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THE POPULATION DYNAMICS OF THE BROWN COCOA MIRID, *SAHLBERGELLA SINGULARIS* HAGLUND IN IBADAN, NIGERIA

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ABSTRACT

The brown cocoa mirid, *Sahlbergella singularis* Haglund has been adjudged the most economically important insect pest of cocoa across West African the sub-region. The pest is capable of causing yield loss of about 30% in the first cocoa growing season and up to 70% yield loss in not less than two cocoa seasons if not controlled. This paper presents the population dynamics of *S. singularis* in Ibadan, Nigeria and the interactions between field populations of mirids and density dependent (natural enemies) and density independent (weather parameters) factors. One hundred mature cocoa trees were randomly sampled from base to 1.5m Girth at Breast Height (GBH) fortnightly on a two hectare plantation for adult *S. singularis* and its natural enemies (*Camponotus species, Crematogaster brevispinosa, Oncophylla longinoda, Acantholepis capensis* and *Palothyreus tarsatus*) using standard procedures. Mirid population and natural enemy abundance were correlated to monthly weather parameters (Temperature, Relative humidity and Rainfall). The population dynamics followed a similar trend over a period of three years of study. The population of the pest rapidly built-up in August of each month and this coincided with the period of the main cropping season of cocoa, as cocoa trees were in massive pod production. Weather parameters such as temperature and relative humidity played a major role in the fluctuations of mirid population. Rainfall did not seem to have any impact on the pest dynamics. Peak relative humidity data of 88.2%, 84% and 83.5% were recorded in August 2004, 2005 and 2006, respectively and the temperature readings declined around this period, inadvertently favouring the multiplication of mirid numbers in the field. The roles of density-dependent factors, that is, natural enemies, were observed in the field and reported. Ants of various genera were observed to exert different degrees of predation in the field, however, there were no parasitoids encountered both in the field and laboratory throughout the period of this study. Knowledge of the seasonal abundance of the pest is important to generate enough background information needed for effective control of mirid in Nigeria.

Key words: Population, Dynamics, Mirid, Weather, Natural-enemies

INTRODUCTION

The cocoa plant, *Theobroma cacao* was first introduced into Nigeria in 1874 [1]. Today, the crop is grown in fourteen Nigerian States, namely, Ondo, Ogun, Osun, Oyo, Ekiti, Kwara, Kogi, Edo, Delta, Abia, Cross River, Adamawa, Taraba and Akwa-Ibom. Nigeria is in the 5th position in the world ranking of cocoa producing countries with an annual production of 281,000 metric tonnes of dry beans after Cote d'Ivoire, Ghana, Indonesia and Brazil [2]. Ondo State is the leading producer in Nigeria, closely followed by Cross River State with production levels of 21% and 19%, respectively [3].

Two varieties of cocoa are cultivated in Nigeria viz; Amelonado and Amazon. The Amelonado variety is fast being replaced with the Amazon hybrids because of the superior growth vigor, high bean yield, precocity and pests' resistance, of the later [1]. The decline of cocoa production in Nigeria over the years from her 2nd position in the late 60's to its present status is attributed to the abandonment of many farms due to the incidence of pests and diseases as well as a result of the oil boom [2].

Of the over 1,500 different insects known to feed on cocoa, only less than two percent are of genuine economic importance [4]. In Nigeria, the brown cocoa mirid, *Sahlbergella singularis* (Hemiptera: Miridae) has been variously reported as the major economic insect pest in cocoa, capable of reducing yield by up to 30% and if left unabated, yield loss may be as high as 70% in a period of three years [1, 5, 6, 7,]. Similarly in Ghana, Padi reported a yield loss of 75% in cocoa farms due to attack by mirid in a period of three years [8].

Damage by the brown cocoa mirid is caused by the feeding activities of the nymphs and adults. Feeding causes characteristic dark markings on pods and shoots known as 'lesions'. Lesions result from the collapse of plant tissues caused by the toxic saliva of mirid. Secondary damage symptomized by canker and dieback occurs when the feeding lesions are infected by a parasitic fungus, notably, *Calonectria rigidiuscula* [4].

