Identification and Abundance of Fruit fly species Responsible for Fruit drop of Sweet Orange (*Citrus sinensis* L. Osbeck) in Benue State, Nigeria

Abstract

Fruit fly identification was done through fruit culture experiments carried out in College of Agronomy Teaching and Research Farm, University of Agriculture, Makurdi in October, 2014 and October, 2015. The experiment was a 2 x 3 factorial in a completely randomized design with four replications. The two factors were Zones (Zone A and B) and Varieties (Ibadan Sweet, Valencia, and Washington Navel). Ten naturally infested orange fruits from each variety in each zone were weighed and placed in each plastic rearing box with dimension 39 x 27 x 26 cm containing sterilized moist soil securely covered with 1 mm mesh net for pupation and adult insect emergence. Emerged adults were killed using Mobil insecticide (Cyphenothrin), counted, sexed and stored in specimen bottles with 70 % alcohol for preservation and later identification. Fruit fly species identified from citrus fruit culture were: *Bactrocera invadens* (Drew), *Ceratitis capitata* (Weid) and *Dacus bivittata* (Biggot). *Bactrocera invadens* was the most abundant species and accounted for 63.70 % in Washington navel and 63.10 % in Valencia in 2014 and 2015 respectively. The varieties showed no significant differences ($p>0.05$) on the abundance of *Ceratitis capitata* and *Dacus bivittata* in 2014. In 2015 however, Ibadan Sweet variety showed significant difference ($p<0.05$) on the abundance of *Ceratitis capitata* (28.30 %) when compared with other varieties. Therefore, fruit fly species responsible for citrus fruit drop in Benue State were *Bactrocera invadens* (Drew), *Ceratitis capitata* (Weid) and *Dacus bivittata* (Biggot) with *Bactrocera invadens* (Drew) recorded as the most abundant species.

Key Words: *Citrus, Fruit fly, Abundance, Benue State.*

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Introduction

Sweet orange (*Citrus sinensis* L. Osbeck) is a tropical to semi-tropical evergreen, small flowering tree, growing to about five to eight metres (5 m-8 m) tall [1]. It is widely cultivated in tropical as well as sub-tropical African countries. Oranges are classified into two: sweet and sour orange. Sweet orange is one of the important fruit crops of the world, occupying third position among the sub-tropical fruits [2] and the second largest by production volume next to banana [3]; [4]. Oranges probably originated from south-East Asia and were cultivated in China by 2500 B.C. [5]. Today it is grown almost all over the world as a source of food for humans because of its high nutritional values, source of vitamins and other uses [6]. Government policy on the promotion of citrus production in Africa as reported by [4] is quite encouraging as the sector has attractive and multiple social and economic advantages. According to [7], citrus is one of the most important and among top ten widely cultivated fruit crop in Nigeria. The production of citrus in Nigeria is more concentrated in the Guinea and Sudan Savanna zones of the country [8] with Benue State giving the highest annual production of the commodity [9]. Also, the relatively higher mean number of fruit flies per trap recorded in Kaduna and Benue states in the Guinea savanna ecological zone as reported by [10] may be due to the presence of large orchards of sweet oranges and mangoes in these states.

Citrus species are attacked by many pests and diseases demanding expenditures in the magnitude of one hundred and sixty million dollars to control them, to avoid what sometimes can develop into total loss [11]. Some of the arthropods that are harmful to this crop include: mite species, fruit flies, scale insects, aphids, etc. [11].

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Fruit flies (*Diptera: Tephritidae)* are the world's worst pest of fruits [12]. They are present in most countries and attack many types of fruits as well as fruiting vegetables, ornamentals, and nuts.

Feeding by fruit fly larvae (maggots) damage the fruits internally causing premature ripening, drop and rot of the fruits. Fruit flies apart from causing losses in horticultural produce across the world are a major quarantine concern for most countries [13]. With the increasing globalization of trade as reported by [14] and with the export promotion drive initiated by the government of the federal republic of Nigeria there is a serious need for production of fruits of good quality that meet the standard of the export market and quarantine regulations. There are many species of fruit flies that can attack fruits and vegetables. The loses from fruit flies infestations can be caused by a single species of a fruit fly or as a result of several species which attack the same plant at the same time.

