Jurnal Littri 14(4), Desember 2008. Hlm. 149 – 154
ISSN 0853 - 8212

DISPERSION PATTERN OF *Helopeltis antonii* Signoret (HEMIPTERA:MIRIDAE) ON CASHEW PLANTATION

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ABSTRACT

Helopeltis antonii is one of the major pests in most cashew growing areas in Indonesia. The pest attacks cashew plants in the nursery and also in the fields which caused significant damage. Apart of cashew the insects have a lot of alternate host plants such as tea, cocoa, neem, pepper, mangoes, jamboes, etc. This research was aimed at investigating the dispersion pattern of *H. antonii* in cashew plantation. The research was conducted in smallholder cashew plantation in Ngadirejo, Wonogiri, Indonesia from March 2004 to May 2006. The observation of *H. antonii* population was carried out on 60 sample plants which selected systematically in about 2 ha cashew plantation area every two weeks. Distribution analysis using various indices of dispersion and regression models was applied to evaluate the dispersion of *H. antonii* in cashew plantation. The result shows that variance to mean ratio ($s^2/\bar{X}$), $\chi 2$, Lloyd mean crowding, Green's coefficient of dispersion and Taylor's power law indicate aggregated distribution when the population is high during flushing-flowering seasons of cashew plants, and it indicates regular or random distribution when the population is low during post-flowering seasons. The aggregated distribution on cashew plants indicated that there is a preferency to food sources of the plants and an individual behaviour to aggregate. Therefore, sampling and monitoring *H. antonii* in cashew plantation should be carried out systematically during flushing-flowering seasons

Key words: Cashew, *Anacardium occidentale*, pest management, *Helopeltis antonii*, dispersion, Central Java

ABSTRAK

Pola sebaran* Helopeltis antonii *Signoret (Hemiptera: Miridae) pada pertanaman jambu mete

Helopeltis antonii merupakan salah satu hama utama tanaman jambu mete yang ditemukan hampir di setiap area pengembangan mete di Indonesia. Hama ini menyerang tanaman jambu mete sejak pembibitan hingga di lapangan dengan kerusakan yang cukup signifikan. Selain jambu mete, serangga ini juga mempunyai banyak inang alternatif antara lain teh, kakao, mimba, lada,mangga, jambu air dll. Penelitian ini bertujuan untuk menentukan sebaran serangga tersebut, khususnya sebaran horizontal pada pertanaman jambu mete. Penelitian dilakukan di pertanaman jambu mete milik petani di daerah Ngadirejo, Wonogiri, Indonesia dari Maret 2004 sampai Mei 2006. Pengamatan populasi *H. antonii* dilakukan pada 60 tanaman sampel yang dipilih secara sistematik pada area pertanaman jambu mete seluas kurang lebih 2 ha setiap 2 minggu sekali. Hasil analisis menggunakan beberapa indek pengelompokan dan model regresi yaitu rasio keragaman terhadap rata-rata ($s^2/\bar{X}$), $\chi 2$,rata-rata pengelompokan dari Lloyd, koefisien sebaran dari Green dan hukum kekuatan Taylor menunjukkan penyebaran yang mengelompok jika populasi tinggi selama musim pembentukan tunas dan pembungaan jambu mete, dan merata atau acak jika populasi rendah sesudah musim pembungaan. Pengelompokan *H. antonii* pada tanaman jambu mete menunjukkan adanya ketertarikan pada ketersediaan makanan pada tanaman jambu mete dan perilaku individu serangga tersebut. Oleh karena itu untuk pengambilan sampel dan pengamatan serangga tersebut sebaiknya dilakukan secara sistematis pada saat musim pembentukan tunas dan pembungaan.

Kata kunci: Jambu mete, *Anacardium occidentale*, pengendalian hama, *Helopeltis antonii,* sebaran, Jawa Tengah

INTRODUCTION

Helopeltis antonii is known as a sap sucker since the nymphs and adults suck the liquid of the young plants and succulent parts (KARMAWATI, 2007). It was also known as tea mosquito, as the pest resembles the mosquito and was formerly found attacked tea plant. DEVASAHAYAM and NAIR (1986) recorded *H. antonii* has a wide host range connected of 17 plant species representing 13 families. Among the major economic crops attacked by *H. antonii* are cocoa (*Theobroma cacao*), tea (*Camellia sinensis*), cashew (*Anacardium occidentale*) (STONEDAHL, 1991), and neem (*Azadirachta indica*) (ONKARAPPA and KUMAR, 1997). Other reported feeding hosts are allspice, annatto, apples, black peppers, camphire (*Lawsonia alba*), cinchona, grapevine, guavas, *Moringa oleifera*, jambos or rose-apples (*Eugenia jambos*), mangoes, *Eucalyptus* sp. cotton, mahogany, redgram and drum stick (DEVASAHAYAM and NAIR, 1986).