Apart from the study carried out over 35 years ago on the population dynamics of mirid on Amelonado cocoa, the authors are not aware of any record of a recent study on the population dynamics of the brown cocoa mirid, *S. singularis* on the Amazon cocoo hybrid in Nigeria [9]. It is against this background that this study was carried out in order to provide the background information towards developing an appropriate plant protection strategy for the pest.

MATERIALS AND METHODS

Study Site

This study was carried out on a two hectare cocoa hybrid plantation planted in year 2000 at the Cocoa Research Institute of Nigeria (CRIN) headquarters in Idi-Ayunre, Ibadan, Nigeria. Ibadan has an annual rainfall average of 2000 mm with a bimodal pattern and Idi-Ayunre is located in the tropical humid rainforest ecosystem (7). It lies between the latitude 7° 30′ N and longitude 3° 54′ E at an altitude of 200m above sea level.

Seasonal fluctuation of mirid population in the field

The studies on the population dynamics of brown cocoa mirid, *S. singularis* were conducted on a hectare cocoa farm containing hybrid Amazonian cocoa established in year 2000 with a planting geometry of 3.1m x 3.1m. The experimental design was a Randomized Complete Block. The farm contains a total of 960 stands of cocoa in four blocks (240 stands/block). Twenty-five stands of cocoa, with obvious mirid damage, were selected and tagged per block in January 2004. Observations and mirid counts records were made up to a height of 1.5 meters from the base of each tagged tree. Tree trunks, flower buds, flower cushions, basal chupons, cherelles and pods, fan branches, abaxial and adaxial surfaces of leaves were closely observed for mirids on a fortnightly basis. Trees were observed very early in the morning between 6:30 and 8:30am. The average number of mirid found per 100 trees per month was computed to show the seasonal fluctuations of the pest population.

Field observation for the natural enemies of mirids and interactions between mirids and other insects in the cocoa plantation were investigated.

Density independent factors such as weather parameters like temperature, relative humidity and rainfall data were collected during the period of this study from CRIN metrological station, Idi-Ayunre, Ibadan.

Density Dependent Variable Studies

Ten adult mirids were collected from the field in five replicates into 2 lbs size kilner jars. These mirids were fed with fragmented chupons in the jars and were cultured in the Entomology laboratory of CRIN at ambient temperature and relative humidity of 26 ± 2^{o} C and 70-80%, respectively which were recorded by a thermometer and hygrometer inside the laboratory. The experimental set-up was observed on a daily basis with the aid of a magnifying glass for the presence of parasitoid on the mirid or emergence of pathogen. After 30 days, and long after the death of the mirids inside the kilner jars, the set-up was further observed for three months.

In the same vein, natural enemies such as predators of the pest were observed on all the 960 cocoa trees sampled fortnightly in the field. Insects of the order Hymenoptera and family *Formicidae* were closely observed around the trunks, branches, flower cushions, flowers, leaves, chupons, pods and cherelles, and soils around the bases of plants. Collection of ants was done with the aid of camel hairbrushes. Ants were brushed into 2 lb sized kilner jars containing cotton wool covered with filter paper and soaked in ethyl acetate. These were later identified at the Insect Museum of CRIN and those that could not be identified at CRIN were identified at the University of Ibadan Insect Museum in the Department of Crop Protection and Environmental Biology, Ibadan.

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RESULTS

Figure 1 shows the mean monthly population of *S. singularis* per 100 sampled trees in Ibadan over a period of three years. The fluctuations in the population of the mirid followed a similar trend with peak populations of 107 mirids in September 2005 while population peaked in October 2004 and 2006 at 42 and 59 mirids, respectively. There was a rapid build-up of the pest population in the last quarter of each year beginning from August. This increase in mirid population coincided with the major fruitbearing season of cocoa trees in the field. The result also showed the absence of *S. singularis* in the field in April and May, 2004, from March to July, 2005 and May to July, 2006. A generally very low pest population was recorded from February to July for the three years [Figure 1]. Massive cherelle production started in August.

