Research Article

Population Abundance, Development and Survival of Peach Fruit Fly *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) on Different Citrus Cultivars in Wasit Province, Iraq

Hasan Al-Khshemawee[1]*, Khais Muri Laabusi[1] and Hassnen T. Kareem[1]

[1]*Department of Plant Protection, College of Agriculture, Wasit University, Wasit, Iraq.*

Abstract | Mandarins and oranges are prime citrus cultivars being cultivated in eastern Iraq. *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) is one of the challenging pests of citrus production in Wasit province, Iraq. This study aimed to monitor the population abundance of *B. zonata* in different months using methyl eugenol-based Tefri® pheromone traps. Moreover, the infestation and development of *B. zonata* in the fruits of sweet oranges, bitter oranges, and mandarins were carried out from October to December 2024 in different orchards of Wasit province. The results showed a significant effect of sampling season or months with maximum and minimum population abundance of *B. zonata* adults found in the months of November and December, respectively. The seasonal distribution of the peach fruit fly correlates with the presence of the fruits and their ripening stage in the field. Mandarin fruits were infested in October, while oranges were infested in November and December. Moreover, the results showed that peach fruit fly exhibited a differential infestation and preference for different citrus fruit types, based on the degree of fruit infestation and the average number of larvae per fruit. Mandarin fruits were the most preferred citrus fruit type by *B. zonata*, followed by sweet oranges and bitter oranges. The average mortality of fruit fly eggs, larvae, and adults was 5.24, 8.89, and 18.53%, 5.62, 10.02, and 12.35% and 12.12, 13.77, and 18.07%, respectively, for October, November, and December, indicating differential survival and development of peach fruit fly *B. zonata* during the citrus fruiting season. These results would help in practical implications for the better management of fruit fly infestations in citrus and other fruit orchards of Wasit province of Iraq.

Received | August 04, 2025; **Accepted** | Oct 4, 2025; **Published** | January 23, 2026
***Correspondence** | Hasan Al-Khshemawee, Department of Plant Protection, College of Agriculture, Wasit University, Wasit, Iraq; **Email:** hasanfaraj@uowasit.edu.iq
Citation | Khshemawee, H.A., K.M. Laabusi and H.T. Kareem. 2026. Population abundance, Development and survival of peach fruit fly *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) on different citrus cultivars in wasit province, Iraq. *Sarhad Journal of Agriculture,* 42(1): 123-130.
DOI | https://dx.doi.org/10.17582/journal.sja/2026/42.1.123.130
Keywords | Peach fruit fly, *Bactrocera zonata*, Citrus cultivars, Differential host preference, Seasonal abundance, Fruit infestation rate, Mortality factors.

Introduction

Citrus is a vital fruit crop all over the world. These fruits are nutritionally rich, containing many vitamins, minerals, and fibers, particularly vitamin C (Liu *et al.*, 2012). A variety of citrus cultivars are being cultivated in different tropical and subtropical regions of the world (Hamid *et al.*, 2024). Mandarins, oranges,

and grapefruits are among the most appraised and economically important citrus cultivars around the globe, including Iraq (Al-Snafi, 2016). However, Iraq is far behind in terms of citrus production per unit area compared to other citrus-producing countries (Singh *et al.*, 2021). Citrus production is primarily hindered by many factors, including biotic and abiotic stresses and the incidence of different insect pests and diseases (Al-Khshemawee *et al.*, 2018; Yesiloglu *et al.*, 2022; Abu-Ragheef *et al.*, 2023).