The general symptoms observed on cashews due to *H. antonii* infestation are the discolourations and presence of necrotic areas or lesions around the entry point of labial stylet of the insect into plant tissue. These lesions darken with age as the tissue around the puncture dies. Nymphs and adults of *H. antonii* mostly attack younger and softer parts of the plant, such as leaves, petioles, shoots, buds, inflorescences, apples and young nuts. They feed by sucking those plant parts and while they are sucking the plant fluid, they pump a secretion which contain a highly toxic substance called poly-phenoloxydase from their salivary glands. This secretion is always accompanied by the free amino acids which include a substrate for the polyphenoloxidase from the accessory glands. The effect of feeding are mostly due to the amino acids secreted into the plant tissues during piercing and sucking. The amino acids in the salive reduce the overall growth of the plant tissues in which they feed. The lesions will turn pinky-brown in 24 hours, scabby black and black within 2 – 3 days (MANDAL, 2000). Feeding on tender leaves by young nymphs causes necrotic lesions. Meanwhile, feeding on inflorescences caused drying of the flowers and feeding on a growing tip or bud (primordial) could kill the bud. When the growing tip one killed, extensive secondary branching forming a rosette growth appearance occur which usually un-productive. Lesions on fruit appear as brownish or black circular spots. As a result of injury, immature nuts shrivel and die on the tree and may drop off. Older nuts are not killed but reduced in their size and circular lesion spots result in the reduction of quality. Seedlings can also become severely stunted and sometimes die from *Helopeltis* attack (OHLER, 1979; SWAINE, 1959). WIRATNO and WIKARDI (1994) observed that one feeding lesion on the primordial can cause death of the shoots, while feeding on other parts of the shoots could be tolerated by the plant. In severe cases, the death of the primordials would affect plant production as they cannot form flowers.

Dispersion is spatial pattern of distribution of members of a population (SCHOWALTER, 2006). The dispersion of members of population affect the sampling program, measuring population size and description of the condition of the population (SOUTHWOOD, 1978). Spatial pattern of distribution is one of the most characteristic ecological properties of species, it yields characteristic parameters that segregate species through their individual behaviour (TAYLOR, 1984). The dispersion of individual can be regular (homogen), random and aggregated (clumped, contagious). Indices of dispersion are commonly used to evaluate dispersion of population in an environment (MYERS, 1978).

Helopeltis antonii is a major pest on cashew. It is always found in most cashew growing areas in Indonesia and some other countries, such as India (STONEDAHL, 1991), Srilanka (RANAWEERA, 2000) and Vietnam (CHAU,1998). To date however a limited report on the quantification of between-plant distribution of *H. antonii* in cashew plant except of KARMAWATI *et al.* (1999) which found that the insect was randomly distributed. They also found that *H. antonii* population is not influenced by wind direction. COLLINGWOOD (1971) mentioned the distribution pattern of other mirids, *S. singularis* and *Distantiella theobromae* on cocoa are aggregated. This study was aimed at investigating dispersion of *H. antonii* in cashew plantation.

MATERIAL AND METHODS

The study was carried out from March 2004 to May 2006 in pesticide free smallholder cashew plantation at Wonorejo, Ngadirejo District, Wonogiri, Central Java, Indonesia. The cashew plants were about 12 – 15 year old, with plant spacing 10 x 8 m. The observation plot was in the centre of cashew plantation area. The observation area was about 2 ha which were homogenous in size and age. A total of 60 sample plants were selected from the area. Observation was done at 2 weeks interval for two consecutive production cycles of the plant (two years). The numbers of *H. antonii* including the eggs, nymphs and adults on each plant were counted at the lower canopy of the plant up to about 2.5 m height.

