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Seasonal abundance of the fig wax scale insect *Ceroplastes rusci* (Hemiptera: Coccidae) on medicinal plant *Withania somnifera* in Beni-Suef Governorate, Egypt

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Abstract:

The present study dealt with the population fluctuations of *Ceroplastes rusci* (L.) (Hemiptera: Coccidae) during two successive seasons (2016-2017) and (2017-2018), on *Withania somnifera* (L.) (Ashwagandha) at Beba district, Beni-Suef Governorate. The obtained data showed that *C. rusci* had four annual peaks on *W. somnifera* in the two successive years of the study. These peaks were recorded during (May, August, October and December) and (May, August, October and January) in the first and second years, respectively. The relationship between the meteorological factors and the total population of the pest was studied in this investigation. During this work was recorded 6 parasitoids and one hyperparasitoid. These are *Habrolebis* sp., *Metaphycus helvolus* (Compere), *M. zebratus* Mercet and *Microterys nietneri* (Motschulsky) (Hymenoptera: Encyrtidae) ; *Scutellista caerulea* (Fonscolombe) (Hymenoptera: Pteromalidae); *Tetrastichus ceroplastae* (Girault) (Hymenoptera: Eulophidae) and hyperparasitoid, *Marietta leopardina* Motschulsky (Hymenoptera:Aphelinidae). Also, the rate of parasitism of these parasitoids was studied.

Introduction

Withania somnifera (L.) (WS) (Ashwagandha), belonging to family Solanaceae, is a wild herb had many common names like Indian winter cherry and Indian ginseng that has been traditionally known since ancient times in India for its numerous beneficial health activities.WS is one of the most important herbs in Ayurveda, India which has been used for >3000 years in stress management, energy elevinting and improving cognitive health and to lower inflammation blood sugar levels, cortisol, anxiety, and depression. The plant is an erect, grayish, evergreen shrub with long tuberous roots, short stems, ovate and petiolate leaves, and greenish axillary and bisexual flowers. The leaves, roots, stems and flowers bear medicinal values with 29 common metabolites derived from the leaves and root extracts. Till now, this medicinal plant has been found to have anti-epileptic, anti-inflammatory, anti-arthritic, anti-depressant, anti-coagulant, antioxidant, anti-diabetic, anti-pyretic efficiencies along with palliative effects such as analgesic,

rejuvenating, regenerating and growth-promoting effects. Leaf extract showed that the highest activity against liver and breast cancer (Dutta *et al.*, 2019). Furthermore, Mahrous *et al.* (2017) recorded that this plant is a common plant in Egypt. The extracts of different parts of the plant in the protection against oxidative stress and its therapeutic potential in the treatment of alzheimer's. Significant anticholinesterase activity, with the highest activity produced by the ripe fruit extract, significant nitric oxide scavenging activity, strong haemolysis protection as well as strong antioxidant activity. Unlike the Indian plant that is reputed for the medicinal use of its roots, both the fruits and leaves of Egyptian plant have promising activities. Withanolides isolated from its leaves extract, could be regarded as an interesting drug candidate for treatment of Alzheimer's. Nassra *et al.* (2017) recorded that WS is a well reputed plant in India as a multi-purpose medicinal agent and is well cherished for the cytotoxic activity of its extracts and isolates.

The fig wax scale (FWS), *Ceroplastes rusci* L. (Hemiptera: Coccidae), is one of the common scale insect species in Jordan (Mustafa-Al-Antary and Sharaf, 1994). In addition, La Notte *et al.* (1997) demonstrated that some species of wax are virus disease vectors, for example *C. rusci* is known to carry plant viruses. Also, Morsi and Mousa (2004) recorded that this scale insect had 2-3 annual peaks of abundance on leaves of guava in Beni-Suef Governorate. The natural enemies of FWS as the most important factor controlling the occurrence and severity of infection. Talhouk (1969) recorded the presence of three natural enemies from Jordan. These are: *Scutellista caerulea* (Fonscolombe) (Hymenoptera: Pteromalidae) , *Tetrastichus* sp. (Hymenoptera: Eulophidae) and *Coccidophaga scitula* (Rambur) (Lepidoptera: Noctuidae) .

