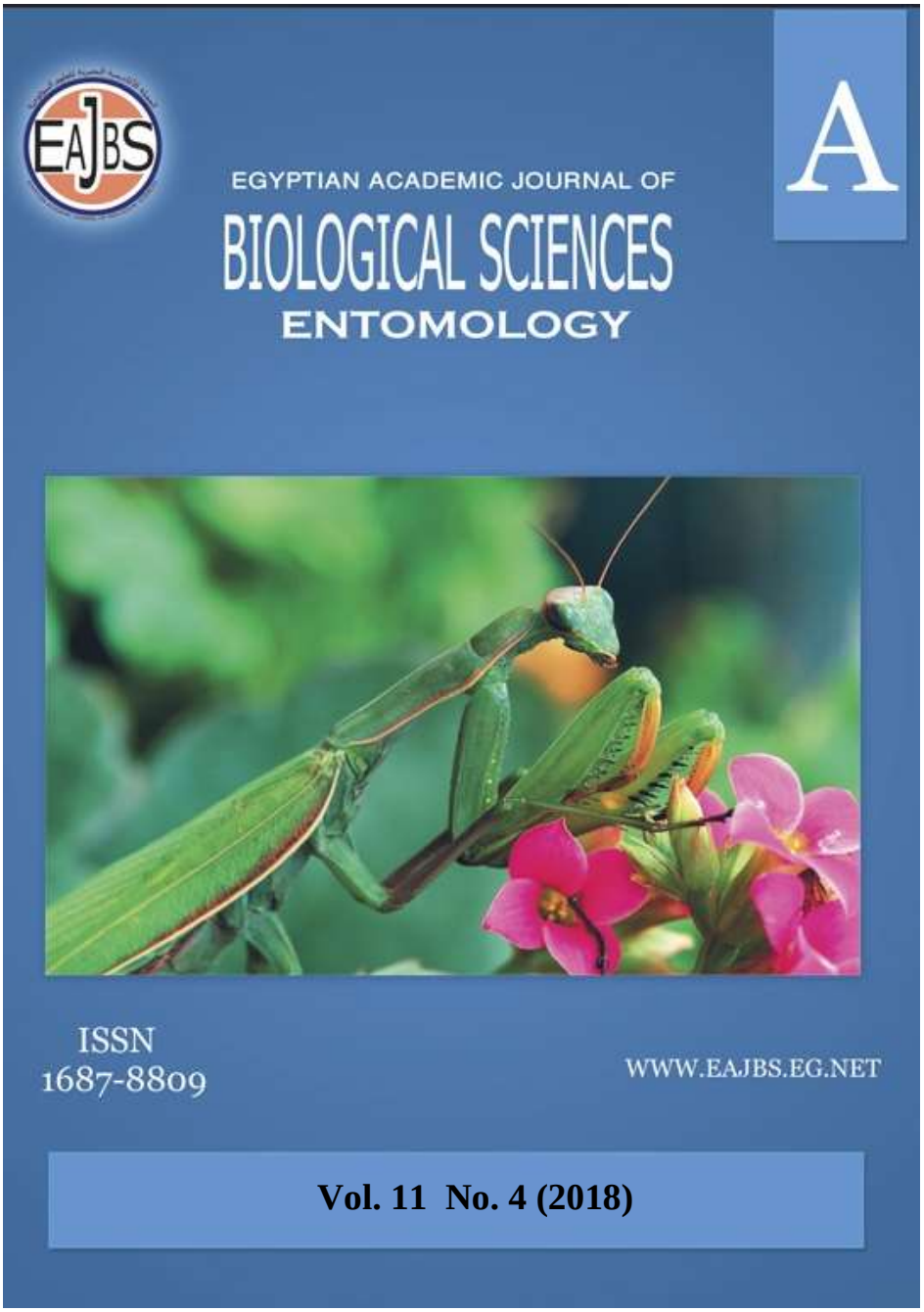

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Population Fluctuations and Infestation Rates of the Peach and Mediterranean Fruit Flies on Fig Fruits in Relation to the Prevailing Weather Factors in Fayoum Governorate