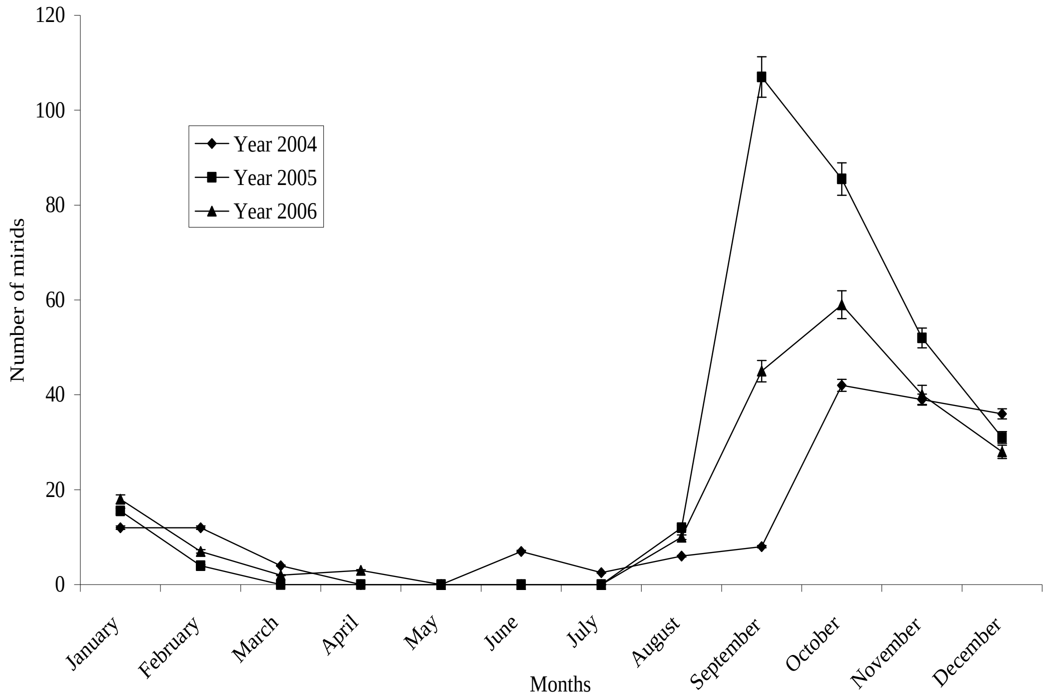

Figure 1: Fluctuation in the mean monthly population of S. *singularis* per 100 trees in Ibadan, Nigeria.

The influences of climatic factors on the population of *S. singularis* are summarized in figures 2, 3 and 4. The peak relative humidity occurred in August with values of 88.2%, 84% and 83.5% for 2004, 2005 and 2006, respectively [Figure 2]. Second instar nymphs of *S. singularis* have been reported to thrive better at very high humidity and tend to desiccate at very low humidity [10]. The gradual decline in the population of mirid in December was in consonance with the drop in the relative humidity of 65.3%, 60% and 66.7% in 2004, 2005 and 2006, respectively. The rainfall figure reflected a double peak within a season. Mirid numbers were very low in the

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field during the main stream of the rainy season. However, with the second rainfall peak in September, having mean monthly records of 254.1mm, 407mm, and 205.1mm in 2004, 2005 and 2006, respectively [Figure 3], the population of mirids shot-up in the field. Figure 4 shows the mean monthly temperature with the least of 24.8^{o}C in August 2006 while the highest temperature of 29.9^{o}C was recorded in March 2005. The low temperature range in the last quarter of each year considered also coincided with the peak period of the mirid population in the field.