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Understanding how to identify the species of fruit flies is an important issue for fruit fly management. Wrong identification may lead to mismanagement. Simple identification methods can be applied under a loupe or binocular microscope. The identification can be made by examining the face mark, thorax, abdominal band

and marks on the wing [15]. The male can be differentiated from the female through the presence or absence of an ovipositor. According to [15], and only adult females can attack the crop. Male fruit flies are not harmful. The diversity of frugivorous tephritoidae has been evaluated in several regions of the world by using two sampling methods: The capture of adults in traps with food baits and the rearing of adults from larvae found infesting fruits [16].

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In Africa south of the Sahara, particularly in Nigeria, limited research work has been carried out on identifying and controlling fruit flies of economic importance to the horticultural industry [10]. Despite the economic, nutritional and health benefits of citrus, unfortunately, according to [17], there have been limited studies involving crucial aspects of citrus production in Benue state. The aim of this study is to identify and study the abundance of fruit fly species responsible for fruit drop of citrus in the state.

Materials and Methods

The experiment was conducted in the College of Agronomy Teaching and Research Farm, University of Agriculture, Makurdi (7°41' N, 8°28' E) and at an altitude of 228 m above sea level, within the Southern Guinea Savanna agro-ecological zone of Nigeria in October 2014 and 2015 respectively. The experiment was a 2 x 3 factorial in a completely randomized design with four replications. The two factors were Zones (Zone A and B) and Varieties (Ibadan Sweet, Valencia, and Washington Navel). Ten naturally infested orange fruits from each variety in each zone were weighed and placed in each plastic rearing box with dimension 39 x 27 x 26 cm containing sterilized moist soil securely covered with 1 mm mesh net for pupation and adult fruit fly emergence. Emerged adults were killed using domestic insecticide (Mobil insecticide–Neo-pynamin, Prallethrin, and Cyphenothrin), counted, sexed and stored in specimen bottles with 70 % alcohol for preservation and later identification. Data recorded were analyzed using GenStat Discovery Edition 4 software and significant treatments means were separated using Fisher's Least Significant Difference (F-LSD) at a 5% level of probability.

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Results

Effect of varieties on the mean number of adult fruit flies that emerged per fruit (NAPF) number of adult fruit flies that emerged per kilogram (NAPKG) showed significant difference ($p<0.05$) in 2014 and 2015 (Table 1). Valencia variety was observed to have significantly ($p<0.05$) higher NAPF (0.86), NAPKG (3.14) in 2014 and higher NAPF (0.92) in 2015 when compared with Ibadan sweet variety (0.40) in both years. There were however no significant difference ($p>0.05$) among the varieties on the number of days to first adult emergence in both years and NAPKG in 2015. There was also no interaction between the varieties and zones in both years.

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The effect of varieties zones and their interaction on the number of adults that emerged (NATE), number of female adults that emerged (NFATE) and number of male adults that emerged (NMATE) in 2014 and 2015 showed significant difference ($p<0.05$) among the varieties in both years (Table 2). Significantly higher NATE, NFATE, and NMATE (8.62, 4.00 and 4.25) which was statistically similar to Washington variety (7.62, 4.00 and 3.62) respectively were recorded in

Valencia variety when compared with Ibadan Sweet (4.00, 2.12 and 1.88). In 2015, Valencia variety had the highest NATE, NFATE and NMATE which were significantly different ($p<0.05$) from Ibadan Sweet (4.12, 2.12 and2.00 respectively) but statistically similar to Washington Variety except in NATE (7.25) and NFATE (3.00). There was no significant difference among the zones and the interaction between zones and varieties in both years.

The following fruit flies species were identified from the citrus fruit culture: *Bactrocera invadens* (Drew), *Ceratitis capitata* (Weid) and *Dacus bivittata* (Biggot). Out of these species, *Bactrocera invedens* was the most abundant (63.70

% and 63.10 % in 2014 and 2015 respectively). Effect of varieties showed a significant difference ($p<0.05$) among the identified fruit fly species in both years. (Table 3). The abundance (63.70 %) of *Bacteocera invadens* was highest in Washington navel variety which was significantly different ($p<0.05$) from its abundance (42.70 %) in Ibadan sweet but statistically similar to its abundance (61.66 %) in Valencia variety in 2014. The varieties showed no significant differences on the abundance of *Ceratitis capitata* and *Dacus bivittata* in 2014. However, in 2015, Ibadan sweet variety showed significant difference ($p<0.05$) on the abundance of *Ceratitis capitata* (28.30 %) when compared with the abundance (15.00 %) each in Valencia and Washington navel varieties respectively. The effect of the zones and their interactions showed no significant difference ($p>0.05$) on the abundance of the identified fruit flies in both years.