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ABSTRACT

The Egyptian fruits are attacked by two of the most harmful tephritid pests, the peach fruit fly, *Bactrocera zonata* (Saunders), and the Mediterranean fruit fly, *Ceratitis capitata* (Wiedmann) causing considerable damage. In Fayoum governorate, fig trees are cultivated in condensed plantations to produce their fruits in two overlapped crops per year from July till December. This paper was contributed to saving more information about the occurrence of *B. zonata* and *C. capitata* flies in a fig cultivated areas in Fayoum governorate in relation to the effect of various weather factors on their activity and estimating the mentioned fruit flies infestation rates. During the 1st season (2016), the highest peaks of *B. zonata* and *C. capitata* population were observed during the 2nd week of October and 1st week of November with respective mean values of captured flies per trap per day (FTD) of 0.48 and 0.74 fly/trap/day. While during the 2nd season (2017), the highest peak of *B. zonata* and *C. capitata* males were observed during the 1st week of September and 2nd week of November with a mean FTD values of 1.31 and 0.62 flies/trap/day, respectively. Concerning infestation rates, during the 1st season, the highest mean percentage of fruit infestation was observed during the 1st week of October with a mean of 4.32% occurring by *B. zonata* females indicating by the emerged flies of *B. zonata* flies from sampled infested fruits. The fig fruits infestation by *B. zonata* females continued until the 1st week of November, while, *C. capitata* females started to attack fig fruits during the 4th week of October and continued until the 3rd week of November. Concerning the 2nd season(2017), the highest mean percentage of fig fruits was recorded during the 1st week of September with a mean of 5.42% occurring by *B. zonata* females, while, *C. capitata* infestation on fig fruits was observed firstly during the 2nd week of October and continued until the 2nd week of December coinciding with end of fig fruits harvesting. Throughout the two studied seasons, the trapped males of *B. zonata* were negatively and insignificantly correlated with both of maximum and minimum temperatures, while, the relative humidity % affected positively insignificantly and positively significantly on *B. zonata* males activity during 2016 and 2017, respectively. On the other side, *C. capitata* trapped males were significantly and negatively correlated with maximum and minimum temperatures, while, relative humidity reflected a significant positive correlation with the population of the fruit fly.

INTRODUCTION

The edible fig trees, *Ficus carica* L. are well spread over a large area at the northern coastal region of Egypt as well as in many other localities such as in Qalubiya and Fayoum governorates (Serag, 2005). Fig grows under a wide range of climates, but the best fruit was produce under Mediterranean basin climate with hot, dry summer and cool wet winter (El –Shazly *et al.,* 2014).

The Egyptian fruits are attacked by two of the most harmful tephritid pests, the peach fruit fly, *Bactrocera zonata* (Saunders), and the Mediterranean fruit fly, *Ceratitis capitata* (Wiedmann) that infesting many commercial fruits, mango, guava, apricot, peach, apple and citrus all over the year causing considerable damage which inflicts significantly economic losses (Hashem *et al.,* 2001). The larvae of the fruit flies feed on the pulp of ripe fruits forming tunnels inside them causing a great damage and make fruits unfavorable for marketing and exportation (White and Elson-Harris, 1992).Adults of *C. capitata* and *B. zonata* were recorded infesting fig fruits at the north-western coast region and Fayoum governorate (Saafan *et al.,* 2000 and Saafan *et al.,* 2006, El-Wakked and Mohamed 2009).

Adult flies of *C. capitata* have been observed foraging for food throughout most of the day on fig and non-host foliage as well as on the figs themselves (Hendrichs *et al.,* 1991), perhaps searching for the nitrogen present in fig fluids (Hendrichs and Hendrichs, 1990). Moreover, nearby orchards of fig trees influenced on capture of fruit flies in citrus orchards by increasing for most of the year but particularly in September and October (Alemany *et al.,* 2006 and Alonso-Muñoz *et al.,* 2008). In Montenegro, figs and persimmons (although without economic importance) are very important for breeding of the fly *C. capitata* in early summer and early autumn. Figs are the first infested fruits in the season (July and August) (Radonjić, 2012). While, in Iraq, the highest numerical density of the *C.capitata* flies in figs orchards was in August 2009 (Khalaf *et al.,* 2012).

Fig fruits complete their maturity and ripening during the period from June to December coinciding with significant variations of weather factors, particularly, temperature which may affect the fruit flies activity. This paper was contributed to saving more information about the occurrence of *B. zonata* and *C. capitata* flies in a fig cultivated areas in Fayoum governorate in relation with the effect of some weather factors on their activity and estimating the fruit flies infestation percentage throughout the two successive seasons 2016 and 2017.

