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Diversity of Frugivore Fruit Fly Species (Diptera: Tephritidae) in Niger State, Southern Guinea Savannah Zone of Nigeria.

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ABSTRACT: The diversity of frugivore fruit fly (Diptera: Tephritidae) species was studied from May-October, 2014 in orchards of mango, cashew, guava and water melon situated in Paikoro and Lapai Local Government Areas of Niger State, Nigeria, The flies were trapped using Ball and Steiner traps baited with torula yeast and a para-pheromone, methyl eugenol, respectively. Traps were cleared at 7-day intervals and serviced monthly. Trapped flies were collected in zip-packs, transferred into 75 % alcohol and identified in the laboratory. Twenty-three fly species within the genera *Bactrocera*, *Ceratitis*, *Dacus*, *Perilampsis* and *Trirhithrum* were collected, with *Ceratitis* species being the richest. The trap with para-pheromone trapped higher number of species than that with torula yeast bait. *Bactrocera invadens* was the most abundant species at all sites. Alpha diversity index showed that the mango orchard was richer in species than other sites while Beta diversity index revealed high similarities among sampling sites.

Keywords: Fruit fly, Tephritidae, Ball trap, Steiner trap, Orchard, Diversity
Running title: Diversity of fruit fly

INTRODUCTION

There are about 4000 species of fruit flies worldwide (Drew, 1989). In the Pacific area alone, there are 350 species of which at least 25 species are regarded as being of major economic importance (Allwood, 1999). The genus *Bactrocera* contains over 400 species, distributed primarily through the Asia-Pacific area including Australia (Drew, 1989). *Bactrocera* spp. are represented by few species in Africa but the genera *Dacus*, *Ceratitis, Capparimyia*, *Carpophthoromyia*, *Perilampsis* and *Trirhithrum* are widely represented (De Meyer *et al.*, 2013). It is generally known that the members of Tephritidae (especially those in the sub-family Dacinae) pose major threat to agriculture worldwide (White and Elson-Harris, 1994).

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Fruits and vegetables have received a significant recognition for their nutritional values and production has been on the increase in Africa (Ekesi and Billah, 2005) and the world at large. Production and marketing of fruits and vegetables in the southern Guinea savanna of Nigeria provide income and economic empowerment to most growers and traders. . The demands for these products are on the increase due to continued increase in population and urbanization. Food insecurity is inherently linked with pests and diseases. Hence, reliable markets for fruits and vegetables can be secured only when farmers' production is not constrained (Danjuma *et al.*, 2013).

Production of high quality fruits is hindered worldwide by fruit flies and the damage, if not controlled, may result in total loss of the fruits with consequent adverse impacts on trade and economy (De Meyer *et al.*, 2013). Hence, with the increasing globalization of trade, fruit flies pose a major quarantine threat to agriculture

and this is a concern that is currently monitored through regional surveillance programs (De Meyer *et al.*, 2013). To control these major economic pests, species identity and a critical study of their ecology are essential.

The southern Guinea savanna fauna of Nigeria is rich in biodiversity, but few studies have been carried out on the diversity of tephritid flies in this zone.

The most recent survey conducted in this zone revealed numbers of species in the following genus; 3 *Bactrocera,* 21 *Ceratitis,* 3 *Caprophthoromyia,* 7 *Perilampsis,* 7 *Trirhithrum* and 36 *Dacus* (De Meyer *et al.*, 2013)

Numerous fruits and vegetables including cashew (*Anacardiumoccidentale)*, oranges (*Citrus sp*), guava (*Psidium guajava)*, kola nut (*Cola acuminate*), water melon (*Citrullus vulgaris*), tomato (*Lycopersicum esculentum*), mango (*Mangifera indica*) okra (*Hibiscus esculentus*), amaranths (*Amarantus hybridus*), cabbage (*Brassica oleracea*) etc. are produced and consumed in southern Guinea savanna . These produce have suffered great infestation from fruit flies which were less known to farmers except for the index of damages visible on the fruits and vegetables, and were miss-represented for other causes. The alpha and beta diversity at different sites will be presented. This diversity study will be enlightenment for all stakeholders in the production of fruits and vegetables and enhance pest advisors with the ideas about what fruit flies were localize and or prevalence in this region, and how to develop ecological friendly control schemes for these notorious pests

MATERIALS AND METHODS

Experimental Site

The study was conducted in a mango orchard in Paikoro Local Government Area (LGA), as well as in cashew and guava orchards and water melon farm in Lapai LGA The orchards are located at latitude 9°26.356'N and longitude 6°38.496'E for mango, latitude 9°05.284'N and longitude 6°57.154 E for guava, latitude 9°05.284' N and longitude 6°57.059' E for cashew, and latitude 9°05.319' N and longitude 6°57.003' E for water melon . Temperature in the area averaged 23°C – 34.4 °C and the minimum and maximum amounts of rainfall per annum were 107.3 and 1500 mm, respectively.