Fruit flies are one of the most economically important insect pests of different horticultural crops, including citrus (Papadopoulos *et al.*, 2024). Fruit fly (*Bactrocera zonata* Saunders), commonly known as peach fruit fly, belongs to the Tephritidae family of the Diptera order. It is basically an oligophagous pest and is one of the most serious insect pests affecting many fruit trees and urban crops, causing significant economic losses to different fruit crops in tropical and subtropical regions of the world (Alzubaidy, 2000; Ashfaq *et al.*, 2020; Riaz *et al.*, 2022; Al Abbas and Mohammad, 2025). It poses a serious threat to citrus production all over the world, including Iraq. Female fruit flies infest the ripened or semi-ripened fruits by depositing their eggs inside the fruits, subsequently causing significant economic loss to citrus production (Al-Khshemawee *et al.*, 2017; Al-Jassany *et al.*, 2018; Saeed *et al.*, 2022). This species inflicts damage worth millions of euros annually in the Far East and approximately 190 million euros in Egypt (Duyck *et al.*, 2004; Abd-Elgawad, 2021). This fruit fly is being ranked first among the economically important fruit fly species (Zingore *et al.*, 2020). It has been recorded on more than 350 plant host species (Draz, 2016), most of which are of high economic importance, such as citrus fruits, oleaginous fruits, and stone fruits such as peaches, apricots, and pomes. Such as apples, pears, quince, vegetables, and many plant families, as well as dates (Ghanim, 2009).

In Iraq, *B. zonata* has been considerably invading citrus and other fruit orchards, particularly in the Wasit province (Alzubaidy, 2000; Younes and Akel, 2010; Alghanimi *et al.*, 2025). This spread of *B. zonata* in Iraq could be the result of weak agricultural quarantine measures, as well as the imports of citrus fruits and vegetables from countries where this pest is more prevalent, such as Iran, Saudi Arabia, and Egypt. It has been found to cause significant economic losses to many fruit crops, including mandarins and oranges (Alghanimi *et al.*, 2025).

Keeping in view the seriousness of this pest species, its rapid spread and adaptation to different environmental conditions, and the abundance of host plants and the extent of damage it causes to different fruit crops (Duyck *et al.*, 2004; Delrio and Cocco, 2010; Afia, 2018; Sallam *et al.*, 2024), this field study aimed to monitor the temporal distribution of the *B. zonata* on different citrus cultivars in Wasit province of Iraq, and to identify the most important mortality factors affecting this pest species.

Materials and Methods

Fruit fly monitoring

Insect sampling was conducted in the orchards of each district of Wasit Province. In addition to citrus cultivars such as mandarins, oranges, and bitter oranges, these targeted fruit orchards were of apple, fig, and date palm. Tefri® pheromone traps, containing methyl eugenol male fruit fly lure, were set up @ 24 traps per acre. Five traps were placed randomly in one orchard unit. Insects (captured male fruit flies) were collected from the traps weekly and placed in polyethylene bags to be carried to the laboratory for calculating the total number of male fruit flies captured per trap. The pheromone or lure station in the traps was replaced every 15 days. Prevailing atmospheric temperature and relative humidity were acquired from the local agricultural meteorological station affiliated with Wasit Agriculture Directorate.

Host preference determination

This experiment was carried out in the orchards of different citrus cultivars in an overlapping manner. In brief, thirty-four trees of each citrus species or cultivar were selected and identified in the study area. These trees of citrus cultivars selected for the study included sweet orange (*Citrus sinensis* L.), bitter orange (*Citrus aurantium* L.), and mandarin (*Citrus reticulata* L.). Ten fruits were randomly taken from each tree, and the percentage of citrus fruit infestation was determined based on oviposition scars made by female *B. zonata*, larval decaying spots, and fruit rot. The infested fruits were taken to the laboratory at 27–31°C. To confirm the diagnosis of the insect, these fruits were placed in plastic containers measuring 30 × 30 × 30 cm, with a 2 cm thick layer of sterile soil inside the containers' bottom. Two fruits were placed in each container, and the container was tightly covered with a muslin cloth

secured with a rubber band. Monitoring was done until the emergence of adult fruit flies, which were later identified up to species level. The percentage of fruit infestation was determined according to the following equation;

$$Fruit\ infestation\ rate\ (\%) = \frac{Number\ of\ infested\ fruits\ in\ the\ sample}{total\ number\ of\ fruits\ in\ the\ sample} \times 100$$

Moreover, ten infested fruits of each citrus cultivar were taken to the laboratory and were dissected to determine the number of fruit fly maggots (larvae) present within the fruit.

