.* 2003c), *Aphidius colemani* (El-Heneidy *et al.* 2004), *Aphelinus albipodus* (Adly *et al.* 2006 and El-Heneidy *et al.* 2010) and *Lysiphlebus testaceipes* (Eid, 2012). Besides, some other studies concerned with morphological characteristics of the aphid parasitoids; *L. fabarum* (Rezq *et al.* 2000), *A. matricariae* (El-Heneidy *et al.*, 2003d), *A. albipodus* (Adly *et al.*, 2010) and *L. testaceipes* (Eid, 2012).

The phenomenon of hyperparasitism is very common in aphid parasitoids. Primary parasitoid species are usually been attacked by secondary parasitoid species mostly that belong to order: Hymenoptera, Fam.: Cynipidae, Encyrtidae, Pteromalidae and Megaspilidae. Food web studies suggest that most primary

parasitoids and hyperparasitoids are relatively specialized so that the community contains a series of relatively compartmentalized aphid - parasitoid – hyperparasitoid interactions. Primary parasitoids only attack a small percentage of the available aphids and this is because their numbers are regulated by secondary parasitoids (Christine *et al.*, 1999). Parasitoid species attack cereal aphids in wheat fields in Egypt were previously recorded by several authors in different locations. On the contrary, few studies concerned with the survey of the cereal aphid species and their natural enemies on barley in Egypt.

Aphid parasitoid species

Survey of both primary and hyperparasitoid species recorded on cereal aphid species in wheat, barley and maize plants in Egypt revealed the presence of:

Primary parasitoids

(Order: Hymenoptera Family: Aphidiidae)

1. ***Aphidius* spp.:** recovered, from specimens of *R. padi* collected at Middle Egypt in March 1957 (Hassan, 1963, El-Heneidy and Attia, 1988/89, El-Heneidy, 1991 and Hafez, 1994).
 - ***Aphidius matricariae* Haliday:** was collected by Ibrahim, (1990 a&b), Ibrahim and Afifi, (1991), El-Heneidy, (1994), El-Serafy, (1999), Megahed, (2000), El-Heneidy and Abdel-Samad, (2001), El-Heneidy *et al.*(2001, 2002, 2003a, 2004), Sobhy *et al.*(2004), Abdel- Rahman, (2005), El-Fatih, (2006) and Slman, (2006).
 - ***A. colemani* Viereck:** was surveyed by Ghanim and Adl, (1983), Abdel- Rahman, *et al.*,(2000), Megahed, (2000), El-Heneidy and Abdel-Samad, (2001), El-Heneidy *et al.*(2001, 2002, 2003a, 2004), Sobhy *et al.*(2004), El-Fatih, (2006) and Slman,(2006).
 - ***A. rhopalosiphi*:** was surveyed by Ghanim and Adl, (1983) and El-Serafy, (1999).
 - ***A. uzbekistanicus* Luz.:** was surveyed by Ibrahim, (1990a) and El-Serafy, (1999).
2. ***Diaeretiella rapae* McIntosh (*Diaeretes dauci*):** was recovered from specimens of *R. padi*, collected from Middle Egypt in March 1957, (Hassan, 1963). It was also surveyed by El-Heneidy and Attia, (1988/89), El-Heneidy (1991, 1994), Abdel- Rahman, *et al.*,(2000), Megahed, (2000), El-Heneidy and Abdel-Samad, (2001), El-Heneidy *et al.*(2001, 2002, 2003a, 2004), Sobhy *et al.*(2004), Abdel-Rahman, (2005), El-Fatih, (2006) and Slman,(2006).
3. ***Ephedrus* spp.:** emerged from specimens of *R. padi* collected at Middle Egypt in March 1957 (Hassan, 1963).
 - ***Ephedrus persicae* Froggatt:** was surveyed by Megahed, (2000), El-Heneidy and Abdel-Samad, (2001), El-Heneidy *et al.*(2001, 2002, 2003a), Sobhy *et al.*(2004) and El-Fatih, (2006).
 - ***Ephedrus plagiator* Ness:** was surveyed by Abdel- Rahman, (2005).
4. ***Praon necans* Mackauer:** was surveyed by Abdel-Rahman, *et al.*(2000), El-Heneidy and Abdel-Samad, (2001), El-Heneidy *et al.*(2001, 2002, 2003a), Sobhy *et al.*(2004), Abdel- Rahman, (2005) and El-Fatih, (2006).
 - ***Praon gallicum* Stary:** was surveyed by Ibrahim, (1990 a&b) and El-Serafy, (1999).
 - ***Praon* sp.:** was surveyed by El-Heneidy, (1991, 1994), Megahed, (2000) and Slman, (2006).
 - ***Praon volcure* Hal.:** was surveyed by Hafez, (1994).
5. ***Lysiphlebus* sp.:** was surveyed by Megahed, (2000).
6. ***Trioxys* spp.:** were recorded by El-Heneidy, (1991, 1994), Megahed, (2000), El-Heneidy and Abdel-Samad, (2001), El-Heneidy *et al.*(2001, 2002), Abdel- Rahman, (2005) and Slman, (2006).

