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Occurrence of *Bactrocera zonata* and *Ceratitis capitata* in chemically untreated and treated orange orchard

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Abstract
The Mediterranean fruit fly (MFF), *Ceratitis capitata* (Wiedemann), and the peach fruit fly (PFF), *Bactrocera zonata* (Saunders), are two of the most significant pests infesting citrus plantations around the world, including Egypt. In two orange orchards, one of which received sexual control attractants while the other did not, the seasonal activity of PFF and MFF was examined during the course of two succeeding fruiting seasons in 2020/21 and 2021/22. In the untreated orchard, PFF showed two to three different peaks of activity each year; however, in the treated orchard, its population was normally low with just one modest surge. In the untreated orange orchard, MFF displayed three to four peaks of activity; in the treated orchard, it recorded three marginal peaks. The ratio of PFF flies in treated vs untreated (FTD) orchards was 1: 11.43 flies and 1: 12.28 flies during the first and second seasons, respectively. For MFF, the ratio was 1: 5.05 and 1: 12.65 flies over the same periods. On the other side, there were adverse correlations between the population levels of PFF and MFF and the farmed orange area.

Keywords: Mediterranean fruit fly, peach fruit fly, FTD, methyl eugenol, trimedlure

Introduction

The Mediterranean fruit fly (MFF), *Ceratitis capitata* (Wiedemann), and the peach fruit fly (PFF), *Bactrocera zonata* (Saunders), are two of the most significant pests infesting citrus groves around the world, including fruit fields in Egypt. Direct fruit damage from PFF and MFF can result in yield losses of up to 90% (Hafez *et al*., 1973; Ghanim, 2009; Darwish, 2016) [19, 11, 9]. Ahmad *et al*. (2010) [3]. claim that the prevalence of PFF and MFF places unique limitations on the export of fruit to various nations throughout the world. PFF is a dangerous polyphagous pest that was first discovered in South and South-East Asia. It infects over 50 host plants, including fig, citrus, guava, mango, peach, and mango (White & Elson-Harris, 1992; Ghanim, 2009; and Metwaa, 2019) [36, 11, 28]. In the Mediterranean basin, MFF is known to infest the fruits of over 300 plant species, and it is a significant pest of important fruit crops in many mildly temperate, subtropical, and tropical countries (Sciarretta *et al*., 2018 and Thomas *et al*., 2019) [34, 35].

In Egypt According to Ghanim (2009) [11] and Lysandrou (2009) [25], PFF and MFF are serious pests in Egypt that target a wide variety of fruits throughout the year that vary in their stage of ripeness. Citrus species (*Citrus sinensis* (L.) Osbeck) are the most economically significant hosts of PFF and MFF. According to White and Elson-Harris (1992) [36] and Borge and Basedow (1997) [7], PFF and MFF females lay their eggs inside fruits, which the hatching maggots then eat away at, leading to secondary infestations with bacterial and fungal diseases that make the fruits unsuitable for either marketing or exportation.

In contrast to neglected orchards, insecticide treatments had negative effects on pest populations, which may have eliminated some pests in managed orchards (Abdel Kareim *et al*., 2018 a, b) [1, 2]. Ghanim *et al*. (2010) [16] claimed that a number of pesticides were efficient against PFF. The impacts of various meteorological conditions on PFF and MFF infesting various host plants have also been the subject of numerous studies (Mahmood *et al*., 2002; Hasyim *et al*., 2008; Robert *et al*., 2013; and Ordano *et al*., 2015) [26, 23, 32, 31]. Continuous research and update of data for PFF and MFF populations in diverse settings are necessary for effective pest control. Therefore, the following topics are the focus of the current research: 1) The PFF and MFF population activity in untreated versus treated orange orchards, 2) The impact of recommended fruit fly control applications on PFF and MFF populations, and 3) The association between the cultivated orange area and the PFF and MFF populations.

Materials and Methods

For the current study, two orange orchards were chosen; the first orchard, which was located in the Experimental Farm of the Faculty of Agriculture, Mansoura University, did not receive any fruit fly control sprays. This orchard covers around 10 feddans (4200m^2 is one feddan). According to the Ministry of Agriculture and Land Reclamation's Adopted Recommendations for Agricultural Pest Control 2020, the second orchard, which is situated in Shirben district and has an area of 80 feddans, received the fruit fly control treatments that were advised. The two places are in Egypt's Dakahlia governorate. The current study was conducted during the course of the two succeeding fruiting seasons in 2020–2021 and 2021–2022.

