COMPARATIVE ABUNDANCE AND COMPETITION BEHAVIOR BETWEEN TWO SPECIES OF TEPHRITID FRUIT FLIES IN GUAVA ORCHARDS AT QUALYUBIA GOVERNORATE

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ABSTRACT

Fruit flies (Diptera: Tephritidae) are very dangerous insect pests for several horticultural crops causing deleterious quantitative and qualitative reduction in crops. Experiments under field conditions were conducted to determine the population dynamics of both *Bactrocera zonata* (Saund.) and *Ceratitis capitata* (Wied.) in guava orchards at Qualyubia Governorate for two successive years. Competitiveness between the two species of fruit flies on guava fruits was also studied. Results indicated that the attracted males of both *B. zonata* and *C. capitata* differently fluctuated on guava trees during the first and second years of investigation. During the first year, the highest two peaks of *B. zonata* of 53.33 and 86.67 individuals/trap/day occurred on the 14th of June and on the 8th of November 2021. However, the highest two peaks of *C. capitata* (148.67 and 219.00 males/ trap/day) were observed on the 11th of October and on the 8th of November 2021. During the second year the highest two peaks represented as FTD (Flies/Trap/Day) were 62.00, 55.00 for *B. zonata* and 153.00, 191.67 for *C. capitata*; and were recorded on the 26th of September, the 24th of October and on the 21st of November, the 19th of December 2022, respectively. The population of the two species highly increased throughout guava fruiting seasons. The grand total of the Mediterranean fruit fly was comparatively much higher than that of the peach fruit fly during the two years of investigation. On the other hand, *B. zonata* failed to compete *C. capitata* to infest guava fruits throughout the two seasons of investigation.

Keywords: Seasonal fluctuation, population, *Ceratitis capitata*, *Bactrocera zonata.*

INTRODUCTION

Lemon guava (*Psidium guajava* L.: Or. Myrtales, Fam. Myrtaceae), which belongs to sub-tropical and temperate fruit trees, is one of the important horticultural trees for both local and exporting markets because of its nutritional value of fruits that contain certain

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highly valuable nutritional constitutes as vitamins (C & A), sugars, proteins, and fibers as well as the delicious taste and flavors. Several components of guava leaves have medicinal curative effects such as antibacterial and antifungal activity (Shruthi *et al*., 2013; Braga *et al*., 2014; Soliman *et al*., 2016; Morais *et al*., 2017 and Kafle *et al*. 2018). The total cultivated area of guava in Egypt is 33883 feddans producing 304378 tons. Guava trees are differently distributed in all districts and governorates of Egypt and widely concentrated in El-Behiera (12064 feddans), Alexandria (4528 feddans), Demiatta (3689 feddans), Qualyubia (3634 feddans), Matrouh (2325 feddans) and Nubaria (2324 feddans) (Central Agency for Public Mobilization and Statistics, 2021). Guava fruits are very preferred host for the tephritid fruit flies as the peach fruit fly, *B. zonata* (Saund.) and the Mediterranean fruit fly, *C. capitata* (Wied.) which cause quantitatively as well as qualitatively deleterious damage (Sarwar *et al*., 2014; Maciel *et al*., 2017 and Amin *et al*., 2019). The two species of fruit flies and others are widely distributed and infest guava and other fruits throughout the fruiting season causing reduction in crop production as well reducing the marketing values of fruits (Sarwar *et al*., 2014; Khan and Naveed, 2017; Vignesh *et al*., 2020; Jaleel *et al*., 2021 and Khan *et al*., 2021). The populations of these dangerous dipteran fruit flies differently fluctuated on many hosts throughout the year (Marangoni-Montes *et al*., 2012; Singh and Sharma, 2013; Kakar *et al*., 2014; Khan and Naveed, 2017; Umesh *et al*., 2018; Amin *et al*., 2019; Galli *et al*., 2019; Bansode and Patel, 2020; Abbas *et al*., 2021 and Khan *et al*., 2021).

In Egypt, most researchers studied population fluctuation of fruit flies in citrus or mango orchards and other hosts (Saafan and Tadros, 1996; Saafan *et al*., 2000 and Draz *et al*., 2016). However, no studies on the population fluctuation of fruit flies on guava could be retrieved. Thus, this work aimed at studying the comparative population fluctuations and competitiveness of the Mediterranean and peach fruit flies in widely distributed guava orchards at Qualyubia Governorate in Egypt where guava fruits are one of the most important hosts of tephritid fruit flies.