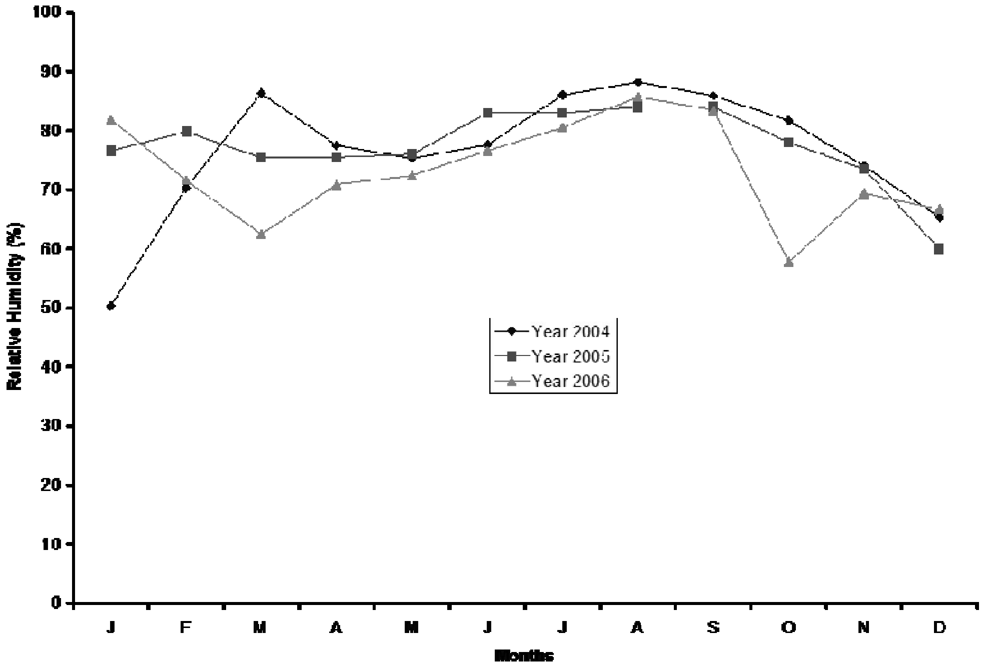

Figure 2: Mean monthly relative humidity record from 2004 to 2006 at CRIN Headquarters, Ibadan, Nigeria.

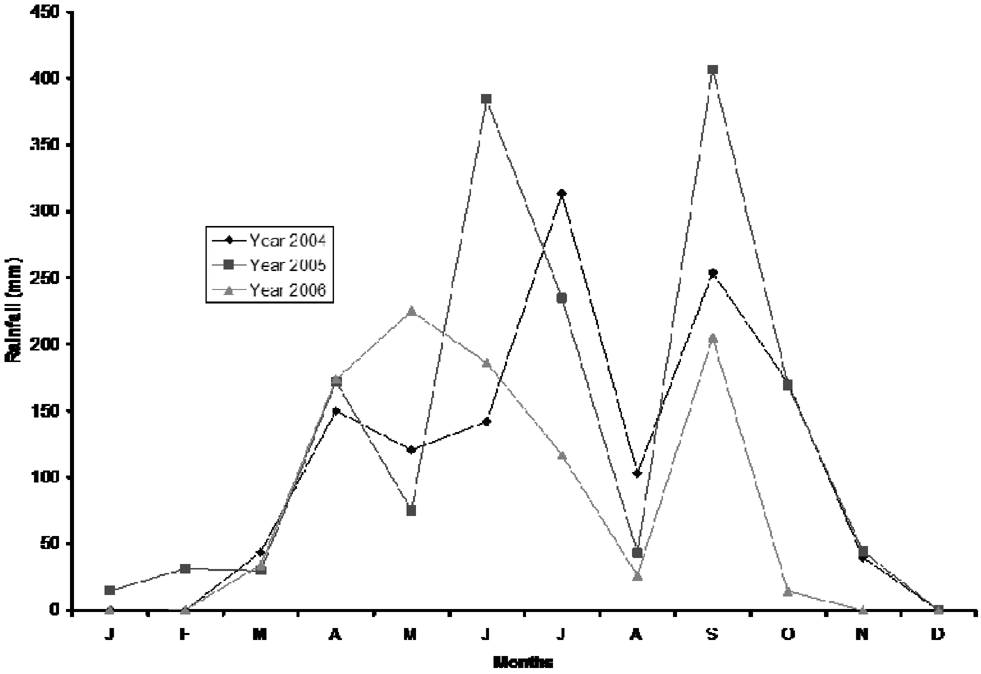

Figure 3: Total monthly rainfall record from 2004 to 2006 at CRIN Headquarters, Ibadan, Nigeria.

