PRELIMINARY SURVEY OF MEALYBUG INCIDENCE AND INFESTATION ON PAWPAW *(Carica papaya* L.*)* IN A RAINFOREST ECOLOGY IN NIGERIA

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ABSTRACT

Field surveys were carried out at four selected locations within Obafemi Awolowo University Campus, Ile-Ife, Nigeria between August and December, 2017 to determine incidence, species richness and relative abundance of mealybugs on pawpaw (Carica papaya L.). Six species of mealybugs namely; Paracoccus marginatus (Williams and Granara de Willink), Ferrisia virgata (Cockerell), Planococcus citri (Risso), Maconellicoccus hirsutus (Green), Phenacoccus solenopsis (Tinsley), and Planococcus njalensis (Laing), were present on pawpaw in the selected locations. The results showed that P. marginatus had the highest mean abundance (160.2 ± 30.36) and had highest relative abundance in the sampling period of August to December. The mean abundance of other mealybug species was P. citri (67.2 ± 9.27), F. virgata (59.4 ± 16.04) and M. hirsutus (52.4 ± 7.16) with the lowest abundance recorded for P. solenopsis (16.2 ± 4.07) and P. njalensis (7.6 ± 1.33) across the locations and the sampling period. The abundance of P. marginatus and M. hirsutus increased progressively throughout the sampling period. In general, there was an increase in population density of the mealybugs from August to December. The significant higher population of P. marginatus and its predominance over other mealybug species suggest its tendency to cause potential damage and yield loss of pawpaw if necessary measures are not put in place to curtail the infestation of the insect.

Key words: pawpaw, rainforest ecology, relative abundance, species richness, survey,

INTRODUCTION

Pawpaw (*Carica papaya* L.) belongs to family Caricaceae, a tropical fruit known for its high nutritive and medicinal value. Ripe pawpaw fruits are eaten throughout the tropics as dessert or fruit salads and are known to be rich in vitamins, carbohydrate, iron, minerals, calcium and fibre (Morton, 1987; Salunke and Desai, 1984; Olubode *et al*., 2008; Evans *et al*., 2012). In addition, *C. papaya* is a source of the digestive enzyme papain, which is useful in brewing, meat tenderizing, pharmaceuticals, beauty products, canning, cosmetic industries and warts removal in surgical operations (Salunke and Desai, 1984; Olubode *et al*., 2008; Evans *et al*., 2012).

Between 1961 and 1976, Nigeria was the leading country in pawpaw production but currently the sixth highest producers behind India, Brazil, Mexico, Indonesia and Dominican Republic with annual production

of 836,702 tonnes and 97,838 hectares dedicated to pawpaw production (FAOSTAT, 2018). In Nigeria, both the local and exotic varieties are cultivated for consumption and sale in local markets and these include: Red royale f1, Large maradol, Homestead, Solo (Pink, Kapoho and Sunrise), Dahomey large, JS.22 (NIHORT, 2003; Agriculture Nigeria, 2019).

The production of pawpaw in Nigeria is limited by factors such as light, water, nutrient, insect pests, diseases, poor seed germination, and difficulty in sex identification of pawpaw at seedling stage (Olubode *et al*., 2016). The insects infest pawpaw mostly during fruit set. The major insect pests include papaya mealybug, fruit fly, webworm, whitefly, mites, aphids, scales, leafhoppers and hornworms (Pena and Johnson, 2006; Agriculture Nigeria, 2019). The mealybugs (Hemiptera: Pseudococcidae) are polyphagous insects feeding on a wide range of host crops namely cassava, papaya, cashew, citrus plants, cocoa, coconut, cotton, mango, pineapple, sugarcane, sweet potatoes, yam and other crops (Heu *et al.*, 2007; Galanihe *et al*., 2010; Muniappan *et al*., 2012; Ameyaw *et al.*, 2014; Centre for Agriculture and Bioscience International [CABI], 2018a; Biovision, 2019).