(Order: Hymenoptera Family: Aphelinidae)

- 1- ***Aphelinus* sp.:** recovered from specimens of *Aploneura lentisci* Pass., collected at Middle Egypt in 1953 (Hassan, 1963). It was surveyed by El-Heneidy and Abdel-Samad, (2001), El-Heneidy *et al.*(2001, 2002), Sobhy *et al.*(2004), Abdel- Rahman, (2005) and El-Fatih, (2006).
- 2- ***Aphelinus albipodus* Hayat and Fatima:** native *Aphelinus* sp. emerged from cereal aphid species, collected from Egyptian wheat fields, were identified by Dr. M. Hayat (the author of the species), Department of Zoology, Aligarh Muslim University, Aligarh, India. The result showed that the native parasitoid species was *A. albipodus* (Adly,2008).

Hyperparasitoids

Surveyed hyperparasitoid species recovered from primary parasitoid species of cereal aphids in Egypt

were found all belong to order Hymenoptera and to five main families:

- Cynipidae: *Alloxysta* spp., *Phaenoglyphis* sp. and other cynipids.
- Chalcididae: chalcids.
- Encyrtidae: *Aphidencyrthus* sp.
- Megaspilidae: *Dendrocerus* spp.
- Pteromalidae: pteromalids (*Asaphes* and *Pachyneuron*)

These hyperparasitoids were recorded by Ibrahim, (1990 a&b), Ibrahim and Afifi, (1991), Hafez, (1994), Megahed, (2000), El-Heneidy and Abdel-Samad, (2001), El- Heneidy *et al.* 2001, 2002, 2003a), Sobhy *et al.* (2004), Abdel-Rahman, (2005) and El-Fatih, (2006).

Seasonal Abundance of Cereal Aphid Parasitoids

1. Primary parasitoids

Highest percentages of parasitism were estimated mostly during the boating and heading growth stages of the wheat plants (late February – mid- April) to coincide more or less with the highest population of cereal aphids on wheat and barley (El-Heneidy and Attia, 1988/89, Ibrahim, 1990 a,b, El-Heneidy, 1991, 1994, Hafez, 1994, El-Serafy, 1999, Abdel- Rahman *et al.*, 2000, El-Heneidy *et al.*, 2001, Abdel-Rahman, 2005 and Slman, 2006). Percentages of parasitism were increased by plantations of flowering plants surrounding wheat fields. That mean, planting some flowering plants surrounding wheat fields enhanced the attraction of parasitoids for controlling the cereal aphids (Hafez, 1994). Increase rate of aphid parasitoids usually follows the increase in the aphid population. Peak of the aphid parasitoids was recorded two weeks post the peak of the aphid species (El-Serafy, 1999 and Megahed, 2000).

Numbers of surveyed parasitoids emerged from aphids attacking weeds were much higher than those emerged from aphids infesting cultivated economic plants such as wheat plants. High population of parasitoids occurs on weeds in October due to the lack of crop plantations during this period between summer and winter seasonal crops, during May due to the decrease of aphids' infestation in wheat and barley fields, when the crops became senescent and during July and August when the chemical control measures sometimes are practiced on maize plantations. These periods may be unsuitable and unadvisable to weed elimination (Megahed, 2000).

2. Hyperparasitoids

Aphid hyperparasitoids are mostly obligate because they are restricted to being secondary parasitoids whose progeny can develop only in or on primary parasitoids. Hyperparasitoids have an ecological impact on both the primary parasitoids and host aphid population dynamics. For instance, hyperparasitism has practical ecological implications in any biological control program because of the negative effect on the beneficial primary parasitoids. Generally, few studies have been carried out on hyperparasitism of aphid's primary parasitoids in Egypt (EL- Heneidy *et al.* 2002).

