# EFFECTIVENESS OF SOME ECOLOGICAL PEST MANAGEMENT PRACTICES AGAINST THE BROWN COCOA MIRID, *SAHLBERGELLA SINGULARIS* (HEMIPTERA: MIRIDAE) IN NIGERIA

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## Abstract

*Sahlbergella singularis*, the brown cocoa mirid, is the most economically important insect pest of cocoa in West Africa, capable of causing over 70% yield loss. The use of synthetic insecticides over the years has led to serious health and environmental issues making research into ecologically sound alternatives inevitable. This study therefore highlights pest management tools that have been developed for the effective control of mirids with minimal deleterious effects on the ecosystem. Cultural control practices involving pruning of chupons, timely phytosanitation and removal of mummified pods were carried out on treated cocoa plots and mirid infestation levels were compared to untreated plots. Field evaluation for resistance was conducted on 44 cocoa genotypes by assessing mirid damage on cocoa as indicated by lesions on pods, twig dieback and cankers of trunks. The predatory efficiency of seven different ant species was conducted on the mirids. Population of mirids in treated plot reduced by 6.2 times. Some international cocoa genotypes (EET59, Ven-C4, UF676, Amaz15-15, BE10, Mocorongo and Pa107) showed high resistance to mirids with very low damage scores whereas the local genotype N38 was highly susceptible to mirid damage in terms of lesions, dieback and canker with mean scores of 2.61, 1.85 and 2.77, respectively. The ant species exhibited varying degree of predation in the laboratory. *Oecophylla longinoda, Acantholepis capensis* and *Camponotus acvapimensis* caused 100%, 50.5% and 35% mortalities of mirids in the laboratory, respectively. Ecological pest management tactics offer safe, effective and environmentally friendly control against this obnoxious insect pest of cocoa.

**Keywords:** *Sahlbergella singularis*, cultural control practices, cocoa genotypes, ant species.

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## Introduction

*Theobroma cacao* Linnaeus is the main source of raw materials used in the multi-billion dollar chocolate and confectioneries industry. The world's exports amount to about U.S. $5-6 billion yearly and use of cocoa and cocoa butter in chocolate manufacturing, cosmetics, and other cocoa products reach approximately US $70 billion market and provides over 60, 000 jobs in the United States of America alone (Guittinan, 2007). West and Central African countries account for about 70% of world cocoa production. The five top cocoa producers in the world are Côte d'Ivoire (29.3%), Indonesia (19.1%), Ghana (14.9%), Nigeria (10.1%) and Cameroun (6.2%). Among the various factors which militate against increase in cocoa production in West and Central Africa is the incidence of pests and diseases, especially the cocoa mirids (Anikwe *et al* 2009).

The brown cocoa mirid, *S. singularis* Haglund (Hemiptera: Miridae) is the most prevalent and harmful insect pest of the cocoa tree in Nigeria (Opeke, 1992) and yield losses of about 30-70% has been attributed to *S. singularis* infestation and damage (Idowu, 1989, Ojelade *et al* 2005). Yield loss by mirids could be as



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high as 75% in cocoa farms left unattended to for a period of three years and above (Padi, 1997). Nymphs and adults of this species feed on cocoa fruits and shoots. Short-term crop losses are mainly due to the destruction of the branch tips while long term losses emanate when feeding lesions become infected by parasitic fungi which usually develop into cankers, weakening and eventually killing cocoa trees (Babin, *et al* 2011).

The control of this obnoxious insect pest has been dominated by the use of synthetic insecticides. However, concerns over chemical residues in the cocoa beans, pest resurgence, secondary pest outbreak, toxic effect on non-target organisms, as well as development of resistance by mirids, amongst other deleterious factors, dictate that alternative control measures which are environmentally friendly, safe and effective are developed. To this end, three major ecological pest management tactics, viz; cultural, biological, and host plant resistance, were individually evaluated as alternative control strategy for the pest.