MATERIALS AND METHODS

The study was carried out in Fayoum governorate, Fayoum district (Dar Al-Ramad and Menshiat Abedullah) during two successive seasons (2016 and 2017). Six plantation areas of fig trees distributed randomly surrounding by different types of field crops, vegetables, mango, guava, mandarin and date palm trees. The minimal distance among selected plantations was about 250 m, while, their cultivate areas ranged 1-2 feddans. Fig trees are cultivated in Fayoum governorate in condensed cultivations with an adjacent distance of 50-70 cm. Fig trees have two crops per year; the first and largest crop appears on August and September(summer crop) and the second crop is usually ripening during October and November extended sometimes to December (autumn crop).

Monitoring of *B. zonata* and *C. capitata* Populations*:*

For monitoring *B. zonata* males, six Jackson sticky traps (according to Harris

et al., 1971) were baited with a mixture of methyl eugenol (as a male lure of *B. zonata*) and technical malathion (as a toxicant agent) in the ratio of 8:2, respectively. Also, an equivalent number of the same trap was baited with trimedlure (as male lure of *C. capitata*). The traps were hung on some scattered trees (mango or *ficus nitida*) that are cultivated internally or around fig plantations at a height of approx., 1.75-2.50 m. and alternatively distributed in the orchards. Traps were installed during the last week of April and inspected weekly with replacing the sheets and replenished with the mentioned attractants by injection the cotton wick by medical syringe. The attracted males of both fruit flies were weekly counted and the mean captured flies per trap per day (FTD) was calculated.

Infestation Percentage Estimation:

Infestation symptoms of both fruit flies are so similar to be individually distinguished for each of them, therefore, the infestation percentages were estimated for both fruit flies together. Infestation percentages were estimated by examining at least 100 fig fruits randomly of each plantation area. The fruit infestation percent was estimated according to the infestation symptoms including females' stings, the watery spot and larvae observation. The infestation percent damage was determined as ratio of number of infested fruits per total of inspected fruits. Moreover, in order to recognize on the attacked fruit fly species, freshly infested fruits were collected and transferred to the laboratory in polyethylene bags. The infested fruits were placed on plastic containers over a layer of soft sand (2-3 cm) until larvae pupation. The produced pupae for each infested fruits were reserved in plastic tubes until emergence to identify the adult of *B. zonata* and *C. capitata.*

Effect of Weather Factors on Population Fluctuations:

The daily means of maximum temperature, minimum temperature and relative humidity were obtained from Fayoum Meteorological Station. The daily records of each weather factor were grouped into weakly means according to the date of traps inspection. Data obtained were subjected to simple correlation analysis using SPSS ® software programme (ver. 19).

RESULTS AND DISCUSSION

Population Fluctuations of *B. zonata* and *C. capitata:*

1-The 1st season (2016):

Data presented in Fig. (1) shows the population fluctuations of *B. zonata* and *C. capitata* during the 1st season(2016) in Fayoum governorate. The males of *B. zonata* were firstly trapped during the 2nd week of May with a low value of FTD (0.02 fly/trap/day), this existence continued fluctuating to reach 0.29 fly/trap/day during the ultimate week of August. The highest level of *B. zonata* population was observed during the 2nd week of October with a mean value of FTD of 0.48 fly/trap/day. Hence, the population declined gradually recording 0.05 fly/trap/day during the ultimate week of December. On the other side, *C. capitata* males recorded their 1st appearance on fig orchards during the 4th week of August with a mean FTD value of 0.02 fly/trap/day following by a gradual increase to reach their 1st peak on the 3rd week of September with a mean FTD of 0.38 fly/trap/day. Hence, the flies decreased to with a mean FTD value of 0.17 fly/trap/day on the 1st week of October.

C. capitata males fluctuated during October, November and December in the higher density of the previous months to record their 2nd and highest peak during the 1st week of November with a mean FTD of 0.74 fly/trap/day.