To evaluate the dispersion of *H. antonii* among cashew plants within observation area, several different techniques were used (MYERS, 1978). The simplest method is the variance to mean ratio, $s^2/\bar{x}$ (SOUTHWOOD, 1978) were initially calculated. The value of $s^2/\bar{x} < 1$ indicated a uniform dispersion, equal to 1 indicated a random dispersion, and > 1 indicated an aggregated dispersion. Lloyd's patchiness index was calculated from $x^*=[\bar{x}+(s^2/\bar{x}) - 1]$, where x^* is the mean crowding index. The mean crowding index was then divided by the mean number of the insects per sample occasion providing $x^*/\bar{x}$ patchiness for each sampling occasion (LLOYD'S. 1967). Patchiness value of <1 indicated a regular dispersion, value equal to 1 indicated random dispersion, and >1 indicated an aggregated dispersion. Green's index, was calculated using the formula $C_x= ((s^2/\bar{x})-1)/\sum x-1)$ (GREEN, 1966). $C_x < 0$ denoted a regular dispersion, $C_x \approx 0$ denoted a random dispersion, and $C_x > 0$ denoted an aggregated dispersion. A chi-square, $\chi 2$, was performed with formula $\chi 2 = (s^2/\bar{x})(N-1)$ (SOUTHWOOD, 1978). $\chi 2$ calculation was compared to $\chi 2$ table on $\alpha = 0.05$ and 0.95 with df= N -1. When $\chi 2$ table(0.95, df=N -1) < $\chi 2$ calc. < $\chi 2$ table(0.05, df=N-1) indicated a random dispersion, $\chi 2$ calc< $\chi 2$ table (0.95, df = N-1) indicated regular dispersion, and $\chi 2$ calc > $\chi 2$(0.05, df=N-1) indicated an aggregated dispersion.

Distribution of *H. antonii* among cashew plants based on phenological plants were carried out using Taylor's power law (TAYLOR, 1961) and Iwao's patchiness regressions (IWAO, 1968). Taylor's power law was estimated from the regression model, $\log s^2 = \log a + b \log \bar{x}$, where parameter b, the gradient/slope of the regression was the index of aggregation. The population being aggregated when b>1, random when b=1 and regular when b<1. Iwao's patchiness regression related mean crowding, $x^*=[\bar{x}+(s^2/\bar{x})-1]$ to $\bar{x}$ by $x^*=a+b\bar{x}$. Intercept [a] was an index of basic contagion and the slope [b] had the same interpretation as b from Taylor's power law.

RESULTS

Table 1 shows the values of various distribution indices for *H. antonii* on cashew plants. The values of

Table 1. Distribution statistics and dispersion indices of *H. antonii* on cashew plantation from March 2004-May 2006

Tabel 1. Statistik penyebaran dan indeks pengelompokan H. antonii *pada pertanaman jambu mete dari bulan Maret 2006 – Mei 2006*

Dates	$\bar{x}$	S^2	$S^2/\bar{x}$	$\chi2$	X*	X*/$\bar{x}$	Cx
03/03/'04	0.0167	0.0167	1	59	0.0167	1	0
17/03/'04	0	0	0	0	-1	0	1
31/03/'04	0	0	0	0	-1	0	1
14/04/'04	0.0333	0.0328	0.985	58.115	0.0183	0.5491	-0.015
28/04/'04	0.2045	0.4921	2.4064	141.9776	1.6109	7.8771	0.1758
12/05/'04	0.1167	0.3082	2.641	155.819	1.7577	15.0614	0.2735
26/05/'04	0.3833	6.6811	17.4305	1028.4	16.8138	43.8658	0.7468
09/06/'04	0.5	8.3898	16.7796	989.9964	16.2796	32.5592	0.5441
23/06/'04	0.3182	2.9197	9.1757	541.3663	8.4939	26.6935	0.6289
07/07/'04	0.7045	6.7711	9.6112	567.0608	9.3157	13.2232	0.287
20/07/'04	0.3	1.739	5.7967	342.0053	5.0967	16.9889	0.2822
03/08/'04	0.1	0.3288	3.288	193.992	2.388	23.88	0.4576
17/08/'04	0.2	2.4	2.4	141.6	1.6	8	0.1273
01/09/'04	0.0455	0.0909	1.9978	117.8702	1.0433	22.9297	0.9978
15/09/'04	0.0667	0.2667	3.9985	235.9115	3.0652	45.955	0.9995
28/09/'04	0	0	0	0	-1	0	1
12/10/'04	0	0	0	0	-1	0	1
27/10/'04	0	0	0	0	-1	0	1
11/11/'04	0	0	0	0	-1	0	1
24/11/'04	0	0	0	0	-1	0	1
07/12/'04	0.0167	0.0167	1	59	0.0167	1	0
22/12/'04	0	0	0	0	-1	0	1
05/01/'05	0	0	0	0	-1	0	1
19/01/'05	0.1	0.4305	4.305	253.995	3.405	34.05	0.661
02/02/'05	0	0	0	0	-1	0	1
15/02/'05	0	0	0	0	-1	0	1
02/03/'05	0	0	0	0	-1	0	1
16/03/'05	0	0	0	0	-1	0	
30/03/'05	0.0833	0.1116	1.3397	79.0423	0.423	5.0785	0.0849
13/04/'05	0.1667	0.4124	2.4739	145.9601	1.6406	9.8417	0.1638
27/04/'05	0.2	2.4	12	708	11.2	56	1
10/05/'05	0.0833	0.1794	2.1537	127.0683	1.237	14.8595	0.2884
24/05/'05	0.4091	3.7822	9.2452	545.4668	8.6543	21.1544	0.485
07/06/'05	0.4318	0.8557	1.9817	116.9203	1.4135	3.2735	0.0545
22/06/'05	0.2727	0.9937	3.6439	214.9901	2.9166	10.6954	0.2404
05/07/'05	0.3833	0.9862	2.5729	151.8011	1.9562	5.1036	0.0715
19/07/'05	1.25	15.6822	12.5458	740.2022	12.7958	10.2366	0.156
03/08/'05	0.1667	0.3785	2.2705	133.9595	1.4372	8.6218	0.1412
18/08/'05	0.0833	0.2811	3.3746	199.1014	2.4579	29.506	0.5936
31/08/'05	0.2	0.4339	2.1695	128.0005	1.3695	6.8475	0.1063
14/09/'05	0.1333	0.1853	1.3901	82.0159	0.5234	3.9265	0.0557
30/09/'05	0.0167	0.0167	1	59	0.0167	1	0
12/10/'05	0	0	0	0	-1	0	1
27/10/'05	0	0	0	0	-1	0	1
09/11/'05	0	0	0	0	-1	0	1
23/11/'05	0	0	0	0	-1	0	