The aim of this research work is to provide further significant ecological data to enhance the integrated management of this scale pest in Egypt. Phenological details such as the number of generations and the population peaks give useful information about the time of applying insecticides or releasing a biocontrol agent.

Materials and methods

1. Seasonal abundance of the fig wax scale insect *Ceroplastes rusci*:

It was carried out for 2 years, (March, 2016 till February, 2018) at Beba District, Beni-Suef Governorate, Egypt. An orchard about one Fadden in area, cultivated with the fig trees, *Ficus carica* L. and heavily infested with the fig wax scale, *C. rusci* was chosen for this study. The orchard was not exposed to any chemical treatment during three years prior to the present study and during the investigation period. Every15 day-intervals hundred leaves with different stages of the scale *C. rusci* were collected at random from the different directions of WS. The leaves represented the different sides, peripheral, inner zones, lower and middle strata of the tree. These leaves were kept in a paper bag and transferred to the laboratory for examination and counting the scale insects. The stages of scale insect considered in counting process were: 1. Nymphal instars. 2. Adult females (Virgin and gravid).

2. Survey of natural enemies:

A survey of the fig wax scale insect *C. rusci* parasitoids was carried out in Beni–Suef Governorate throughout two successive years, from March, 2016 till February, 2018. Samples of infested leaves and branches with WS . The samples were 30 branches (20 cm/ branch). They were packed in paper bags and transferred to the laboratory for examination. The parasitoids species

were identified in Biological Control Res. Dept. Plant Prot. Res. Institute, Agric. Res. Center. The examined leaves were enclosed in plastic jars of 15 cm. diameter and 20 cm height covered with muslin held in position by a rubber band and kept under preferential conditions for securing any emergence of parasitoids. The parasitoids were collected, sorted into species and preserved in vials contain 70 % ethyl alcohol and glycerin, in addition to slide mounting species for identification.

3. Abundance of the parasitoids associated with the fig wax scale insect *Ceroplastes rusci*:

WS leaves infested with nymphs and adult females, (Virgin and gravid females) of *C. rusci* were half monthly, (100 scale insects/15 days) from March, 2016 to February , 2018 . Each leaf was stored in well-ventilated glass emergence tube for its parasitoids emergence that their numbers were recorded daily and their percentages were calculated.

4. Percentage of parasitism:

The rates of parasitism in different stages of *C. rusci* infesting WS were estimated throughout two successive years of study from the beginning of March, 2016 to the end of February, 2018. Samples 100 randomly selected scales were chosen. These samples represented nymphal instars, the newly developed adult females, the full-grown adult females. This sample divided into 4 replicates with 25 scales. Each scale was removed, transferred and mulched on a slide in a water film. Scales in each sample were dissected under a binocular microscope and classified as follows:

Live unparasitized, parasitized scale insects having (Parasitic larvae, pupal parasitoids and emergence holes). The total percentage of parasitism of the fig scale insect was estimated from data obtained throughout the two years 2016-2018 according to:

$$R = \frac{\text{Total population of the parasitoid}}{\text{Total population of the scale insect + Total population of the parasitoid}} \times 100$$

5. Effect of biotic and abiotic factors on the abundance of *Ceroplastes rusci*:

Weather factors as maximum, minimum temperature and relative humidity were considered from Central Laboratory for Agricultural Climate. The weekly maximum and minimum temperatures as well as relative humidity were calculated and total number of parasitism. Multiple regressions were conducted for weather factors combined as well as plant age as described. The obtained determination factor (R^2) of E.V. % was used to explain the effect of testing factors. Process Correlation and Regression were used in SAS to analysis the obtained date **(SAS Institute, 1998).**