Mealybugs are group of small gregarious insects with elongate to oval shape bodies and are distinguishable by the presence of mealy or powdery waxy secretions covering both dorsal and ventral surfaces of the body of immature stages and adult wingless females (Jackson, 2014; Mani and Shivaraju, 2016). The adult females are wingless while adult males are generally winged and lower in population (Moghaddam, 2013; Mani and Shivaraju, 2016). They mostly live in protected habitats such as between two touching fruits, in the crown of a plant, in branch crotches, on stems near soil, or between the stem and touching leaves (Mani and Shivaraju, 2016; UC IPM, 2018)

Mealybug is an invasive insect pest that can establish easily when introduced into a new country due to its high tendency to spread via natural means such as wind, rainfalls, water splash, ants, birds, farm animals and human beings; the waxy coating on the dorsal side which protects mealybugs against insecticides and other mortality factors; their high fecundity and capability to hide in cracks and crevices in soil and plant parts (Nagrare *et al*., 2011; Plant Health Australia, 2011).

Notable mealybugs species are pawpaw mealybug (*Paracoccus marginatus*), striped mealybug or two tailed mealybug (*Ferrisia virgata*), citrus mealybug (*Planococcus citri*), pink mealybug (*Maconellicoccus hirsutus)*, cotton mealybug (*Phenacoccus solenopsis*), long tail mealybug (*Pseudococcus longispinus*), solanum mealybug (*Phenacoccus solani*), pink sugarcane mealybug (*Saccharicoccus sacchari*), pineapple mealybug (*Dysmicoccus brevipes*) and mango mealybug (*Drosicha mangiferae*) (CABI, 2018a; Biovision, 2019). Papaya mealybug (*P. marginatus*) has been reported to infest more than 40 host-plant species in Sri Lanka (Galanihe *et al*., 2010) while cotton mealybug (*P. solenopsis)* was reported on cultivated crops such as cotton in India (Nagrare *et al*., 2011), *C. papaya* in Brazil (Martins *et al*., 2015) and also infest other 290 host plants from 64 families through-out

the world (García-Morales *et al*., 2016). In 1989, mango mealybug (*Rastrococcus invadens*) was widely distributed in Lagos, Ogun and Oyo States in Nigeria on 20 host plants of 12 families (Ivbijaro *et al*., 1992) while five mealybug species (*R. invadens*, *Icerya aegyptica*, *Rastrococcus* sp., *Phenacoccus madeirensis* and *P. solenopsis*) were also reported on different host plants in the South Guinean savannah of the country (Akintola and Ande, 2009). Cotton mealybug (*P. solenopsis*) was first reported in Nigeria by Akintola and Ande (2008) on *Hibiscus rosa-sinensis.* Egho *et al.* (2013) reported infestation of mealybug on leaves and fruits of pawpaw in Delta State, and IITA (2015) reported papaya mealybugs on different crops such as pawpaw, cassava, beans, coffee, pepper, melon, guava, tomato, eggplant, cotton, and jatropha in Nigeria, Togo, Ghana and Tanzania with preference to pawpaw.

The Mealybugs (Hemiptera:Pseudococcidae) are reported to cause plant damage through direct effects of sap sucking and injection of toxins which causes yellowing of leaves (chlorosis), defoliation of leaves, reduction in plant growth (stunting), drop in fruit settings, young fruits dropping and death of plants (Heu *et al.*, 2007; Germain *et al.*, 2010; CABI, 2018b; Biovision, 2019). The indirect effects include honeydew excretion and its associated sooty mould growth that decreases photosynthesis and may reduce the marketability of fruits while some can transmit plant viruses (Mibey, 1997; Culik *et al*., 2006; Heu *et al.*, 2007; Muniappan *et al*., 2012; Saillog, 2017). In Pakistan, papaya mealybug reduced area covered by pawpaw from 921 hectares in 2008 to 307 hectares in 2014 (Science Development Net [SDN], 2017) while in India, newly detected cotton mealybug reduced yields by 40-50% in affected cotton fields (Nagrare *et al*., 2011). The reductions in yield up to 85% due to *P. manihoti* infestation was also recorded in Nigeria (Emehute and Egwuatu, 1990).

