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Delimiting survey and seasonal activity of peach fruit fly, *Bactrocera zonata* and Mediterranean fruit fly, *Ceratitis capitata* (Diptera: tephritidae) at El-Beheira Governorate, Egypt

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ABSTRACT

Peach fruit fly (PFF), *Bactrocera zonata* (Saunders) and Mediterranean fruit fly (MFF) are the most destructive insect pests of fruit and vegetables in Egypt. The current study was carried out over two successive years; 2012 and 2013 in thirteen districts of El-Beheira governorate and aimed to conduct a delimit survey and monitor the seasonal activity of PFF and MFF populations. The results showed that the PFF was recorded in almost all of the examined districts except for Edko district. Moreover, the PFF was not found in El-Mahmodiya district throughout the second study period, while the MFF was spread throughout all tested districts at both years. Inter–site comparison revealed significant differences in the abundance of PFF and MFF across the tested districts during 2012 and 2013 seasons. A significant positive correlation was reported between the population activity of PFF and MFF through 2012 (r=0.34), while a non-significant positive correlation (r=0.24) was obtained in 2013. Population growth rate (r_0) of PFF was higher than that of the MFF through the first interval of population increase through both 2012 and 2013 seasons; 1.02 and 0.17 for PFF, and 0.83 and 0.13 for MFF, respectively. The r_0 values of the MFF was higher than the PFF through the second interval of increase through both tested seasons; 1.04 and 1.10 for MFF, and 0.16 and 0.21 for PFF. It could be concluded that these two insects exchange their role as a key-pest of fruit hosts along the tested seasons.

Keywords: Fruit flies, Peach fruit fly; *Bactrocera zonata*, Mediterranean fruit fly; *Ceratitis capitata*, Ecology

INTRODUCTION

Fruit flies (Diptera: Tephritidae) are arguably the most destructive insect pests of fruits and vegetables throughout the world. The dipteran family Tephritidae includes of over 4000 species and nearly 700 species belong to the Dacinae fruit flies (Fletcher, 1987), of which the Peach Fruit Fly (PFF), *B. zonata* (Tephritidae: Dacini) originated in South and South-East Asia (Agarwal *et al*., 1999). The first record of PFF in Egypt was in 1990s in Kalubia governorate (East of Cairo, Egypt) in 1993 at

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guava (*Psidium guajava*) plants (De Meyer *et al*., 2007). Currently, it had become widespread all over Egypt and on many host plants (El-Minshawy *et al*., 1999; Hashem *et al*., 2001; Draz *et al*., 2002; OEPP/EPPO, 2005; El-Gendy and El-Saadany, 2012). Mediterranean Fruit Fly (MFF), *C. capitata* (Tephritidae: Tephretini) was originated in Sub-Saharan Africa and spread throughout the Mediterranean region including Egypt (CABI, 1999).

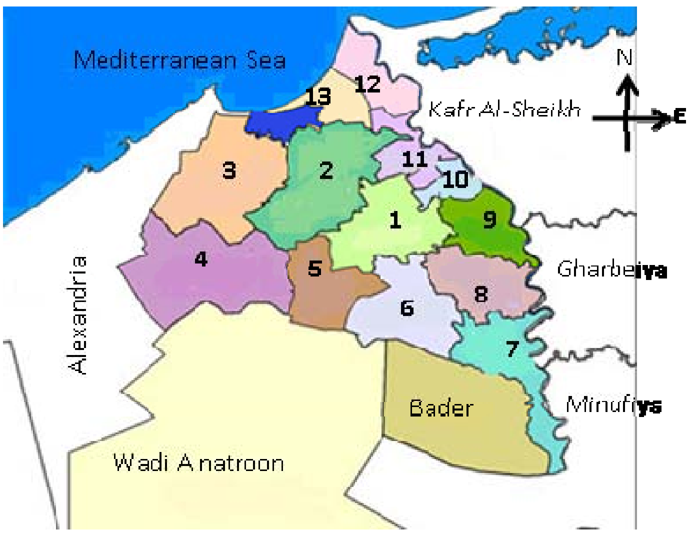
The PFF and MFF are serious pests of ripped fruits in Egypt, they are polyphagous insects and they almost have the same host plants, particularly peach, guava, mango, and citrus (Duyck *et al*., 2008). Specifically, the MFF attacks more than 300 different fruit species (Liquido *et al*., 1991), while the PFF attacks more than 40 host plants. Adults of MFF survive a long time in the field and they disperse rapidly when no mature fruits available in a particular area (Fletcher, 1989). In Egypt, the PFF is an active insect-pest throughout the year with the exception of cold months, especially January (Draz *et al*., 2002).

The phenology and population dynamics of fruit flies have been studied extensively in the tropics, but at less extend in temperate areas that lay within the Northern and cold areas of its current geographical distribution (Dhillon *et al*., 2005). Current research aimed to study the distribution, seasonal activity pattern, and the natural balance of both PFF and MFF populations at El-Beheira districts at North of Egypt.