Results and discussion

1. Seasonal abundance of the fig wax scale insect *Ceroplastes rusci*:

Data presented in, (Figures 1 and 2) illustrated that nymphs, adult females and gravid females stages curves had four peaks during the first year, (2016-2017) and four peaks during the second year, (2017-2018) on WS leaves. In the first year, (2016-2017) the peaks of nymphs recorded on (25^{th} of April,10^{th} of August, 25^{th} of October and 10^{th} of December) with 390,520 ,479 and 295(nymph/30 branches), respectively. The peaks of adult females recorded on (The 10^{th} of May, 25^{th} of August, 25^{th} of November and 25^{th} of January 2017 with 273, 228, 227 and 91 individuals/30 branches), respectively. The peaks of gravid females recorded on (The10^{th} of May, 25^{th} of August, 25^{th} of November and 25^{th} of January 2017 with 183,187,177 and 68 individuals/30 branches), respectively. The peaks of total

population of insects recorded on (10th of May, 10th of August, 25th of October and 25th of January 2016) with 817 ,905 ,875 ,392 individuals/30 branches), respectively. In the second year, (2017-2018) the peaks of nymphs recorded on (the10thof May, 10thof August, 1stof October and 25thof December) with 343, 536, 469 and 319 (nymph/30 branches), respectively. The peaks of adult females recorded on (the 25thof May, 25thof August, 25thNovember and 25thof January 2018 with 270, 234, 226 and 95 individuals/30 branches), respectively. The peaks of gravid females recorded on (the 25thof May, 25thof August, 25thof October and 25thof January 2018 with 179, 192 ,177 and 71 individuals/30 branches), respectively. The peaks of total population of insects recorded on (the 25thof May, 10th of August, 25thof October and 10thof January 2018 with 781, 934, 836 and 420 individuals/30 branches), respectively.