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MATERIAL AND METHODS

Location of Experimental Farm

Experiments were conducted on a guava orchard of about 20 feddans at El-Khanka district, Qualyubia Governorate (the northern east of Cairo or the southern east of Nile Delta, N 31 21 32, E 31 13 30). Guava trees of more than 25 years old were chosen. These trees were cultivated in clay soil at 5×5 meters distances between trees and irrigated as flooding regime. The trees were about 2.5-3 meters in height. All horticultural practices of irrigation, fertilization and pruning were regularly done except for chemical pest control which were not applied.

Seasonal Population Fluctuation

To study population fluctuations of the two species of fruit flies of *C. capitata* and *B. zonata*, six yellow Jackson traps **(Harris *et al.*, 1971)** with sticky cardboard (20 cm long × 10 cm width) and cotton wicks (1.5 cm long × 0.5 cm diameter) saturated with the recommended sex attractants obtained from Plant Protection Research Institute (methyl eugenol for males of *B. zonata* and trimedlure for males of *C. capitata*) were used. Three traps for each species were hung on the north-western direction of tree at 1.5 to 2 meters of the ground on the 24th of April 2021. Traps were weekly inspected and captured males of each species were sorted and counted. The sticky cardboards were changed weekly, whereas the cotton wicks were biweekly changed.

Competition in Guava Fruits

For determining the competition in guava fruits infestation between the two species, 30 fallen fruits under 10 trees as replicates (3 fruits for each tree) were randomly collected every week from 18/8/2021 (in the first season) and 4/9/2022 (in the second season) for 6 and 5 successive weeks of the first and second years, respectively. These fruits were individually incubated in plastic boxes (20 × 12 × 9 cm) with a little of fine sand in the laboratory for 7 days. All larvae and pupae were sieved and individually kept in plastic tubes until adult emergence. The emerged adults of each tube were sorted, identified, and counted for further statistical analysis with Chi square (χ^2) test for goodness of fit considering the

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expected values of sex ratio 1 (female):1 (male) (McDonald, 2023). The obtained data statistically analyzed with Analysis of Variance (ANOVA) according to Snedecor and Cochran (1972) (SAS, 1985). Data was considered significant at $p \leq 0.05$.

RESULTS

1. Comparative Distribution

1.1. The first year of 2021/2022

Data illustrated in Fig. 1 indicate that the Mediterranean fruit fly was more abundant than the peach fruit fly on guava orchards at El-Khanka district, Qalyubia Governorate during the fruiting season of 2021/2022 year. On contrast, at the beginning of summer season, individuals of *B. zonata* were slightly more abundant than the other species of *C. capitata*. The two species of tephritid fruit flies completely disappeared throughout 18 successive weeks during the winter/ spring season (from the17th of January to the 16th of May for *B. zonata* and from the 10th of January to the 9th of May for *C. capitata*). In general, the average number of captured flies of the Mediterranean fruit fly, all over the year, was higher than that recorded for the peach fruit fly (36.60 flies for *B. zonata* and 13.03 flies for *C. capitata*) (Fig. 2).

1.2. The second year of 2022/2023

The population fluctuations of both peach and Mediterranean fruit flies during fruiting season of the second year of investigation (2022/2023) were illustrated in Fig. 3. The population of *B. zonata* fluctuated differently to record nearly five convergent peaks that ranged between 24- 62 flies/trap/day from the first week of October to the ultimate week of December. The population of *C. capitata* was predominant showing two very high peaks from the 31st of October 2022 to the 16th of January 2023**.**