Determination of life table parameters of B. zonata

The life table parameters of the fruit fly were determined in the field based on the data obtained from the semi-monthly field surveys conducted from October to December 2024 in the citrus orchards of Wasit Province of Iraq. In addition, the key factor (Kf), which represents the sum of the logarithms of mortality for each age group, is calculated according to the following equation.

$$Key\ factor\ (Kx) = Log10\ (nx) - Log10\ (nx + 1)$$

Where, kx = age-specific mortality (x), nx = number of individuals at the given age, nx + 1 = number of individuals at the subsequent age, and the total generation mortality, represented by the value K was calculated by summing the K values of all age groups *i.e.*, K = K1 + K2 + K3 ... + KN (Smith, 1993).

Statistical analysis

The statistical software SPSS (Version 22.0) was used for statistical analysis of the data. The results regarding the fruit fly captures, mortality, and life table parameters were analyzed using an analysis of variance according to the design used, and the mean values were compared using the least significant difference (LSD) at a probability level of 0.05.

Results and Discussion

Fruit fly *B. zonata* has been a challenging and hard-to-control pest of fruit orchards, particularly of oranges, mandarins, and other citrus fruits (Zingore *et al.*, 2020; Tramontini *et al.*, 2025). This pest has threatened citrus production in Iraq (Delrio and Cocco, 2010; Alghanimi *et al.*, 2025). This study aimed to better understand the incidence and development of *B. zonata* in different citrus fruit orchards under the prevailing agro-climatic conditions of Wasit Province of Iraq. Random fruit fly samplings were done using pheromone traps, and the infestation and development of fruit flies in the fruits of sweet oranges, bitter oranges, and mandarins were carried out from October 2024 to December 2024 in different orchards of Wasit province.

According to the results, the fluctuations in the number of male peach fruit fly (*B. zonata*) individuals caught in the Tefri® traps were according to the prevailing temperature and relative humidity parameters. The results showed that the temperature and relative humidity significantly affected the number of male fruit flies attracted and trapped in the pheromone traps. The number of adult female flies began to increase at the beginning of November till the end of November. The average number of male fruit flies trapped was 252.6, 292.6, and 233 individuals per trap per week, respectively, for October, November, and December 2024. The average prevailing temperature and relative humidity values for the study period were 29.0°C and 55.5%, respectively. The capture numbers of fruit flies (males/trap/week) increased from early to end November, and then began to decrease as the temperature decreased, reaching their lowest population density at the end of December (Table 1).

Table 1: *Population density of peach fruit fly B. zonata during different months in the fruit orchards of Wasit Province, Iraq.*

Sample No.	Sampling months		
	October	November	December
1	210*	255	211
2	234	245	216
3	244	286	243
4	265	276	287
5	310	401	208
Average	252.6	292.6	233

**Number of male fruit fly individuals caught in Tefri® fruit fly traps per trap per week.*

Our results corroborate that the prevailing temperature and relative humidity had a significant impact on the population density of peach fruit fly *B. zonata*, with the highest density recorded in November (Ali *et al.*, 2011; Sarwar *et al.*, 2023). Duyck *et al.* (2004) indicated that the optimum temperature for the

development of peach fruit fly (*B. zonata*) ranges between 25 and 30°C, and that the development time decreases with increasing temperature. Choudhary *et al*. (2020) and Nisar *et al*. (2021) reported that the lower temperatures reduced the hatch rate of eggs from 80 to 20% when the temperature decreased from 30 to 16°C.

Table 2: *Average percent infestation of fruits of different citrus cultivars of wasit province, iraq by peach fruit fly b. zonata during different months.*

Type of citrus	Months			Average
	October	November	December	
Orange	15.26	34.45	8.43	19.38
Mandarin	33.50	65.43	16.54	38.49
Bitter orange	0.45	14.46	9.76	8.22
Average	16.40	38.11	11.57	
LSD	citrus cultivar: 2.992		months: 3.874	