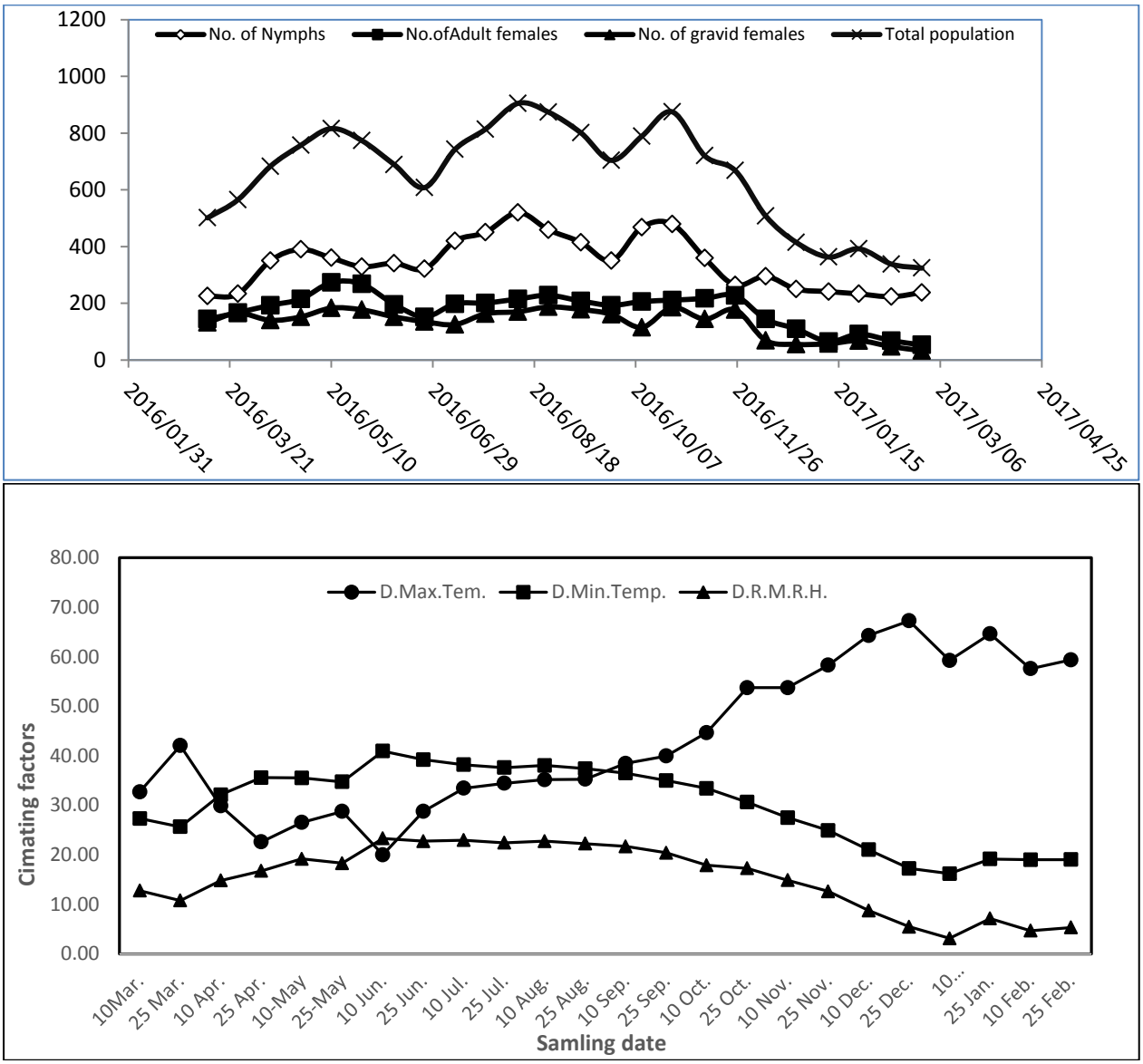


Figure (1): Seasonal abundance of *Ceroplastes rusci* population in response to max., min. temperatures and relative humidity, on *Withania somnifera* branches at Beba district, Beni-Suef Governorate during 2016-2017.