Biological control has been utilized in the control of mealybugs which includes; the introduction of parasitic wasp, *Epidinocarsis* (*Apoanagyrus*) *lopezi* (DeSantis) from the Neotropics against cassava mealybug by International Institute of Tropical Agriculture (IITA) and International Centre for Tropical Agriculture (CIAT), which notably reduced the impacts of the mealybug (Michaud, 2002). In Puerto Rico, early detection of pink hibiscus mealybug coupled with biological control measures caused no agricultural or economic losses while in Hawaii, an exotic parasitoid, *Anagyrus kamali,* introduced simultaneously with pink hibiscus mealybug (*M. hirsutus)* in 1983 resulted in unexpected biological control of the mealybug (Michaud, 2002). Other control methods include cultural methods such as early planting and application of fertilizer.

In Nigeria, the presence of mango mealybugs and four other species of mealybugs have been reported on different host plants in Nigeria (Ivbijaro *et al*., 1992; Akintola and Ande, 2009). Recently, Egho *et al*. (2013) reported pawpaw as one of the alternative hosts of cassava mealybugs in Delta State. There is dearth of information on the level of infestation, species diversity and distribution of mealybugs on fruits most especially pawpaw (*C. papaya*). Also, Pawpaw is one of the fruit crops not given the required attention in terms of allocation of land for its

cultivation on a large scale when compared to other fruit crops. With reports that earlier detection of invasive pests such as mealybugs is key to prevent major pest outbreak, there is need for a study on the incidence and infestation of this group of insects on pawpaw. Thus, this study was undertaken to investigate and document the species composition, their prevalence and the population build-up of mealybugs on pawpaw in a rainforest ecology in Nigeria.

MATERIALS AND METHODS

Field survey of mealybug infestation at four different locations namely; Screenhouse area (7° 52′ 3″ N, 4° 52′ 8″E), Teaching and Research Farm (7° 33′ 0″N, 4° 34′ 0″E), Residential area (7° 52′ 8″ N, 4° 52′ 1″E) and Faculty of Agriculture orchard area (7° 52′ 3″ N, 4° 52′ 6″E) all at Obafemi Awolowo University, Ile-Ife, Nigeria. The survey was carried out from August to December, 2017. Mealybug species were collected from leaves and unripe fruits of *Carica papaya* plants with the aid of yellow sticky traps, fine and soft camel brush and forceps at monthly intervals in order to give room for the insect build-up.

The yellow sticky trap of 20 x 12.5 cm was attached to a long stick tip approximately 1.7 m above the ground level placed beside two trees in each of the sampling location. At each location and sampling date, all the traps were removed and replaced with new ones. The collected traps were taken to the laboratory where mealybugs were removed from the traps using forceps and soft camel brush.

The collected mealybugs were sorted and counted at the Insectarium of the Department of Crop Production and Protection, Obafemi Awolowo University, Ile-Ife, Nigeria. After every sampling, the specimens were preserved in mixture of 80% ethanol with 20% glycerine and each of the species of the insect were mounted following the standard permanent mount procedure (Borrer *et al*., 1989). The specimen on each of the prepared slides were examined and identified under a binocular dissecting microscope and a compound research microscope following standard mealybugs identification keys of Williams and Granara de Willink (1992) and García-Morales *et al*. (2016).

Data on population counts were used for estimation of population density, species richness and relative abundance of the mealybugs on pawpaw. Bar chart was also used to present differences observed in population density of mealybug species encountered during the sampling periods.