2- The 2nd Season (2017):

Data presented in Fig. (2) shows the population fluctuations of *B. zonata* and *C. capitata* during the 2nd season(2017) in Fayoum governorate. Similarly to the previous season, the *B. zonata* males were observed firstly during the 4th week of May with a mean FTD of 0.05 fly/trap/day continuing their existence in low numbers during June weeks. Two peaks of B. *zonata* males were observed during the 1st week of September and 2nd week of October with a mean FTD values of 1.31 and 1.24 flies/trap/day. The population decreased gradually to record their last appearance during the last week of December with a mean FTD of 0.26 fly/trap/day. Regarding the *C. capitata* population, the flies were firstly trapped during the 3rd week of September with a mean FTD of 0.05 fly/trap/day later than the 1st season. Two peaks of *C. capitata* flies were observed during the 2nd week of November and 1st week of December with respective means FTD of 0.55 and 0.62 fly/trap/day.

Data revealed that existence of *B. zonata* population in earlier time during the period from June till October compared to the appearance of *C. capitata* which was almost abundant from last weeks of October till December. Besides being one of the most significant hosts of fruit flies, fig fluid represents an important source of exogenous nitrogen for adult *C. capitata* (Hendrichs and Hendrichs, 1990). The fecundity and longevity of flies feeding on figs have been shown to be relatively high (Hendrichs *et al*., 1991). *B. zonata* is shown to increase gradually coinciding with fruits development against ripening stage during July and August, while the followed fluctuations of both fruit flies during the following months may be affected by the migratory flies from nearby orchards that previously infested or the emerged flies of early fig infested fruits for each season. The higher numbers of *B. zonata* that were recorded during the 2nd season compared to the previous season may be due to low efficiency of *B. zonata* control applications. Reduction of attracted numbers of both fruits flies on fig orchards may be affected by coinciding mango and guava fruiting during this period of the year, also, availability of mango fruits in high cultivated areas neighbored to fig orchards (Amin, 2008).

The obtained data are in agreement with that of Saafan *et al*., 2000 who indicated existence of *C. capitata and B. zonata* in fig orchards from July to December, at the north-western coast of Egypt. Also, Saafan *et al.,* 2006 who pointed out that *C. capitata* and *B. zonata* were observed in lower numbers compared to that recorded on peach and guava orchards. *C. capitata* flies are abundant in early summer and early autumn in Montenegro (Radonjić, 2012). Also, in Iraq, the highest numerical density of the *C.capitata* flies in figs orchards was in August (Khalaf *et al.*, 2012).

B. Infestation Percentage Determination:

Data in Table 1 presents the field estimation of fig fruits infestation, mean numbers of obtained fruit flies pupae and emerged adult of *B. zonata* and *C. capitata* infested fig fruits that were sampled during successive seasons of 2016 and 2017 in Fayoum governorate. During the 1st season (2016), the obtained data revealed that the 1st infestation by the mentioned fruit fly fertile females was observed on the 1st week of August with a mean of 1.15%, while, the highest mean percentage was

observed during the 1st week of October with a mean of 4.32% that maybe occurred by *B. zonata* females indicating by the emerged flies of *B. zonata* flies from sampled infested fruits during this week, the fig fruits infestation by *B. zonata* females continued until the 1st week of November, while, *C. capitata* females started to attack fig fruits during the 4th week of October and continued until the 3rd week of November coinciding with end of fig fruits harvesting. The highest mean number of obtained pupae was recorded during the 3rd week of September with a mean of 4.53 pupae/infested fruit. Concerning the 2nd season(2017), fig fruits were infested firstly by *B. zonata* with a mean percentage of 2.24% during the ultimate week of July and continued until the 1st week of November. The highest mean percentage of fig fruits was recorded during the 1st week of September with a mean of 5.42%. *C. capitata* infestation on fig fruits was observed firstly during the 2nd week of October and continued until the 2nd week of December coinciding with end of fig fruits harvesting. The highest mean number of obtained pupae was observed during the 1st week of August which absolutely due to *B. zonata* flies.

Generally, *B. zonata* was the most abundant fruit flies that attacking fig fruits, however, *B. zonata* flies were not observed attacking fruits during the last weeks of November, thus maybe affecting by gradual decrease of their population under temperature reduction during this period of the year. On the other hand, ability of *C. capitata* for attacking fig fruits was clearly observed beginning from October during the two studied seasons which may be due to the suitability of weather factors for their activity.