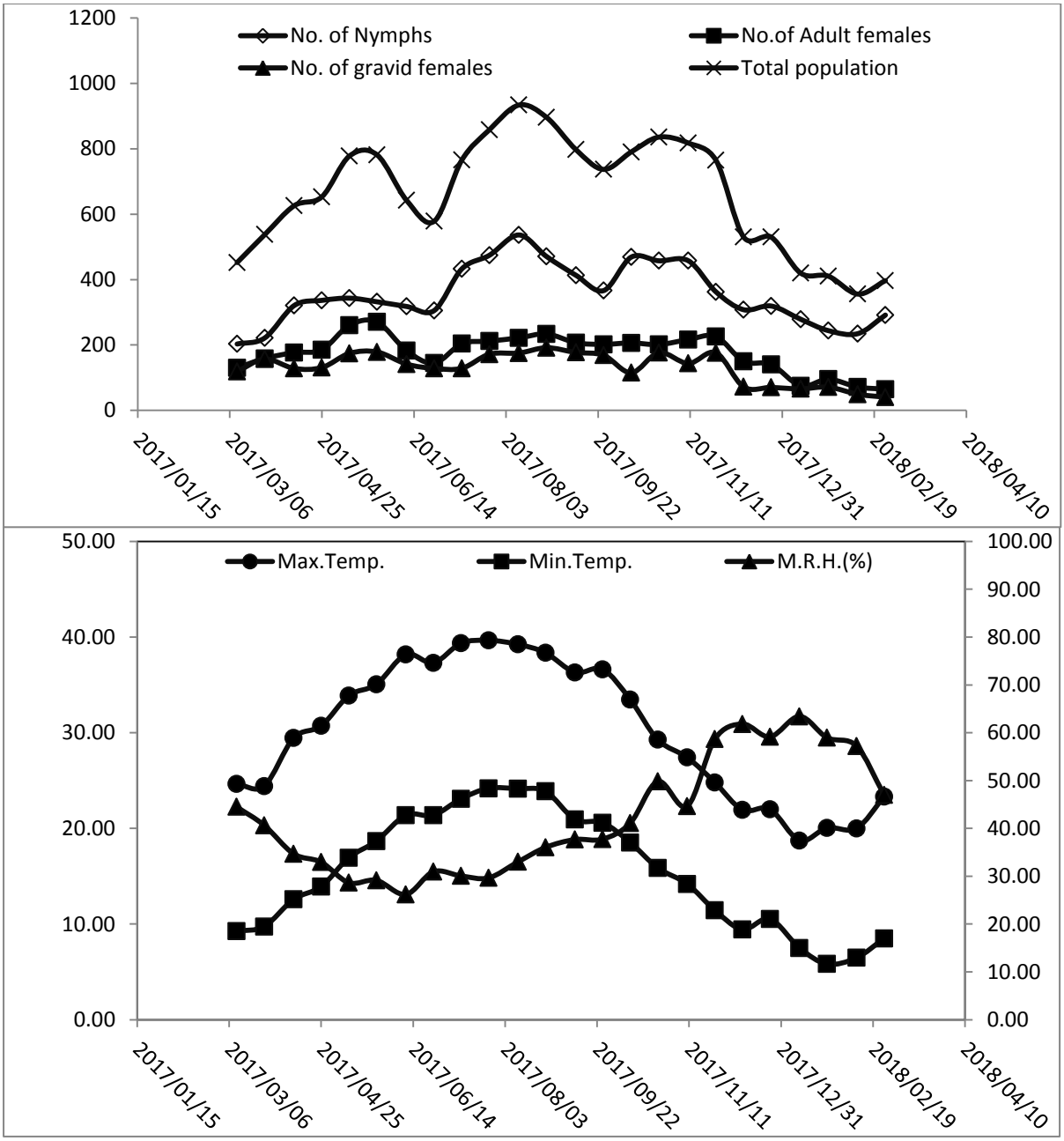
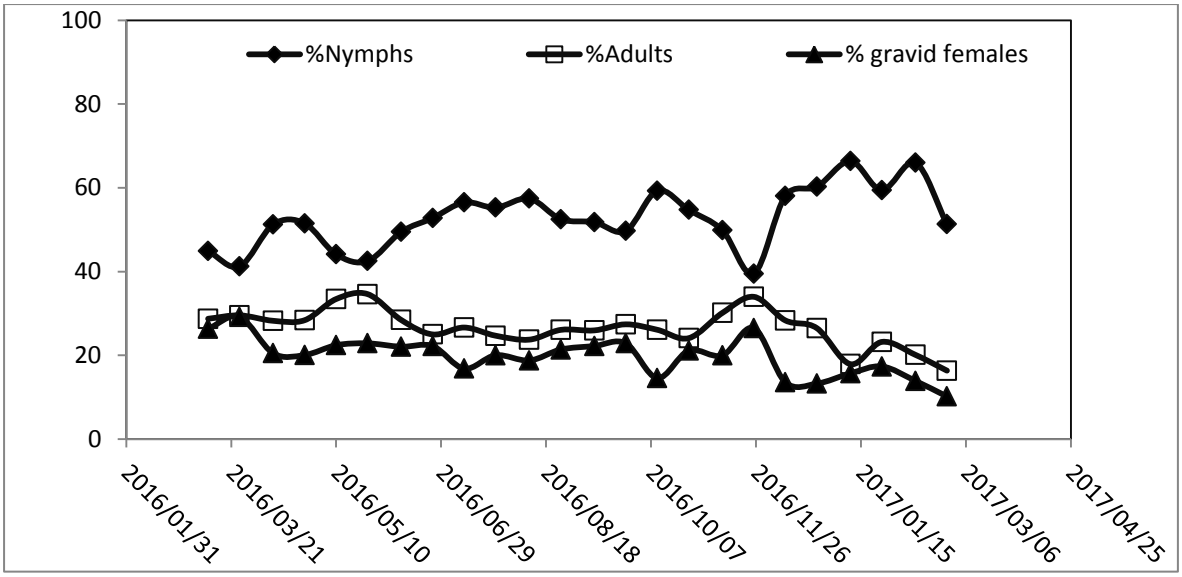