MATERIAL AND METHODS

Study Area

The study was conducted at El-Beheira governorate (total area of 9,826 Km2) (Map 1), which is a coastal governorate and located at the West of Nile Delta. It shares borders with Mediterranean Sea (South), Alexandria (North-West), Matrouh (South West), Kafr Al-Sheikh, Gharbeiya, and Minufiya (East), and Giza (South). The study was conducted in thirteen districts of El-Beheira governorate, which has the largest agricultural activity and area in Egypt (Map 1 and Table 1).



Map 1: Study locations at El-Beheira governorate.1; Damanhour, 2; Abo-Homos, 3; Kafr-El-Dawar, 4; Abo-El-Matamer, 5, Hosh-Essa, 6, Al-Dalangat, 7; Kom-Hamada, 8; Itay-El-Baroud, 9; Shubrakhite, 10; Al-Rahmaniya, 11; El-Mahmodiya, 12; Rashid, and 13; Edko.

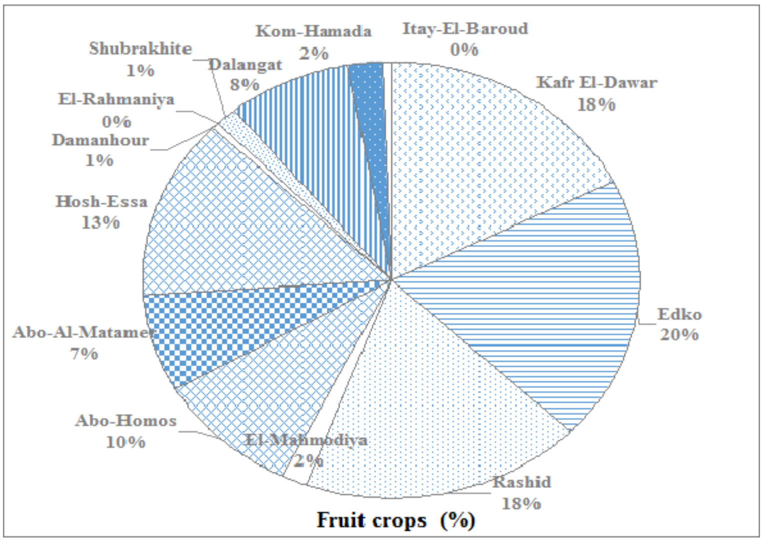


Fig.1: Total area percent of horticulture crops in the thirteen districts of El-Beheira Governorate during 2012 and 2013.

Table 1: Distribution of horticulture crops area (Feddan) at El-Beheira Governorate districts, through the 2012 and 2013.

District	Fruit Crops (Feddan)											
	Citrus Orchards					Peach	Apricot	Mango	Gauva	Apple	Kaka	Total
	Navel Orange	Mandarin	Sour Orange	Balady	Valencia							
Kafr El-Dawar	11722.2	-	50.0	156.2	21.1	-	0.6	161.1	2534.8	719.2	26.6	15391.8
Edko	1100.3	-	-	-	-	-	-	2647.3	12626.3	783.2	-	12157.1
Rashid	10177.2	-	100.0	1191.5	120.0	67.0	-	826.8	3219.3	465.0	-	16166.8
El-Mahmodiya	1038.4	22.2	-	-	8.0	27.2	-	11.0	248.2	4.0	-	1359.0
Abo-Homos	4712.4	50.0	156.0	40.0	143.2	-	-	194.1	2718.2	317.0	10.2	8341.1
Abo-Al-Matamer	2787.0	81.1	102.2	56.1	930.2	-	28.0	83.1	1725.4	517.0	62.0	6372.1
Hosh-Essa	8670.0	1258.0	739.0	543.0	219.0	-	-	6.0	165.0	-	23.0	11623.0
Damanhour	215.3	8.1	4.1	-	54.1	-	-	8.1	21.2	247.0	-	557.9
El-Rahmaniya	32.3	-	-	14	18.2	-	-	-	3.1	0.0	-	67.6
Shubrakhite	825.2	-	69.6	52.3	255.0	-	-	4.6	8.4	0.0	-	1215.1
Dalangat	3279.4	1769.1	351.2	400.8	755.2	4.5	24.0	369.1	37.1	0.0	60.0	7050.4
Kom-Hamada	548.1	525.1	3.3	2	174.1	305.0	-	238.2	4.0	112.0	14.1	1925.9
Itay-El-Baroud	176.2	48.2	11.2	70.13	81.2	-	-	1.8	13.7	9.0	-	441.4
Total	45584.3	3761.8	1586.6	2526.0	2779.2	403.7	52.6	4551.3	18324.7	3173.4	195.9	82669.2

Traps Distribution

Jackson traps **(Haris *et al*., 1971)** were randomly distributed in a completely randomized design (CRD) throughout the thirteen districts in a way to cover the district area. Each district has an equal number of traps for each fly species within the investigated location, which was distanced approximately 1000 – 2000 m from one location to the next one depending on mainly the number of horticulture crops density in the area (Figure 1 and Table 1) and towns (fruit markets, and back yard gardens). Each location had three traps (replicates) for each fly species (Table 2).