Hyperparasitism has traditionally been viewed in the context of applied ecology as being harmful and so it is believed to have usually a negative impact on beneficial primary parasitoids. There is a contrary speculation as to hyperparasitoids' possible positive role in maintaining a proper balance between the primary parasitoids and their hosts by preventing an excessive buildup of parasitoid numbers (Stary, 1970, May, 1973 and Van den Bosch *et al.*, 1979).

Hyperparasitoid species were observed by late February until end of April (Ibrahim, 1990 a,b, El- Heneidy *et al.*, 2001, 2002 and Abdel- Rahman, 2005). Highest percentage of hyperparasitism (51.5%) was found in the New Valley (Upper Egypt) during 1997/98 season, while the lowest (2.8%) was recorded in the Delta at the same season (El- Heneidy *et al.*, 2001).

Generally, diversity of species and number of the parasitoids and their potential to control cereal aphids in wheat fields in Egypt has been adversely influenced by:

- 1- Regular pesticides treatments. A sharp decline (66%) in the number of the parasitoids in wheat fields, following pesticides applications was recorded (El-Heneidy, *et al.*, 1991).
- 2- Significant role of hyperparasitoids species in suppressing the primary parasitoids. Maximum percentage of naturally occurring parasitism, recorded on the cereal aphids was 36% in Upper Egypt (El-Heneidy and Abdel-Samad, 2001).

b- Predators

Aphids are subject to predation by number of groups of relatively specific predators, as well as by more generalist species that also feed on other groups of insects. The most important specialists are ladybird

beetles (Coccinellidae, both adults and larvae), lacewing larvae (Chrysopidae), hoverfly larvae (Syrphidae), midge larvae (Cecidomyiidae) and certain genera of true bugs (Heteroptera)(Christine *et al.*, 1999).

Recorded predatory species associated with cereal aphids in Egypt were:

Order: Coleoptera Family: Coccinellidae

- ***Coccinella undecimpunctata* L.:** was recorded associated with cereal aphid species; *R. padi*, *R. maidis*, *S. graminum* and *S. avenae* by Hassan, (1957), Tawfik *et al.* (1974 a,b), El-Heneidy and Abbas, (1984), El-Heneidy and Attia, (1988/89), Salem and Megahed, (1990), Darwish, (1991), El- Heneidy *et al.*(1991), Ibrahim and Afifi, (1991), El- Heneidy, (1994), Hafez, (1994), Ali and Abdel-Rahman, (2000), Megahed, (2000), El-Heneidy and Abdel-Samad, (2001), El-Heneidy, (2004), Slman and Ahmed, (2005), El-Fatih, (2006) and El-Gapaly, (2007).
- ***C. septempunctata* L.:** was recorded associated with cereal aphid species; *R. padi*, *S. graminum* and *S. avenae* by Hafez, (1994).
- ***Scymnus interruptus* L.:** was recorded associated with cereal aphid species; *R. padi*, *R. maidis*, *S. graminum* and *S. avenae* by Hassan, (1957), Tawfik *et al.* (1974 a,b), El-Heneidy and Abbas, (1984), El-Heneidy, (1994), El-Heneidy and Abdel-Samad, (2001) and El-Fatih, (2006).
- ***S. gilvifrons* Muls.:** was recorded associated with *R. maidis* by El-Gapaly, (2007).
- ***S. pallidivestis* Muls.:** was recorded associated with *R. maidis* by El-Gapaly, (2007).
- ***Scymnus* spp.:** were recorded associated with different cereal aphid species by El-Heneidy and Attia, (1988/89), Darwish, (1991), Hafez, (1994), Ali and Abdel-Rahman, (2000), Megahed, (2000) and El-Gapaly, (2007).
- ***Cydonia vicina* var. *nilotica* Muls.:** was recorded associated with *R. maidis* by Hassan, (1957), Tawfik *et al.* (1974 a,b), El-Heneidy and Abbas, (1984) and the aphid species; *R. padi*, *S. graminum* and *S. avenae* by Hafez, (1994).
- ***Cydonia vicina* var. *isis* Muls.:** was recorded associated with cereal aphid species; *R. padi*, *S. graminum* and *S. avenae* by Hafez, (1994).