Results of the host preference study showed that the peach fruit fly (*B. zonata*) exhibited a differential preference for fruits of different citrus cultivars, as significant differences were found between the infestation rates in different citrus fruits. Mandarin fruits were the insect's preferred choice among other citrus fruit types, with the highest fruit fly infestation rate of 38.49%, followed by sweet oranges (19.38%) (Table 2). Bitter oranges exhibited a minimum fruit fly infestation rate (8.22%). The results revealed that the fruit fly infestation was concentrated on mandarins at the beginning of November, while no infestation was recorded or a slight infestation was found on sweet oranges and bitter oranges. The infestation then began to increase, reaching its peak, *i.e.*, 35% on mandarins and 15 – 35% on sweet oranges and bitter oranges in November due to favorable environmental conditions. The infestation remained severe on mandarins until their harvest in mid-November.

The insect's preference for mandarins over other citrus fruits during the season may be due to the fact that mandarins are the first citrus fruits to ripen, their fruit becoming juicy and appealing the fruit flies out in the field (Huang *et al*., 2022; Hasnain *et al*., 2025). This, in addition, would be due to the thinness of the fruit's peel. Fruit ripeness is one of the factors affecting insect population density and larval survival rates. It also plays a significant role in influencing insect reproduction and growth parameters (El-Gendy *et al*., 2020). Sarwar *et al*. (2013) and Amin (2017) explained that the differences in the nutritional content of host fruits are part of a series of insect attractants and repellents, thereby distinguishing the preferred plant hosts. Ni *et al*. (2012) and El-Genaidy *et al*. (2024) indicated that the fruits have differences in sugars, amino acids, and other nutrients, which play a significant role in the insect's structural and chemical reactions and play a fundamental role in the insect's preference for fruits such as the mandarin. Moreover, Younes and Akel (2010) mentioned that sugar content varies across citrus fruit species, in addition to the differences in nutritional elements and amino acids. This prompted the insects, particularly fruit flies, to prefer mandarins due to their high sugar content and low acidity, unlike bitter oranges. Our results are also in line with the findings of Al-Khshemawee *et al*. (2020), who found that peach fruit flies (*B. zonata*) prefer mandarin fruits over oranges and other fruit types.

Moreover, results of fruit fly development parameters indicated that there were 9.84, 7.22, and 17.81% average failure rates for the eggs, larvae, and adults of *B. zonata* for the orange, mandarin and bitter orange fruits, respectively (Table 3). The biotic and abiotic factors, particularly prevailing temperature

Table 3: *Life table parameters of peach fruit fly B. zonata on different citrus cultivars of Wasit Province, Iraq by during different months.*

Citrus	October			November			December			average
	EM (%)	LM (%)	AM (%)	EM (%)	LM (%)	AM (%)	EM (%)	LM (%)	AM (%)	
Orange	4.39	3.25	12.76	6.14	7.88	11.34	13.14	11.78	17.89	9.84
Mandarin	2.99	2.87	4.63	4.87	5.21	9.76	9.90	8.08	16.67	7.22
Bitter orange	8.34	10.76	18.97	15.68	16.98	20.21	32.56	17.19	19.65	17.81
Average	5.24	5.62	12.12	8.89	10.02	13.77	18.53	12.35	18.07	
LSD	Citrus: 0.982		Months: 1.879		Egg: 1.987		Larvae: 0.879		Adults: 1.011	

EM = egg mortality, LM = larval mortality, AM = adult mortality

and relative humidity, had a significant effect on the average mortality of fruit fly eggs, larvae, and adults as these values were 5.24, 8.89, and 18.53%, 5.62, 10.02 and 12.35% and 12.12, 13.77, and 18.07%, respectively for October, November, and December (Table 3). Our results are in line with the findings of Duyck *et al.* (2004) and Sarwar *et al.* (2023), who indicated that prevailing temperature and relative humidity in different months of the citrus fruit ripening time period would affect the fruit fly survival and development in the orchards. In December, the fruit fly population trend began to decrease compared to the previous month due to lower temperatures and because of the influence of various mortality factors.