## Materials and Methods

### Study site

Laboratory bioassay of ant species on mirids was conducted at the Entomology Laboratory of the Cocoa Research Institute of Nigeria (CRIN) while anti-xenosis and cultural practice studies were carried out in the field at CRIN Headquarters in Ibadan, Nigeria. Ibadan has an annual rainfall average of 2,000 mm with a bimodal pattern. It is located in the tropical rain forest ecosystem with mean solar radiation of 18 mj/m2/day. It lies between the Latitude 7° 30′ N and Longitude 3° 54′ E at an altitude of 200 m above sea level.

### Cultural control practices as a tool for mirid control

Twenty cocoa trees were individually randomly tagged on treated and untreated plots measuring 0.5 ha each at Zone 1 CRIN, Ibadan. Cultural practices which included timely weeding, pruning of basal and lateral chupons, removal of mummified and diseased pods, were carried out on the treated plot whereas the untreated plot was left uncared for. Each tagged cocoa tree was observed from the base to 1.5 m Girth at Breast Height (GBH) on a fortnightly basis for the presence of mirids and damage symptoms for a period of one year (January-December, 2010).

### Screening of cocoa genotypes for resistance to mirid in the field

Screening of cocoa genotypes for mirid damage was conducted for three years between 2004 and 2006. The cocoa genotypes were established on three different trial plots in a randomized complete block design. A total of 44 genotypes were evaluated and these include 24 hybrids, 10 local genotypes and 10 international genotypes (Table 1). All selected cocoa genotypes were monitored at two weekly intervals for the following mirid damage parameters:

(i) Presence of canker on trunks and main branches.
(ii) Mirid lesions on pods.
(iii) Dieback of twigs.

Visual ratings of the trees were based on the methods used by Brun *et al* (1997) and N' Guessan, (1998) to assess damage due to canker on trunk and main branches, mirid damage (lesions) on pods and dieback of twigs (Table 2).

**Table 1:** List and key to cocoa genotypes (hybrids and clones) evaluated for resistance to *S. singularis.*

| S/N | Hybrids | S/N | International | S/N | Local geno-types |
|---|---|---|---|---|---|
| geno-types | | | | | |
| 1. | T65/7xT57/22 | 1. | EET 59 | 1. | T9/15 |
| 2. | T12/11xN38 | 2. | VEN-C4 | 2. | T65/7 |
| 3. | T65/7xT9/15 | 3. | Pa 150 | 3. | T12/11 |
| 4. | Pa150xT60/887 | 4. | UF 676 | 4. | T16/17 |
| 5. | P7xT60/887 | 5. | Amaz 15-15 | 5. | T12/5 |
| 6. | P7xPa150 | 6. | BE 10 | 6. | T30/13 |
| 7. | T65/7xT22/28 | 7. | SPEC 54 | 7. | C77 |
| 8. | T53/5xN38 | 8. | T85/799 | 8. | T53/8 |
| 9. | T65/7xN38 | 9. | Mocorongo | 9. | T53/5 |
| 10. | T53/5xT12/11 | 10. | Pa 107 | 10. | N38 |
| 11. | T65/35xT30/13 | | | | |
| 12. | T86/2xT9/15 | | | | |
| 13. | T9/15xT57/22 | | | | |
| 14. | F3 Amazon | | | | |
| 15. | T86/2xT22/28 | | | | |
| 16. | T82/27xT12/11 | | | | |
| 17. | T86/2xT16/17 | | | | |
| 18. | T65/7xT53/8 | | | | |
| 19. | T65/7xT101/15 | | | | |
| 20. | T86/2xT53/8 | | | | |
| 21. | T86/2xT65/35 | | | | |
| 22. | T101/15xN38 | | | | |
| 23. | T82/27xT16/17 | | | | |
| 24. | T86/2xT57/22 | | | | |

N38 was used as control.