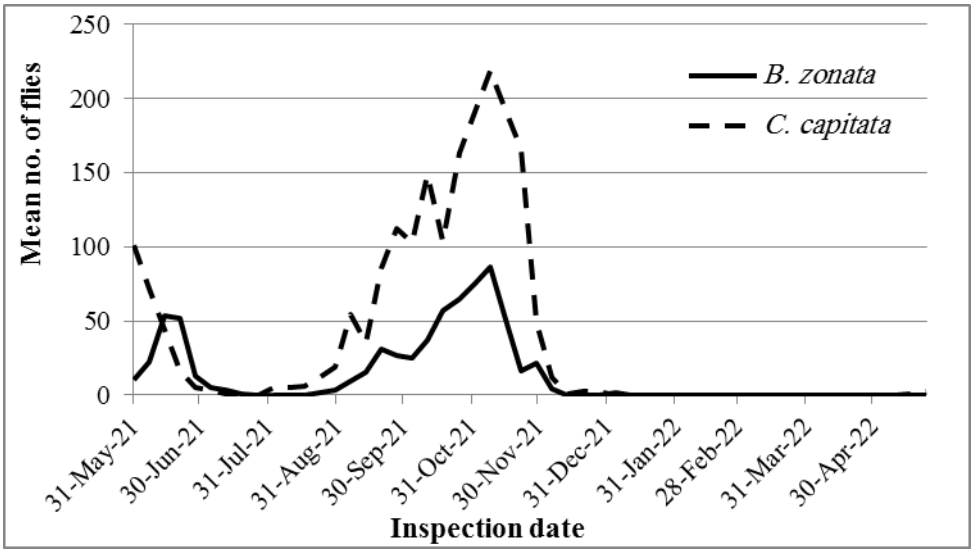

Figure (1): Seasonal population fluctuation of two tephritid fruit flies in guava orchards at El-Khanka district, Qualyubia Governorate during 2021/2022.

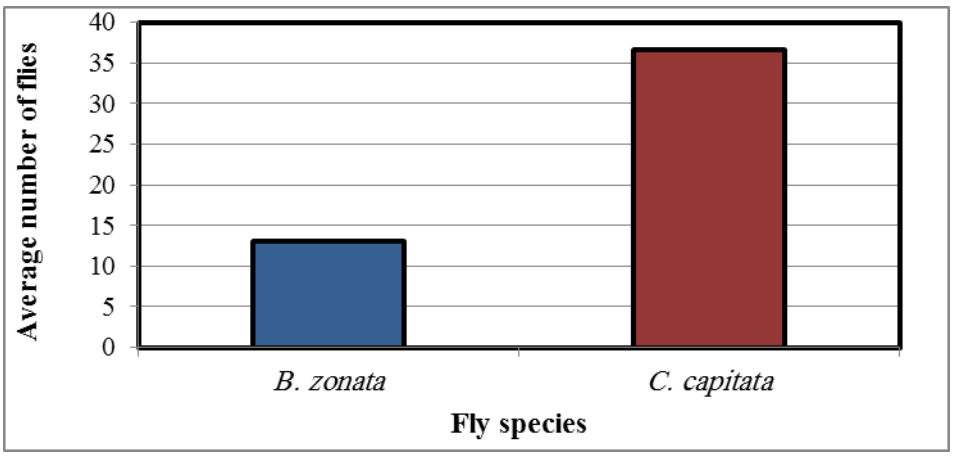

Figure (2): Average number of two tephritid fruit flies in guava orchards at El-Khanka district, Qualyubia Governorate during 2021/2022.

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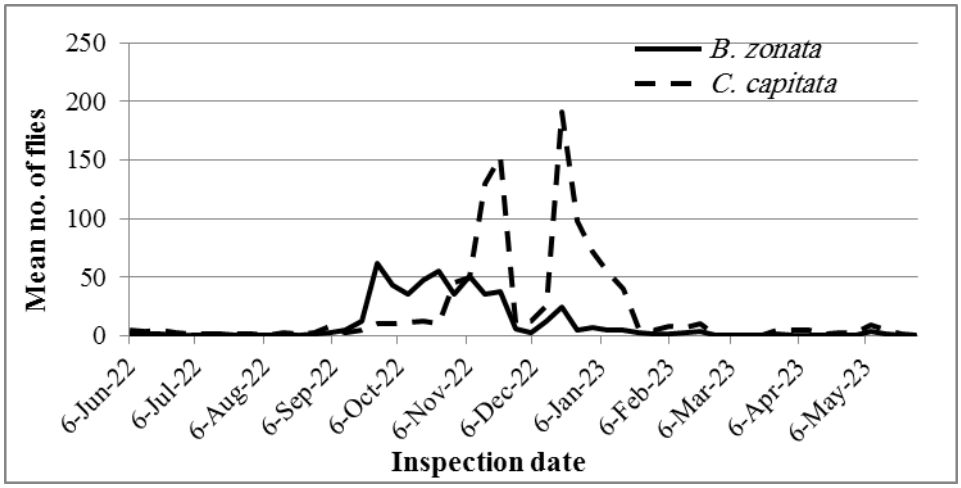

Figure (3): Seasonal population fluctuation of two tephritid fruit flies in guava orchards at El-Khanka district, Qualyubia Governorate during 2022/2023.

