

Table 1: Approximated duration of several generation numbers of MFF, *C. capitata* and PFF, *B. zonata* and accumulated degree-days units on apple, plum, mango and navel orange orchards throughout the 2019 season at El-Beheira governorate, Egypt

Host	Fruit fly species	Generation numbers														
		1st			2nd			3rd			4th			5th		
		From	To	ADD	From	To	ADD	From	To	ADD	From	To	ADD	From	To	ADD
Apple	MFF	27/5	20/6 25d*	354.18	21/6	12/7 22	359.23	13/7	3/8 22d	359.92	4/8	25/8 22d	356.56	26/8	16/9 21	359.1
	PFF	19/6	18/7 30d	490.7	19/7	18/8 31d	492	19/8	26/8 8d	502.2	-	-	-	-	-	-
Plum	MFF	1/7	22/7 22d	355.8	23/7	13/8 22d	356.9	14/8	4/9 22d	360.2	5/9	25/9 21	356.7	-	-	-
	PFF	19/6	18/7 30d	490.7	19/7	18/8 31d	492	19/8	9/9 22d	502.2	-	-	-	-	-	-
Mangoes	MFF	17/6	8/7 22d	355	9/7	31/7 22d	358.69	1/8	22/8 22d	355.86	23/8	13/9 22d	360.07	14/9 24d	10/8	354.92
	PFF	10/6	10/7 31d	497.9	11/7	9/8 30d	488.5	10/8	9/9 31d	488.5	10/9	12/10 33d	500.7	13/10	14/10 2d	488.1
Navel orange	MFF	9/9	4/10 30d	354.02	5/10	1/11 28d	350.94	2/11	16/12 45d	349.74	18/12	12/2/ 2020	348.48	-	-	-
	PFF	9/9	11/10 33d	500	12/10	26/11 33d	490	27/11	22/1/ 2020	488	-	-	-	-	-	-

MFF: Mediterranean fruit fly, PFF: Peach fruit fly, ADD: Accumulated-degree-days and d*: Generation duration (day)

PFF: PFF female was first detected in the mango orchard, where females had five generations. The 2nd generation was the most dangerous, followed by the 3rd, 4th and 1st, respectively. The first fruit fly generation in apple and plum was recorded 1 week later than in mango, on Jun 19th, followed by two generations each. In the plum orchard, the 1st PFF generation was higher density and more dangerous than the 2nd one. While in the apple orchard, the 2nd generation had a higher abundance than the 1st one. Remarkably, the 3rd generation stayed 8 days with no fruit damage. Similar to apple and plum, PFF had three generations on the navel orange orchard, oranges were at risk by the 2nd and the 3rd generations and the last one continued in the field until Jan 22nd, 2020.

Season 2020: MFF needed 1438-2142 ADD and PFF 1534-2507 ADD to develop (Table S4 and Table 2).

MFF: The 1st generation of MFF females was detected for the first time in the mango orchard on 7th May, this generation began earlier than in the 1st season, followed by five more. The 1st and 2nd generations were not very active on mangoes, while the 3rd and 4th caused fruit damage. In the apple orchard, MFF produced five generations, the 2nd and 3rd generations were more dangerous for apple fruits. Also, in the plum orchard, the

MFF females had five generations, the first began on June 18th and the 5th disappeared after nine days with no damage, however, the 3rd generation was more destructive for plums, followed by the 2nd, 1st and 4th. In the navel orange orchard, females had four field generations. The 1st generation had no damage, while the most destructive generation was the 3rd.

PFF: The 1st generation of PFF females was detected in the mango orchard. Based on ADD, five generations of the fly were recorded on this host. The 1st generation in both seasons began at a similar time (Jun 11th). The 2nd and 3rd generations were the most dangerous for mangoes, followed by the 1st and 4th, while the 5th stayed only one day with no effects. One week after the appearance of flies in the mango orchard, the 1st generation in plum was recorded (Jun 18th), followed by two generations. The 1st generation was the most destructive for plum fruits, followed by the 2nd generation, while the 3rd one was hazardless. In the apple orchard, the PFF had three generations, the 1st one appeared on Jul 2nd, with a higher risk for fruits, followed by the 2nd generation, the last generation lasted only three days, with no effects. In navel orange, PFF had three field generations. Navel oranges were at risk by the 2nd and 3rd generations, especially the 3rd one.