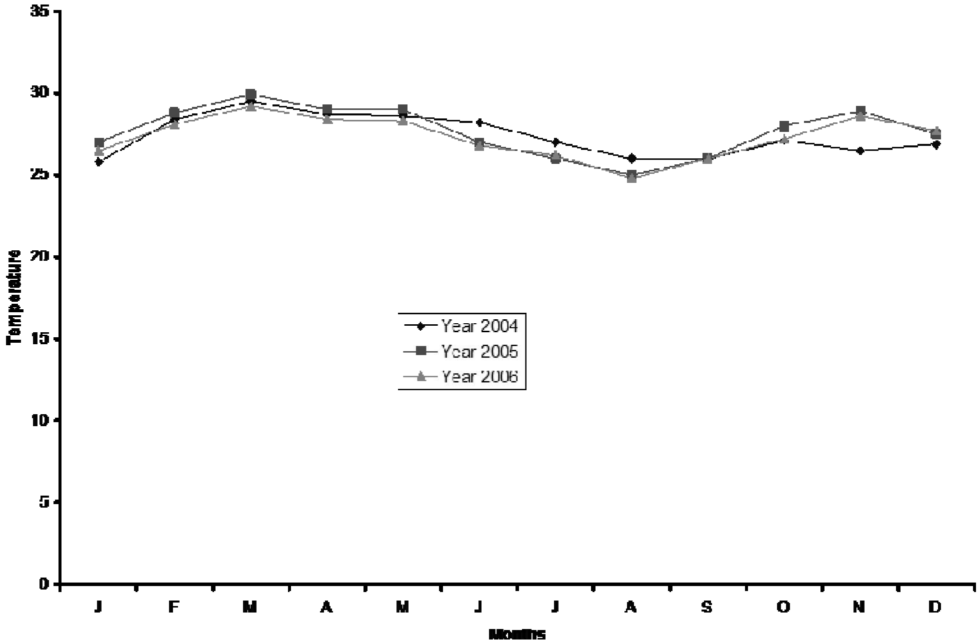

Figure 4: Mean monthly temperature record from 2004 to 2006 at CRIN Headquarters, Ibadan, Nigeria.

Natural Enemies population studies
No parasitism of the brown cocoa mirid, *S. singularis* was observed in the field and laboratory during the period under study. Table 1 presents the summary of ant species, their nesting behaviour and associated coccoids in cocoa plot in Nigeria. All seven species were attracted to secretions by coccoids (honey dew) on pods infested with mealybugs. Cocoa trees infested by ants have from very few to no other insects on such trees. Fewer mirid damage symptoms such as lesions on pods were found on trees with ant species whereas on trees inhabited by the tailor ants, *O. longinoda,* there were no symptoms of pod damage by mirids and none of the insect pests of cocoa was found on such trees.

O. longinoda built many small nests averaging 24 per tree by binding adjacent living leaves together with a silk-like material produced by the younger larvae. These larvae were held in place by the workers who weave them backwards and forwards against the edges of leaves to be joined [10]. It is believed that this habit earned the ant the name tailor or weaver ant. *O. longinoda* was more predominant than any of the other ant species surveyed. *O. longinoda* appeared to be very aggressive when disturbed and always showed a peculiar 'alarm dance' to alert other members of the colony of the presence of an intruder and during this period cocoa leaves vibrated for about 50 – 60 seconds. They were attracted to evergreen cocoa trees, so that nest materials could be available all the year round. Some 259 tailor ant collections were made out the whole lot during the sampling period. The ant was the most abundant.

C. brevispinosa had brown carton nests measuring 6.0 x 4.5 x 2.5 cm on the average. The nests were formed as carton structures attached to the outside of trunks, main stems and branch unions. A total of 128 ants were collected and 12 nests were found.

Three species of the *Camponotus* genus were identified which differ in their pattern of nesting. While *C. flavomarginnatus* nested in the soil around the base of cocoa trunks, *C. acvapimensis* and *C. zoc* has an arboreal nesting behaviour in which their nests were found on dead parts of branches in cocoa trees. They were exclusively tending the mealybug, *Planococcus citri* and the cocoa aphid, *Toxoptera aurantii.*

Only one nest of *A. capensis* was found and the activities of this species were rather sporadic and were actively involved in attending to coccoids on cocoa pods. Subterranean nests of soil nesting ants were usually difficult to locate.

P. tarsatus was the least abundant and members of this species were found individually on the cocoa trunks. The nest was found under a dry dead wood in the cocoa plot. *P. tarsatus* also tends coccoids.