The sizes of farms were 3, 15, 2, and 5 hectares approximately for mango, cashew, guava and water melon, respectively. All sites were similar in vegetation. Trees and crops common to all sites include ... Vegetation abounds were cashew (*Anacardium occidentale*), mango (*Magnifera indica*), guava (*Psidium guajuva*), melina trees (*Gmelina arborea*), locust bean trees (*Parkia biglibosa*), shea butter (*Butyrospermum parkii*), banana (*Musa spp.*), pawpaw (*Carica papaya*) and citrus (*Citrus sinensis*) are planted. Among the creepers are pumpkin (*Cucurbita maxima*), water melon (*Citrulus lanatus*), egusi melon (*Cucumis melo*) and cucumber (*Cucumis sativus*). Cereals and legumes that were sited included maize (*Zea mays*), ground nut (*Arachis hypogea*) and Cowpea (*Vigna unguiculata*). The vegetables include Tomato (*Lycopersicon esculentum*), Garden egg (*Solanum melongena*) and Okra (*Abelmoschus esculentus*). Root and Tuber crops found were cassava (*Manihot. esculenta*), potato (*Ipomea botata*) and yam (*Dioscorea* spp.).

Traps and Trapping

Trapping was done from May-October, 2014. Two types of traps were used for this research; Steiner trap (Thailand modified) and Ball trap AR934 (ISCA Technologies, USA). Methyl eugenol (Benzene, 1, 2,-dimethoxy-4-(2-propenyl); a para-pheromone (attractants) was used as bait in Steiner trap and torula yeast was used as bait for the Ball trap. For the Steiner trap bait, 0.5ml of DD Force (Dichlorvos DDVP) was introduced into vial of 10 ml of methyl eugenol with the aid of needle and syringe. One ml of the mixture was used to impregnate cotton that was placed in the lid inside each trap to attract the flies. For the ball trap, three pellets of torula yeast were dissolved in 1.5 liters of water in the trap (Danjuma *et al.*, 2013). The traps were hung about 1m – 1.5m high from

RESULTS

Table 1 shows the fruit fly species trapped and the relative abundance of each. A total of 7,798 flies were collected at all sites over the 6 months trapping period.. Flies trapped in mango, cashew, guava and water melon orchards numbered 2,472, 2,086, 2,404 and 836, respectively. Flies caught per trap per day was in the range of 0.76 and 2.26 individuals. The mango orchard had the highest number (23) of fruit fly species followed by cashew and guava orchards (20 species each), and lastly water melon with 15 species. . *B. invadens was the most abundant and together with C. capitata, B. cucurbitae* and *B. mesomelas,* accounted for 93.97 % of the total collections. Out of the 23 species, 15 were common to all sites. These were *B. invadens, B. cucurbitae, B.mesomelas, C. capitata, C. paracolae, C. colae, C. cosyra, C. bremii, D. bivattatus, D. goergeni, D. fucovittatus, D. humeralis, D. punctotifrons, P. deeming* and *T. obscurum* (Table I).

The genus *Bactrocera* was represented by just three species but were abundant in traps at all farms compared to all other tephritid flies caught. In contrast, species of the genera *Ceratitis* and *Dacus* were more but number of trapped flies few at all sites. *D. goergeni* was observed for the first time in this zone (Table I). Species in the genera *Perilampsis* and *Trirhithrum* were poorly represented going by the number of individuals caught.

Table I: Fruit fly species and the numbers trapped at each site.