The obtained results are in agreement of Saafan *et al.*, 2006 who indicated that the infestation rate of both fruit flies on the fig fruits was lower than that of peach and guava fruits, while, El-Wakked and Mohamed (2009) pointed out the fig was the highest infested-fruits by both of *B. zonata* and *C. capitata* during August and September. In Montenegro, figs are the first infested fruits in the season (July and August) (Radonjić, 2012).

Effect of Weather Factors on Population Fluctuations:

As shown in Fig. (1) and (2) the weekly changes of maximum temperature, minimum temperature and relative humidity% during May-December of the two successive seasons 2016 and 2017, while, data in Table (1) presents the correlation analysis of weather factors (Max. temp., Min. temp. and R. H%) and the weekly attracted males of *B. zonata* and *C. capitata* trapping expressing by FTD values on fig trees in Fayoum governorate during the two successive seasons 2016 and 2017. The obtained data indicated that the studied weather factors varied in their influence on activity of mentioned both fruit flies. Concerning *B. zonata* flies, both of maximum and minimum temperatures correlated insignificantly with the trapped male flies during the two studied seasons, while, the relative humidity % correlated positively insignificantly on *B. zonata* males activity during the 1st season($r= 0.333$, $P<0.05$), while, during the second season, it effected positively significantly($r= 0.398$, $P<0.05$) On the other side, the value of the coefficient of correlation between the *C. capitata* males population and the weather factors of the two successive seasons indicated a significant negative association with maximum and minimum temperatures ($P<0.01$). Relative humidity reflected a significant positive correlation ($P<0.01$) with the population of the fruit fly.

Weather factors were not entirely the major factors that controlling the population fluctuations of *B. zonata* and *C. capitata*(Afia, 2007 and Amin, 2008), fruit maturation may also affect, guava rate of maturation was the most independent

variables for attracting *B. zonata* adults during summer season (Darwish *et al.*, 2014). However, development of fig fruits including maturity and ripening stages during the period from July to December presents a state that the weather factors could be influence population density either negatively or positively supporting. The obtained data ensure such suggestion, particularly, under temperature reduction that starting from that last week of October to December coinciding with *C. capitata* activity, the significant effect of temperature maybe acceptable.

On the other side, the insignificant effect of both maximum temperature and minimum temperature on *B. zonata* males maybe due for being the recorded weekly temperature fluctuated around the activity range of *B. zonata* except that of December last weeks. Effect of weather factors on population activity of *B. zonata* were varied according to the study area, host suitability and host ability for infestation. In Sohag, the prevailing weather factors were varied in its significant on *B. zonata*, but the efficiency of these factors were maximum temperature came first (Mohamed 2002). Also, in Assuit, significant positive correlation of *B. zonata* population was noted with maximum and minimum temperature, while, relative humidity negatively correlated for two years recorded with the fly catch (Ali *et al.*, 2011).

Moreover, in order to understand the effect of weather factors on fruit flies population, Fletcher (1989) mentioned that temperature plays a dominant role in the rate of development of immature stages of *B. zonata* and consequently determines the timing of population increase. Afia (2007) reported some biological aspects that may be demonstrate the current status. The range of temperature 20-35°C was the suitable for preoviposition period of *B. zonata*, while, the range of 15-30°C was suitable for *C. capitata*. The oviposition period was generally longer for *C. capitata* than *B. zonata* at low temperature (15-30°C). In other words, the available temperature may be support completion of sexual maturity and also inhibiting the flies activity. Moreover, Ducky *et al.*, (2004) reported that ovarian maturation of *B. zonata* was obtained only over a very narrow range of temperature (25–30°C).

In the conclusion, maturity and ripening of fig fruits under different weather factors, especially, temperature indicated the effect of weather factors on activity of fruit flies. *B. zonata* flies were the abundant during period of summer season and its population reduced under effect of temperature reduction during autumn season(October and November). While, *C. capitata* flies were almost absent or observed in lower numbers compared to that of *B. zonata* during the summer season, while, under temperature reduction during autumn season, the flies were observed in relative numbers to *B. zonata*. Cultivation of fig under condensed plantations maybe make fruit flies controlling more complicated according to difficult movement internally the trees for partial bait spraying or removal the infested fruits. In same time, alternation of dominance fruit flies on fig fruits requires more of attention that should be paid to activate control techniques by using male inhalation applications or saving an alternative method of partial bait spray that could be applicable and efficient under the condensed plantations of fig trees.