Table 4: *Average number of larvae of peach fruit fly B. zonata per fruit of different citrus cultivars of Wasit Province, Iraq during different months.*

Type of citrus	Months			Average
	October	November	December	
Orange	7	16	11	11.33
Mandarin	11	19	12	14.00
Bitter orange	6	13	9	9.33
Average	8	16	10.66	
LSD	citrus cultivar: 2.331		months: 1.101	

Duyck *et al.* (2004) studied the effect of different temperatures on some aspects of the life cycle of *B. zonata* and showed that a decrease in temperature from 30 to 15°C increased the duration of adult emergence from 8 to 53 days. Similarly, Abu-Ragheef *et al.* (2023) showed that a decrease in temperature from 30 to 20°C affected the duration of egg incubation and the larval development period, increasing it from 8.7 to 17.8 days. It also affected the number of eggs laid by *B. zonata* females from 218 to 70.8. These findings, including this study's results, demonstrate that the environmental conditions can play a significant role in the development and population dynamics of insect pests such as fruit flies during fruiting seasons (Choudhary *et al.*, 2021).

Regarding fruit fly maggots per infested fruit, significant differences were found between the fruits of three citrus cultivars. Mandarins were the *B. zonata*'s preferred fruits among other citrus fruit types, with the highest infestation rate (*i.e.*,14 larvae per fruit), followed by oranges with an infestation rate of 11.33 larvae per fruit and bitter oranges with 9.33 larvae per fruit (Table 4). These results revealed that the fruit fly infestation was concentrated on mandarins at the beginning of October, while no infestation was recorded on oranges and other citrus fruits. The infestation then began to increase, reaching its peak at the beginning of November. The infestation remained severe on mandarins until harvest, with the infestation rate on oranges rising to 21.86% by mid-November. This was due to the mandarin crop being harvested and the insect shifting to other fruit crops nearby. The average number of larvae was highest (14.00 larvae per fruit) on mandarins, and the lowest (9.33 larvae per fruit) on bitter oranges. The insect's preference for mandarin fruits over other citrus fruits during the season may be because mandarins are the first citrus fruits to ripen and become juicy, and the color of their peel changes from green to yellow, in addition to the thinness of the fruit's peel (El-Gendy *et al.*, 2020). The ripeness of the fruit is one of the factors affecting the insect's population density, the survival rate of the larval stages, and the number of eggs laid (El-Gendy *et al.*, 2020).

Conclusions and Recommendations

Based on overall study results, it is concluded that the population density of peach fruit fly (*B. zonata*) significantly differs among the three sampling months as indicated by the average number of male fruit captures in pheromone traps. Moreover, *B. zonata* showed a differential infestation, development, and preference for different citrus fruit types, based on the degree of fruit infestation, varied mortality rates of eggs, larvae, and adults, and the average number of larvae per fruit. Mandarin fruits were the most preferred citrus fruit type for the insect, followed by oranges and bitter oranges, with the highest and lowest larval mortality recorded for December and November, respectively. These results would help in practical implications regarding the management of fruit fly infestations in citrus and other fruit orchards of Wasit province of Iraq.

Acknowledgements

The authors would like to thank Department of Plant Protection, College of Agriculture, and University of Wasit for their support and provide the equipment and tools.

Novelty Statement

The results of the study would help in practical implications for the better management of fruit fly infestations in citrus and other fruit orchards of Wasit province of Iraq

Author's Contribution

Khais Muri Laabusi: Methodology and writing-original draft preparation
Hassnen T. Kareem: Software, data curation and supervision
Hasan Al-Khshemawee: Investigation, writing-review & editing and supervision

Generative AI or AI assisted technology statement
The authors declare that no generative artificial intelligence (AI) tools or AI assisted technologies were used in the preparation, writing, data analysis or editing of this manuscript.

Conflict of interest
The authors have no conflict of interest.