Monitoring the Population of Adult Peach Fruit Fly (PFF), *Bactrocera zonata* and Mediterranean Fruit Fly (MFF), *Ceratitis capitata*

Monitoring the population of adult insects of Peach Fruit Fly (PFF), *Bactrocera zonata* and Mediterranean Fruit Fly (MFF), *Ceratitis capitata* was conducted throughout two successive seasons; 2012 and 2013 using Jackson traps. Traps were baited with methyl eugenol lure for PFF and trimed-lure for MFF. Approx. 2.5 ml of the lures were applied on cotton wicks. The traps were hung on the tree canopy at 1.5-2 m above the ground at a distance of about 50 m apart for PFF and 25 m for MFF (El-Gendy, 2012). Traps were examined weekly and the cotton wicks with the lures were renewed once every month in winter and once every two weeks in the summer season. Trapped flies of both PFF and MFF were counted and expressed as number of capture male flies/trap/day (CTD) per each region.

Table 2: Number of locations of Jackson traps, which were placed at each investigated district of El-Beheira Governorate.

Trail district	No. of Locations*	
	MFF	PFF
Rashid	29	29
Edko	30	30
Kafr El-Dawar	39	39
El-Mahmodiya	19	19
Abo-Homos	25	25
Hosh-Essa	21	21
Abo El-Matamer	19	19
Damanhour	22	22
Itay-El-Baroud	20	20
El-Rahmaniya	19	19
Shubrakhite	29	29
Dalangat	39	39
Kom-Hamada	24	24

*Within each location there were three replicates (three Jackson traps).

The growth rate of the population (r_0) and relative abundance of species (RA %) were calculated using the following formula (Putman and Wratten, 1985) :

$r_0 = \Delta N / \Delta T * N_0$

RA (%) = $\sum$ N of species A* 100/ $\sum$ N of all recorded species

Meteorological Data

Daily weather data of the meteorological parameters; maximum- and minimum-temperature and relative humidity were collected from El-Dalangat weather station throughout 2012 and 2013 seasons. El-Dalangat weather station covers the area of El-Beheira Governorate.

Statistical Analysis

Statistical analyses were achieved using CoStat (CoHort software, USA). The data were transformed to ln(x+1) to reduce heterogeneity of variances and analyzed with one-way ANOVA as a completely randomized design and means were compared using the least significant difference (LSD) test. Spearman's of rank correlation was used for non-parametric data and Pearson for parametric data.

RESULTS

Geographical Distribution of PFF, *B. zonata* and MFF, *C. capitata* Flies

The PFF and MFF males were monitored at thirteen localities at El-Beheira governorate over two successive seasons, 2012 and 2013. Data of trapped flies (Table 3) showed that the PFF population occurred in almost all of the tested districts; Rashid, Kafr El-Dawar, El-Mahmodiya, Abo-Homos, Hosh-Essa, Abo El-Matamer, Damanhour, Itay El-Baroud, El-Rahmaniya, Shubrakhite, Dalangat and Kom-Hamada, while Edko district was fly-free during both tested seasons (2012 and 2013). As well as, it was absent from El-Mahmodiya district in 2013. With respect to the MFF, it was recorded at all of the tested districts throughout both of the tested seasons; 2012 and 2013.

Table 3: Occurrence of PFF, *B. zonata* and MFF, *C. capitata* males at El-Beheira Governorate districts through the 2012 and 2013 seasons.

District	PFF		MFF	
	2012	2013	2012	2013
Rashid	+*	+	+	+
Edko	-**	-	+	+
Kafr-Dawar	+	+	+	+
El-Mahmodiya	+	-	+	+
Abo-Homos	+	+	+	+
Hosh-Essa	+	+	+	+
Abo El-Matamer	+	+	+	+
Damanhour	+	+	+	+
Itay-El-Baroud	+	+	+	+
El-Rahmaniya	+	+	+	+
Shubrakhite	+	+	+	+
Dalangat	+	+	+	+
Kom-Hamada	+	+	+	+

*the fly was present, **the fly was absent.