DISCUSSION

The role of pods and their availability to the annual population pattern of *S. singularis* was critical as population build-up in August coincided with increase in the number of pods in the field. This correlation was corroborated with the report of Entwistle that mirids in Africa, especially the brown cocoa mirid, *S. singularis* showed preference to pods for feeding and oviposition sites, and when pod numbers decline with progressive harvesting, the proportion of mirids on vegetative tissues increases [10]. Prior to this time, there were difficulties in quantifying the direct effects of environmental factors on the activities and abundance of *S. singularis.* The difficulty arose out of a high interaction which often exists between environmental factors and host plant factors, such as production and availability of suitable pods for feeding and breeding as well as favourable temperature and relative humidity which are required for the survival of the pest [5]. The low number of mirid population during the main stream of the rainy season is in consonance with the assertion of Mariau that rainfall in general exerts no direct influence on the fluctuation of the pest population [11]. It was also stated that very high rainfall could cause a temporary fall in the nymphal populations. The relative humidity levels were highest in August of each year and this favoured the multiplication of mirid in the field [Figure 2]. This result agreed with earlier reports that mirid populations decline in periods of low humidity. The influence of the dry season was more pronounced when augmented by the effect of the harmattan wind coming from the North. When a water deficit appears in the tissues of the cocoa tree, the mortality of the young stages is greatly affected leading to the belief that water is probably an extremely critical factor during periods of low humidity [10]. Mariau also reported that gradation in population begins to increase rapidly after the temperature cools down in the month of August [11]. This agrees with the result of this work as generally low temperatures were recorded in the last quarter of the three years.

No parasitoid was found in the course of this work. However, Idowu reported the braconid parasite, *Euphorus sahlbergella* as a parasite of the nymphs of *S. singularis* under field conditions [5]. Some pathogenic diseases which attack mirid include *Bauveria, Aspergillus and Bacillus species* [12]. All the ants sampled were coccoidophillic and did not cause any damage on cocoa. In addition, cocoa trees with ant occupation had little or no presence of insect pests of cocoa and this is particularly true of the tailor ant, *O. longinoda.* The predatory activities of *O. longinoda* as observed from the field and laboratory experiments consequently present this species as the best natural enemy of mirid pest of cocoa and invariably protect the cocoa plant from insect pest herbivory. The brown cocoa mirid, *S. singularis* is the most economic insect pest of cocoa capable of reducing the yield of cocoa by up to 30% [5]. Entwistle observed that *O. longinoda* is pugnaciously active and has a characteristic nesting habit of joining living leaves on trees inhabited [10]. This result is in consonance with the report of Letourneau who 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 [13]. Khoo and Ho reported that early this century cocoa planters in Indonesia observed that the presence of a species of ant, *Dolichoderus thoracicus*, was associated with greatly reduced damage caused by mirids, an important group of pests attacking cocoa [12].

CONCLUSION

The result of this work, therefore, shows that a lot of factors which ranged from climatic factors to pod availability as well as the presence of natural enemies, especially ants, all come into play in determining the population dynamics of the brown cocoa mirid, *S. singularis* in Nigeria. This knowledge of this pest dynamics provides a good basis for the development of an ecologically-based method of pest management.

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Table 1: Occurrence of ant species, their nesting behaviour and associated coccoids in cocoa plot in Nigeria

Ant Species	Nesting behaviour	Number of collected Ants	Number of collected Nests	Nests per tree	Associated coccoids
Crematogaster brevispinosa	carton-structured nests attached to main stems and trunks	128	12	2	*Planococcus citri*
Camponotus flavomarginatus	soil-nesting at the base of trunks of mature tree	48	2	-	*Planococcus citri* *Toxoptera aurantii*
Camponotus zoc	arboreal nests on dead branches of tree	62	6	1	*Planococcus citri* *Toxoptera aurantii*
Camponotus acvapimensis	nests on dead tree branches	93	6	1.5	*Planococcus citri*
Acantholepis capensis	soil-nesting near the base of tree	56	1	-	*Planococcus citri*
Palothyreus tarsatus	Nested under felled dead wood in the plot	22	1	-	Planococcus citri
Oecophylla longinoda	arboreal nests formed by binding together adjacent living leaves of cocoa	256	78	24	*Planococcus citri* *Stictococcus sp.*

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