For this investigation, four feddans from each orchard were chosen. Two Jackson traps (described by Harris *et al*., 1971) [20] were used in each feddan, one of which was baited with trimedlure and the other with methyl eugenol (a PFF sex attractant) (as a sex attractant of MFF). Four copies of each sex attractant were placed in each area. On the shady side of the fruit trees, traps were hung at a height of around two meters. To prevent fly interference, each trap of the same sex attractant was placed more than 60 meters apart from the others. Weekly inspections of the hanging traps included counting and recording the number of drawn-in flies on the sticky cardboard interiors of the traps. New cardboard strips were used for each inspection. The mean number of captured flies per trap per day (FTD) was used as a measure of fly abundance. The sex attractant of methyl eugenol was renewed biweekly; while, trimedlure was renewed every month.

The reduction percentages of PFF or MFF population caused by the recommended fruit fly control applications in the controlled orchard in comparison with the uncontrolled one all over the season was calculated according to the following sub model:

Reduction% = (NUC – NC)/NUC

Where, NUC is the mean number of PFF or MFF in uncontrolled orchard

NC is the mean number of PFF or MFF in controlled orchard

Four orange orchards in the Dakahlia governorate, each with a different area (3, 10, 17 and 80 feddans), were selected in order to estimate the relationships between the cultivated orange area and the populations of PFF and MFF. They also all received roughly the same agricultural and pest control treatments. At least five kilometres separated each orchard from the others. Two Jackson traps (one for PFF and the other for MFF) were hung in the middle of each orchard and looked at as previously mentioned. The fruiting season for orange trees in 2021/22 was used for this experiment. Each orchard's season-long average FTDs for PFF and MFF were statistically examined using the regions of regression analysis (CoHort Software, 2004) [8].

Results

Data illustrated in (Fig. 1) showed that PFF exhibited three distinct peaks of activity during the first season (2020/21) in orange orchard which did not receive any fruit fly control applications (uncontrolled). These peaks were recorded in the 6th of September (FTD = 9.54), 4th of October (FTD = 8.04) and 1st of November (FTD = 6.21). After the third peak, PFF population decreased gradually till the end of fruiting season. In the orange orchard which received the recommended fruit fly control applications (controlled), PFF population was generally slight in comparison with the uncontrolled orchard with no distinct peaks. PFF occurred during the period from the 6th of September till the 15th of November with FTD-values ranged between 0.14 and 0.86 flies.

During the second season (2021/2022), PFF exhibited two distinct peaks of activity in uncontrolled orange orchard. FTD-values of these peaks were recorded as 21.46 flies (in the 3rd of October) and 19.29 flies (in the 14th of November). In controlled orchard, PFF showed only one slight peak of activity (FTD was recorded as 3.61) in the 17th of October. After these peaks, PFF population decreased gradually till the end of fruiting season in the two orchards (Fig., 1).

With respect to MFF (Fig., 2), it exhibited four peaks of activity in the uncontrolled orange orchard during the first season. The FTD-values of these peaks reached 1.73, 1.36, 2.39 and 0.39 flies recorded in the 20th of September, 18th of October, 6th of December and 31st of January, respectively. In the controlled orange orchard, MFF population was generally slight in comparison with the uncontrolled orchard with three slight peaks of activity. These peaks were recorded in the 25th of October (FTD = 0.54), 29th of November (FTD = 0.54) and 31st of January (FTD = 0.14).

As it illustrated in (Fig 2), MFF exhibited three distinct peaks of activity in the uncontrolled orchard and exhibited three slight peaks in the controlled one. In the uncontrolled and controlled orchards, the first peak was recorded in the 19th and 26th of September (FTDs were 7.17 and 0.25), respectively; while, the second peak was recorded in the 24th and 31st of October (FTDs were 4.11 and 0.75). The third peak was recorded in the 12th of December in the uncontrolled and controlled orchards with FTD-values of 4.36 and 0.46 flies, respectively.