Inter–Site Comparison of PFF, *B. zonata* and MFF, *C. capitata* Abundance

Data presented in Table (4) showed significant differences in the annual mean density numbers of both PFF and MFF between the tested districts at both 2012 and 2013 seasons. Where, MFF was more prevailing than the PFF at most districts during the tested period. During 2012, the highest relative abundance (RA%) of recorded fruit flies was obtained for MFF at El-Mahmodiya district with 99.63 % of the total recorded flies of PFF and MFF, followed by 97.98, 97.59, 90.63, 89.44, 83.93, 81.31, 77.15, 62.48, 54.34 and 53.15 % at Rashid, Abo-Homos, Kafr El-Dawar, Shubrakhite, El-Rahmaniya, Hosh-Essa, Damanhour, Abo El-Matamer, Kom-Hamada, and Itay-El-Baroud districts, respectively. On the other hand, the MFF was the predominant fly at Edko district and the PFF was absent. Whereas, the PFF was the major fly at Dalangat district with 82.16 % of the total recorded flies of PFF and MFF. The statistical analysis showed significant differences in the abundance of PFF (df= 12, f= 107.89, $P \leq 0.000$) and MFF (df= 12, f= 38.57, $P \leq 0.000$) across the tested districts.

Table 4: Annual mean numbers ± SD of PFF, *B. zonata* and MFF, *C. capitata* males at El-Beheira Governorate districts through the 2012 and 2013 seasons.

District	PFF		MFF	
	2012	2013	2012	2013
Rashid	0.011 ± 0.05^{e}	0.008 ± 0.06^{de}	0.536 ± 0.88^{b}	1.183 ± 2.84^{a}
Edko	0.000 ± 0.00e	0.000 ± 0.00^{e}	0.210 ± 0.15^{d}	0.326 ± 0.43^{ef}
Kafr El-Dawar	0.006 ± 0.07^{e}	0.004 ± 0.04^{e}	0.058 ± 0.59^{e}	0.034 ± 0.38^{h}
El-Mahmodiya	0.001 ± 0.01^{e}	0.000 ± 0.00^{e}	0.132 ± 0.30^{de}	0.173 ± 0.27^{g}
Abo-Homos	0.008 ± 0.06e	0.029 ± 0.13^{de}	0.325 ± 0.93^{e}	0.589 ± 1.25^{c}
Hosh-Essa	0.123 ± 0.48^{d}	0.077 ± 0.15^{c}	0.535 ± 2.06^{b}	0.302 ± 0.93^{efg}
Abo El-Matamer	0.239 ± 0.82^{c}	0.079 ± 0.18^{c}	0.398 ± 1.36^{bc}	0.522 ± 1.03^{cd}
Damanhour	0.098 ± 0.37^{d}	$0.041 \pm .17^{cde}$	0.331 ± 2.10^{c}	0.629 ± 2.40^{c}
Itay-El-Baroud	$0.141 \pm .66^{cd}$	0.076 ± 0.20^{c}	0.160 ± 0.73^{d}	0.390 ± 1.30^{de}
El-Rahmaniya	0.081 ± 0.40^{de}	0.042 ± 0.35^{cde}	0.423 ± 2.09^{bc}	0.528 ± 2.76^{cd}
Shubrakhite	0.100 ± 0.31^{d}	0.043 ± 0.14^{cd}	0.847 ± 2.21^{a}	0.969 ± 1.92^{b}
Dalangat	0.972 ± 2.07^{a}	0.543 ± 1.28^{a}	0.211 ± 0.73^{d}	0.242 ± 0.61^{fg}
Kom-Hamada	0.389 ± 0.93^{b}	0.182 ± 0.25^{b}	0.463 ± 0.91^{b}	0.272 ± 0.41^{efg}
Mean ± SD	0.183 ± 1.07	0.099 ± 0.49	0.333 ± 1.27	0.449 ± 1.46
$LSD_{0.05}$	0.13	0.06	0.16	0.18

Means followed with the same superscript letter(s) were not significantly different according to the $LSD_{0.05}$ multiple comparison test.

Also, in 2013 the highest RA (99.33 %) was recorded for the MFF at Rashid area. Followed by, 95.75, 95.30, 93.88, 92.63, 89.47, 86.85, 83.69, 79.68, and 59.90 % at Shubrakhite, Abo-Homos, Damanhour, El-Rahmaniya, Kafr El-Dawar, Abo El-Matamer, Itay-El-Baroud, Hosh-Essa, and Kom-Hamada districts, respectively. In addition, MFF was the dominant fly at both Edko and El-Mahmodiya compared to PFF. In contrast, the PFF was the dominant fly compared at Dalangat district with RA 69.24 %.

On the other hand, there were significant differences in the population abundance of PFF (df= 12, f= 161.06, $P \leq 0.000$) and MFF (df= 12, f= 63.60, $P \leq 0.000$) across the tested districts. There was a weak correlation between the weekly mean numbers of PFF ((through 2012 (r=0.19, $P \leq 0.000$) and 2013 (r=0.22, $P \leq 0.000$)), MFF ((through 2012 season (r=0.06, $P \leq 0.000$)) and the tested locations. Whereas, no correlation was recorded between the weekly mean numbers of MFF and the tested locations during 2013 (r=0.01, $P \leq 0.08$).