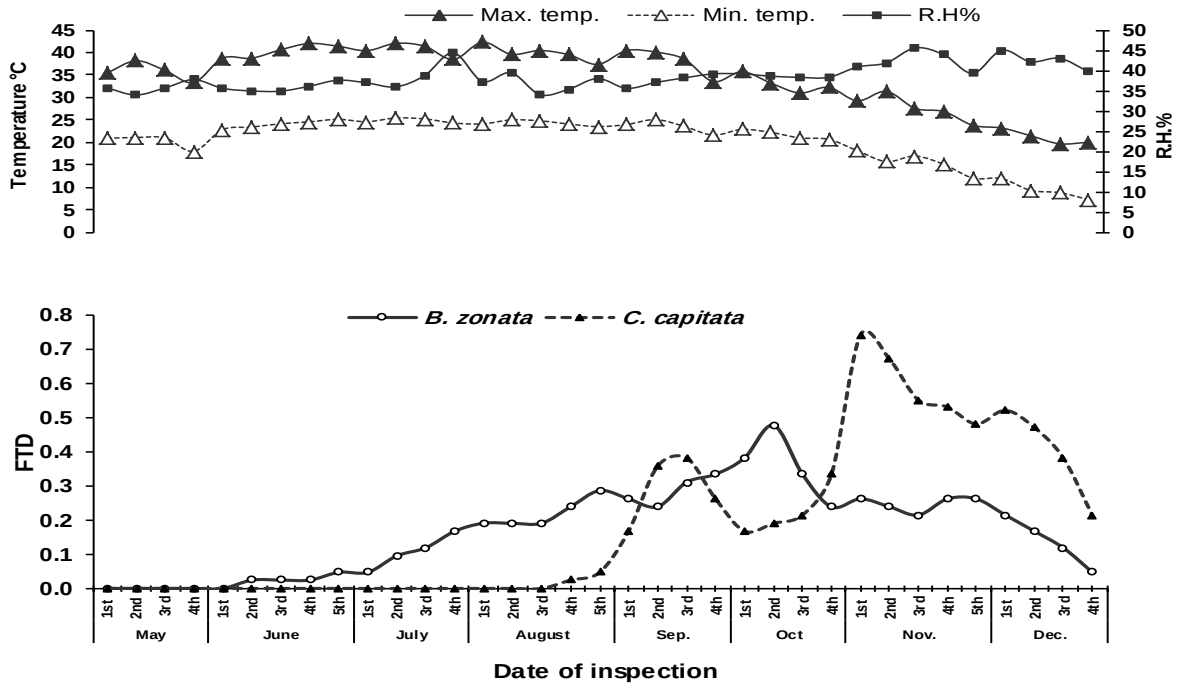

Fig. (1) : Captured flies / trap / day (FTD) of *B.zonata* and *C. capitata* males in fig orchards and weekly means of Max., Min. temp. and R. H.% in Fayoum Governorate during season of 2016.