**Table 2:** Key to visual rating scale for damage to cocoa caused by *Sahbergella singularis* in the field.

| Plant part damaged | Damage Index | Damage characteristics |
|---|---|---|
| Trunks and main branches | 0 | No canker found on trunks or main branches. |
| | 1 | 25% of the trunk and branch surface showing canker. |
| | 2 | 50% of the trunk and branch surface showin canker. |
| | 3 | 75% of the trunk and branch surface showing canker. |
| | 4 | Almost all the entire trunk and branches cankered. |
| Pods and Cherelles | 0 | No lesions found on pods. |
| | 1 | 25% of pods and cherelles with presence of lesions. |
| | 2 | 50% of pods and cherelles with presence of lesions. |
| | 3 | 75% of pods and cherelles with presence of lesions. |
| | 4 | Almost all the pods showing symptoms of lesions. |
| Dieback of twigs and leaves | 0 | No dieback. |
| | 1 | 25% of leaves and twigs showing dieback. |
| | 2 | 50% of leaves and twigs showing dieback. |
| | 3 | 75% of leaves and twigs showing dieback . |
| | 4 | Almost all the leaves and twigs showing dieback. |

Adapted from Brun *et al* 1997 and N' Guessan, 1998.

Evaluation of ant species for predatory efficiency against *S. singularis* in the laboratory

Seven different field-collected ant species viz; (*Oecophylla longinoda, Crematogaster brevispinosa, Camponotus acvapimensis, Camponotus zoc*, *Acantholepis capensis, Camponotus flavomarginatus and Palothyreus tarsatus)* were separately evaluated for their predatory efficiencies. Five ants, each of the same species, were introduced into transparent plastic cylindrical containers with dimensions of 15 cm by 18 cm (height x diameter). These containers were lined at the base with tissue paper to avoid condensation and a pod containing one-day-old adult mirid was placed inside each container. This set-up was replicated five times for each ant species evaluated. The containers were covered with plastic lids that have a portion of 14 cm by 12 cm (length x breadth) made of muslin to allow for aeration and placed on a platform inside the Entomology Laboratory for observation. A control experiment was also set-up but without any ant species. The temperature and relative humidity were maintained at ambient levels of 26±2°C and 70-80%, respectively. The set-up was monitored and observed at two hourly intervals for a period of 5 days. Accumulated mortality was recorded each day for the period of observation and expressed in percentage mortality.

## Results

The mean monthly population of mirids on treated and untreated plots is presented in Figure 1. The number of *S. singularis* found on cocoa that received adequate crop husbandry via pruning, regular weeding and routine removal of diseased and mummified pods was significantly lower than those found on the plot on which these cultural practices were not implemented. The peak mean population on untreated plot occurred in November with a mean value of 56.5 whereas the peak on treated plot occurred in October with a mean value of 12.5. Mirids were not found on the treated plot from March to July, 2010, but this was not the case with the untreated plot during the same period (Figure 1). The incidence of mirid on the untreated plot was 6.2 times more than that of the treated plot during the survey period (Figure 1).

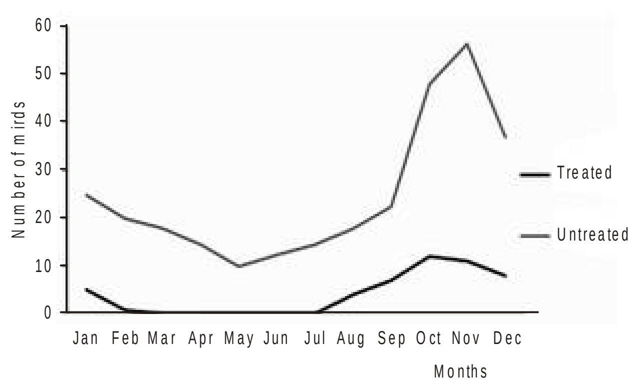


**Figure 1:** Mean monthly population of mirids on treated and untreated cocaa plantations.

The results of field anti-xenosis on cocoa hybrid, international and local genotypes for lesions, dieback of twigs, and canker on trunks are presented in Figures 2, 3 and 4, respectively. Ten out of the 24 hybrids showed low mirid damage symptoms in the field while seven out of the international genotypes (EET 59, VEN-C4, UF 676, Amaz 15-15, BE 10, Mocorongo, and Pa 107) had very low mirid damage scores (<25%) for lesions, twig dieback and canker (Figures 2, 3 and 4).