Seasonal Fluctuation of PFF, *B. zonata* Compared to MFF, *C. capitata* through 2012 and 2013 Seasons

Monitoring the seasonal fluctuation of PFF and MFF males was extended from the first of January, 2012 to end of December, 2013. The data in Fig. 2 and 3 showed that both of PFF and MFF males were present with discrepancy in the population density throughout the study periods. In 2012 season, the PFF population was low during the winter to the end of spring and increased from the 20th week with peaks of increase at the 32nd, 38th, 41st, 43rd 46th and 47th weeks. It was clear that the PFF population had two intervals of increase, the first was from the 20th to 43rd week (r_0 (Population growth rate)) = 1.02) and the second was from 45th to 47th week (r_0= 0.16), so it had a uni-pattern model through this season. Also, the MFF had a low density at the winter season, but it was higher than the density of PFF. It began to increase early at the first of spring (13th week) to peak at 21st, 23rd, 25th and 27th weeks, and then decline to reach the lowest mean density number at the 40th week to peak at 46th, 47th and 49th weeks. There were two intervals of population increase in case of MFF, the first occurred at the 13th to 25th week (r_0= 0.83) and the second was from 41 to weeks 49th (r_0= 1.04), where it had bi-pattern model.

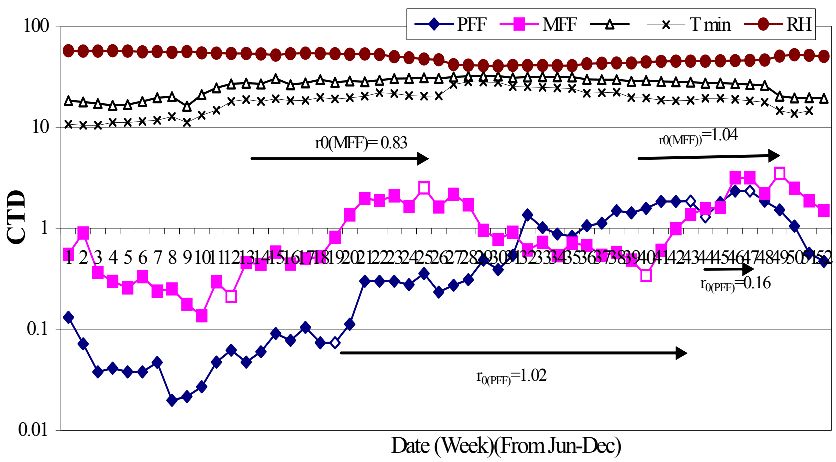


Fig. 2: Seasonal fluctuation of PFF, B. zonata and MFF, C. capitata males at E-Beheira Governorate through 2012.

The previous trend of population activity of both MFF and PFF was nearly repeated in 2013 season (Fig. 3). It was obvious that PFF fluctuated along the year to record peaks at the 22nd, 24th, 26th, 31st, 33rd, 36th, 41st, 43rd, 47th and 50th weeks. It was obvious that there was two intervals of increase; the first interval was from the 20th to 26th (r_0= 0.17), while the second was from 43rd to 50th week (r_0=0.21) in a uni-model pattern. On the other hand, the MFF started its activity early in winter with a peak at the 15th week and declined at the 22nd, 26th, 36th, 41st, 44th and 47th weeks. The data showed two intervals of population increase for the MFF; from the 12th to the 26th week (r_0= 0.12) and from the 36th to the 47th week (r_0= 1.01), where it had a bi-model pattern.

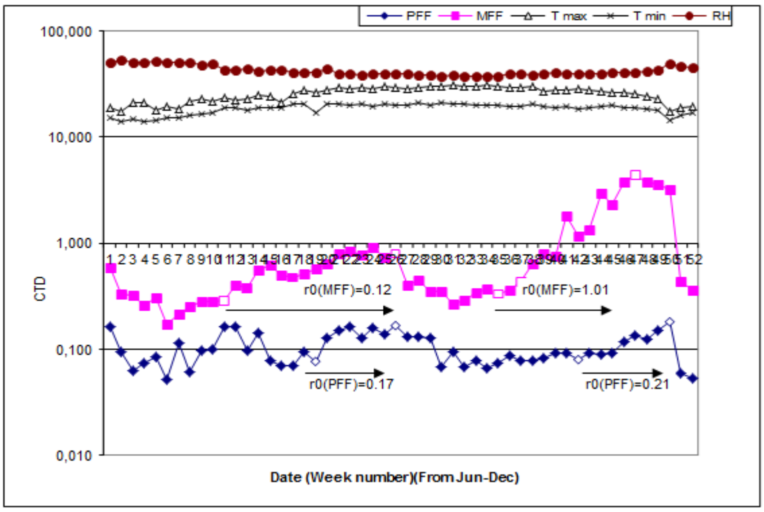


Fig. 3: Seasonal fluctuation of PFF, B. zonata and MFF, C. capitata males at El-Beheira Governorate through 2013.

