RESEARCH PAPER

Studies on the population dynamics of fruit flies (diptera: tephritidae) on mango orchards in Multan, Punjab, Pakistan

Qaisar Abbas[1]*, Muhammad Hasnain[1], Mussurrat Hussain[1], Qurban Ali[2], Muhammad Jafir[3], Muhammad Shahid[2], Muhammad Iqbal[2] and Hasnain Abbas[5]

[1]Entomological Research Sub-Station, Multan, Pakistan
[2]Entomological Research Institute, Faisalabad, Pakistan
[3]Department of Entomology, University of Agriculture, Faisalabad, Pakistan
[4]Cotton Research Institute, Multan, Pakistan
[5]Muhammad Nawaz Sharif University of Agriculture, Multan, Pakistan

*Corresponding author's email**:** ent_1387@yahoo.com

Key Message: This study indicates that fruit flies traps can play a significant role in the reduction of fruit flies damage, and it may help in devising the integrated fruit flies management.

ABSTRACT: Fruit flies (diptera: tephritidae) are considered as key pests of fruits and vegetables causing huge losses in yield and quality of the crops. Population dynamics of fruit flies was carried out by the use of methyl eugenol to investigate distribution and abundance in mango orchards. The experiment was carried out at farmer field in Multan. The population data was recorded from January, 2015 to December, 2016. Result indicated that overall maximum fruit flies catches were observed in pheromone trap i.e. 178.1 flies/trap followed by Bottle trap with 150.4 flies/trap. However, minimum fruit flies catches were observed in Jar trap with 90 flies/trap. Fruit flies infestation on mango started on 2nd week of February and it increased gradually with the passage of time and reached at peak level in the month of June which continued up to September. Then it showed decline in the months of October which continued until December when its population became zero. Data regarding meteorological factors showed the significant effects on fruit flies population. The temperature (minimum and maximum) show positive correlation with fruit flies population and temperature gradient showed negative correlation with fruit flies population. Similarly the humidity showed the negative correlation with fruit flies population. This study gives activity of the pest in Multan and approximate population fluctuation throughout the year. This information may be helpful in the management of fruit flies.

Keywords: Abiotic factor, Fruit flies, Mango, Methyl eugenol, Population dynamics, Traps

How to cite this article:

Abbas, Q., Hasnain, M., Hussain, M., Ali, Q., Jafir, M., Shahid, M., Iqbal, M., & Abbas, H. (2018). Studies on the population dynamics of fruit flies (diptera: tephritidae) on mango orchards in Multan, Punjab, Pakistan. *Journal of Pure and Applied Agriculture*, *3*(1), 42-48.

INTRODUCTION

Mango (*Mangifera indica* L.) is called king of fruits, one of key fruit of tropical areas of world (Purseglove, 1972). It originated in the South East Asian or Indo-Burma region and was grown in more than 100 countries of the world with annual production of 2500 million tones (Singh et al., 2016). Fruit is rich source of sugar 10-20% and vitamins like A, C and B (Larrauri et al., 1999). Pakistan is ranked at 4th position by producing 916.4 million tones mango, which is 8.5% in the total world production (Ministry of Food, Agriculture and Livestock [MINFAL], 2002). Mango yields in Pakistan are considerably low being 9-10 tons/ha compared with the world yielding 10 –30 tons/ha in countries like China, Mexico and India. The main reason for low yield is insect pests attack. Among the insect pests, fruit flies (diptera: tephtritidae) are considered as important pests to fruits especially mangos (Drew et al., 2005; Vayssieres et al., 2005; Ekesi et al., 2009). Fruit flies (diptera: tephtritidae) are considered as key pests to fruits like guava, citrus,ber especially mangoes (Vayssieres et al., 2005; Drew et al., 2005; Ekesi et al., 2009). Female fruit flies lay eggs under the membrane of the fruit which hatch into maggots that feed within the fruits but it can also damage twigs, buds stems and flowers of the crop (Weems & Heppner, 2001). Among 250 species, about 44 species