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DISCUSSION

Although in earlier field trial carried out by [18], *Dacus* and *Bactrocera* species were observed at such a low number that they were not included in the result, the result of this study, however, showed that *Bactrocera invadens* (Drew) was the most abundant (63.70 % and 63.10 %) fruit fly species in 2014 and 2015 respectively in Benue State. This result agreed with the result of [19] which revealed that the most abundant fruit fly species associated with sweet orange in a similar experiment carried out in Ibadan was *Bactrocera invadens* (Drew). *Ceratitis capitata* (wied) species abundance was low. The result, therefore, confirmed other works that indicated the displacement of indigenous fruit fly species (*Ceratitis capitata)* by the invasive *Bactrocera invadens* [20]; [21]. The spread of this invasive fruit fly was further confirmed by the report of [10] which

revealed that although *Bactrocera invadens* was not observed in Anambra, Benue, Nasarawa and Plateau States in 2003, it was captured in all the states in 2006 trial. This situation calls for urgent national attention to check its spread and destruction of fruits of economic importance.

The influence of varieties on fruit flies' emergence from citrus fruit culture showed a significant difference ($p<0.05$) among the identified fruit fly species in both years. While *Bactrocera invadens* (Drew) were more abundant in Washington Navel and Valencia Varieties in 2014 and 2015 respectively. *Ceratitis Capitata* (wied) although not significant ($p>0.05$) in 2014, was significiantly abundant (28.30 %) in Ibadan Sweet in 2015. *Dacus bivittata* (Biggot) was the least abundant of the identified fruit fly species and showed no significant difference ($p>0.05$) among

the varieties in both years. The result which indicated that *Bactrocera invadens* was more abundant in Valencia variety and showed a significant difference in 2015 contradicted [10]'s report that revealed no significant difference in the fruit fly that emerged from Valencia variety. The contradiction could be due to the farmers' preference to grow Valencia variety in the state when compared to other varieties thereby reducing the growth of other host varieties which could result in more fruit fly attack on Valencia variety. *Ceratitis capitata* (Wied) was more abundant and significantly higher in Ibadan sweet variety when compared to Washington navel and Valencia varieties. The result could probably be due to the species preference of Ibadan sweet variety over Washington navel and Valencia varieties. Earlier studies by [22] and [23] had shown that some citrus varieties were less attacked by the indigenous *Ceratitis capitata*. Valencia and Washington navel varieties significantly ($p<0.05$) showed higher number of adults, female adults and male adults that emerged (8.62, 4.00 and 4.25; 7.62, 4.00 and 3.62 respectively) in 2014

and (9.25, 4.38 and 4.88; 7.25, 3.00 and 4.25 respectively) in 2015 when compared with Ibadan sweet variety were (4.00, 2.12 and 1.88) in 2014 and (4.12, 2.12 and 2.00) in 2015 emerged from fruit culture experiments. The result suggested that Valencia and Washington navel varieties were probably more attacked by fruit fly species than Ibadan sweet variety.

Zones did not have any significant influence on fruit fly species' emergence in 2014 and 2015 citrus fruit cultures, neither was there any interaction between the zones and the varieties on the emergence of fruit fly species in both years. The result suggested an even distribution of fruit flies in the zones.

Conclusion

Fruit fly species identified from citrus fruit culture were: *Bactrocera invadens*, *Ceratitis capitata,* and *Dacus bivittata*. *B. invadens* was the most abundant species and accounted for 63.70 % in Washington navel and 63.10 % in Valencia in 2014 and 2015 respectively in Benue State.

References

1. Umesh R. (2009). Orange Fruit Nutritional Facts. Available online at www.nutrition-and-you.com.

2. Tariq, M. M., Sharif, Z. S. and Khan, R. (2007). Effect of Foliar Application of Micronutrients on the yield and Quality of Sweet Orange (*Citrus sinensis) L.D. Pakistan Journal of Biological Sciences*, 10 (11):1823-1828. ISSN 1028-8880. Published by Asian Network for Scientific Information.