References

Abd-Elgawad, M.M. 2021. The Mediterranean fruit fly (Diptera: Tephritidae), a key pest of citrus in Egypt. J. Integ. Pest Manage., 12: 1–10. https://doi.org/10.1093/jipm/pmab025

Abu-Ragheef, A.H.H., F.J. Al-Behadili and S.A. Abbas. 2023. Competition between the Mediterranean fruit fly, *Ceratitis capitata*, and the peach fruit fly, *Bactrocera zonata* under the agricultural ecosystem in central Iraq. In: IOP Conf. Ser.: Earth Environ. Sci., 1262: 032053. IOP Publishing. https://doi.org/10.1088/1755-1315/1262/3/032053

Afia, Y.E. 2018. Seasonal abundance of peach fruit fly (PFF), *Bactrocera zonata* Saund., and Mediterranean fruit fly (MFF), *Ceratitis capitata* Wied., (Tephritidae-Diptera) on varieties of different grapes, in Giza Gov. Egypt. J. Plant Prot. Pathol., 9: 683–689. https://doi.org/10.21608/jppp.2018.43958

Al Abbas, K.A.Z.M.S. and A.A. Mohammad. 2025. Evaluating the efficiency of some plant extracts in controlling the different stages of the peach fruit fly, *Bactrocera zonata* (Diptera: Tephritidae). J. Kerbala Agric. Sci., 12: 73–83. https://doi.org/10.59658/jkas.v12i1.3242

Alghanimi, S.A., A.A. Talebi, R.G. Ghavamabad and M. Pedram. 2025. Evaluation of two free-living, and one entomopathogenic nematode species (Rhabditida) for controlling *Bactrocera zonata* (Diptera: Tephritidae) in Iraq. J. Nematol., 57: 20250001. https://doi.org/10.2478/jofnem-2025-0001

Ali, N.A., A.A. Awad and H.O. Mohamed. 2011. Population fluctuation of the peach fruit fly, *Bactrocera zonata* (Saunders)(Diptera: Tephritidae) in relation to prevailing weather factors in Assuit Governorate. Assiut Univ. J. Zool., 40: 1–15.

Al-Jassany, R.F. and A.H. Abu Raghef. 2018. Population density of the peach fruit fly *Bactrocera zonata* (Diptera: Tephritidae) and some plant species that infect it. Int. J. Agric. Stat. Sci., 14: 279–285.

Al-Khshemawee, H., M. Agarwal, B. Du, J.O. Yang and Y. Ren. 2020. Efficacy of D-glucose-13C6 as a label for amino acid identification and quantification in Mediterranean fruit flies (Diptera: Tephritidae). J. Entomol. Sci., 55: 117–125. https://doi.org/10.18474/0749-8004-55.1.117

Al-Khshemawee, H., M. Agarwal, X. Du and Y. Ren. 2017. Detection of Mediterranean fruit fly larvae *Ceratitis capitata* (Diptera: Tephidae) in different types of fruit by hs-SPME GC-MS method. J. Biosci. Med., 5: 154–169. https://doi.org/10.4236/jbm.2017.53017

Al-Khshemawee, H., X. Du, M. Agarwal, J.O. Yang and Y.L. Ren. 2018. Application of direct immersion solid-phase microextraction (DI-SPME) for understanding biological changes of Mediterranean fruit fly (*Ceratitis capitata*) during mating procedures. Molecul., 23: 2951. https://doi.org/10.3390/molecules23112951

Al-Snafi, A.E. 2016. Nutritional value and pharmacological importance of citrus species grown in Iraq. IOSR J. Pharm., 6: 76–108. https://doi.org/10.9790/3013-0680176108

Alzubaidy, M. 2000. Economic importance and control/eradication of peach fruit fly, *Bactrocera zonata*. Arab J. Plant Prot., 18: 139–142.

AMIN, A.A. 2017. Field and laboratory studies on infestation of immature mango fruits by the peach fruit fly, *Bactrocera zonata* (saunders). Egypt. J. Agric. Res., 95: 89–106. https://doi.org/10.21608/ejar.2017.146275

Ashfaq, M., M.A. Khan, M.D. Gogi and A. Rehman. 2020. Loss assessment and management of *Bactrocera zonata* (Diptera: Tephritidae) in citrus orchards. Pak. J. Agric. Sci., 57: 451–456.