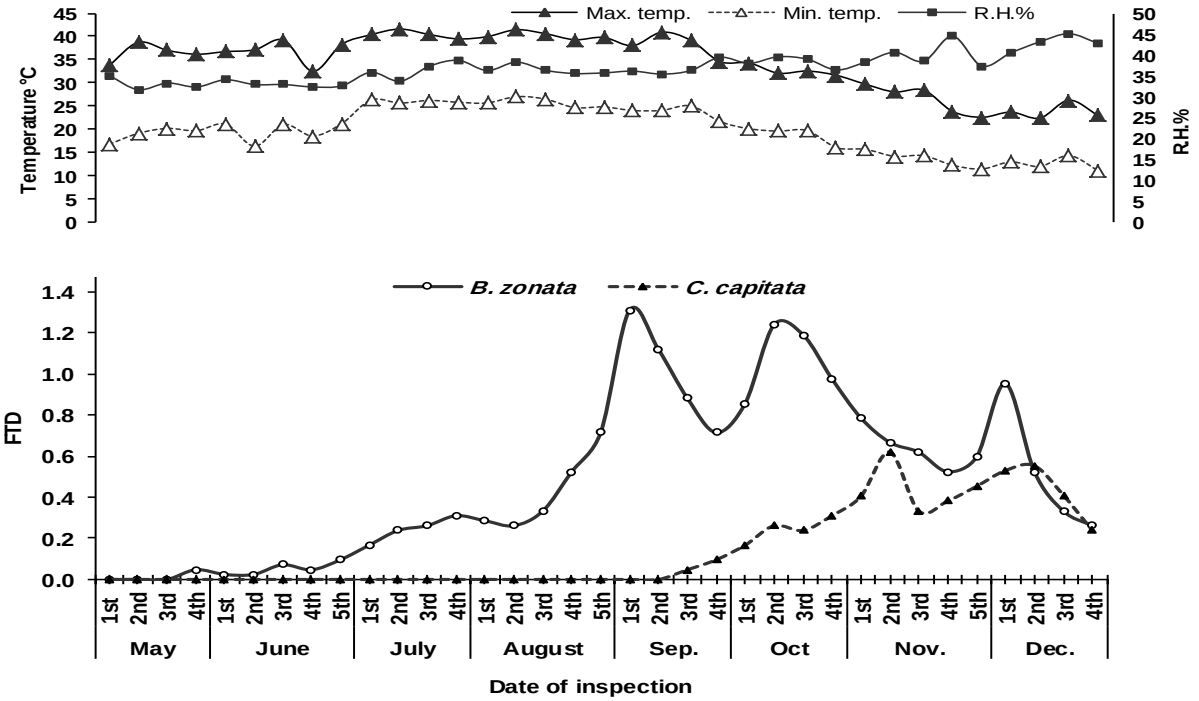

Fig. (2) : Captured flies / trap / day (FTD) of *B.zonata* and *C. capitata* males in fig orchards and weekly means of Max., Min. temp. and R. H.% in Fayoum Governorate during season of 2017.

Table (1): Infestation % and man no. of emerged adults of *B. zonata* and *C. capitata* / infested fig fruits during the two successive seasons 2016 and 2017 in Fayoum governorate.

Date of sampling			Infestation %	No. of collected infested fruits	Mean no. of obtained pupae / infested fruit	Mean no. of emerged adults/ infested fruit	
Season	Month	Week				*B. zonata*	*C. capitata*
2016	August	1st	1.15	42	2.93	2.74	0.00
		2nd	1.88	38	3.76	3.37	0.00
		3rd	1.70	66	3.26	3.08	0.00
		4th	2.38	110	3.04	2.71	0.00
		5th	2.64	108	3.27	2.64	0.00
	Sep.	1st	2.80	115	3.32	2.13	0.00
		2nd	3.24	123	3.76	3.28	0.00
		3rd	3.70	113	4.53	3.92	0.00
		4th	3.38	105	4.36	3.98	0.00
	Oct.	1st	4.32	124	3.35	3.09	0.00
		2nd	3.92	118	3.31	3.03	0.00
		3rd	3.76	88	3.55	3.20	0.00
		4th	4.08	92	3.10	2.08	0.72
	Nov.	1st	3.65	72	3.78	2.26	1.28
		2nd	2.37	80	3.03	0.00	2.71
		3rd	1.68	63	3.68	0.00	3.44
		4th	0.00 *	-	-	-	-
2017	July	4th	2.24	27	4.22	4.04	0.00
	August	1st	2.12	48	4.48	4.31	0.00
		2nd	3.18	78	3.69	3.56	0.00
		3rd	2.82	93	3.53	3.39	0.00
		4th	3.46	124	3.91	3.81	0.00
		5th	4.66	118	3.72	3.64	0.00
	Sep.	1st	5.42	142	3.61	3.55	0.00
		2nd	4.62	135	3.48	3.35	0.00
		3rd	4.25	143	3.81	3.62	0.00
		4th	3.83	139	3.09	2.93	0.00
	Oct.	1st	4.45	110	3.38	3.20	0.00
		2nd	5.12	122	3.16	2.36	0.96
		3rd	4.66	88	3.53	1.44	1.89
		4th	4.48	107	3.13	0.82	2.03
	Nov.	1st	3.15	92	3.42	0.71	2.51
		2nd	3.88	75	3.65	0.00	3.57
		3rd	3.62	87	4.45	0.00	4.32
		4th	4.17	48	3.87	0.00	3.65
		5th	3.87	58	3.45	0.00	3.22
	Dec	1st	2.54	55	3.78	0.00	3.71
		2nd	2.68 *	37	3.11	0.00	3.05

* End of fruit harvesting

Table 2 . Simple correlation between population of *B. zonata* and *C. capitata*, and the weather factors (Max. temp., min. temp. and R. H. %) for the two seasons 2016 and 2017 in Fayoum governorate.