Order: Coleoptera Family: Staphelinidae

- ***Paederus alfieri* Koch:** was recorded associated with different cereal aphid species by Hassan, (1957), Tawfik *et al.* (1974 a,b), El-Heneidy and Abbas, (1984), El-Heneidy and Attia, (1988/89), Salem and Megahed, (1990), El-Heneidy, (1994), Hafez, (1994), Megahed, (2000), El-Heneidy and Abdel-Samad, (2001), El-Fatih, (2006) and El-Gapaly, (2007).

Order: Neuroptera Family: Chrysopidae

- ***Chrysoperla carnea* Steph.:** was recorded associated with cereal aphid species; *R. padi*, *R. maidis*, *S. graminum* and *S. avenae* by Hassan, (1957), Tawfik *et al.* (1974 a,b), Ghanim and El-Adl, (1983), El-Heneidy and Abbas, (1984), El-Heneidy and Attia, (1988/89), Salem and Megahed, (1990), Darwish, (1991), Ibrahim and Afifi, (1991), El- Heneidy, (1994), Hafez, (1994), Ali and Abdel-Rahman, (2000), Megahed, (2000), El-Heneidy and Abdel-Samad, (2001), El-Fatih, (2006) and El-Gapaly, (2007).

Order: Diptera Family: Syrphidae

- ***Syrphus corolla* Fab.:** was recorded associated with cereal aphid species by Ghanim and El-Adl, (1983), Salem and Megahed, (1990), Ibrahim and Afifi, (1991), Hafez, (1994), Ali and Abdel-Rahman, (2000) and El-Fatih, (2006).
- ***Syrphus* spp.:** were recorded by Hassan, (1957), Tawfik *et al.* (1974 a,b), El-Heneidy and Abbas, (1984) El-Heneidy and Attia, (1988/89), El-Heneidy, (1994), Megahed, (2000) and El-Heneidy and Abdel-Samad, (2001).
- ***Lasiophthicus flavicauda* Zetterstedt:** was recorded associated with cereal aphid species by El-Fatih, (2006).
- ***L. pyrastris* L.:** was recorded associated with cereal aphid species by Efflatoun, (1922).
- ***L. albomaculatus* Macq.:** was recorded associated with cereal aphid species by Efflatoun, (1922).
- ***Xanthogramma aegyptium* and *Sphaerophoria flavicauda* Zett.** were recorded associated with *R. padi*, *S. graminum* and *S. avenae* by Hafez, (1994) and with *R. maidis* by El-Gapaly, (2007).
- ***Sphaerophoria flavicauda* Zett.:** was recorded associated with *R. maidis* by El-Gapaly, (2007).
- ***Paragus aegyptium* Macq.:** was recorded associated with *R. padi*, *S. graminum* and *S. avenae* by Hafez, (1994).

Order: Hemiptera Family: Anthocoridae

- ***Orius albidipennis* Reut.** was recorded associated with *R. maidis* by El-Gapaly, (2007).
- ***Orius laevigatus*:** was recorded associated with *R. maidis* by El-Gapaly, (2007).
- ***Orius* spp.:** were recorded by Hassan, (1957), Tawfik *et al.* (1974 a,b), El-Heneidy and Abbas, (1984), El-Heneidy and Attia, (1988/89), Darwish, (1991), El-Heneidy, (1994), Megahed, (2000) and El-Heneidy and Abdel-Samad, (2001).

Spiders

Acrina: spiders (several species) were recorded by El-Heneidy and Abbas, (1984), Darwish, (1991), El-Heneidy, (1991&1994), El-Heneidy and Abdel-Samad, (2001).

Seasonal Abundance of Predators Associated with Cereal Aphid Species:

In wheat fields, population of aphidophagous predators increased gradually towards the end of the season reached their maximum during April. *C. undecimpunctata* was the dominant predator in the two seasons 1987 and 1988 on wheat fields (El-Heneidy and Attia, 1988/89 and Hafez, 1994). Predatory numbers increased in wheat treatments surrounded with flowering plants (Hafez, 1994). Peak numbers of predators in wheat fields occurred during March and by mid-April (El-Heneidy and Attia, 1988/89, El-Heneidy, 1991, Hafez, 1994, El-Heneidy and Abdel-Samad, 2001), while Ghanem and El-Adl, 1983, Ibrahim and Afifi 1991, Hafez 1994 and El-Heneidy, 1994) reported that the peak number of predators occurred during April, which was later than the highest infestation period of cereal aphids in wheat, usually in March. Decrease of population numbers of the predators occurred after pesticide applications (El-Heneidy *et al.*, 1991).