belongs to genus Bactrocera (Syed, 1969; Kapoor et al., 1981). However, eleven species have been reported in Pakistan; the most important one among them are *B. dorsalis, B. cucurbitae* and *Bactrocera zonata* (Abdullah & Latif, 2001; Abdullah et al., 2002; Stonehouse et al., 2002). *B. zonata* has been found as a severe pest in guava, citrus (Syed, 1970). The activity of fruit flies mostly depends on prevailing meteorological conditions and availability of hosts in a particular agro ecosystem. Temperature and rainfall are key factors which determine population distribution of fruit flies (Zhou et al., 1996; Jiang et al., 2001; Liu & Ye, 2005, 2006; Chen et al., 2006; Chen & Ye, 2007). *B. dorsalis* completes less than four generation per year in subtropical regions of world, however, it completes more than five generations per year in some tropical regions of world and 10 generation per year some particular tropical regions (Li & Ye, 2000; Hui, 2001; Shi & Ye, 2004; Shi et al., 2005; Ye & Liu, 2005). Therefore, this study was designed to determine the population trend, seasonal abundance and role of climatic factors on activity of fruit flies for proper implementation of fruit flies management program.

MATERIALS AND METHODS

Experimental site

Studies on the seasonal monitoring of fruit flies were carried out in farmer field Mouza Bouch Mubarak at Multan, Pakistan during the years 2015 and 2016. The experiment was conducted by installation of methyl eugenol pheromone traps. The selected orchards contained mango trees as the main plantation, and in neighboring were citrus tress grown along with field crops. The selected orchards were isolated from other orchards. All the cultural practices were done simultaneously in the whole orchards. The experiment was done using randomized complete block design with three repeats.

Installation and adjustment of pheromone traps

Three different types of traps (pheromone trap, jar trap and bottle trap) were used to assess their performance. Pheromone trap and Jar trap were purchased from commercial bazaar, Multan, while bottle traps were made from plastic bottles that measured 20 cm in length and 8 cm in diameter. These bottle traps had two holes on each side to allow the flies to enter inside. Male attractant were suspended in each trap near centre. The attractant consists of small cotton wick soaked with methyl eugenol and some drops of insecticides. These attractant were replaced fortnightly throughout the year. Male fruit flies which come to pheromone traps were killed by the insecticide on the cotton wick. The traps were hung at height of two meters with braches of fruit trees in the experimental orchards.

Observation of fruit flies populations

The captured male flies were collected and counted on weekly basis and then added to monthly basis. Mean number of flies caught per trap per week and per month were determined every year and average of both the years of study worked out. The observations thus obtained were correlated with the meteorological parameters like temperature (minimum, maximum and gradient), humidity (minimum, maximum and gradient) and rainfall. Meteorological data used in this study were provided by Cotton Research Institute, Multan.

RESULTS

The population fluctuation of fruit flies on mango orchards in Multan was carried out during the year 2015-16.
The data in the tables indicated that fruit flies adults show different response of population and infestation trends during the experimental season.

Population of fruit flies on mango orchards in different types of traps during 2015

Results regarding population fluctuation are presented in Table 1. The results indicated that maximum population of fruit flies was observed on pheromone trap i.e. 155.83 male flies/trap which was followed by bottle trap with 116.66 male fruit flies/trap and least male fruit flies were observed in the jar trap with 50 male fruit flies/trap. The results also indicated that fruit flies population appeared in the 2nd week of February i.e. 0.94 male flies/trap. It increased gradually with the passage of time. The population reached on maximum level in the 2nd week of June i.e. 104 male flies/trap. Then it showed decline and decreased gradually, it reached at zero level in the 2nd week of December.

Population fluctuation of fruit flies in different types of traps during 2016

Results regarding population fluctuation are presented in Table 2. These results indicated that during 2016 maximum population of fruit flies was observed in pheromone trap i.e. 200.33 male flies/trap followed by bottle trap i.e. 194.33 male flies/trap. The population of fruit flies observed was 132.83 male flies/trap. Results regarding population fluctuation of fruit flies indicated that fruit flies appeared in the month of 2nd week of February i.e. 13 fruit flies/trap. Its population increased with the passage of time and reached at maximum level during the 3rd week of June i.e. 156 fruit flies/trap. After that, it showed decline in population and reached at zero level in the month of December.

Population fluctuation of fruit flies in different types of traps during the both years (2015 and 2016)

The result indicated that fruit flies population starts in the month of February in all three studied traps. Its population increase with passage of time and reach maximum in the month of june i.e. 128.93/trap. Then it showed decline. However it showed 2nd peak in the month of July i.e. 98/trap. It was observed that the pheromone trap catches maximum male fruit flies i.e. 45 followed by Bottle trap i.e. 42.20 and Jar trap 31.95/trap.

Average population of fruit flies during years 2015 and 2016

Results presented in Table 3 indicate the average population fluctuation of fruit flies during the years 2015 and 2016. This table showed that the highest population of fruit flies was recorded in the month of June in pheromone trap i.e. 178.1/trap followed by bottle trap i.e. 150.4/trap.