As shown in Fig. 4, the population of the Mediterranean fruit fly (19.92 flies) surpassed that of the peach fruit fly (9.74 flies) on guava orchards at El-Khanka district, Qualyubia Governorate during year 2022/2023.

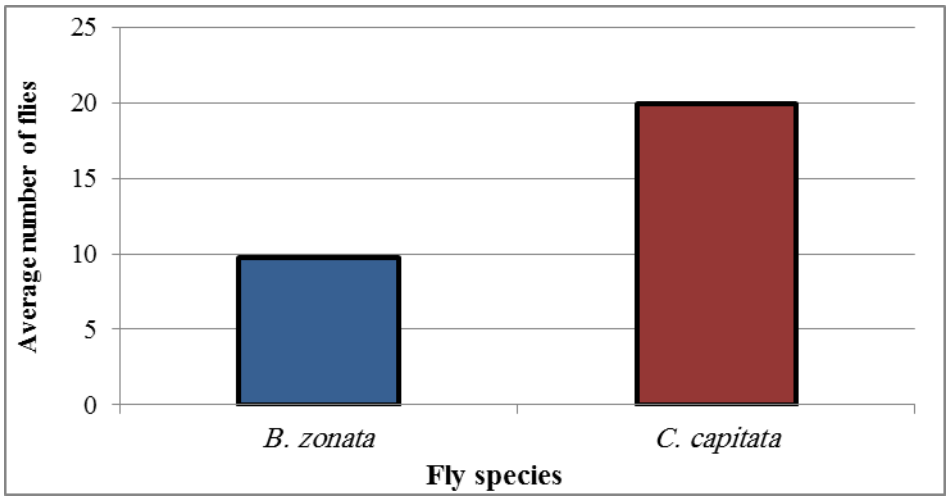

Figure (4): The average number of two tephritid fruit flies in guava orchards at El-Khanka district, Qualyubia Governorate during 2022/2023.

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2. Competition on Guava Infestation of Fruit Flies

2.1. The first season

As shown in Table 1 the mean number of pupae collected from guava fruits varied according to the sample and ranged between 13.20- 31.40 pupae showing a range of mean numbers of 4.40-10.47 pupae/fruit. The percentages of pupal mortality were very high in the first two and latest two samples recording 10.96, 10.78 and 11.46, 14.77, respectively. The percentage of fruit fly emergence increased with time to reach the highest percentage of 93.94 for the fourth sample. The emerged adults were, unfortunately, sorted as *C. capitata* throughout the first five samples, but in case of the six and latest sample, very low numbers of *B. zonata* were investigated that representing 7.22%, whereas the emerged adults of *C. capitata* recorded 78.01%. The sex ratio of emerged adults of the two species of fruit flies insignificantly tended to males showing ranges of sex ratio as % males of 53.75- 77.42 (for *C. capitata*) and 62.99 (for *B. zonata*) [tabulated Chi square value ($\chi^{2)}$ at .05 = 3.841].

2.2. The second season

Data tabulated in Table 2 indicate that the same trend of the first season took place. The mean numbers of pupae/fruit ranged between 1.73- 6.33. The percentage of natural pupal mortality ranged between 24.47- 73.08%. The percentages of adult emergence ranged between 26.92- 75.53%. The sex ratio of emerged adults not significantly showed tendency to males that ranged between 50.70- 85.84% males of *C. capitata* only [tabulated Chi square value (χ^2) at .05 = 3.841]. All observed adults were *C. capitata*, whereas *B. zonata* individuals were nil.

From data compiled in Tables 1 and 2, statistical analysis of variance revealed that all tested parameters were high significantly affected with the date of sample during the two investigation seasons, except with the mean number of dead pupae which was insignificantly different during the second season. According to the emerged flies, individuals of peach fruit fly failed to compete or infest guava fruits with Mediterranean fruit fly in the region of investigation.