The general mean of FTD-values of PFF allover the first season were recorded as 2.63 and 0.23 flies in the uncontrolled and controlled orange orchards, respectively and recorded as 8.72 and 0.71 flies during the second season. Also, the general mean of FTD-values of MFF in uncontrolled and controlled orchards was recorded as 1.01 and 0.20 flies, respectively during the first season and recorded as 2.15 and 0.17 flies during the second season (Fig. 3).

The ratio between fruit flies in uncontrolled and controlled orchards was estimated as the number of flies in the uncontrolled orchard per one fly in the controlled one. This ratio of PFF reached 11.43:1 and 12.28:1 during the first and second season, respectively. With respect to MFF this ratio was recorded as 5.05:1 and 12.65:1 during the first and second season, respectively (Fig. 4). So, the recommended control applications against fruit flies reduced PFF population allover the first and second season by 91.25 and 91.86%, respectively. Also, PFF population was reduced according to the recommended control applications against fruit flies allover the first and second season by 80.20 and 92.09%, respectively (Fig. 5). The population levels of both PFF and MFF had negative correlations with the cultivated area, as shown in (Fig. 6). According to this association, the number of PFF and MFF flies per trap each day reduced by 0.009 and 0.008 for every feddan that the culivated orange area increased (FTD). These results might explain why PFF and MFF populations were lower in the controlled orchard (80 feddans) than they were in the uncontrolled one (which was ten feddans).

Discussion

The peach fruit fly (PFF), *B. zonata*, clearly displayed up to three peaks of activity throughout the fruiting season of orange orchards, according to the findings of the prior study. These results concur with those of Ghanim (2016) [13], who claimed that PFF activity in grape and guava plantations showed one to three peaks. Furthermore, in mandarin, mango, and *guava orchards*, two and three peaks of PFF activity were recorded by Ghanim (2009) [11], Ghanim *et al.* (2015) [17], and Bayoumy *et al*., (2021) [6]. According to Draz *et al*., (2002) [10], Mohamed (2002) [29], and Ibrahim (2005) [24], PFF revealed two seasonal abundance peaks. While PFF showed four maxima of seasonal abundance, Amin (2003) [5] and Hashim *et al*., (2007) [22] highlighted this. The Mederranean fruit fly (MFF), *C. capitata*, had three peaks of activity throughout the course of the study. Additionally, MFF in the mango orchard displayed three peaks of activity, according to Ghanim *et al*., (2018) [18]. Additionally, according to Ghanim (2012) [12], Moustafa *et al.*, (2014) [30], Ghanim (2016 & 2017) [13], Amara (2017) [4], and Bayoumy *et al*., (2021) [6], seasonal activity peaked between two and four times in persimmon, apple, guava, grape, peach, and citrus orchards. According to Hashem *et al*., (2001) [21], the

MFF population had one to two seasonal abundance peaks. While MFF was noted to have four seasonal abundance maxima every year by Ghanim and Moustafa (2009) [11]. The difference between the current results and others could be attributed to variations in the cultivated host plant species in each studied district, as well as variations in weather factors. According to Abdel Kareim *et al*., (2018 a and b) [1, 2], chemical control showed adverse effect twards harmfull insects and their natural enemies in mango orchards. These findings are in agreement with the persent study; where the fruit fly control applications showed adverse effect against both of PFF and MFF populations in orange orchards. These control application reduced PFF and MFF population upto more than 90% in controlled orchard compared to non-controlled one. Also, Abdel Kareim *et al*., (2018 b) [2], recorded a reduction of *Cryptoblabes gnidiella* Mill. Population in mango orchrds reached 100% as a result of chemical control on mango orchard.

It is clear from the aforementioned perspective that PFF and MFF were more active during the relatively mild months than they were during the chilly months. This might be explained by how PFF and MFF population activities are positively impacted by temperature levels. The lower population of PFF and MFF during the cold months towards the end of fruiting season is explained by the correlation between temperature levels and fruit fly populations. These results are similar with those discovered by Saafan *et al*., (2006) [33], Ghanim (2009) [11], Ghanim and Moustafa (2009) [11], Ghanim (2012) [12], Moustafa *et al*., (2014) [30], Ghanim *et al*., (2015) [17], Ghanim (2017) [14] and Bayoumy *et al*., (2021) [6]; According to their findings, PFF and MFF responded well to temperature increases and vice versa. On the other hand, PFF population starts to diminish before MFF population because of the drop in temperatures. This might be explained by the fact that PFF is more sensitive to lower temperatures than MFF, which explains why it is less sensitive to low temperatures. Ghanim (2012) [12], Metwaa (2019) [28] and Bayoumy *et al*., (2021) [6] all reported that PFF is more susceptible to the low temperature degrees than MFF. These findings are corroborated by those studies.

