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HOST PLANTS OF THE COTTON MEALYBUG, *PHENACOCCUS SOLENOPSIS* TINSLEY (HOMOPTERA: PSEUDOCOCCIDAE) IN THREE SELECTED TOWNS OF NIGERIA, AND ITS INFESTATION PATTERN

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ABSTRACT

Reconnaissance surveys were carried out for field infestation of *Phenacoccus solenopsis* Tinsley from 2006 to 2010 in seventy five (75) vegetable gardens located in three (3) towns– Ogbomoso, Abeokuta and Ibadan in Nigeria. No cotton mealybug infestation was observed in Abeokuta and Ibadan, but twenty four (24) plants in 16 different families were observed as its hosts in Ogbomoso area. Of the 24 species, weeds constituted 45.8%, vegetables 29.1%, herbs 12.5%, cereals 4.2%, fruit trees 4.2% and pulse 4.2% each. Infestations started on the abasial leaf surface and advanced to the mid-ribs, petiole, young and succulent stems and buds. *Corchorus olitorius* and *Amaranthus hybridus* were the most susceptible of the trialled plant species with heavy root infestation in addition to that of the leaf. On heavily infested plants, certain ants were found together with *P. solenopsis*; on cowpea however, *Aphis craccivora* and the ants formed a complex with the mealybug on the flower buds. Of the three towns surveyed, *P. solenopsis* could be said to be restricted to backyard gardens around Ogbomoso at the moment. However, a nation-wide survey is very necessary now to determine the current status of the mealybug in Nigeria.

Key words: *Phenacoccus solenopsis,* infestation level, damage pattern, vegetable garden, surveys, pest status

INTRODUCTION

The cotton mealybug, *Phenacoccus solenopsis,* is a polyphagous pest worldwide; its host range includes field crops, vegetables, ornamentals, medicinal plants, bushes, trees and weeds (Arif *et al.,* 2009). The mealybug was recorded as a pest of cotton in Texas, United States of America in 1898, in Central America, the Caribbean and Ecuador in 1992 (Williams and Granara de Willink, 1992), Chile in 2002 (Larrain, 2002), Brazil (Mark and Gullan, 2005), Pakistan in 2005 (Arif *et al.,* 2009) and Ghana in 2007 (Muniappan, 2009). Although there are indications of

earlier record of the insect intercepted from Nigeria in 1993 (Hodgson *et al*., 2008), Akintola and Ande (2008) recorded the mealybug as a pest of *Hibiscus rosa-sinensis* in Ogbomoso, Nigeria.

Phenacoccus solenopsis has the ability to hide in the soil cracks and crevices and corner regions of plants. Although the mealybug was described originally from specimens collected from plant roots (Ben-Dov, 2004), it also attacks stems and leaves. The morphological variations and its biology have been described by Hodgson *et al*. (2008). The live appearance of *P. solenopsis* differs from *P. solani* and *P. defectus* in that the adult female *P. solenopsis* has paired dark spots and/or stripes dorsally whereas the females of the other two appear to be uniformly white dorsally (Miller *et al*., 2005). *P. solenopsis* also possesses short lateral wax filaments and slightly longer terminal wax filaments that are half as long as the body.

Damage characteristics of *P. solenopsis* include distortion and bushy shoots, crinkled and/or twisted and bunchy leaves, stuntedness, reduction in plant vigour and early crop senescence. They also secrete copious amount of honeydew that attracts ants and help in development of black sooty mould which inhibits the photosynthetic ability of plants. Sap-sucking by the nymphs and adults may result in withering and yellowing of leaves, premature fruit drop, poor development of flowers or ultimately, plant death. On cotton, retarded growth could occur if there is a severe attack of the mealybug; there could also be late opening of bolls which may affect yield badly. Curling and contortion of leaves could result when saliva is injected into the plant tissues during feeding (Mark and Gullan, 2005; Osborne, 2005).