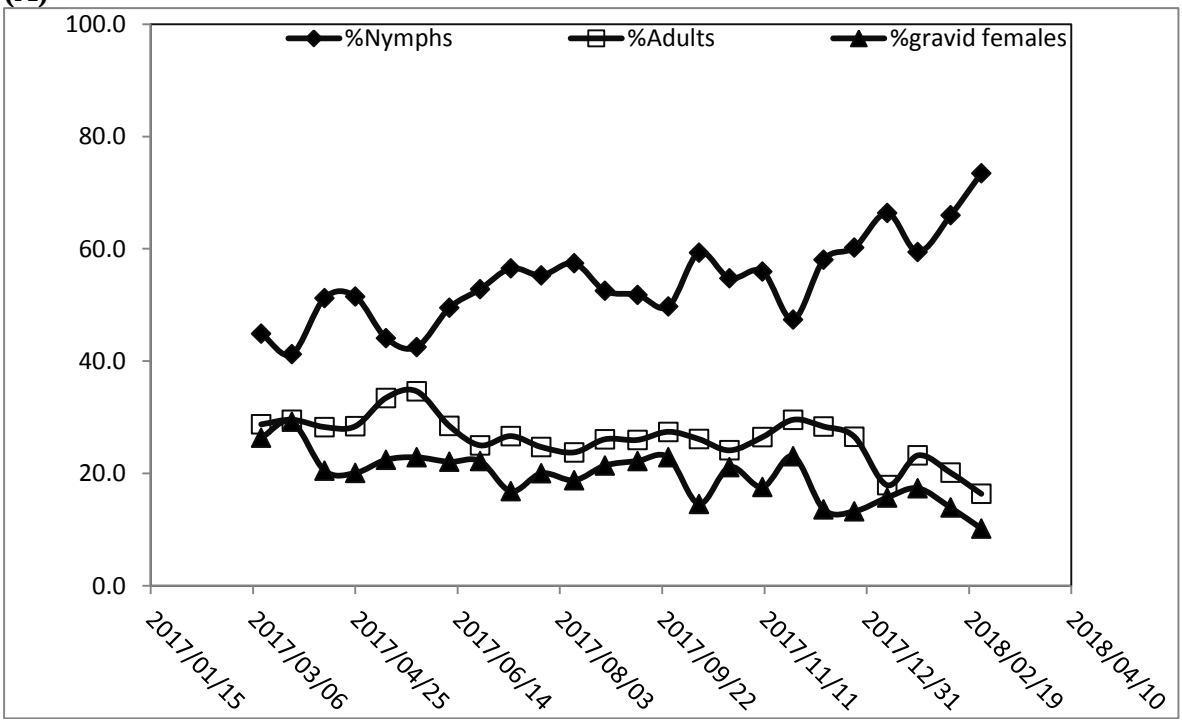
Figure (2): Seasonal abundance of *Ceroplastes rusci* population in response to max., min. temperatures and relative humidity on *Withania somnifera* branches at Beba district, Beni-Suef Governorate during 2017-2018.

2. Age structure:

The results of using the age structure technique to be obtained from seasonal data of *C. rusci* along the two years of investigation on WS were graphically illustrated in Figure 3 (A and B). *C. rusci* had four generations in the first year, the highest generation started from end March to 1st June. Ozsemerci and Askit (2003) observed that this scale had 2 generations / year on fig trees in Aydn province (Turky). Although Oueed *et al.*, 2007 found that *C. rusci* had 3 generations / year on fig trees in North of Iraq. Biche *et al.* (2012) demonstrated that *C. rusci* had 2 generations autumnal and spring in the area of Medea (Algeria).



(A)



(B)

Figure (3): Age structure of *Ceroplastes rusci* on *Withania somnifera* branches 2016 (A) and 2017(B).

1. Survey of natural enemies:

During the present study was recorded 6 parasitiods and one hyperparasitiod. These are:

Family: Encyrtidae.

Habrolebis sp., *Metaphycus helvolus* (Compere), *M. zebratus* Mercet and *Microterys nietneri* (Motschulsky)

Family: Pteromalidae.

Scutellista caerulea (Fonscolombe)

Family: Eulophidae.

Tetrastichus ceroplastae (Girault)

Hyperparasitoid:

Family: Aphelinidae.