Effect of abiotic factors on population build-up of mango fruit flies

Results regarding correlation between climatic factors and fruit flies population are presented in Table 4 and 5. The results indicated that fruit flies population showed positive correlation with maximum temperature. As temperature increased, its population increased and the population reached at maximum level in the month of June. However minimum temperature showed negative correlation with fruit flies population. Similarly, the relative humidity and rainfall also showed negative correlation with fruit flies population.

Table 1 Average population of fruit flies caught in different types of pheromone traps during the year 2015

	Number of fruit flies caught during 2015						
Months	Pheromone trap	Bottle trap	Jar trap	Max. Temp.	Min. Temp.	R.H.	Rainfall
January	0	0	0	16.70	6.30	85.90	5.00
February	1.33	1.5	0	23.10	10.80	85.50	6.00
March	6.83	8.33	6	25.70	13.90	78.70	110.50
April	21.66	22.66	18	36.00	21.70	64.50	11.00
May	36.33	28.33	22.3	40.00	24.00	42.60	15.00
June	155.83	116.66	40.66	40.00	24.00	47.20	36.00
July	48.83	21.33	48.33	36.10	27.70	78.80	163.00
August	35.33	14.83	49.5	36.20	26.70	79.40	101.00
September	22.83	15.33	14.5	36.30	25.40	70.90	19.00
October	4	3	2.5	33.70	21.00	65.50	9.00
November	1	1	0.33	27.80	14.30	72.40	0.00
December	0	0	0	22.90	6.10	85.20	0.00

∴ Max. Temp. denotes maximum temperature (ºC); Min. Temp. denotes minimum temperature (ºC); R.H. denotes relative humidity (%); Rainfall was measured in mm

Table 2 Average population of fruit flies caught in different types of pheromone traps during the year 2016

	Number of fruit flies caught during 2016

Months	Pheromone trap	Bottle trap	Jar trap	Max. Temp.	Min. Temp.	R.H.	Rainfall
January	0	0	0	20.00	7.80	86.40	2.00
February	13.16	12	6	24.80	9.10	78.30	1.00
March	15.83	14.66	81	27.70	16.50	79.70	31.00
April	68.1	64.2	37	35.20	21.40	72.50	17.00
May	109.5	87.66	69	42.50	28.50	39.80	3.00
June	**200.33**	184.16	76	42.20	30.80	46.00	5.00
July	142.66	**194.33**	132.83	39.10	30.10	70.10	48.00
August	92.83	102.5	95.5	37.30	27.90	79.90	90.00
September	89.5	84.16	47	37.40	26.40	67.60	4.00
October	16	27.27	17	35.70	21.90	69.40	0.00
November	11	9	3	28.50	13.30	81.90	0.00
December	0	0	0	24.90	10.30	86.60	0.00

∴ Max. Temp. denotes maximum temperature (ºC); Min. Temp. denotes minimum temperature (ºC); R.H. denotes relative humidity (%); Rainfall was measured in mm; The bold letters denote the highest values

Table 3 Average population of fruit flies caught in different types of pheromone traps during the both years (2015 and 2016)

Average number of fruit flies caught during the both years (2015 and 2016)			
Months	Pheromone trap	Bottle trap	Jar trap
January	0.0	0.0	0.0
February	7.2	6.8	3.0
March	11.3	11.5	43.5
April	44.9	43.4	27.5
May	72.9	58.0	45.7
June	178.1	150.4	58.3
July	95.7	107.8	90.6
August	64.1	58.7	72.5
September	56.2	49.7	30.8
October	10.0	15.1	9.8
November	6.0	5.0	1.7
December	0.0	0.0	0.0

Table 4 Correlation between fruit flies population and climatic parameters during the year 2015

Insect Traps	Max. Temp.	*p-Value*	Min. Temp.	*p-Value*	R.H.	*p-Value*	Rainfall	*p-Value*
Pheromone trap	0.6803	0.0149	0.701	0.0111	-0.4504	0.1418	0.5451	0.0668
Bottle trap	0.727	0.0074	0.684	0.0142	-0.6045	0.0373	0.3991	0.1988
Jar trap	0.7201	0.0083	0.8483	0.0005	-0.2357	0.4607	0.636	0.0262

∴ Max. Temp. denotes maximum temperature (ºC); Min. Temp. denotes minimum temperature (ºC); R.H. denotes relative humidity (%); Rainfall was measured in mm