It remains uncertain how this insect was introduced into Nigeria, but insects having the size of mealybugs could very easily be transported for long distances by ocean-going vessels, by air currents or by movement of plant materials. Specifically, *P. solenopsis* has the propensity to spread through natural carriers such as raw cotton seeds, wind, water, rain, birds, human beings and farm animals (Mark and Gullan, 2005). The mealybug possesses immense potential to emerge as a serious crop pest, thereby causing severe economic damage to a wide range of crops and pose a grave threat to agriculture. Unlike the introduced *P. manihoti* that has been extensively studied (Akinlosotu and Leuschner, 1981; Akinlosotu, 1983; Odebiyi and Bokononon-Ganta, 1986, Emehute and Egwuatu, 1990; James, 1987; Neuenschwander *et al*., 1990; Le Ru and Tertuliano, 1993; Neuenschwander and Ajounu, 1995; Neuenschwander, 2001), host range information on *P. solenopsis* is still scanty in Nigeria.

Our previous observations from 2006-2008 revealed that the pest has a wide host range in vegetable gardens. Therefore in 2009, a survey was carried out to record the host range of *P. solenopsis* and to determine its spread, infestation level and damage on different hosts. The purpose of this paper is therefore to summarise the information gathered on the host range and infestation pattern of the pest.

MATERIALS AND METHODS

The study was carried out in two experiments: field and survey. Field experiments were carried out only in crop gardens, while surveys were carried out in crop gardens and farms in Ogbomoso (where the first report of the mealybug was made), Abeokuta and Ibadan in the derived savannah zone, southwestern Nigeria.

Field experiment to determine infestation characteristics of P. solenopsis

Plots made up of seven (7) different crops were established in 2007 and 2008 within an area earlier infested with *P. solenopsis*. The crops planted in the plots were *Vigna unguiculata, Lycopersicum esculentum, Corchorus olitorius, Capsicum annuum, Amaranthus hybridus, Abelmoschus esculentum* and *Zea mays.* The crops were established in an additive manner. Plot size was 36.5 x 32.0 m replicated three times. Planting was done via seed sowing and weeding was done manually when necessary.

Observations made included the infestation pattern of *P. solenopsis* on its hosts. On aerial parts, infestation level was rated as incidental, low, medium or high. The adasial and abasial leaf surfaces of ten (10) randomly selected plants per plot were visually inspected for the mealybug infestation. Young stems, terminal and axillary buds were also examined where infestation level was high on the leaves. Plants with high level of aerial infestation were sampled destructively by uprooting the plants and examining the roots for mealybug infestation.

Survey

Field surveys were carried out between May and October, 2010 in seventy five (75) vegetable gardens to determine the host range of *P. solenopsis* in Ogbomoso and Ibadan. Plants along the route and in adjoining gardens were critically examined for the presence or absence of the mealybug, including its life stages. Only plants with the life stages of *P. solenopsis* were considered as hosts. Attention was paid to infestation level and damage pattern of the mealybug. Insects associated with the mealybugs were also collected and identified.

***Scoring method for* P. solenopsis**

In all the experiments, scoring of *P. solenopsis* was done by visual inspection of adasial and abasial leaf surfaces of 10 randomly selected plants. Young stems, terminal and axillary buds were also examined where infestation level was high on the leaves. Destructive sampling was done for flora with high level of aerial infestation by uprooting the plants and examining the roots for mealybug infestation. Severity of infestation on the aerial parts was based on the number and proportion of foliage and twigs showing the mealybug infestation; the rating was incidental, low, medium and high where:

Incidental	=	Only a few individuals of the mealybug found on the leaves; less than 3 per leaf.
Low	=	Mealybug population less than 10 per leaf; just a stage of mealy bug found; no adverse symptoms observed on the plant; < 25% of the foliage covered.
Medium	=	Mealybug population ranging from 11 to 25 per leaf; different stages of mealybug found; infested plants normally survived; 25 -60% of foliage covered.
High	=	All stages of mealybug found in very large number; almost all plant parts covered with mealybug; leaf shedding; growth distortion; death of infested plants; >60% of foliage covered.

RESULTS AND DISCUSSION

The seven crops planted on the field viz: *Vigna unguiculata, Lycopersicum esculentum, Corchorus olitorius, Capsicum annuum, Amaranthus hybridus, Abelmoschus esculentum* and *Zea mays,*

were all infested by *P. solenopsis*. From the survey, twenty four (24) plants were found to be infested by the mealybug (Table 1).