Table 2: Approximated duration of several generations of MFF, *C. capitata* and PFF, *B. zonata* and accumulated degree-days units on apple, plum, mango and navel orange orchards throughout the 2020 season, at El-Beheira Governorate, Egypt

Host	Fruit fly species	Generation numbers																							
		1st		2nd		3rd		4th		5th		6th													
		From	To	ADD	From	To	ADD	From	To	ADD	From	To	ADD	From	To	ADD	From	To	ADD	From	To	ADD			
Apple	MFF	11/6	4/7	351.9	5/7	27/7	356.14	28/7	17/8	356.81	18/8	9/9	344.89	10/9	24/9	357.95	-	-	-	-	-	-	-		
	PFF	2/7	1/8	500.6	2/8	28/8	501.8	1/9	3/9	498.8	-	-	-	-	-	-	-	-	-	-	-	-	-		
Plum	MFF	18/6	10/7	350.3	11/7	2/8	356.4	3/8	23/8	355.9	24/8	15/9	345.4	16/9	24/9	349	-	-	-	-	-	-	-		
	PFF	19/6	18/7	495.7	19/7	17/8	503.4	18/8	10/9	491.3	-	-	-	-	-	-	-	-	-	-	-	-	-		
Mangoes	MFF	7/5	6/6	348.8	7/6	31/6	349.8	1/7	23/7	345.4	24/7	14/8	359.6	15/8	5/9	358	6/9	24/9	345.8	-	-	-	-		
	PFF	11/6	12/7	492.3	13/7	12/8	504.2	13/8	12/9	506.4	13/9	20/10	501	21/10	22/10	490.7	-	-	-	-	-	-	-		
Navel orange	MFF	3/9	26/9	346.5	27/9	27/10	348	28/10	17/12	349.7	18/12	-	-	-	-	-	-	-	-	-	-	-	-		
	PFF	20/8	25/9	493	26/9	1/11	501	2/11	-	495	-	-	-	-	-	-	-	-	-	-	-	-	-		

MFF: Mediterranean fruit fly, PFF: Peach fruit fly, ADD: Accumulated-degree-days and d*. Generation duration (day)

DISCUSSION

Suitable hosts of PFF and MFF are available all year round under the Egyptian agro-ecosystem conditions. Furthermore, the seasonal fluctuation of males and females of MFF and PFF showed an overlapped multivoltine pattern. On navel orange orchards, MFF males were active throughout the 2019 and 2020 seasons, while PFF males were active throughout the 1st tested season, 2019 and in part of the second season in 2020. In the mango orchard, males of both fruit fly species were active during most of the season. Also, the activity of PFF and MFF males was seasonal in plum and apple orchards, throughout both tested seasons. These results are in parallel with those of Abdel-Galil *et al.*¹, who mentioned that PFF males were active all year round. Host species affect the population level of both PFF and MFF males, during 2019, densities were higher on mango than those on apple, navel orange and plum orchards. In the 2nd season, also PFF was higher in density on mango than those on plum, navel orange and apple. These results also agree with Radonjić *et al.*¹³, who mentioned that the population densities of MFF are affected by host species and variety. El-Gendy and Nassar³ reported that differences in population density levels of PFF and MFF males in a specific area might be due to the availability and sequence of host plants. However, MFF males in the 2nd season on apple and plum were higher than those in mango and navel orange hosts. This switch on population numbers from different hosts probably was caused by immigrant flies dropping from post-harvest fruits, a suitable reservoir of these pests, for instance, navel orange fruits are preserved on the trees until Mar, dropping all along this time. PFF and MFF male abundance reached the highest levels during the harvest period from June to August in apple and plum, from July-October in mango and from September-December in navel orange orchards. These results agree with Saeed *et al.*⁷, the highest peaks of PFF in mango orchards occurred in October.

Our findings reveal that MFF females flew 1-7 weeks earlier than those of PFF in navel oranges, apples and plums. Thus, MFF females invade their hosts during the fruiting stage before PFF females. Furthermore, the appearance of PFF and MFF females in the field was related to the host phenology of the tested hosts. The highest catch of flies happened during the fruiting and fruit ripening period². Females of MFF had a strong relationship with the host phenology, with a sequential availability of ripe or semi-ripe fruits¹⁴. All these indicate that host availability might be an essential factor influencing the phenology of PFF and MFF in the tested area, PFF and MFF male and female arrival in Egypt agro-ecosystems was similar

on the same host during the tested seasons. Whereas, natural fruit hosts can be used by PFF, depending on their fruit phenology¹⁵. According to de Villiers *et al.*¹⁶, on the phenology of *C. capitata*, *C. rosa* and *C. cosyra*, host availability was more relevant than climate. It might be the determinant factor in the seasonal phenology of all three species.