Table 5 Correlation between fruit flies population and climatic parameters during the year 2016

Insect Traps	Max. Temp.	*p-Value*	Min. Temp.	*p-Value*	R.H.	*p-Value*	Rainfall	*p-Value*
Pheromone trap	0.9016	0.0001	0.9354	0.000	-0.7397	0.006	0.3265	0.3003
Bottle trap	0.8757	0.0002	0.921	0.000	-0.6702	0.0171	0.3603	0.2499
Jar trap	0.7666	0.0036	0.8741	0.0002	-0.499	0.0986	0.6169	0.0326

∴ Max. Temp. denotes maximum temperature (ºC); Min. Temp. denotes minimum temperature (ºC); R.H. denotes relative humidity (%); Rainfall was measured in mm

DISCUSSION

The seasonal dynamic of fruit flies were carried out during the year 2015-16 by the installation of different types of pheromone traps. The pheromone traps were installed in the mango orchards at Chah Fazil Wala, Mouza Bouch Mubarik, Multan, Pakistan for the period of two years (2015-16) to monitor male fruit flies population. The results indicated that maximum male fruit flies caught were recorded in pheromone trap (178.1/trap) followed by bottle trap (150.4/trap) followed by jar trap with 90.6/trap. These results are in confirmation with Casana-Giner (2003) who reported that cuelure (the acetate of raspberry ketone) is one of the practical lures for male melon flies. The fruit flies population appeared in the February i.e. 0.94 male flies/trap. It increased gradually with the passage of time. The population reached on maximum level in the month of June i.e. 178.1 male flies/trap. Then it showed decline and decreased gradually, it reached at zero level in the month of December.

Our results are similar with those of Chen & Ye (2007) who reported that slight activity of *B. zonatus* and *B. dorsalis* was noted from the start of experiment before 7th April (Chen & Ye, 2007). The population consistently increased till 25th May (Chen et al., 2006). In June, the activity slowed down that may be due to rainfall or temperature but again increased in July till end of the experiment i.e. 1st August (Mahmood & Mishkatullah, 2007). It may be concluded that the population may sustain or increase further in coming months (Chen & Ye, 2007). The correlations between catching fruit flies and temperature and relative humidity were also worked out. The fruit flies infestation showed significant positive correlation with maximum temperature. This interpretation is sustained by the fact that fruit flies damage was high from April to July during 2015 and 2016, which coincided with fruiting and harvesting periods of mango fruit where temperature (19.01 to 39.03 ºC) and relative humidity (39.57 to 95.71%) were also gradually increasing. The positive correlation between temperature and fruit flies population was reported by Mishra et al. (2012) in Lucknow. Further, Verghese & Devi (1998) in Karnataka found positive correlation between wind speed and fruit flies population in mango orchards. Kannan & Rao (2006) showed significant positive relationship with maximum temperature and negatively correlated with rainfall and relative humidity.

Among the metereological factors, population of fruit flies was negatively correlated with minimum temperature. This negative correlation is most likely because population of fruit flies increases with ripening of fruits. These results are similar to that of Liu & Yeh (1982); Shukla & Prasad (1985); Tariq et al. (2002) who related the population of fruit flies with the ripening of crops. The minimum temperature showed significant effect while climatic factors expressed non-significant influence on the fruit flies population which is in conformity with the results of Raghuvanshi et al. (2012).

CONCLUSION

Mango fruit is one of important source of foreign exchange earnings for Pakistan. It is being exported to many countries of the world. These countries has concerned on sanitary requirements. Fruit flies are one of the key pests which have potential to devastate the whole export of fruits to the developed countries. This pest can be controlled by integrated pest management methods. As a part of this venture, population monitoring is important to identify the presence of pest and determine the control measures that are essential for managing fruit flies. This study helps us in determine the peak periods of fruit flies populations throughout the year. This information is helpful in making the management strategies of fruit files.

Author Contribution Statement: Qaisar Abbas, Muhammad Hasnain, Mussurrat Hussain and Muhammad Iqbal planned the research, collected the field data and wrote up manuscript. Hasnain Abbas and Muhammad Jafir helps in writing the manuscript. Muhammad Shahid performed the statistical analysis and arranged the tables. Qurban Ali reviewed the manuscript

Conflict of Interest: The authors declare that they have no conflict of interest.

Acknowledgements: Current studies were conducted at Entomological Research Sub Station Multan, Punjab, Pakistan. We are thankful to Government of Punjab, Pakistan for providing funds for this study.