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Table (1). Competition between two tephritid fruit flies in guava fruits at El-Khanka district during fruiting season of 2021

Sample	Species	Mean no of pupae±SD	Mean no. of pupae/ fruit±SD	Mean no. of dead pupae±SD	% pupalmort-ality.	Mean no. of emerged adults±SD	% Emerge-nce.	♂	♀	Sex ratio as % males	χ^2
18/8/2021	***B. zonata***	14.60±3.2	4.87±1.9	1.60±0.2	10.96	0	0	0	0	0	-
	C. capitata					13.00±3.1	89.04	8.40	4.6	64.62	1.11
25/8/2021	***B. zonata***	20.40±4.01	6.80±1.7	2.20±0.6	10.78	0	0	0	0	0	-
	C. capitata					18.20±3.1	89.22	11.80	6.40	64.84	1.6
31/8/2021	***B. zonata***	13.20±2.3	4.40±1.2	0.80	6.06	0	0	0	0	0	-
	C. capitata					12.40±2.5	93.94	9.60	2.80	77.42	3.37
6/9/2021	***B. zonata***	18.20±2.2	6.07±1.41	1.20±0.5	6.59	0	0	0	0	0	-
	C. capitata					17.00±3.1	93.41	9.60	7.40	56.47	0.28
14/9/2021	***B. zonata***	31.40±4.6	10.47±2.1	3.60±0.6	11.46	0	0	0	0	0	-
	C. capitata					27.80±2.8	88.54	16.80	11.00	60.43	1.21
21/9/2021	***B. zonata***	17.60±2.5	5.87±1.01	2.60	14.77	1.27	7.22	0.8	0.47	62.99	0.09
	C. capitata					13.73±1.6	78.01	7.38	6.35	53.75	0.08
"F" value		37.45**	27.06**	42.74**		43.86**		8.29**	7.80**	n.s.	
"LSD" value		2.37	0.93	0.35		1.94		2.61	0.74		

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Table (2): Competition between two tephritid fruit flies on guava fruits at El-Khanka district during fruiting season of 2022

Sample	Species	Mean no. of pupae±SD	Mean no. of pupae/ fruit±SD	Mean no. of dead pupae±SD	% pupal mortality	Mean no. of emerged adults±SD	% Emergence.	♂	♀	Sex ratio as % males	χ^2
04/09/22	*B. zonata*	9.20±2.1	3.07±0.2	4.00±1.3	43.48	0	0	0	0	0	-
	C. capitata					5.20±1.0	56.52	3.40	1.8	65.40	049
12/09/22	*B. zonata*	19.00±3.2	6.33±0.5	6.60±2.3	34.74	0	0	0	0	0	-
	C. capitata					12.40±2.2	65.26	6.80	5.60	54.84	0.12
18/09/22	*B. zonata*	18.40±2.4	6.13±0.2	5.00±2.1	27.17	0	0	0	0	0	-
	C. capitata					13.40±1.3	72.83	7.81	5.59	58.3	0.37
27/09/22	*B. zonata*	18.80±3.6	6.27±0.4	4.60±1.9	24.47	0	0	0	0	0	-
	C. capitata					14.20±0.3	75.53	7.20	7.00	50.70	0.003
04/10/22	*B. zonata*	5.20±1.2	1.73±0.3	3.80	73.08	0	0	0	0	0	-
	C. capitata					1.40±0.2	26.92	1.2	0.20	85.84	0.71
"F" Test		58.00**	279.65**	2.86 n.s.		441.98**		8.48**	19.86**	n.s.	
"D" value		1.89	0.29	-		0.60		2.18	1.44		

DISCUSSION

1. Comparative Distribution

The obtained results revealed that *C. capitata* was the most abundant species in guava orchards at El-Khanka district, Qualyubia Governorate showing variable high peaks throughout fruiting seasons during the two years of investigation. The results are in harmony with those found by Saafan *et al*. (2000) studied the population dynamics of *C. capitata* and *B. zonata* in fig orchards at the north-western coastal regions in Egypt recording *C. capitata* from July to December, whereas *B. zonata* from August to December. The occurrence of the two species of fruit flies was differently showing variable summits during fruiting seasons of fig trees. Marangoni-Montes *et al*. (2012) found in a mixed orchard containing mango cultivars in Brazil, that the highest densities of fruit flies took place during the fruit-ripening period (from November to March). Kakar *et al*. (2014) showed that, on guava orchards in Pakistan, fruit fly infestations gradually increased from mid-April and reached to its peaks in mid-August and September whereas the fruit fly infestation were reduced from the end of September to mid-November. Sarwar *et al*. (2014) found, in Pakistan, that fruit fly