The present results revealed that PFF females had an additional generation compared to MFF, independently of hosts or seasons. In parallel to these findings, Khalil *et al.*⁶ reported that PFF males had 6-8 generations per year in North Sinai, El-Beheira and Asyut, Egypt, during season 2008, according to ADD. Also, Saeed *et al.*⁷ mentioned 7 field generations of PFF males in Kafer El-Shikh, Egypt, from May, 2014-April, 2015.

The present findings evidenced that the incidence of MFF and PFF females in the field varied with fruit. These results were in parallel with those of El-Gendy and Villanueva-Jimenez¹⁵ in laboratory assays of PFF host preference, where mango was the most preferred host, followed by peach and apple, respectively. Also, El-Gendy⁴ demonstrated that mango was the most preferred host of PFF, compared to apricot, peach and plum, while apple was the last one. However, in the 2nd season, the abundance of MFF males and females in the field and emerged flies from apple samples were higher than mango, navel orange and plum.

CONCLUSION

The current study's findings demonstrated the relationship between PFF and MFF in Egyptian agro-ecosystems and provided a baseline on the periodical appearance of males and females of PFF and MFF in the field. Furthermore, the study appraised and predestined the field generations of PFF and MFF female flies on four significant commercial hosts in Egypt.

SIGNIFICANCE STATEMENT

This study revealed for the first time the periodical activity of PFF and MFF females in the field related to tested hosts. This study will help the applicator of control implement the control techniques against fly at a suitable time.

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SUPPLEMENTARY MATERIALS

Table S1: Correlation coefficients between trapped MFF and PFF on tested hosts in the El-Beheira Governorate in Egypt during the 2019-020 season

		Coefficients					
		2019			2020		
Fruit species	Host	r	Se (±)	p-value	r	Se (±)	p-value
MFF	Plum	0.71	0.06	0.000***	0.51	0.069	0.000***
	Apple	0.91	0.04	0.000***	0.72	0.056	0.000***
	Mango	0.59	0.06	0.000***	0.54	0.068	0.000***
	Navel orange	0.36	0.08	0.000***	0.29	0.077	0.002***
PFF	Plum	0.55	0.07	0.000***	-0.16	0.079	0.052 ^{ns}
	Apple	0.69	0.06	0.000***	0.018	0.08	0.83 ^{ns}
	Mango	0.62	0.063	0.000***	0.65	0.06	0.000***
	Navel orange	0.74	0.05	0.000***	0.82	0.05	0.000***

MFF: Mediteranean fruit fly, PFF: Peach fruit fly, r: Correlation coefficient, Se: Standard error, ns: Non significant and ***High significant

Table S2: Correlation coefficients between trapped MFF and PFF sexes and abiotic factors on tested hosts during 2019 season at El-Beheira Governorate, Egypt

		Coefficient											
		Plum			Apple			Mango			Navel orange		
Species	Abiotic factors	r	Se (±)	p-value	R	Se (±)	p-value	r	Se (±)	p-value	r	Se (±)	p-value
MMFF	T° (max)	0.60	0.06	0.000***	0.64	0.06	0.000***	0.60	0.06	0.000***	0.25	0.08	0.002**
	T° (mim)	0.64	0.06	0.000***	0.68	0.06	0.000***	0.72	0.05	0.000***	0.37	0.07	0.000***
	RH (%)	-0.04	0.08	0.6 ^{ns}	-0.05	0.08	0.5 ^{ns}	0.04	0.08	0.59 ^{ns}	0.13	0.08	0.09 ^{ns}
MPFF	T° (max)	0.42	0.07	0.000***	0.67	0.06	0.000***	0.63	0.06	0.000***	0.21	0.08	0.009**
	T° (mim)	0.48	0.07	0.000***	0.68	0.06	0.000***	0.77	0.05	0.000***	0.37	0.07	0.000***
	RH (%)	-0.02	0.08	0.77 ^{ns}	-0.02	0.08	0.01*	0.12	0.08	0.14 ^{ns}	0.14	0.08	0.08 ^{ns}
FMFF	T° (max)	0.47	0.07	0.000***	0.61	0.06	0.000***	0.59	0.06	0.000***	-0.15	0.08	0.06 ^{ns}
	T° (mim)	0.55	0.06	0.000***	0.63	0.06	0.000***	0.68	0.06	0.000***	0.003	0.08	0.97 ^{ns}
	RH (%)	0.11	0.08	0.16 ^{ns}	-0.08	0.08	0.32 ^{ns}	0.03	0.08	0.69 ^{ns}	0.39	0.07	0.000***
FPFF	T° (max)	0.48	0.07	0.000***	0.44	0.07	0.000***	0.60	0.06	0.000***	0.12	0.08	0.13 ^{ns}
	T° (mim)	0.52	0.06	0.000***	0.52	0.07	0.000***	0.69	0.06	0.000***	0.26	0.07	0.001**
	RH (%)	-0.03	0.08	0.72 ^{ns}	-0.02	0.08	0.74 ^{ns}	0.06	0.08	0.45 ^{ns}	0.19	0.08	0.018*