3. Food and Agriculture Organization (2006): Statistical database, Citrus production.

4. Mohammed Y. (2013). Pseudocercospora leaf and fruit spot disease of citrus: Achievements and challenges in the citrus industry: A review. Ethiopian Institute of Agriculture (EIAR). *Agricultural Sciences*, 4 (7): 324-328.

5. Nicolasi, E., Deng, Z.N., Gentile, A., La Malfa, S., Continella, G., Tribulato, E. (2008). Citrus Phylogeny and genetic Origin of important species as investigated by molecular markers. *Theoretical and Applied Genetics*, 100(8):1155-1166.

6. Etebu, E. and A.B. Nwauzoma (2014). A review of sweet orange (*Citrus sinensis* Osbeck) health, diseases and management. *African Journal of Research communication*, 2 (2):33-70 also available online at www.USA-journals.com. Accessed on 23/07/14. ISSN:2325-4076.

7. Adewale, J. A., L.O. Oladosun and E.A. Laogun (1996). Factors Limiting Fruit trees Production in South- Western Nigeria, Implication of extension strategy. Proceeding of 14th Annual conference of the Horticultural Society of Nigeria (HORTSON) at Ago-Iwoye, Nigeria 1st -4th April, 1996:200-204.

8. Olaniyan, A.O. (2004). General information about Mango and Citrus Production in Nigeria. Paper presented at the Mashv. International training on Mango and Citrus Orchards growing and Management held at Maizube Farms, Minna, Niger State. 22nd November to 3rd December, 2004.

9. Avav, T. and Uza, D.V. (2002). Agriculture. In: Pigeonnire A.L. (Ed) Africa Atlases: Nigeria, Les Editions J.A. Paris: 92-95.

10. Umeh, V. C., Loyd, E. G.and Mark, M. (2008). Fruit flies of citrus in Nigeria: species diversity relative abundance and spread in major producing areas. *Fruit –Journal* 63: 145-153 also available at http:www.fruit-jounral.org.accessed on 23/07/2015.

11. Parra, J. R., Jose, M. S., Bento, M.S., Garcia, P. T., Yamanoto, E. F. V.and Walter S. L. (2004). Development of a Control alternative of the Citrus Fruit borer, *Ecdytolopha aurantiana* (Lepidotera: Totricidae): From basic research of the grower. *Revista Brasileira de Entomologia*, 48(4):561-567.

12. Heaven, D. (2006). Managing Fruit-Fly in Citrus. Fruit Fly Fact Sheet 21/77/06. Primary Published by state government of Victoria ISSN 1329-8062.

13. Bernard C. D., David. D. and Richard M. (2011). Review 0f the Outbreak Threshhold for Queensland Fruit Fly *Bactrocera tryoni* (Froggatt). *Plant Protection Quarterly*, 26 (4): 141-147.

14. Stanway, M.A.; Zalucki, M., Gillespie, P.S., Rodrigues, C.M. and Maynard, G.V. (2001). Pest Risk Assessment of Insects in Sea Cargo Containers. *Australian Journal of Entomology*, 40 :180-192.

15. Field Exercise Guide on Fruit Fly Integrated Pest Management (2011) for Farmers. Field Schools and training of trainers course on fruit flies Integrated pest Management of fruit flies in South and South –east Asia. Asian fruit fly IPM project.

16. Uchoa-Fernandes M. A., Isaias,O. Rosa, M.S.M. and Roberto, A. Z. (2003). Bio diversity of Frugivorous flies (Diptera: Tephritidea) Captured in Citrus Groves, Mato Grosso do Sul Brazil. : 239-246.

17. Ortese, E., K.P. Baiyeri and F.O. Ugese (2012). Demographic Features of Citrus producers and Agronomic management of Citrus in Benue state, Nigeria PAT June,2012:8(1): 180-190; ISSN: 0794-5213 publication of Nasarawa state University, Keffi,: Online Copy available at www.patnsukjournal.net/currentissue. accessed on 10/06/2013.

18. Umeh, V. C. and Garacia, L. E. (2008), Monitoring and Managing ceratitis species complex of sweet orange varieties using locally made protein bait of brewery waste. *Fruit Journal* 63: 209 – 217.

19. Umeh V. C. and Onukwu (2011). Effectiveness of folier protein bait sprays in controlling Bactrocera invadens (Diptera: Terphritidae) on Sweet Orange. *Fruit Journal* 66: 307 – 314.