Table 1: List of host plants of *Phenacoccus solenopsis* and the severity of attack in three towns in Nigeria

Family/Botanical Name	Pant Classification	Status	Parts Infested	Infestation Level
Amaranthaceae				
Amaranthus hybridus	Broadleaf	Vegetation	Leaf, bud, root	++++
Amaranthus spinosus	Broadleaf	Weed	Leaf	++
Asteraceae				
Ageratum conyzoides	Broadleaf	Weed	Leaf	+
Chromolaena odorata	Broadleaf	Weed	Leaf, bud, twig	++++
Laggera aurita	Broadleaf	Weed	Leaf, bud,	++++
Laggera alata	Broadleaf	Weed	Leaf, bud,	+
Laggera alata	Broadleaf	Herb		
Tithonia diversifolia	Broadleaf	Weed	Leaf, bud,	+
Boraginaceae				
Heliotropium ovalifolium	Broadleaf	Weed	Leaf	+
Capparidaceae				
Cleome ciliata	Broadleaf	Weed	Leaf, bud, twig	+
Commelinaceae				
Commelina benghalensis	Grass	Weed	Leaf, stolon	++
Curcurbitaceae				
Telfaria occidentalis	Broadleaf	Vegetable	Leaf	++
Cyperaceae				
Cyperus spp.	Sedges	Weed	Leaf	+
Euphorbiaceae				
Phylanthus amarus	Broadleaf	Weed	Leaf	++
Fabaceae				
Vigna unguiculata	Broadleaf	Pulse	Leaf, bud	++++
Gramineae				
Zea mays	Grass	Cereal	Leaf, ear	+
Lamiaceae				
Ocimum gratissimum	Broadleaf	Herb	Leaf, bud, twig	++++
Malvaceaea				
Abelmoschus esculentum	Broadleaf	Vegetable	Leaf	++++
Myrtaceae				
Psidium guajava	Broadleaf	Fruit Tree	Leaf	+
Solanaceae				
Capsicum annuum	Broadleaf	Vegetable	Leaf, bud, root, fruit	++++
Lycopersicum esculentum	Broadleaf	Vegetable	Leaf	+++
Solanum carprocarpium	Broadleaf	Vegetable	Leaf, bud	++
Tiliaceae				
Corchorus olitorius	Broadleaf	Vegetable	Leaf, bud, stem, root	++++
Urticaceae				
Laportea aestuans	Broadleaf	Herb	Leaf	++

+= incidental**; ++=** low; **+++=** medium; **++++=** high.

Figure 1: Fruit of *Capsicum annuum* infested by *Phenacoccus solenopsis*

Figure 2: Root of *Corchorus olitorius* infested by *Phenacoccus solenopsis*

There was no mealybug infestation on plants outside the gardens. These 24 plants in 16 different families were considered as hosts of *P. solenopsis* since the various life stages of the mealybug were found on them.

Of the 24 species of host plants found, weeds constituted 45.8%, vegetables 29.1%, herbs 12.5%, cereals 4.2%, fruit trees 4.2% and pulse 4.2% each. Based on severity of attack, important host plants were *Corchorus olitorius, Amaranthus hybridus, Vigna unguiculata, Abelmoschus esculentum, Capsicum annuum* and many species of weeds (Table 1). Many workers also reported similar wide ranges of host plants. Arif *et al* (2009) recorded 154 host plants in 53 plant families in Pakistan. *P. solenopsis* is thus a highly polyphagous pest that deserves immediate control attention in Nigeria. Mealy bugs and scale insects are known to be polyphagous pests; their hosts usually range from cultivated to wild species (Meyerdirk *et al*., 2004; Arif *et al*., 2009; Walton *et al.,* 2009). This high level of polyphagy observed suggested that *P. solenopsis* may attack more plants with the passage of time (Arif *et al,* 2009).

With the growing love for backyard garden rising rapidly among urban dwellers in Nigeria, *P. solenopsis* infestation may become more severe if not controlled, through the interchange and free movement of planting materials. This may result in severe reduction in the yield of fruits and vegetables, and ultimately in the output from industries that process these crops. The socio-economic consequences of severe reduction or near complete loss of yields -as in the cases of mango mealybug and cassava mealybug (Pitan *et al*., 2002) - are grave on the nation, because much of the population depends on these host plants as ready sources of cheap energy, vitamins and minerals. The aesthetic values provided by ornamentals around rural and urban houses are seriously undermined because of the plant canopies that may be rendered unsightly and unacceptable by *P. solenopsis* infestation and the associated ants and flies that feed on the honeydew.