Choudhary, J.S., S.S. Mali, N. Naaz, D. Mukherjee, L. Moanaro, B. Das, and B.P. Bhatt. 2020. Predicting the population growth potential of *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) using temperature development growth models and their validation in fluctuating temperature condition. Phytoparas., 48: 1–13. https://doi.org/10.1007/s12600-019-00777-4

Choudhary, J.S., S.S. Mali, N. Naaz, S. Malik, B. Das, A.K. Singh, and B.P. Bhatt. 2021. Spatio and temporal variations in population abundance and distribution of peach fruit fly, *Bactrocera zonata* (Saunders) during future climate change scenarios based on temperature driven phenology model. Climat. Risk Manage., 32: 100277. https://doi.org/10.1016/j.crm.2021.100277

Delrio, G. and A. Cocco. 2010. The peach fruit fly, *Bactrocera zonata*: A major threat for Mediterranean fruit crops?. In: XXVIII Int. Hort. Cong. Sci. Hort. Peopl., (IHC2010), 940: 557–566. https://doi.org/10.17660/ActaHortic.2012.940.80

Draz, K.A. 2016. Population activity of peach fruit fly *Bactrocera zonata* (Saunders) (Diptera: Tephiritidae) at fruits orchards in Kafer El-Shikh Governorate, Egypt. Arthropod., 5: 28–43.

Duyck, P.F., J.F. Sterlin and S. Quilici. 2004. Survival and development of different life stages of *Bactrocera zonata* (Diptera: Tephritidae) reared at five constant temperatures compared to other fruit fly species. Bull. Entomol. Res., 94: 89–93. https://doi.org/10.1079/BER2003285

El-Genaidy, M.A.E., Y.E. Afia and S.M. Elmahdy. 2024. Laboratory studies on the nutritional content effect of fruits on the competitive ability for *Bactrocera zonata* and *Ceratitis capitata*. Int. J. Entomol. Res., 9: 74–79.

El-Gendy, I.R., K.A. Draz, M.A. El-Aw and H.F. Darwish. 2020. Interaction among peel hardness, fruit-age and gibberellic acid on infestation susceptibility of citrus fruits by peach fruit fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae). Afr. Entomol., 28: 125–132. https://doi.org/10.4001/003.028.0125

Ghanim, N.M. 2009. Studies on the peach fruit fly, *Bactrocera zonata* (Saunders) (Tephritidae, Diptera). Ph. D. Dissertation, Fac. Agric. Mansoura Univ. Egypt.

Hamid, S., K. Sharma, K. Kumar and A. Thakur. 2024. Types and cultivation of citrus fruits. In: Citrus Fruits and Juice: Processing and Quality Profiling (pp. 17–43). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-99-8699-6_2

Hasnain, M., Q. Ali, S. Nadeem, D. Hussain, F. Hafeez, M. Akram, and M.J. Saleem, 2025. Ovipositional preferences of the peach fruit fly (*Bactrocera zonata*, Saunders) (Diptera: Tephritidae) among different host fruits. Agric. Sci. J., 7: 01–8. https://doi.org/10.56520/asj.v7i1.445

Huang, A.L., X.Y. Wang, W. Lu and X.L. Zheng. 2022. Ovipositional preference of oriental fruit fly *Bactrocera dorsalis* to different host fruits and its correlation with physical and chemical properties of host fruits. J. Plant Prot., 2: 595–602

Liu, Y., E. Heying and S.A. Tanumihardjo. 2012. History, global distribution, and nutritional importance of citrus fruits. Compr. Rev. Food Sci. Food Saf., 11: 530–545. https://doi.org/10.1111/j.1541-4337.2012.00201.x

Ni, W.L., Z.H. Li, H.J. Chen, F.H. Wan, W.W. Qu, Z. Zhang and D.J. Kriticos. 2012. Including climate change in pest risk assessment: the peach fruit fly, *Bactrocera zonata* (Diptera: Tephritidae). Bull. Entomol. Res., 102: 173–183. https://doi.org/10.1017/S0007485311000538