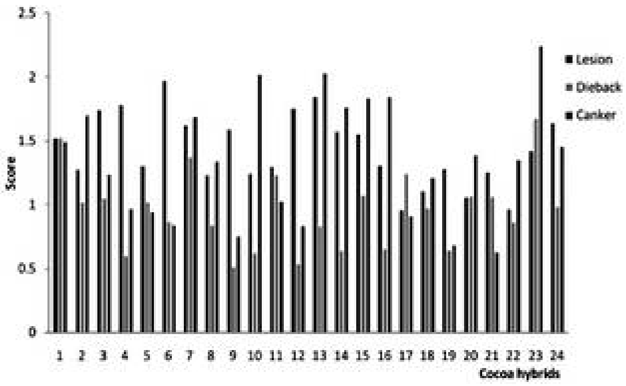


**Figure 2:** Mirid damage scores on cocoa hybrids in Ibadan, Nigeria.

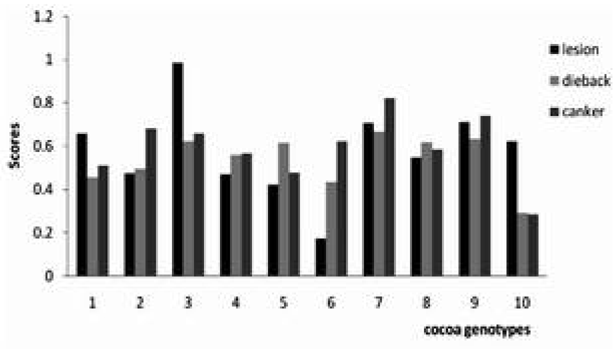


**Figure 3:** Mirid damage scores on international cocoa genotypes in Ibadan, Nigeria.

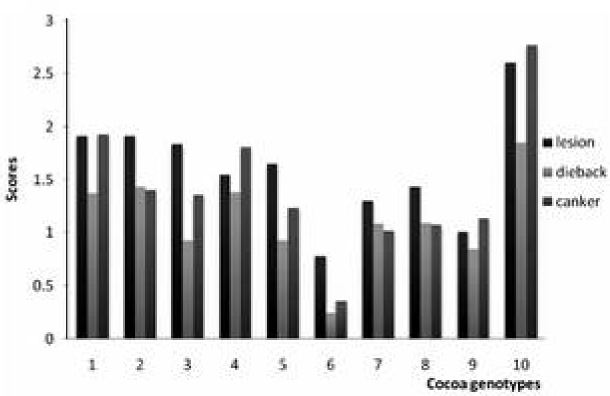


**Figure 4:** Mirid damage scores on local cocoa genotypes in Ibadan, Nigeria.

The local genotypes had generally high mirid damage scores for lesions, twig dieback and cankers, thereby suggesting susceptibility of the genotypes to mirid infestation except for genotype 6 (T30/13) which had less than 25% for all damage parameters assessed. Cocoa genotype N38 was highly susceptible to mirid damage with relatively higher mean scores of 2.61, 1.85 and 2.77 for lesions, dieback, and canker, respectively.

The seven different ant species exhibited varying degrees of predation on mirids in the laboratory. The tailor ant, *O. longinoda* caused 80-100% mortality of *S. singularis* in the laboratory within three days (Table 3). The tailor ants consumed all the mirids without any leftover. *A. capensis* killed 50% of the mirids at the end of 5 days while *C. acvapimensis* recorded 35% predation within the same period. Mirids in the control set-up without ants were all intact at the end of the 5th day. Field observations when collecting the ants showed that the tailor ant was most pugnacious.

**Table 3:** Mortality of the cocoa mirid, *S. singularis* kept with various ant species in laboratory cages.

| Ant species | Mortality of mirid (%) | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 (days) | 4 | 5 |
| *Oecophylla longinoda* | 75..5 | 80 | 100 | 100 | 100 |
| *Crematogaster brevispinosa* | 0 | 0 | 10.5 | 10.5 | 10.5 |
| *Camponotus acvapimensis* | 0 | 15 | 30 | 35 | 35 |
| *Camponotus zoc* | 0 | 10 | 10 | 15.5 | 15.5 |
| *Camponotus flavomarginatus* | 15 | 15 | 20.3 | 20.3 | 20.3 |
| *Acantholepis capensis* | 30.8 | 45 | 45 | 50 | 50 |
| *Palothyreus tarsatus* | 0 | 20 | 30.8 | 30.8 | 30.8 |
| Control | 0 | 0 | 0 | 0 | 0 |