It was clear from Fig. 2 and 3 that the population growth rate (r_0) of the PFF was higher than that of the MFF through the first interval of increase through both 2012 and 2013 seasons; 1.02 and 0.17 for PFF, and 0.83 and 0.12 for MFF. In contrast, r_0 values of the MFF was higher than the PFF through the second interval of increase through both tested seasons; 1.04 and 1.10 for MFF, and 0.16 and 0.21 for PFF. Accordingly, the PFF was the key-pest during the periods of occurrence of peach, guava, and mango fruits, while the MFF was the key-pest in the presence of orange fruits. We concluded based on results presented herein that these two insects exchange their role as a key-pest of fruit hosts along the tested seasons.

Generally, the average number of MFF increased from year to year was shown in Table 3. Numbers were from 0.332 to 0.449 CTY (capture/trap/year) at 2012 and 2013 seasons. In contrast, the numbers of PFF were decreased from 0.183 in 2012 to 0.099 CTY in 2013. A significant positive correlation was obtained between the population activity of MFF and PFF through 2012 (r=0.34, P≤0.01), while a non-significant positive correlation (r=0.24 P≤0.09) was obtained in 2013.

Effect of Abiotic Factors on Population Activity of *B. zonata* and *C. capitata*

In 2012 season, the correlation analysis (Table 5) of population activity of both PFF and MFF flies and weather factors revealed that the abiotic factors (max- and min- temperature and relative humidity (RH %)) were correlated significantly with the number of fruit flies of PFF. The population activity of PFF was positively correlated to both max- (r= 0.31*) and min- (r= 0.35*) temperatures, while it was negatively correlated to relative humidity (RH %) (r= -0.62***). The same trend was obtained for population activity of MFF and the abiotic factors but non-significant correlation. In

2013 season, population activity of both PFF and MFF flies and weather factors revealed that the tested abiotic factors were not significantly correlated with the number of fruit flies trapped of both PFF and MFF.

Table 5: Correlation coefficients and adjusted multiple regression among weekly mean numbers trapped of PFF, *B. zonata* and MFF, *C. capitata* and abiotic factors through 2012 and 2013 seasons at El-Beheira Governorate.

Season	Fruit flies	Abiotic Factor	Correlation Coefficients			R^2 (Adj.)	
			r	± SE	p		
2012	PFF	T°(max)	0.31	0.13	0.02*	0.50	0.000***
		T°(min)	0.35	0.13	0.01*		0.10 ^{ns}
		RH%	-0.62	0.11	0.000***		0.11 ^{ns}
	MFF	T°(max)	0.15	0.13	0.29 ^{ns}	0.61	0.000***
		T°(min)	0.18	0.14	0.20 ^{ns}		0.70 ^{ns}
		RH%	-0.24	0.13	0.08 ^{ns}		0.54 ^{ns}
		PFF	0.34	0.13	0.012*		
2013	PFF	T°(max)	0.013	0.14	0.92 ^{ns}	0.89	0.000***
		T°(min)	0.13	0.14	0.37 ^{ns}		0.007***
		RH%	-0..03	0.14	0.81 ^{ns}		0. 448 ^{ns}
	MFF	T°(max)	0.02	0.14	0.88 ^{ns}	0.43	0.000***
		T°(min)	0.07	0.13	0.61 ^{ns}		0. 214 ^{ns}
		RH%	-0.17	0.14	0. 20 ^{ns}		0. 495 ^{ns}
		PFF	0.24	0.12	0.09 ^{ns}		

r: correlation R^2: Adjusted multiple regression SE: Standard error *P*: probability level

Multiple regression analysis of trapped PFF and the abiotic factors explained 50 and 61 % of total variance of the population activity of PFF and MFF respectively was related to max- temperature in 2012. About 89 and 43 % of total variance of the population activity of PFF and MFF, respectively were related to temperature, through 2013 season. Max- and min- temperatures affective the PFF density, while the MFF abundance was affected only by the max- temperature for. Hence, it was suggested that the population abundance of PFF and MFF was partially dependant on max- and min- temperatures.