Nisar, M.J., M.D. Gogi, B. Atta, M. Tufail, R.A. Ali, W.A. Naveed and M. Iqbal. 2021. Pathogenicity of fungal and bacterial bioinsecticides against adult peach fruit fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) admixed with adult diet under controlled conditions. Egypt. J. Biol. Pest Cont., 31: 146. https://doi.org/10.1186/s41938-021-00481-8

Papadopoulos, N.T., M. De Meyer, J.S. Terblanche and D.J. Kriticos. 2024. Fruit flies: challenges and opportunities to stem the tide of global invasions. Ann. Rev. Entomol., 69: 355–373. https://doi.org/10.1146/annurev-ento-022723-103200

Riaz, M.A., M. Usman, M. Saadia, S. Ahmed and

M.Z. Majeed. 2022. Synergistc effect of phytochemicals against citrus fruit fly *Bactrocera zonata* (Diptera: Tephritidae). J. Agric. Res., 60: 211–218.

Saeed, M., T. Ahmad, M. Alam, L.A. Al-Shuraym, N. Ahmed, M.A. Alshehri, and S.M. Sayed. 2022. Preference and performance of peach fruit fly (*Bactrocera zonata*) and melon fruit fly (*Bactrocera cucurbitae*) under laboratory conditions. Saudi J. Biol. Sci., 29: 2402–2408. https://doi.org/10.1016/j.sjbs.2021.12.001

Sallam, R.F., N.F. Abdel-Hameid, S.A. Shairra, A.A. Hafez and F.F. Shalaby. 2024. Efficacy of *Eucalyptus citradora* (Hook.) extract against the peach fruit fly pupae, *Bactrocera zonata* (Saund.) (Diptera: Tephritidae). Benha J. Appl. Sci., 9: 59–64. https://doi.org/10.21608/bjas.2024.269791.1330

Sarwar, M., B. Rasool, M.M. Shah and N. Ahmad. 2023. Effects of environmental variables and role of food attractants for management of *Bactrocera zonata* (Saunders, 1842) and *Bactrocera dorsalis* (Hendel, 1912) (Diptera: Tephritidae). J. Entomol. Res. Soc., 25: 563–578.

Sarwar, M., M. Hamed, B. Rasool, M. Yousaf and M. Hussain. 2013. Host preference and performance of fruit flies *Bactrocera zonata* (Saunders) and *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae) for various fruits and vegetables. Int. J. Sci. Res. Environ. Sci., 1: 188–194. https://doi.org/10.12983/ijsres-2013-p188-194

Singh, J., V. Sharma, K. Pandey, S. Ahmed, M. Kaur and G.S. Sidhu. 2021. Horticultural classification of citrus cultivars. Citrus Res., Develop. Biotechnol., 1–24. Intech Open. https://doi.org/10.5772/intechopen.96243

Smith, S. M. 1993. Insect parasitoids: A Canadian perspective on their use for biological control of forest insect pests. Phytoprotection, 74(1): 51-67.

Tramontini, S., G. Gilioli, E. de la Peña, D. Rzepecka, M. Scala, and F. Paoli. 2025. European Food Safety Authority (EFSA), Bactrocera zonata Pest Report to support the ranking of EU candidate priority pests. 22: p. 9403E. https://doi.org/10.2903/sp.efsa.2025.EN-9403

Yesiloglu, T., B. Yilmaz, M. Incesu and B. Cimen. 2022. Challenges to the citrus industry. In: Citrus Production (pp. 23–33). CRC Press. https://doi.org/10.1201/9781003119852-2

Younes, M.W. and F.A. Akel. 2010. Effect of temperature on development and reproduction of peach fruit fly, *Bactrocera zonata* (Saund.) (Diptera: Tephritidae). Egypt. J. Exp. Biol., 6: 255–261.

Zingore, K.M., G. Sithole, E.M. Abdel-Rahman, S.A. Mohamed, S. Ekesi, C.M. Tanga and M.E. Mahmoud. 2020. Global risk of invasion by *Bactrocera zonata*: Implications on horticultural crop production under changing climatic conditions. PLoS One., 15: e0243047. https://doi.org/10.1371/journal.pone.0243047