REFERENCES

Abdullah, K., & Latif, A. (2001). Studies on baits and dust formulations of insecticides against fruit fly (Diptera: Tephritidae) on melon (Curcumis melo) under semi-arid conditions of Dera Ismail Khan. *Pakistan Journal of Biological Sciences*, *4*(4), 334-335.

Abdullah, K., Akram, M., & Ali Zai, A. A. (2002). Nontraditional control of fruit flies in guava orchards in D. I. Khan. *Pakistan Journal of Agricultural Research*, *17*(2), 195-96.

Casana-Giner, V., Oliver, J. E., Jang, E., & Carvalho, L. (2003). Syntheses and behavioral evaluations of fluorinated and silylated analogs of raspberry ketone as attractants for the melon fly, *Bactrocera cucurbitae* (Coquillett). *Journal of Entomological Sciences*, *38*(1), 111-119.

Chen, P., & Ye, H. (2007). Population dynamics of *Bactrocera dorsalis* (Diptera: Tephritidae) and analysis of factors influencing populations in Baoshanba, Yunnan, China. *Entomological Science*, *10*, 141-147.

Chen, P., Ye, H., & Liu, J. (2006). Population dynamics of *Bactrocera dorsalis* (Diptera: Tephritidae) and analysis of the factors influencing the population in Ruili, Yunnan Province, China. *Acta Ecologica Sinica*, *26*(9), 2801-2808.

Drew, R. A. I., Tsuruta, K., & White, I. M. (2005). A new species of pest fruit (Diptera: Tephritidae: Dacinae) from Sri Lanka and Africa. *African Entomology*, *13*, 149-154.

Ekesi, S., Billah, M. K., Nderitu, P. W., Lux, S. A., & Rwomushana, I. (2009). Evidence for competitive displacement of *Ceratitis cosyra* by the invasive fruit fly *Bactrocera invadens* (Diptera: Tephritidae) on mango and mechanisms contributing to the displacement. *Journal of Economic Entomology*, *102*(3), 981-991.

Hui, Y. (2001). Distribution of the oriental fruit fly (Diptera: Tephritidae) in Yunnan province. *Insect Science*, *8*(2), 175-182.

Jiang, X. L., He, W. Z., & Xiao, S. (2001). Study on the biology and survival of *Bactrocera dorsalis* in the border region of Yunnan. *Journal of Southwest Agricultural University*, *23*, 510-517.

Kannan, M., & Rao, N. V. (2006). Ecological studies on mango fruit fly, *Bactrocera dorsalis* Hendel. *Annals of Plant Protection Sciences*, *14*(2), 340-342.

Kapoor, V. C., Hardy, D. E., Agarwal, M. L., & Grewal, J. S. (1981). *Fruit fly (Diptera: Tephritidae) systematics of the Indian subcontinent*. Jullundur, India: Export India Publications.

Larrauri, J. A., Goni, I., Martin-Carron, N., Ruperez, P., & Saura-Calixto, F. (1999). Measurement of health promoting properties in fruit dietary fibres: Antioxidant capacity, fermentability and glucose retardation index. *Journal of the Science of Food and Agriculture*, *71*, 515-519.

Li, H. X., & Ye, H. (2000). Infestation and distribution of the oriental fruit fly (Diptera: Tephritidae) in Yunnan Province. *Journal of Yunnan University*, *22*(6), 473-475.

Liu, J. H., & Ye, H. (2005). Population dynamics of *Bactrocera dorsalis* (Diptera: Tephritidae) in Yuanjiang dry-hot valley, Yunnan with an analysis of the related factors. *Acta Entomologica Sinica*, *48*, 706-711.

Liu, J. H., & Ye, H. (2006). Effects of light, temperature and humidity on the flight activities of the oriental fruit fly, *Bactrocera dorsalis*. *Chinese Bulletin Entomology*, *42*, 211-214.

Liu, Y. C., & Yeh, C. C. (1982). Population fluctuation of oriental fruit fly *D. dorsalis* Hendel in sterile fly release and control area. *Chinese Journal of Entomology*, *2*, 57–76.

Mahmood, K., & Mishkatullah. (2007). Population dynamics of three species of genus Bactrocera (Diptera: Tephritidae: Dacinae) in BARI Chakwal (Punjab). *Pakistan Journal of Zoology*, *39*(2), 123-127.

Ministry of Food, Agriculture and Livestock (MINFAL). (2002). Govt. of Pakistan, Ministry of Food, Agriculture and Livestock Economic Wing, Islamabad.