DISCUSSIONS

Monitoring of PFF and MFF, males at El-Beheira governorate districts showed that the MFF was spread throughout the tested areas, while the PFF localized in some areas. This may be a result of the suitability of both climatic condition and host plants for the MFF compared with PFF. Similar results were reported by Elekcioğlu (2012) in Turkey, where MFF was widely spread all over the country (citrus orchards were planted). Current results revealed that MFF was the dominant fly at Edko region during both of 2012 and 2013. While, the PFF had been completely absent from this area despite the presence of its preferred host (mango and guava). Also, the climate plays an important role more than the host diversity that allow the coexistence of fruit fly species in La Reunion Island (Duyck *et al.,* 2006)

Also, the MFF was more abundant than PFF with 96.5-fold in the annual mean density through the first season at El-Mahmodiya district and increased to be the predominant fly in the second season, while the PFF disappeared from this area. The obtained result probably due to the presence of the non-preferred citrus fruits for PFF and/or it was displaced by MFF in this area. These findings were supported by the results of the PFF traps monitoring at El-Beheira Governorate, which revealed that mango was more preferred than the citrus by PFF (Draz *et al*., 2002; El-Gendy and

El-Saadany, 2012). Also, in La Reunion Island, Duyck *et al* (2008) revealed that the number of MFF was more than PFF and *C. rosa* on *Minusops elengi* and *Pithecelobium dulce* hosts.

The PFF was more dominant than MFF at Dalangat district through both tested seasons, this may be attributed to the ability of PFF to compete and displace the MFF in warm and dry conditions. *Bactrocera sp.* was strong in interspecific competition and capacity to largely displace the indigenous tephritid flies (Drew *et al.,* 2005; Duyck *et al*. 2006). Also, PFF invaded New Valley Oases in Egypt because of the vigorous competitiveness compared with the MFF (Abdel-Galil *et al.,* 2010). As well as, Hashem *et al*. (2001) mentioned that the spread of PFF restricted the presence of MFF in the horticultural areas in Egypt. Saafan *et al*., (2005 a and b) in Al-Fayoum, Egypt, mentioned that the population of MFF, was very low compared with PFF on citrus and apricot orchards. Also, the infested fruits by both PFF and MFF produced flies mostly of PFF irrespective of which insect firstly infested the fruit (Mohamed, 2004). In La Reunion Island, the PFF invaded and partially displaced the established *Ceratitis* species. PFF turned to be the dominant fly and MFF became relatively rare on mango, guava and Indian almond fruits. Under the same climatic conditions of warm and dry while the PFF had become more dominant than MFF, *C. rosa* and *C. catoirii* on all these fruits in the lowlands and its relative abundance was low in the highlands (Duyck *et al*., 2008). The confirmed results extend to the results of Agarwal and Kapoor (1986) whom reported that PFF superseded the oriental fruit fly, *B. dorsalis* in Northern India. But, in Southern parts of India and Sri-Lanka, the oriental fruit fly is still dominating the PFF (Tsuruta *et al*., 1997).

The inter-site comparison results showed significant differences in the annual mean density of both PFF and MFF between the tested districts at both 2012 and 2013 seasons. As well as, a significant correlation was obtained between population density of both PFF and MFF, and tested locations through 2012 only. It seemed that the locations have an important role in the population density of fruit flies. Similar results were obtained by Ghanim (2009) in Dakahlia, El-Gendy *et al.* (2012) in El-Beheira and El-Kousy *et al.* (2012) in Assiut, Egypt. They recorded a highly significant difference in the PFF incidence between examined areas.

The seasonal activity of PFF and MFF revealed that the MFF had higher density than PFF during both tested periods, this may be as a result of suitable both climatic conditions and hosts for the MFF. Similar results were reported by Darwish (2007) at Al-Noubariya and Abou El-Matamer, El-Beheira, Egypt, through 2004/05 and 2005/06 seasons. While, in the New Valley Oases study, the PFF occurred in high numbers all over the study period compared to MFF (Abdel-Galil *et al.,* 2010). So, the present study revealed that the MFF numbers were increased from year to year; 0.332 and 0.449 CTY (capture males/trap/year) at 2012 and 2013 seasons. In contrast, the results of Saafan *et al.* (2005b) at El-Fayoum, Egypt, revealed that the MFF population was clearly decreased from 2003 to 2004 season.

Generally, our results showed that both of PFF and MFF males were present with discrepancy in the population densities throughout the study periods. This may be due to the seasonal changing of climate, availability and sequence its host plants. These results were supported by the result of Martínez-Ferrer *et al.* (2010) in Eastern Spain, who mentioned that the adults of MFF were present throughout the study period (2003-07), even in winter. Delrio and Cocco (2012) mentioned that population density of the MFF in different fruit-growing areas were affected by host species and variety, crop sanitation practices, climate factors and type of cultivation. Also, El-

Gendy and El-Saadany (2012) at Kom-Hamada, El-Beheira, Egypt, mentioned that the population activity of PFF was in discrepancy from year to year.