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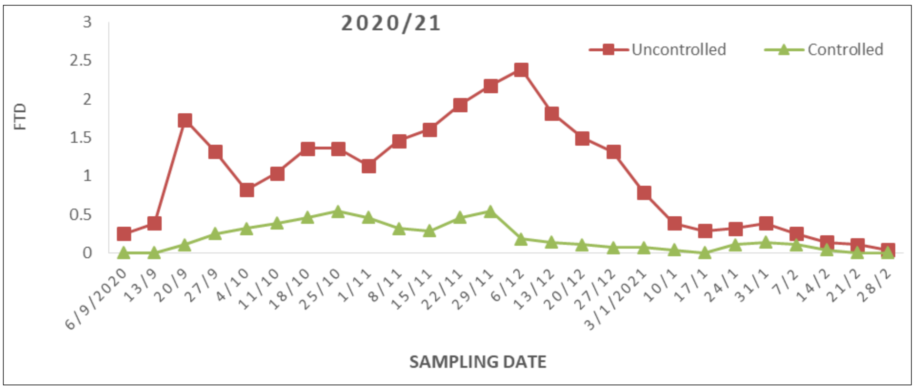
Fig 1: Occurrence of *Bactrocera zonata* adults in uncontrolled and controlled orange orchards during 2020/21 and 2021/22 fruiting seasons.



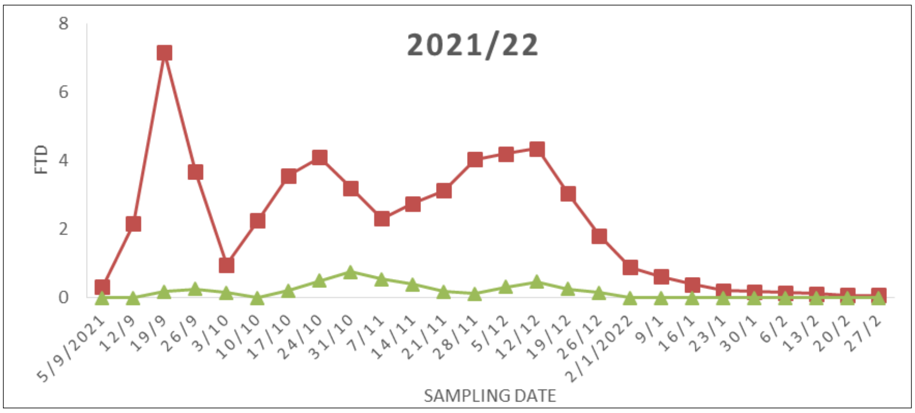


Fig 2: Occurrence of *Ceratitis capitata* adults in uncontrolled and controlled orange orchards during 2020/21 and 2021/22 fruiting seasons.

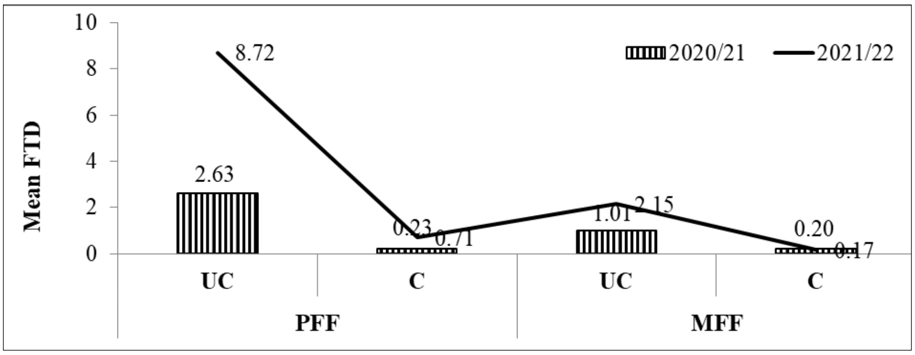


Fig 3: General mean FTDs of *Bactrocera zonata* and *Ceratitis capitata* adults allover 2020/21 and 2021/22 fruiting seasons of uncontrolled (UC) and controlled (C) orange orchards.