Mishra, J., Singh, S., Tripathi, A., & Chaube, M. N. (2012). Population dynamics of oriental fruit fly, *Bactocera dorsalis* (Hendel) in relation to abiotic factor. *HortFlora Research Spectrum*, *1*(2), 187-189.

Purseglove, J. W. (1972). Mangoes West of India. *Acta Horticulturae*, *24*, 107-174.

Raghuvanshi, A. K., Satpathy, S., & Mishra, D. S. (2012). Role of abiotic factors on seasonal abundance and infestation of fruit fly, *Bactrocera cucurbitae* (Coq.) on bitter gourd. *Journal of Plant Protection Research*, *52*, 264–267.

Shi, W., & Ye, H. (2004). Genetic differentiation in five geographic populations of the oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) in Yunnan Province. *Acta Entomologica Sinica*, *47*, 384-388.

Shi, W., Kerdelhue, C., & Ye, H. (2005). Population genetics of the oriental fruit fly, *Bactrocera dorsalis* (Diptera: Tephritidae), in Yunnan (China) based on mitochondrial DNA sequences. *Environmental Entomology*, *34*, 977-983.

Shukla, R. P., & Prasad, V. G. (1985). Population fluctuations of the oriental fruitfly, *Dacus dorsalis* Hendel in relation to hosts and abiotic factors. *Tropical Pest Management*, *25*(3), 389–392.

Singh, N. K., Mahato, A. K., Jayaswal, P. K., Singh, A., Singh, S., Singh, N., Rai, V., Amitha Mithra, S. V., Gaikwad, K., Sharma, N., Lal, S., Srivastava, M., Prakash, J., Kalidindi, U., Singh, S. K., Singh, A. K., Khan, K., Mishra, R. K., Rajan, S., Bajpai, A., Sandhya, B. S., Nischita, P., Ravishankar, K. V., Dinesh, M. R., Kumar, N., Jaiswal, S., Iquebal, M. A., Kumar, D., Rai, A., & Sharma, T. R. (2016). Origin, diversity and genome sequence of mango (*Mangifera indica* L.). *Indian Journal of History of Science*, *51*, 355-368

Stonehouse, J. M., Mahmood, R., Poswal, A., Mumforda, J. K., Baloch, N., Chaudhary, Z. M., Makhdum, A. H., Mustafa, G., & Huggett, D. (2002). Farm field assessments of fruit flies (Diptera: Tephritidae) in Pakistan: distribution, damage and control. *Crop Protection*, *21*(1), 661-669.

Syed, R. A. (1969). *Studies* on the *ecology of some important species of fruit flies and their natural enemies in West Pakistan*. Pakistan Commonwealth Institute – Biological Control Station, pp 12.

Syed, R. A. (1970). Studies on the Tephritids and their natural enemies in West Pakistan. Dacus spp of lesser importance. *Pakistan Journal of Zoology*, *2*, 17-24.

Tariq, M., Hussain, S. I., Khokhar, K. M., Ahmad, M., & Hidayatullah, G. H. (2002). Studies on methyl eugenol as a sex attractant for fruit fly *D. zonatus* (Saund) in relation to abiotic factors in peach orchard. *Asian Journal of Plant Sciences*, *4*, 401–402.

Vayssieres, J. F., Goergen, G., Lokossou, O., Dossa, P., & Akponon, C. (2005). A new Bactrocera species in Benin among mango fruit fly (Diptera: Tephritidae) species. *Fruits*, *60*(6), 371-377.

Verghese, A., & Devi, K. S. (1998, October). *Relation between trap catch of B. dorsalis and abiotic factors*. Proceeding of first national symposium on pest management in horticultural crops. Environmental Implication and Thrusts, Bangalore, India.

Weems, H. V., & Heppner, J. B. (2001). *Melon fly, Bactrocera cucurbitae Coquillet (Insecta: Diptera: Tephritidae)*. Institute of Food and Agricultural Services Publication EENY-119. University of Florida. Gainseville: Florida, USA.

Ye, H., & Liu, J. H. (2005). Population dynamics of *Bactrocera dorsalis* (Diptera: Tephritidae) in Xishuangbanna of Southern Yunnan. *Chinese Journal of Applied Ecology*, *16*, 1330-1334.

Zhou, Y. S., Shen, F. R., & Zhao, H. P. (1996). Study on the biology of *Bactrocera dorsalis* (Hendel) and synthetical control. *Journal of Southwest Agricultural University*, *18*, 210-213.