Generally, the results revealed that PFF numbers decreased in annual mean from 0.183 to 0.099 CTY for 2012 and 2013, respectively. These results were in agreement with that of Draz *et al*. (2002). They mentioned that the annual mean of population density of PFF on mango trees was reduced from 0.61 to 0.16 CTY through 1999/2000 and 2000/2001. Also, it was 2.84 and 1.53 CTY at Kom-Hamada, El-Beheira, Egypt, through 2010 and 2011 seasons, respectively (El-Gendy and El-Saadany, 2012). Also, the population of PFF in apricot orchards at El-Fayoum, Egypt, ranged between 12.2 to 133.9 flies (CTD) and between 7.00 to 23.57 flies during 2003 and 2004, respectively (Saafan *et al.*, 2005 b).

The obtained data revealed that the population activity of PFF through 2012 was significantly correlated with the maximum and minimum temperature and relative humidity. Results were supported by the data of Hui and Liu (2005) in China, who reported a positive significant correlation between monthly capture rates of *B. dorsalis* and the monthly average minimal temperatures. Also, our results were in agreement with that of Mahmood and Tullah (2007) in Punjab, on PFF, *B. dorsalis* and *B. cucurbitae,* Hasyimab *et al.* (2008) in Indonesia, on *B. tau*., Abdul Alim *et al.* (2012) in Bangladesh, on *B. cucurbitae*, Ghanim (2009) in Dakahlia, Egypt, on PFF in spring season 2006/07, El-Metwally and Amin (2010) in Egypt, on PFF through 2010, and El-Gendy and El-Saadany (2012) in Egypt, on PFF.

The tested factors had impacted the population activity of the PFF through the tested seasons; 50 and 89% in population activities of PFF at 2012 and 2013, respectively attributed to these factors. These results were similar to data reported by Ghanim (2009) in Egypt, who found that the mean temperature and relative humidity contributed with 42.9 to 83.9 % of the total population changes of PFF through 2005 and 2006. Also, El-Gendy and El-Saadany (2012) in Egypt, they found that 53 and 43% of total variance of population density of PFF on mango orchard was related to the tested weather factors. It was clear that the tested abiotic factors were more effective on the fly population activity of PFF than MFF through both of the tested seasons; 2012 and 2013.

CONCLUSIONS

In general, the PFF and MFF were synchronized in their field activity but varied in abundance. As well as, they exchanged their roles as a key-pest; the PFF was the key-pest at the period of occurrence of peach, guava, and mango fruits, while the MFF was the key-pest when orange fruits were present. Also, the results revealed that variation in weather impacted the population abundance not only species but also from year to year. Our results indicated that presence of PFF and MFF in certain area was governed by host plant, weather conditions, and many other factors (for example, altitude and soil type) that should be studied. It was suggested that the population abundance of PFF and MFF was partially weather-dependent.

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ARABIC SUMMERY

حدود انتشار والنشاط الموسمي لذبابة ثمار الخوخ وفاكهة البحر المتوسط في محافظة البحيرة بمصر

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ذبابة ثمار الخوخ (PFF) وذبابة فاكهة البحر الأبيض المتوسط (MFF) هي آفات حشرية تسبب خسائر مادية فادحة للفاكهة والخضروات في مصر. قد أجريت الدراسة الحالية بهدف تحديد انتشار والنشاط الموسمي للـ PFF والـ MFF على مدى عامين متتاليين ٢٠١٢ و٢٠١٣ في ثلاثة عشر مركز بمحافظة البحيرة. وأظهرت النتائج أن الـ PFF تم تسجيلـها تقريبا في جميع مناطق الدراسة باستثناء مركز إدكو. وعلاوة على ذلك، لم يتم رصدها في مركز المحمودية طوال فترة الدراسة الثانية (٢٠١٣)، في حين ان ذبابة ال MFF تم رصدها في جميع المناطق المختبرة على مدار الدراسة (٢٠١٢ و٢٠١٣). وكشفت المقارنة بين المواقع اختلافات كبيرة في اعداد كل من PFF وMFF بين المناطق المختبرة خلال عامي ٢٠١٢ و٢٠١٣. كذلك تم الحصول على علاقة ارتباط إيجابية معنوية بين PFF وMFF خلال عام ٢٠١٢ (r=0.34) ينما كانت هذة العلاقة غير معنوية (r=0.24) في عام ٢٠١٣. كان معدل نمو المجموع (r_0) ل PFF أعلى مما فى MFF خلال الفترة الأولى من النشاط الحشرى خلال كل من عامي ٢٠١٢ و٢٠١٣ حيث كان 1.02و ٠.١٧ لPFF، و٠.٨٣ و ٠.١٣ لMFF، على التوالي. فى حين كانت قيم r_0 ل MFF أعلى مما فى PFF خلال الفترة الثانية من النشاط الحشرى خلال موسمى الإختبار حيث كانت 1.04 .و 1.10 لMFF، و ٠.١٦ و ٠.٢١ ل PFF.

يتضح من النتائج المعروضة في الدراسة الحالية إلى أن هاتين الحشرتين تبادلت دورها كآفة رئيسية لمحاصيل الفاكهة خلال فترة الدراسة.