The infestation of *P. solenopsis* appears to be presently limited to gardens that are in close proximity to humans. From the surveys carried out, *P. solenopsis* was not found in farms far away from human activities but in backyard gardens. Although human activities around these gardens that may cause ecosystem amplification were not quantified, it is likely that human activities around these gardens might have encouraged the establishment of these mealybugs. Pitan (2008) reported that smoke pollution resulting from certain human activities enhanced the survival and establishment of the mango mealybug, *Rastrococcus invadens.*

Ants (*Crematogaster* species) were found together with *P. solenopsis* on almost all the infested plants except for cowpea where *Aphis craccivora* formed a complex with it in addition to the ants on the new flower buds at its podding stage.

On leafy vegetables and broadleaf weed species, infestation started on the abaxial leaf surfaces starting with the lamina and spreading to the midribs, latter to the young stems, and occasionally to the buds. On plants where all developmental stages were found, more of the neonates were found on the abaxial part of the leaves, while adults were found on the succulent nodes and internodes. This infestation pattern was similar to the observations of Agounke *et al.* (1988) on the mango mealybug, *R. invadens*. Young *P.*

solenopsis was found on the lamina because their mouthparts are not strong enough to penetrate the more lignified tissues such as the stem. The adults, however, migrated to the stem for sufficient plant juice because they have more developed mouth parts. On fruit vegetables, infestation started on the leaves; adults were later found on the fruits. For instance, on *Capsicum annuum*, adults were found on the crevices of the fruits (Figure 1). It could then be useful to link phenological plant models to models of insect development to describe the possible area of occurrence for any particular mealybug stage. Knowledge of spatial patterns is obviously essential to any sampling plan, so also is the interaction of several mechanisms that will determine the spatial pattern, such as plant and insect physiology, environmental heterogeneity and insect behaviour (Pitan, 2002).

The most susceptible species which suffered die-back due to high level of mealybug infestation were *Corchorus olitorius* and *Chromolaena odorata*. The results of damage at high infestation level included reduction in sizes of terminal and axillary leaves, leaf mottle and discolouration that resemble symptoms of viral infections, and stunted growth. Similar observations were made by Arif *et al.* (2009) in Pakistan in cotton. Roots of *Corchorus olitorius* and *Amaranthus hybridus* were also infested by *P. solenopsis* (Figure 2). Although factors that led to root infestation were unknown, 50% and 20% of *Corchorus* and *Amaranthus* sampled, respectively, were such infested. Die-back which was observed on *Corchorus* as a result of high mealybug infestation was not observed in *Amaranthus. P. solenopsis* is therefore a serious pest of *Chromolaena odorata* and *Corhorus olitorius* with the occurrence of die back noticed in those crops. The potential of using these two plants as trap crops in the control of *P. solenopsis* is therefore recommended for further evaluation.

The level of the mealybug infestation on maize was low; there were also no symptoms of any physiological damage on the crop although the mealybugs were found on fresh leaves and ears. On cowpea, the infestation pattern during the pre-flowering stage was similar to that on vegetables. As leaves became lignified with age, adults migrated to the internodes.

As with other invasive homopterans, over-dependence on chemical application may not be the best approach to manage this pest. Going by the list of hosts recorded in this work, effective manipulation of alternative hosts such as weeds, crop rotation, quarantine measures and rouging infested plants may be effectively combined with judicious use of modified chemicals while developing integrated pest management strategy for the pest. Similarly, being exotic and polyphagous, *P. solenopsis* is a good candidate for biological control. Interestingly, some mealybugs share a number of predators and those of a mealybug may also adapt to exploit the other. The coccinellid beetles such as *Cheilomenes sexmaculatus, Rodolia fumida, Scymnus coccivora* and *Nephus regularis* are effective predators. *Anagyrus pseudococci*, *Leptomastix dactylopii* (parasitoids), *Hypoaspis* sp. (mite), *Verticillium lecanii* and *Beauveria bassiana* (pathogens) are also effective (Mark and Gullan, 2005). Thus, the already existing natural enemies must be properly studied and their ability to control the pest determined before any consideration is given to the introduction of another one. If the existing ones are really suppressing the population of the mealybug for instance, then there would be no need for a new introduction;

only the augmentation of the existing population would then be necessary to effectively control this insect pest.

In conclusion, nation-wide surveys are needed to establish the spread and current status of the pest as well as its natural enemy complex in order to begin to plan for the management of the mealybug.

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