Marietta leopardina Motschulsky

Agyriou and Santorini (1980) surveyed the parasitiods of *C. rusci* on fig trees in Greece. They recorded these parasitiods, *Scutellista cyanea* Motsch, *Eublemma scitulum* (Ramb.),

Coccophagus lycimina (Wlk.), *Paracera ptrocerusitalicus* (Masi) and *T. ceroplastae.* Morsi and Mousa (2004) recorded that parasitiods of fig wax scale *C. rusci* on guava leaves in Beni-Suef Governorate, Egypt. These are, *M. helvolus, M.zebratus, Habrolepis* sp., *S. caerulea, M.nietneri, Microtyres* sp., *T. ceroplastae.* Awamleh *et al.* (2009) stated that parasitiods of the fig wax scale *C. rusci* in Jordan are: *M. helvolus, M. zebratus, S.* cyanea and *T. ceroplastae*.

4. Abundance of the parasitoid *Tetrastichus ceroplastae* attacking fig wax scale insect *Ceroplastes rusci*:

The parasitoid *T. ceroplastae* is an effective parasitoid which keeps populations of the wax scale under control in Egypt. In the first year, 2016 there were four peaks of parasitism could be observed and three peaks in the second year. The highest peak was observed in 10th of August in two years. The highest rate of parasitism was 4.64 % in August in the first year 2016. While in the second year was 5% in 25th of April 2017 (Figure 4). These results are agreement with Morsi and Mousa (2004), the authors, Talhouk,1969; Ozsemerci and Aksit, 2003 and Hammad, 2006 also supported the same findings. They also, reported the highest parasitism was observed in month of March in both the year. Awamaleh *et al.* (2009) has also observed *T. ceroplastae* as a dominant parasitoid of *C. rusci*.

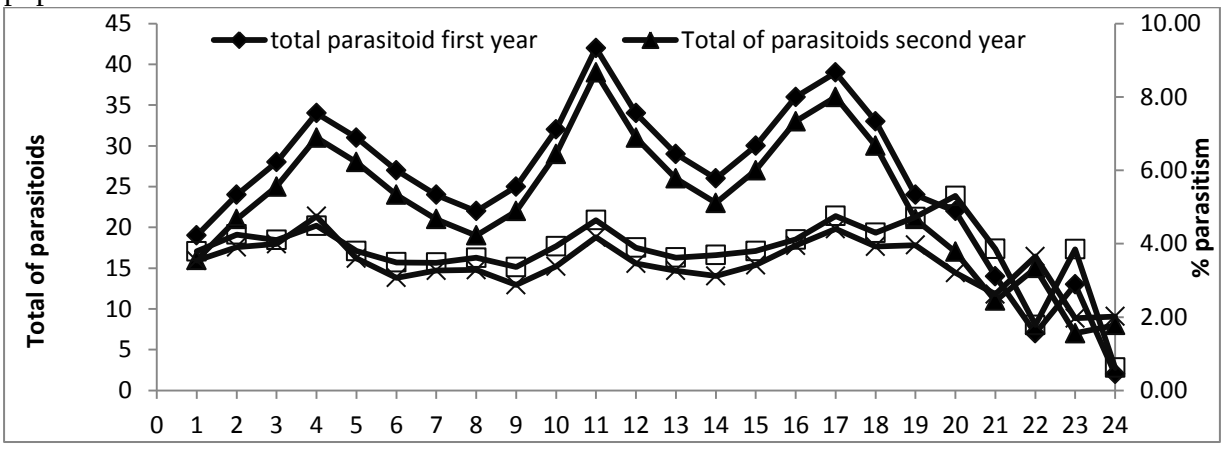


Figure (4). Total population and % parasitism of the parasitoid *Tetrastichus ceroplastae* associated with *Ceroplastes rusci* on *Withania somnifera* at Beba district, Beni-Suef Governorate during the two years.

5. Effect of biotic and abiotic factors on the abundance of *Ceroplastes rusci*:

We studied the effect of a biotic factor as parasitoids and abiotic factors maximum, minimum temperature and relative humidity. Correlation, regression analysis and multi regression between biotic and abiotic factors and population of *C. rusci* was in liner degree, in two years of study 2016/2017and 2017/2018. Statistically, the results represented in Tables (1 and 2) showed the effect of the weather factors (maximum, minimum temperature and relative humidity) activity of *C. rusci*. With the respect to abiotic factors had significant effect on the population of the nymph stage *C. rusci* in the two years of study, while adult had significant effect on the population with maximum temperature in the wo years of study 2016/2017and 2017/2018 (Tables 1 and 2).