Species	Mango	Cashew	Guava	Water melon	Total	%
B. invadens	1879	1564	1896	546	5885	**75.47**
B. cucurbitae	155	142	112	99	508	**6.51**
B. mesomelas	109	116	97	65	387	**4.96**
C. capitata	168	157	131	92	548	**7.03**
C. bremii	8	3	8	5	24	**0.31**
C. paracolae	34	23	45	2	104	**1.33**
C. colae	15	12	25	4	56	**0.76**
C. cosyra	44	23	50	13	130	**1.67**
C. ditissima	4	7	6	0	17	**0.22**
C. lentigera	23	16	10	0	49	**0.63**
C. penicillata	5	2	2	0	9	**0.12**
C. punctata	5	6	3	0	14	**0.18**
D. bivittatus	3	2	1	1	7	**0.09**
D. goergeni	1	1	1	1	4	**0.05**
D. diastatus	1	1	0	2	4	**0.05**
D. fuscovittatus	2	3	2	1	8	**0.1**
D. humeralis	2	2	1	1	6	**0.08**
D. punctatifrons	5	3	7	2	17	**0.22**
D. vertebratus	3	0	5	0	8	**0.1**
Perilampsis atra	1	0	0	0	1	**0.01**
P. deemingi	2	2	1	2	7	**0.09**
Trirhithrum nigerum	2	0	0	0	2	**0.03**
T. obscurum	1	1	1	0	3	**0.04**
Total	**2472**	**2086**	**2404**	**836**		
Species richness	**23**	**20**	**20**	**15**		
Fisher's Alpha	**3.5085**	**3.0675**	**2.9937**	**2.59**		
Berger Parker	**0.76011**	**0.74976**	**0.79297**	**0.64311**		
Fly trapped per day	**2.26**	**1.91**	**2.2**	**0.76**		

Table 2: Diversity indices of the fruit fly species at different sites

	Mango	Cashew	Guava	Water Melon
Mango	-	0.93	0.93	0.78
Cashew	-	-	1	0.85
Guava	-	-	-	0.85

*** Sorenson's Similarity Index**

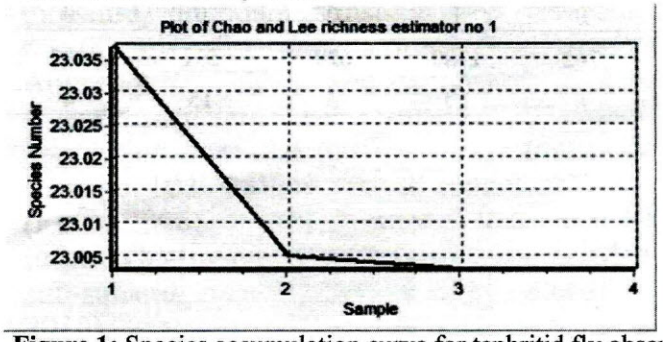

Figure 1: Species accumulation curve for tephritid fly observed among study sites in orchards 1 to 4.

Hence, both CHAO & Lee 2 and Boostrap gave higher estimated species richness (mean CHAO & Lee 23.037; mean Boostrap 23.746). The range of similarity index observed for this study was 0.78 – 1. The index observed for this study revealed that all sites were strongly similar in species compositions (Table 2). From this study, methyl eugenol had the higher catch of fly in terms of population (5271 flies) and species abundance (23 species) compared with 2527 flies and eight species For torula yeast. Hence, tephritid fly species were more abundant in the orchards than in the farm (Table I).The species accumulation curve (Fig. 1) does not reveal critical differences among sites. The Fisher's Apha and Berger Parker revealed similarities for species richness among sites. Mango, cashew and guava orchards had close and higher probabilities but a low probability was recorded for the water melon farm.

Table 3: Fly caught by trap based on attractants

	Mango		Cashew		Guava		Wmelon	
Species	**ME**	**TY**	**ME**	**TY**	**ME**	**TY**	**ME**	**TY**
B. Invadens	1154	725	905	659	1361	535	305	241
B. cucurbitae	89	66	85	57	68	44	67	32
B. mesomelas	86	23	102	14	76	21	52	13
C.paracolae	149	19	132	25	109	22	73	19
C. bremii	8	0	3	0	8	0	5	0
C. capitata	32	2	19	4	43	2	2	0
C. colae	15	0	12	0	25	0	4	0
C. cosyra	44	0	23	0	50	0	13	0
C. ditissima	4	0	7	0	6	0	0	0
C. lentigera	23	0	16	0	10	0	0	0
C. penicillata	5	0	2	0	2	0	0	0
C. punctata	5	0	6	0	3	0	0	0
D. bivittatus	3	0	2	1	1	0	1	0
D. goergeni	1	0	1	0	1	0	1	0
D. diastatus	1	0	1	0	0	0	2	0
D. fuscovittatus	2	0	2	1	2	0	1	0
D. humeralis	2	0	2	0	1	0	1	0
D. punctatifrons	5	0	3	0	7	0	2	0
D. vertebratus	3	0	0	0	5	0	0	0
Perilampsis atra	1	0	0	0	0	0	0	0
P. deemingi	1	1	1	1	1	0	2	0
Trirhithrum nigerum	1	1	0	0	0	0	0	0
T. obscurum	1	0	1	0	1	0	0	0
Total	**1635**	**837**	**1325**	**762**	**1780**	**624**	**531**	**305**
Species richness	**23**	**7**	**20**	**8**	**20**	**5**	**15**	**4**

ME: Methyl Eugenol, TY: Totula yeast.