## Discussion

The study on the use of various cultural control practices indicated that Good Agricultural Practices (GAP), if well implemented, will amongst other benefits reduce the population of *S. singularis* to levels below economic threshold in cocoa plantations. The decline in mirid population of 6.2 times on treated plots as against untreated is in consonance with the work of Owusu-Manu (2002) who reported a 42 percent yield increase after 18 months of good farm management without the use of insecticides. Idowu (2001) established guidelines for rational insecticidal application against mirids in line with IPM principles which stipulates that there should be no spraying if less than 5% field infestation of mirids is observed; there should be spot spraying between 20 to 25% infestation levels, and blanket spraying if over 25% mirid infestation is observed. However, if harvesting is not due in two weeks, there should be no spray application. Therefore, the findings in this study show that when GAP is fully and well implemented through cultural practices, mirids infestations would be drastically reduced to population densities that may not warrant the use of synthetic insecticides. This will ultimately boost the production of good quality cocoa beans with tolerable pesticide residues as well as help poor resource farmers conserve meagre resources used in procuring inputs such as insecticides.

The international cocoa genotypes screened in this study were outstanding in terms of resistance to mirids in the field. The following international genotypes: EET 59, VEN-C4, UF 676, Amaz 15-15, BE 10, Mocorongo, and Pa 107 showed resistance to mirids in the field in Nigeria. This result is in agreement with that of N'Guessan *et al* (2004) in Cote d'Ivoire which shows that out of 500 cocoa clones screened for antixenosis, Ven-C4, BE 10 and Amaz 15-15 were identified as resistant to mirid. The need for continuous evaluation of cocoa genotypes becomes imperative as this will help strengthen cocoa breeding programmes. The benefits of using resistant varieties as an option in pest control cannot be over-emphasized because it is an ecologically sound method of pest control and no external input is required, making it acceptable and affordable to local farmers. Resistant cocoa varieties can be easily incorporated into Integrated Pest Management (IPM) strategy for mirid control in Nigeria.

The study on predatory efficiency showed that the tailor ant, *O. longinoda* was most efficacious on mirid predation as the ant did not only give 100% mortality but also consumed mirid left-over in the experimental containers. Padi (1997) identified the indigenous natural enemies of cocoa capsids in West Africa but quickly stated that there have been attempts at the biological control of capsids. Recorded predators of the capsids include the ant *Oecophylla longinoda*, salticid spiders, reduviids, mantids, Grillidae and Pentatomidae. This study has further identified six other natural enemies of the Order: Hymenoptera to include *C. brevispinosa, C. acvapimensis, C. zoc, A. capensis, C. flavomarginatus and P. tarsatus.*

This study also observed that *O. longinoda* was pugnaciously active and has a characteristic nesting habit of joining living leaves of inhabited trees. This is in consonance with the findings of Entwistle (1972). The weaver ants, *O. longinoda, A. capensis* and *C. acvapimensis* gave good predation of mirid in this study. Letourneau (1998) discovered a similar phenomenon in *Piper* ant-plant, in which ants increased plant fitness by reducing the loss of photosynthetic area or plant injury due to herbivore exploitation. Khoo and Ho (1992) reported that cocoa farmers in Indonesia observed that the presence of a species of ant, *Dolichoderus thoracicus*, was associated with greatly reduced damage caused by mirids. Our findings therefore suggest that *O. longinoda* could be exploited as a biological control agent for the control of mirids in the field. Although, the ranging mode of life and especially their primary course of tending to coccoids for honeydew which is the main stay of the ants' economy/livelihood could be a major limitation in the field.

The control of the brown cocoa mirid in Nigeria has been dominated by the sole use of synthetic insecticides, most of which have been banned for use on cocoa due to taint/residue issues (Anikwe *et al* 2009). This paper has therefore presented three ecological pest management tactics that could be combined in a compatible manner with the aim of developing an effective IPM strategy for the brown cocoa mirid in Nigeria.

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