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occurrence in guava orchard showed high population frequency of *B. zonata* of 116.67-307.58 captured flies/trap/week in June to August. In Egypt Draz *et al*. (2016), found that *B. zonata* had 7-8 annually generations. The highest numbers of males were investigated on orchards of navel orange intercropped with guava, while the lowest ones were shown in guava and navel orange. In McPhail traps, the highest population was investigated in autumn (20.353 flies/trap/week), while that recorded in seasons of spring, summer and winter were nearly the same. In Brazil, Maciel *et al*. (2017) recorded the highest number of captured fruit flies in May 2008, a period of increased guava fruit suitability in the orchard. Khan and Naveed (2017) found, in Pakistan, that the highest mean number of *B. zonata* was 499 in August, whereas the lowest populations of 26, 3, 2 and 1 were investigated in November, December, January, and February, respectively. Umesh *et al*. (2018) stated that the maximum and minimum population of *B. dorsalis* was recorded in August and January in mango orchard, but the maximum and minimum population of *B. zonata* was recorded in July and January. The populations of both *B. diversa* and *B. correcta* were very low in mango orchard throughout the year. Amin *et al*. (2019) monitored seasonal abundances of fruit flies in a guava orchard and found two species of fruit fly, *B. tryoni* which showed significantly higher abundance compared to *B. dorsalis* in winter and summer seasons. *Bactrocera tryoni* reached its peak at the 2nd week of January, but the peak in summer occurred at the 1st week of May. On other hand, Galli *et al*. (2019) found the genus *Anastrepha* in higher numbers in guava orchards. Bansode and Patel (2020) recorded the maximum population of *Bactrocera* spp. during June- November with peak activity during the 2nd week of September, coinciding with fruiting period of guava. The fly population declined during January to April. Vignesh *et al*. (2020) investigated the population dynamics of fruit flies (*B. dorsalis* and *B. correcta*) on guava trees observing a high peak of 110/trap in August and the least captured flies (7.00/trap) in February. Abbas *et al*. (2021) found population peaks of fruit fly in May-July in guava orchards with maximum population of 69.06-70.36/trap. Khan *et al*. (2021) recorded the population dynamics of *B. zonata* and *B. dorsalis* in guava orchards. The population of the two species highly fluctuated round the

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year. *B. zonata* appeared to be the most abundant species compared to *B. dorsalis*. The highest mean number of *B. zonata* (3690.57flies/trap) was observed in August 2018. From October 2018 onward up to February 2019, population of *B. zonata* tended to decline showing the lowest catches (122.5 and 152.8 flies/trap, respectively) during January and February 2019.

2. Competition in Guava Infestation of Fruit Flies

Our results indicated that guava fruits only infested with *C. capitata* during the two seasons of study, where nil infestation with *B. zonata* was observed. These results are confirmed with that obtained by the previously data of Keiser *et al*. (1974) conducted, in the laboratory, super-imposed oviposition of *B. dorsalis* or *C. capitata* in either sequence in fresh guava fruits following oviposition by the other species. Oriental fruit flies completely or almost completely suppressed the development of Mediterranean fruit flies. Duyck *et al*. (2004) stated that when polyphagous tephritid species have been introduced in areas already or previously occupied by another polyphagous tephritid, interspecific competition had resulted in a reduction in number and niche shift of the pre-established species. No reciprocal invasions had been observed. Ekesi *et al*. (2009) reported that, within 4 years, *B. invadens* had displaced *C. cosyra* becoming the predominant fruit fly pest of mango in Kenya, constituting 98 and 88% of the total population in traps and in mango fruits, respectively. Singh and Sharma (2013) determined the biology of fruit flies, *B. dorsalis* and *B. zonata*in crop fruits and indicated that number of egg punctures in Kinnow and peach were less to that of guava and pear. The larval duration was minimum in guava followed by pear, peach and Kinnow. Numbers of maggots, pupae and adults were the maximum in guava compared to the other hosts. The pupal duration was minimum in guava followed by pear, peach and Kinnow, whereas the sex ratio of both species was almost the same in all hosts. Results of Fabrice *et al*. (2019) showed that behavior of fruit flies on fruits differed between the species and that the interspecific competition affected their developmental duration and larval survival in both watermelon and zucchini. *Zeugodacus cucurbitae* were more aggressive and active than the other species which tended to oviposit more frequently.