DISCUSSION

The tephritid fauna of the southern Guinea savanna is very rich, presenting an estimate of 29% of all known species observed in Nigeria by De Meyer *et al.* (2013). With the observed species richness of this zone there is high prospect of discovering more species with proper and more prolonged baiting. Most of the species observed in this study were endemic to Nigeria and are being documented in this zone for the first time. The notable exception is *B. invadens*, an invasive species that was introduced into Africa and which has spread to most African countries (Drew *et al.*, 2005). *D. goergeni* was was first collected by Dr. Georg Goergen from Benin and Togo in the year 2006 (De Meyer *et al.*, 2013) and might have been introduced into Nigeria via commerce.

The population of the *B. invadens* was found to be tremendously high in this zone while the other species occurred at low densities. The former might have invaded the local fauna forcing other fruit flies to shift and redefine their niches due to competition for the limited resources (Duyck *et al.*, 2004; Ekesi *et al.*, 2009).

The beta diversity indices were high for all the sites. This could be a reflection of the similarities observed in the vegetation surrounding the trapping sites as all sites were established farms far off from the forest and surrounded by the plants in the following Families; *Anacardiaceae, Caricaceae, Cucurbitaceae Leguminosae, Malvaceae, Musaceae, Myrtaceae, Rutaceae, Sapotaceae* and *Solanaceae*. Some of the plants in the aforementioned Families are host of these fruit flies. *Bactrocera, Ceratitis*, *Trirhithrum* and *Perilapmsis* species, for example, are mainly infesters of orchard fruits and shrub fruits of *Anacardiaceae*, *Sapotaceae*, *Rutaceae*, *Myrtaceae*, (De Meyer *et al.*, 2002; White *et al.*, 2003). Very few members of these Families are domesticated while majority are still in the wild. *Dacus* species are major pest of creeping and climbing plants of the Family *Cucurbitaceae* (White 2006). All sites are rich in *Ceratitis* and *Dacus* species, which are closely followed by the *Bactrocera*, *Perilampsis* and *Trirhithum* species, respectively. However, there is paucity of information on the various hosts of these flies . Hence, a critical study and review of the host of these tephritid flies is required for their biology, ecology and good management practices. It is not surprising that very high similarity indices were recorded for the orchards as myriads of these flies do infest orchard fruits (White and Elson, 1994; Drew and Hancock, 1994; De Meyer *et al.*, 2002; White *et al.*, 2003; White, 2006). Though a low similarity index was recorded on water melon farm when compared to other orchards, this might be due to the few fly species that attack this plant.

Regarding the attractants , methyl eugenol attracted more flies than torula yeast, an essential source of protein for the development of egg. Similar observation was made by Danjuma *et al.* (2013) in their study in Thailand.. Flies in the genera *Bactrocera* and *Ceratitis* were abundantly trapped than those of other genera. This might be due to the fact that the attractants employed were more effective for these flies and less so for others. Generally, methyl eugenol has been recorded as a potent attractant to many of the genera of fruit flies especially, the *Bactrocera* species (White and Elson-Harries, 1992; Drew and Hancock, 1994). Danjuma *et al.* (2013) reported a relative replica of this scenario in Southern Thailand.

With the incursion of the *B. invadens* into this region, the fruit fly fauna of this region has been tremendously tampered with and this fly has become invasive and notorious attacking different plant host species. This may lead to competition and displacement of the earlier flies to narrower niches as two species could not co-subsit/coexist or share a single host (Duyck *et al.*, 2004; Danjuma *et al.*, 2014). This might have led to intergeneric competition and subsequently reducing the number of hosts attacked by other fruit flies. Other factors could be related to the life history strategies of the flies and the nature of the orchards where samples were taken. *B. invadens* multiply rapidly and hence possess the ability to colonize a new area quickly than any other species (Salum *et al.*, 2013). Following *B. invadens*, is the relatively less aggressive genus, *Ceratitis* species. These two species should be properly curtailed. Otherwise, a great treat is already posed to fruit and vegetable production in this region.

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