RESULTS

Table 1 shows the population density of mealybugs and the species richness at different sampling periods across locations. The species of mealybugs encountered includes pawpaw mealybug (*Paracoccus marginatus*), striped mealybug or two tailed mealybugs (*Ferrisia virgata*), citrus mealybug (*Planococcus citri*), pink mealybug (*Maconellicoccus hirsutus)*, cotton mealybug (*Phenacoccus solenopsis*) and West African cocoa mealybug *Planococcus njalensis* which were observed in all sample locations. In total, highest population of mealybugs was recorded in November and December but lowest in August.

TABLE 1: POPULATION DENSITY, SPECIES RICHNESS AND RELATIVE ABUNDANCE (%) OF MEALYBUGS AT OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA FROM AUGUST – DECEMBER, 2017

Sampling period	Total population	Mean population	Abundance (%) of mealybugs species					
			F. virgata	*P. citri*	*P. marginatus*	*P. solenopsis*	*P. njalensis*	*M. hirsutus*
August	267.0	11.1	77 (28.8)	66 (24.7)	83 (31.1)	9 (3.4)	3 (1.1)	29 (10.9)
September	381.0	15.9	108 (28.3)	79 (20.7)	128 (33.6)	6 (1.6)	8 (2.1)	52 (13.6)
October	363.0	15.1	60 (16.5)	87 (24.0)	135 (37.2)	26 (7.2)	7 (1.9)	48 (13.2)
November	403.0	16.8	37 (9.2)	71 (17.6)	198 (49.1)	25 (6.2)	11 (2.7)	61(15.1)
December	401.0	16.7	15 (3.7)	33 (8.2)	257 (64.1)	15 (3.7)	9 (2.2)	72 (18.0)

% abundance in parenthesis

With respect to proportion of insect species to total mealybugs encountered, *P. marginatus* had highest % abundance of 31.1, 33.6, 37.2, 49.1 and 64.1 % of total mealybugs detected for August, September, October, November and December respectively which shows a progressive increase from August to December. The population of *M. hirsutus* was also highest in December and lowest in August with percentage abundance of 18.0% and 10.9% respectively. In contrast, the population of *F. virgata* showed a decline from August to December with a highest percentage abundance of 28.8% recorded in August and the least percentage abundance of 3.7% in December. The population of *P. citri* was also highest in August with 24.7% of total species recorded. Out of all mealybug species encountered, *P. njalensis* had the least percentage abundance of 1.1% in August and *P. solenopsis* had 1.6% of total mealybug population in September.

The population density of different species of mealybugs sampled on pawpaw across different locations on Obafemi Awolowo University, Campus in Ile Ife, Nigeria is presented in Fig 1. At 0.05 level of probability, the predominant and most abundant species was *P. marginatus* with mean population of (160.2 ± 30.36), while the least encountered species was *P. solenopsis* (16.2 ± 4.07) and *P. njalensis* (7.6 ± 1.33).