20. Vayssiere, J. f., Georgen, G., Lokossou, O., Dossa, P. and Akponon, C. (2005). A new Bactrocera species in Benin among mango fruit fly (Diptera : Tephriti dae) species. *Fruits* 60:371 – 377.

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

22. Umeh, V. C. Ahonsi, S. and Kolade, J. A. (1998). Insect pests encountered in a citrus orchard in nigeira. *Fruits* 53: 397 – 408.

23. Umeh, V. C., Anikwe, J. C., Okelana, F.A., Bokonon, G.A. and Onukwu, A. (2007). Recent Observations on fruit flies of coffee and their level of infestation on other economic tree crops in Nigeria proceedings of 25th Annual conference of Horticultural Society of Nigeria (HORTSON) 4th – 8th November, 2007: 321.

Table 1: Effect of varieties and zones and their interactions on days to first adult fruit fly emergence, number of adults per fruit and number of adults per KG in 2014 and 2015.

	2014					2015				
Treatments	DTFAE	NAPF	NAPKG			DTFAE	NAPF	NAPKG		
Varieties										
IBS	9.00	0.40	2.12			9.12	0.40	2.34		
VAL	9.38	0.86	3.14			9.12	0.92	3.43		
WN	9.00	0.76	2.34			9.25	0.72	2.27		
Mean	9.12	0.67	2.54			9.17	0.68	2.68		
LSD(0.05)	NS	0.15	0.18			NS	0.15	NS		
Zones										
A	8.83	0.69	2.43			9.25	0.69	2.54		
B	9.42	0.65	2.65			9.08	0.67	2.82		
Mean	9.12	0.67	2.54			9.17	0.68	2.68		
LSD(0.05)	NS	NS	NS			NS	NS	NS		
Var. x Zones	NS	NS	NS			NS	NS	NS		

DTFAE : Days to first adult fruit fly emergence, NAPF : Number of adults per fruit. NAPKG: Number of adults per kilogram. IBS: Ibadan Sweet, VAL; Valencia WN: Washington Navel.

NS: Non-significant.

Table 2: Effect of varieties, zones and their interactions on number of adults that emerged, number of fe

	2014			2015		
Treatments	NATE	NFATE	NMATE	NATE	NFATE	NMATE
Varieties						
IBS	4.00	2.12	1.88	4.12	2.12	2.00
VAL	8.62	4.00	4.25	9.25	4.38	4.88
WN	7.62	4.00	3.62	7.25	3.00	4.25
Mean	6.75	3.38	3.25	6.88	3.17	3.71
LSD(0.05)	1.55	1.64	1.17	1.49	1.21	1.24
Zones						
A	6.92	3.25	3.42	6.92	2.75	3.5
B	6.58	3.50	3.08	6.83	3.25	3.92
Mean	6.75	3.38	3.25	6.88	3.00	3.71
LSD(0.05)	NS	NS	NS	NS	NS	NS
Var. x Zones	NS	NS	NS	NS	NS	NS

NATE: Number of adults that emerged. NFATE: Number of female adults that emerged.
NMATE: Number of male adults that emerged. IBS: Ibadan Sweet. VAL: Valencia WN: Washington Navel.
NS: Non-significant

Table 3: Effects of varieties zones and their interactions on the abundance (%) of identified fruit fly species in Benue State in 2014 and 2015.

	2014			2015		
	Bactrocera invadens	*Ceratitis capitata*	*Dacus bivittata*	*Bactrocera invadens*	*Ceratitis Capitata*	*Dacus Bivittata*
Treatments						
Varieties						
IBS	42.70	24.00	33.30	43.70	28.30	27.90
VAL	61.60	17.20	22.30	63.10	15.80	21.90
WN	63.70	15.30	21.50	59.00	15.80	25.20
Mean	56.00	18.80	25.70	55.30	20.00	25.00
LSD(0.05)	18.01	NS	NS	12.417.250	NS	
Zones						
A	58.50	18.80	23.80	54.70	20.50	25.30
B	53.50	18.90	27.60	55.90	19.40	24.70
Mean	56.00	18.80	25.70	55.30	20.00	25.00
LSD(0.05)	NS	NS	NS	NS	NS	NS
Var. x Zones	NS	NS	NS	NS	NS	NS

IBS : Ibadan Sweet . VAL : Valencia . WN : Washington Navel.
NS: Non-significant