The combined effect of temperature and relative humidity was responsible for 73.94 % and 69.78 % of the nymph stage, adult females was

(60.84 % and 51.99 %), gravid females was (66.93 % and 52.62%) and total populations was (73.48 % and 69.15%) during the first and second seasons, respectively (Tables 1 and 2). To evaluate the common effect of biotic and abiotic factors was responsible for 89.22 % and 84.71 % of the nymph stage, adult females was (82.25 % and 79.06 %), gravid females was (81.62 % and 74.56%) and total populations was (93.73 % and 94.26%) during the first and second seasons, respectively (Tables 1 and 2).

Table (1): The simple correlation and regression coefficients and multiple regressions between the different stages of *Ceroplastes rusci* on *Withania somnifera* in Beba district, Beni-Suef Governorate, Egypt first year 2016/2017.

Factor		Simple correlation and regression			Multiple regression		
		R	B	P	F	P	E.V.%
Nymph	T. Max.	0.69	8.10	0.0002	18.91	<.0001	73.94
	T. min.	0.75	10.45	<.0001			
	RH.%	-0.36	-2.28	0.0870			
	Parasitoid	0.846	8.23	<.0001			
	All above				39.33	<.0001	89.22
Adult	T. Max.	0.76	5.85	<.0001	10.36	0.0003	60.84
	T. Min.	0.78	7.09	<.0001			
	RH.%	-0.62	-2.61	0.0011			
	Parasitoid	0.85	5.38	<.0001			
	All above				22.02	<.0001	82.25
Gravid	T. Max.	0.78	4.82	<.0001	13.49	<.0001	66.93
	T. Min.	0.79	5.82	<.0001			
	RH.%	-0.66	-2.22	0.0005			
	Parasitoid	0.79	4.08	<.0001			
	All above				21.10	<.0001	81.62
Total	T. Max.	0.80	18.77	<.0001	18.47	<.0001	73.48
	T. Min.	0.84	23.41	<.0001			
	RH.%	-0.56	-7.14	0.0045			
	Parasitoid	0.91	17.68	<.0001			
	All above				71.06	<.0001	93.73

T. Max.: Maximum temperature. T.Min.: Minimum temperature. RH.% : Relative humidity percentage.

Table (2): The simple correlation and regression coefficients and multiple regressions between the different stages of *Ceroplastes rusci* on *Withania somnifera* in Beba district, Beni-Suef Governorate, Egypt second year 2017/2018.

Factor		Simple correlation and regression			Multiple regression		
		R	B	P	F	P	E.V.%
Nymph	T. Max.	0.66	8.41	<.0001	15.39	<.0001	69.78
	T. Min.	0.75	11.06	<.0004			
	RH.%	-0.61	-2.79	<.0001			
	Parasitoid	0.79	8.66	<.0001			
	All above				26.32	<.0001	84.71
Adult	T. Max.	0.72	5.74	<.0001	7.22	0.0018	51.99
	T. Min.	0.72	6.68	<.0001			
	RH.%	-0.62	-2.92	0.0015			
	Parasitoid	0.80	5.79	<.0001			
	All above				17.94	<.0001	79.06
Gravid	T. Max.	0.72	4.72	<.0001	7.40	0.0016	52.62
	T. Min.	0.72	5.47	<.0001			
	RH.%	-0.63	-2.44	0.0011			
	Parasitoid	0.80	4.50	<.0001			
	All above				13.92	<.0001	74.56
Total	T. Max.	0.78	18.83	<.0001	14.94	<.0001	69.15
	T. Min.	0.82	23.16	<.0001			
	RH.%	-0.56	-8.13	0.0043			
	Parasitoid	0.90	18.95	<.0001			
	All above				78.00	<.0001	94.26

T. Max.: Maximum temperature. T.Min.: Minimum temperature. RH.% : Relative humidity percentage.

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