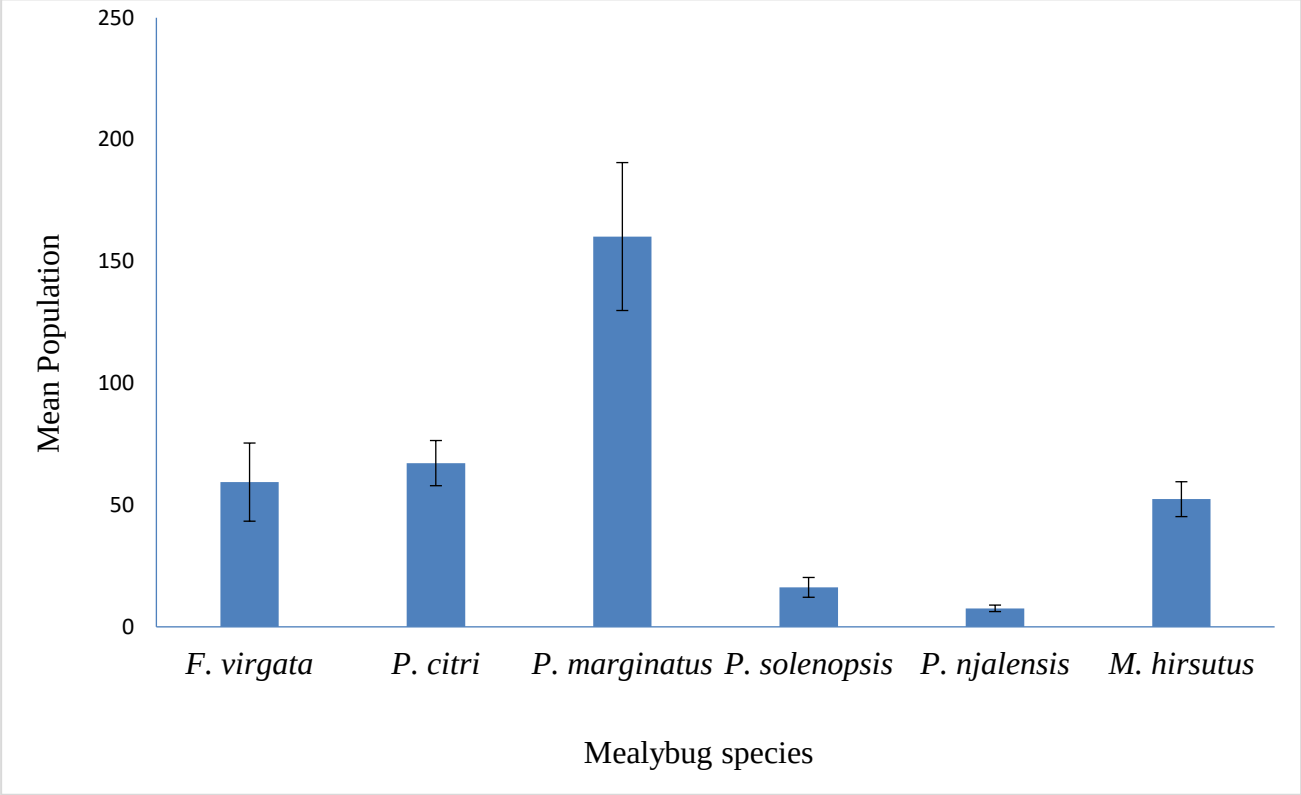

FIG 1: MEAN POPULATION OF MEALYBUG SPECIES ENCOUNTERED ON PAWPAW ACROSS LOCATIONS IN OBAFEMI AWOLOWO UNIVERSITY CAMPUS, ILE-IFE, NIGERIA FROM AUGUST – DECEMBER, 2017.

DISCUSSION

This study reported a total of six species of mealybugs with *P. marginatus* as the species with the highest population density followed by *P. citri*, *M. hirsutus* and *F. virgata* while *P. solenopsis* and *P. njalensis* had the lowest population on pawpaw in all the locations in the University campus and throughout the sampling period.

The prominence of papaya mealybug (PMB), *P. marginatus* in the current study is consistent with earlier work of Heu *et al.* (2007) on pawpaw in Hawaii, Tanwar *et al*. (2010) on pawpaw in India and Alamu *et al*. (2016) on jatropha in Nigeria. Earlier, IITA (2015) reported the insect on pawpaw in Nigeria, Garbon, and Tanzania and Nagrare *et al*. (2011) stated that PMB present its greatest threats to countries within 30° of the equators. According to Seni and Sahoo (2014), *P. marginatus* completes up to 11 generations in a year and also has preference for pawpaw (*C. papaya*) as host. The high population density recorded in this study suggests that the insect has tendency to reach a pest status in Nigeria. This mealybug species was reported to cause severe damages and huge loss to farmers in India (Tanwar *et al*., 2010) while in Ghana, its infestation caused a

drastic reduction of about 85% destruction in papaya cultivations in 2009 with a resultant effect of 65% reduction in the export level in 2008 (FAO, 2014).