In maize fields, highest numbers of predators associated with cereal aphids were recorded in August and October, while the lowest was recorded in September. *P. alfieri* dominated in August, *Orius* spp. and *C. undecimpunctata* mainly occurred in September and October. The population of predatory species follows that of the preys (El-Heneidy and Abbas, 1984).

Occurrence of *C. undecimpunctata*, *Syrphus* spp., *C. carnae*, *Orius* spp., *P. alfieri* were observed on weeds all over the year, on wheat (February – April), on maize (August – September) but *Orius* spp. on weeds during (October - November), (March), and (June -September), *P. alfieri* on weeds during (October - November) and (February - September) (Megahed, 2000).

c- Entomopathogenic Fungi

Entomopathogenic fungi are principal pathogens among Homopteran piercing sucking insects (Hajek and St. Leger, 1994). Several species of entomopathogenic fungi; *Beauveria bassiana*, *Verticillium lecanii*, *Pandora neoaphidis*, *Conidiobolus thromboides*, *C. obscurus*, *C. coronatus*, *Entomophthora planchoniana* were recorded infecting cereal aphid species; *R. padi*, *R. maidis* and *S. graminum* in wheat fields in Egypt, particularly at Upper Egypt (Abdel-Rahman *et al.*, 2006). El-Fatih, (2006) recorded four entomopathogenic fungal species; *P. neoaphidis* and *C. thromboides* (Order: Entomophthoraceae) and *V. lecanii* and *Paecilomyces farinosus* species (Order: Moniliales) infected *R. maidis* and *M. dirhodum* in Egypt.

Fungal infections to cereal aphids in wheat fields were found starting by mid-March, while the peak was counted in April (Hafez, 1994).

Biological Control Applications

Diversity and populations of parasitoids and predators seem to be relatively low to play a significant role for aphid management of cereal aphids in Egypt. Additional work should be done to make the agro-ecosystem more favorable to the natural enemies (El-Heneidy and Attia, 1988/89).

El-Heneidy *et al.* (2006) imported through an Egyptian/American collaborative project (1997-2002), four cereal aphid exotic parasitoid species from different countries to provide additional mortality factors to the indigenous ones, against key cereal aphid species in Egyptian and American wheat fields. The exotic cereal aphid parasitoid species were collected from Syria, Morocco, and Iran, in localities near the reported areas of the origin of cereal species and from habitats of climatic patterns similar to those in Upper Egypt and Southern California, USA. *A. matricariae*, *D. rapae*, *A. rhopalosiphi* and *A. albipodus* were the parasitoid species introduced and evaluated under laboratory, field cages and open wheat field conditions. The exotic

parasitoid species showed different performances under several tested conditions. The most promising species for its potential field effectiveness against cereal aphids was *A. matricariae* imported from Syria as it showed efficiency against wheat aphids in hot areas in Upper Egypt.

Sabbour, (2007) evaluated different species of fungi and the predator *C. septempunctata* under laboratory and field conditions against cereal aphids' species *R. padi* and *R. maidis* for two successive wheat growing seasons 2005 and 2006. The fungus *B. bassiana* showed significantly best result, followed by *Paecilomyces fumosoroseus*, *Metarhizium anisopliae*, *V. lecanii* and *Nomuraea rileyi* against *R. padi* and *R. maidis*. Under field conditions, the treatments with the different fungi after releasing the predator (*C. septempunctata*) decreased the infestations with the cereal aphids. Also, the percentage of yield loss was significantly decreased to 17% after predators releasing and fungal treatments, as compared to 51% in untreated plots.

A. albipodus was released as mummies, collected from the laboratory stock culture, in field cages and open field at Giza Governorate (Middle Egypt) during the season 2005/06. Evaluation of the release of the parasitoid in the field cages and open field were carried out. Percentage of parasitism in the control was higher ($27.49\% \pm 2.58$) than that in the field cages ($21.96\% \pm 2.45$), which might be due to the competition among different other parasitoid species. *A. albipodus* had the lowest percentages in both open field and the control and with no difference between the percentages of the *A. albipodus* before and after releases (Adly, 2008).

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