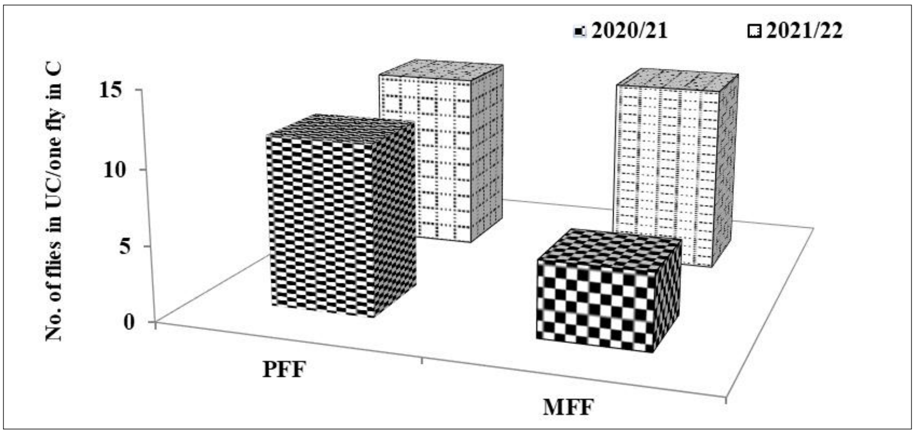


Fig 4: General mean number of flies (PFF and MFF) in uncontrolled orchard (UC) per one fly in controlled orchard (C) allover orange fruiting seasons of 2020/21 and 2021/22.

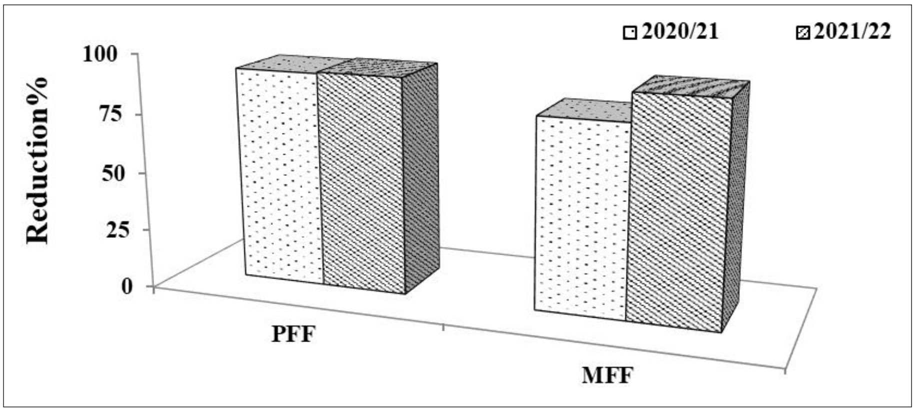


Fig 5: Reduction percentages in PFF and MFF populations caused by control applications allover orange fruiting seasons of 2020/21 and 2021/22.

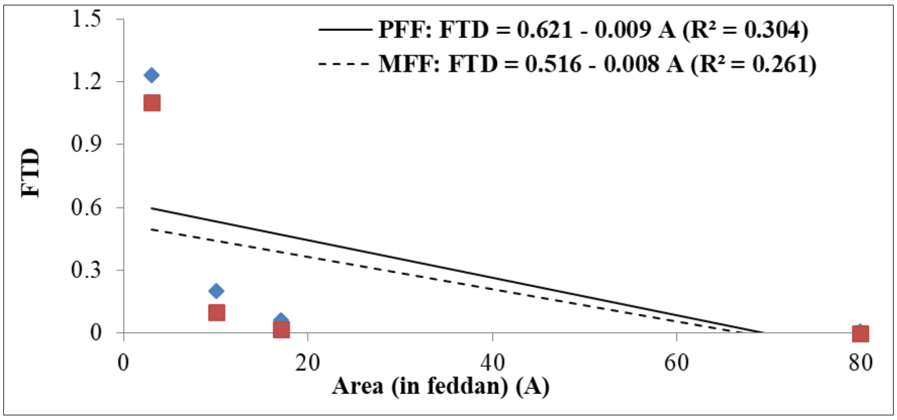


Fig 6: The relationships between the cultivated orange area (A) and PFF & MFF populations (as FTD) during 2021/22 season.

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