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Emergence of both *D. ciliatus* and *D. vertebrates* reduced when inoculated together with *Z. cucurbitae* in watermelon but not in zucchini. Zida *et al*. (2020) studied the relationships between *B. dorsalis* and *C. cosyra*in mango fruits. *Bactrocera dorsalis* recorded 66.30% of fruit flies reared from mango fruits, whereas *C. cosyra* was represented by 33.52%. Among mango fruits infested by fruit flies, 53.50% were attacked only by *B. dorsalis*, 22.14% by *C. cosyra* and 20.35% were infested by both species. In mango fruits co-infested, 54.03% of adults belonged to *B. dorsalis* and 45.96% of adults of *C. cosyra*. Infestation level of *C. cosyra* was higher at the beginning of mango season, while *B. dorsalis* was nil, but the opposite took place at the end of mango season. Jaleel *et al*. (2021) stated, in China, that both *B. dorsalis* and *B. correcta* were economically important insect pests of fruits. *Bactrocera correcta* was the second economic pest of fruits after *B. dorsalis*. Results of response of both *Bactrocera* species on banana, guava, and mango fruits showed that the number of males of both species on each type of fruits were lower than females. The number of flies and oviposition punctures by *B. dorsalis* were the maximum on mango fruits than those of the others. But, in case of *B. correcta*, guava fruits were preferable for visits and oviposition than those of the other two fruits.

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الكثافة العددية المقارنة والسلوك التنافسي بين نوعين من ذباب ثمار الفاكهة في بساتين الجوافة بمحافظة القليوبية

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المستخلص

يعتبر ذباب ثمار الفاكهة من الآفات الحشرية شديدة الخطورة لعديد من المحاصيل البستانية حيث تسبب نقصاً حاداً في كمية وجودة المحصول الناتج. أجريت تجارب حقلية لدراسة الكثافة العددية لذبابتي ثمار الخوخ وفاكهة البحر المتوسط في بساتين الجوافة بمحافظة القليوبية خلال عامين متتاليين وتحديد القدرة التنافسية بين كلا النوعين في ثمار الجوافة. أوضحت النتائج تذبذب أعداد ذكور كلا النوعين المنجذبة لأشجار الجوافة خلال عامي الدراسة. سجلت ذبابة ثمار الخوخ خلال العام الأول للدراسة أعلى ذروتي التعداد (53.33 و86,67 فرداً/ مصيدة/ يوم) في الرابع عشر من يونيو والثامن من نوفمبر عام 2021، بينما ظهر أعلى ذروتين من تعداد ذبابة فاكهة البحر المتوسط (148.67 و219 ذبابة/ مصيدة/ يوم) في الحادي عشر من أكتوبر والثامن من نوفمبر في نفس العام. في حين وخلال العام الثاني للدراسة سجلت أعلى قمتين للتعداد 62، 55 ذبابة للمصيدة الواحدة في اليوم (لذبابة ثمار الخوخ) و153، 191,67 ذبابة/ مصيدة/ يوم (لذبابة فاكهة البحر المتوسط) في السادس والعشرين من سبتمبر والرابع والعشرين من أكتوبر وفي الحادي والعشرين من نوفمبر والتاسع عشر من ديسمبر لعام 2022 على التوالي. لوحظ زيادة تعداد كلا النوعين من ذباب الثمار خلال موسمي إثمار أشجار الجوافة وكان المتوسط العام لإجمالي تعداد ذبابة فاكهة البحر المتوسط أعلى بدرجة كبيرة

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منه لذبابة ثمار الخوخ وذلك خلال عامي الدراسة. ومن جهة أخرى اتضح انخفاض القدرة التنافسية لإناث ذبابة ثمار الخوخ في منافسة إناث ذبابة فاكهة البحر المتوسط لإصابة ثمار الجوافة خلال موسمي الدراسة.

الكلمات المفتاحية: التقلبات الموسمية، التعداد، ذبابة فاكهة البحر المتوسط، ذبابة الخوخ