r: Correlation coefficient, Se (±): Standard error, MMFF: Mediterranean fruit fly males, FMFF: Mediterranean fruit fly females, MPFF: Peach fruit fly males, FPFF: Peach fruit fly females, T° (mim): Minimum temperature, T° (max): Maximum temperature, RH (%): Relative humidity, ns: Non significant, *Low significant, **Medium significant and ***High significant

Table S3: Correlation coefficients between weekly mean number of trapped males and females of MFF and PFF and abiotic factors on tested hosts during 2020 season at El-Beheira Governorate, Egypt

		Coefficient											
		Plum			Apple			Mango			Navel orange		
Species	Abiotic factors	r	Se (±)	p-value	R	Se (±)	p-value	r	Se (±)	p-value	r	Se (±)	p-value
MMFF	T° (max)	0.66	0.06	0.000***	0.55	0.07	0.000***	0.53	0.07	0.000***	0.56	0.06	0.000***
	T° (mim)	0.60	0.06	0.000***	0.53	0.06	0.000***	0.63	0.06	0.000***	0.58	0.06	0.000***
	RH (%)	-0.47	0.07	0.000***	-0.50	0.07	0.000***	-0.53	0.07	0.000***	-0.68	0.05	0.000***
MPFF	T° (max)	0.33	0.08	0.000***	0.14	0.07	0.07 ^{ns}	0.67	0.06	0.000***	0.09	0.08	0.12 ^{ns}
	T° (min)	0.38	0.07	0.000***	0.20	0.07	0.012*	0.78	0.05	0.000***	0.18	0.07	0.023*
	RH (%)	-0.39	0.07	0.000***	-0.35	0.08	0.000***	-0.75	0.05	0.000***	-0.29	0.08	0.000***
FMFF	T° (max)	0.47	0.07	0.000***	0.62	0.06	0.000***	0.58	0.07	0.000***	-0.11	0.07	0.15 ^{ns}
	T° (min)	0.50	0.07	0.000***	0.66	0.06	0.000***	0.59	0.06	0.000***	0.03	0.06	0.12 ^{ns}
	RH (%)	-0.43	0.08	0.000***	-0.58	0.07	0.000***	-0.53	0.07	0.000***	-0.23	0.08	0.005***
FPFF	T° (max)	0.52	0.07	0.000***	0.43	0.07	0.000***	0.67	0.06	0.000***	0.09	0.08	0.22 ^{ns}
	T° (min)	0.55	0.06	0.000***	0.46	0.07	0.000***	0.74	0.05	0.000***	0.22	0.08	0.005**
	RH (%)	-0.48	0.07	0.000***	-0.38	0.07	0.000***	-0.67	0.06	0.000***	-0.36	0.07	0.000***

r: Correlation coefficient, Se (±): Standard error, MMFF: Mediterranean fruit fly males, FMFF: Mediterranean fruit fly females, MPFF: Peach fruit fly males, FPFF: Peach fruit fly females, T° (mim): Minimum temperature, T° (max): Maximum temperature, RH (%): Relative humidity, ns: Non significant, *Low significant, **Medium significant and ***High significant

Table S4: Accumulated degree days and generation number of MFF, *C. capitata* and PFF, *B. zonata*, in orchards through 2019 and 2020 seasons at El-Beheira Governorate, Egypt

Host	Seasons	ADD		Number of generation/year	
		PFF	MFF	PFF	MFF
Mango	2019	2492	1785	5.11	5.165
	2020	2507	2142	5.14	6.16
	Mean	2500	1963	5.13	5.66
Citrus	2019	1626	1480	3.33	4.28
	2020	1873	1438	3.84	4.16
	Mean	1750	1459	3.59	4.22
Apple	2019	1622	1789	3.33	5.17
	2020	1534	1768	3.14	5.11
	Mean	1574	1779	3.23	5.14
Plum	2019	1858	1655	3.00	4.67
	2020	1861	1757	3.81	5.08
General mean		1860	1706	3.81	4.94

MMFF: Mediterranean fruit fly, MFF: Mediterranean fruit fly, PFF: Peach fruit fly and ADD: Accumulated-degree-days