Fruit fly	Season	Predictors variables	r	*p*
B. zonata	**2016**	Max. temp.	-0.194	٠,265
		Min. temp.	-0.014	0.936
		R.H.%	0.333	0.051
	2017	Max. temp.	-0.227	0.190
		Min. temp.	-0.065	0.710
		R.H.%	0.398	0.018
C. capitata	**2016**	Max. temp.	-0.707	٠,٠٠٠
		Min. temp.	-0.639	٠,٠٠٠
		R.H.%	0.691	٠,٠٠٠
	2017	Max. temp.	-0.885	٠,٠٠٠
		Min. temp.	-0.789	٠,٠٠٠
		R.H.%	0.739	٠,٠٠٠

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ARABIC SUMMARY

تقلبات التعداد ومعدلات الاصابة لذبابتي ثمار الخوخ وفاكهة البحر المتوسط على ثمار التين وعلاقتها مع الظروف الجوية السائدة في محافظة الفيوم

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تُصاب ثمار الفاكهة المصرية بذبابتي ثمار الخوخ وفاكهة البحر المتوسط مما يسبب لها خسائر بالغة وفي محافظة الفيوم تزرع أشجار التين بطريقة مكثفة لتؤتي ثمارها خلال محصولين متداخلين خلال الفترة من يوليو الى ديسمبر من كل عام. وقد أجريت هذه الدراسة لتوفير مزيد من المعلومات عن التواجد الموسمي لذبابتي ثمار الخوخ وفاكهة البحر المتوسط على ثمار التين وتأثير العوامل الجوية على نشاطهما وكذلك تقدير النسبة المئوية للإصابة بهما. وخلال الموسم الأول (2016) سجل أعلى تعداد لذبابتي ثمار الخوخ وفاكهة البحر المتوسط في الاسبوع الثاني من أكتوبر والاسبوع الأول من نوفمبر بمتوسطي 0.48 و 0.74 ذبابة/ مصيدة / يوم على الترتيب بينما خلال الموسم الثاني من الدراسة (2017) سُجلت قمتي التعداد للذبابتين في الاسبوع الأول من سبتمبر والاسبوع الثاني من نوفمبر بمتوسطي 1.31 و 0.62 ذبابة/ مصيدة / يوم على الترتيب. وفي الموسم الأول سُجلت أعلى نسبة مئوية لإصابة ثمار التين بذبابة ثمار الخوخ بمتوسط 4.32% خلال الاسبوع الأول من أكتوبر واستمرت الاصابة بذبابة ثمار الخوخ حتى الاسبوع الأول من نوفمبر بينما بدأت الاصابة بذبابة فاكهة البحر المتوسط من الاسبوع الرابع من أكتوبر واستمرت حتى نهاية حصاد الثمار في الاسبوع الثالث من نوفمبر. وفي الموسم الثاني من الدراسة سجل أعلى معدل من الاصابة على ثمار التين في الاسبوع الأول من سبتمبر بمتوسط 5.42% وسجلت أول اصابة بذبابة فاكهة البحر المتوسط في الاسبوع الثاني من أكتوبر واستمرت حتى الاسبوع الثاني من ديسمبر تزامناً مع نهاية حصاد الثمار. وعن تأثير العوامل الجوية على نشاط ذبابة ثمار الخوخ خلال موسمي الدراسة فقد كان الارتباط موجباً وبدون معنوية بين كل من درجتي الحرارة العظمى والصغرى ومعدل الجذب اليومي للذكور لموسمي الدراسة فحين اثر متوسط الرطوبة النسبية ايجاباً وبدون معنوية خلال الموسم الأول وايجاباً وبمعنوية خلال الموسم الثاني وعلى الجانب الأخر فقد كان هناك ارتباط سالباً ومعنوياً بين كل من المتوسطات الاسبوعية لدرجتي الحرارة العظمى والصغرى ومعدلات الجذب اليومي لذبابة فاكهة البحر المتوسط فحين كان الارتباط موجباً ومعنوياً بين متوسط الرطوبة النسبية ومعدلات الجذب اليومي لذبابة فاكهة البحر المتوسط.