Striped mealybug, *Ferrisia virgata* which is also a polyphagous insect and regarded as secondary host of pawpaw also has economic significance on cocoa and cotton (Ameyaw *et al.*, 2014; Oliveira *et al*., 2014). This species is also reported to transmit cocoa swollen shoot virus (Ameyaw *et al*., 2014) and piper yellow mottle virus (Bhat *et al*., 2003).

Citrus mealybug *(P. citri)* is a species of mealybugs native to Asia and known to be associated with orange but attack wide range of crop plants including pawpaw (CABI, 2018a) with an earlier report on potato tubers in storage in several locations in Jos, Nigeria (Onazi, 1969). An estimated annual loss of US$ 3.5 million was reported in Grenada due to pink hibiscus mealybugs (*M. hirsutus)* damage to crops and environment before introduction of biological controls to curb its ravaging effect (Francois, 1996). The insect was reported to be present in Nigeria as an introduced pest (CABI/EPPO, 2015) but its favoured hosts was *Hibiscus rosa-sinensis* without any previous report on pawpaw in the country.

Cotton mealybug *(P. solenopsis)* was reported to be a pest of cotton in Pakistan and India (Hodgson *et al*., 2008), cotton in India (Jhala *et al*., 2008; Nagrare *et al*., 2009), *Hibiscus* sp. and *Plumeria* sp. in Senegal and Mali respectively (Muniappan *et al*., 2012), tomatoes in Brazil (Culik and Gullian, 2005), pawpaw in Brazil (Martins *et al*., 2015) and on *Hibiscus rosa-sinensis* in Nigeria (Akintola and Ande, 2008). It is likely that this may be the first record of the insect on pawpaw in Nigeria. The low population of *P. solenopsis and P. njalensis* could be associated with high presence of natural enemies as the mealybugs only tend to be serious pests with the lower presence of its natural enemies and presence of ants which offer protections against its predators (Nagrare *et al*., 2011) or due to the presence of other preferred hosts as a result of its polyphagous potentials. Environmental factors such as low temperature and humidity could limit its distribution (Wang *et al*., 2010) while biotic factors, particularly parasitism are reported to be useful in regulating population of solenopsis mealybug (Kedar *et al*., 2012). The three species of mealybugs viz: the pink hibiscus mealybug (*M. hirsutus*), striped mealybug (*F. virgata)* and West African cocoa mealybug (*P. njalensis)* have not been reported on any crop from the study area and thus can be noted as new emergent insect pest of pawpaw.

The progressive and steady increase in population density of *P. marginatus* and *M. hirsutus* may be attributed to favourable weather factors, the presence of ants and absence of natural enemies (predators and parasitoids). Baovida *et al*. (1995) reported that population density of mango mealybug (*R. invadens*) decreased during the rainy seasons and peaked during dry seasons while Kumar (2009) stated that temperature and moisture affect mealybug growth, development, hatching and other life parameters of the insects. However, Karar *et al.* (2013) reported all the weather factor had no significant effect on the population of mango mealybug (*D. mangiferae)*. This indicates that mealybugs generally exhibit different behaviour to weather factors and this might be responsible for the variation observed in population density of the mealybug species recorded in this study.

CONCLUSION

This study has provided information on the species richness and abundance of mealybug species on pawpaw with the presence of the pink hibiscus mealybug (*M. hirsutus*), striped mealybug (*F. virgata)* and West African cocoa mealybug (*P. njalensis) on* pawpaw being reported for the first time in the study area. The high population density and the relative abundance of *P. marginatus* suggests that the insect has the tendency to reach a pest status. Therefore, more studies are required in different agroecological zones in Nigeria to determine the distribution, population dynamics and pest status in relation to damage likely to be caused by infestation of these invasive insect pests. This will assist in the development of reliable pest management programme for these insects in order to curb future threat to pawpaw production in Nigeria.

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