Continued Table 1
Lanjutan Tabel 1

Dates	$\bar{x}$	S^2	$S^2/\bar{x}$	$\chi 2$	X^*	$X^*/\bar{x}$	Cx
08/12/'05	0.0167	0.0167	1	59	0.0167	1	0
21/12/'05	0	0	0	0	-1	0	1
03/01/'06	0	0	0	0	-1	0	1
20/01/'06	0	0	0	0	-1	0	1
01/02/'06	0	0	0	0	-1	0	1
14/02/'06	0	0	0	0	-1	0	1
28/02/'06	0	0	0	0	-1	0	1
14/03/'06	0.0167	0.0167	1	59	0.0167	1	0
28/03/'06	0.3333	1.819	5.4576	321.9984	4.7908	14.374	0.2346
12/04/'06	0.1667	0.8531	5.1176	301.9384	4.2843	25.7005	0.4575
25/04/'06	0.2667	1.0124	3.796	223.964	3.0627	11.4838	0.1864
09/05/'06	0.6833	5.9828	8.7557	516.5863	8.439	12.3504	0.1939
23/05/'06	0.5333	1.7107	3.2078	189.2602	2.741[illegible]	5.1398	0.0712

Note : $\bar{x}$ = mean; s^2 = variance; $\chi 2$ = calculate chi-suare.
Keterangan: x^* = Lloyd's mean crowding *Rata-rata pengelompokan dari Lyod*
$x^*/\bar{x}$ = Lloyd's patchiness mean crowding *Rata-rata pengolompokan dari Lloyd's*
C_x = Green's index *Koefisien sebaran dari Green*

variance to mean ratio in most of observations shows higher than 1 ($s^2/\bar{x} > 1$) indicating aggregated distribution of the insect among cashew plants. Six observations have variance values about similar to mean values, hence, resulting variance to mean ratio value around 1 indicating random distribution. In the rest of observations no *H. antonii* population were found, hence the values of variance to mean ratio were null. The Lloyd's patchiness index also shows aggregated distribution ($x^*/\bar{x} > 1$) in most of the observations. Five observations indicated random distribution since the number of *H. antonii* population found was only 1. The values of mean and variance was similar, hence $x^*/\bar{x} = 1$. The other observations resulting $x^*/\bar{x} < 1$, since no *H. antonii* population was found. Green's coefficient (C_x) values also shows that most of observations indicated aggregated distribution among the plants ($C_x > 0$). Only 1 observation indicated regular distribution ($C_x < 0$), and five observations indicated random distribution ($C_x = 0$). The distribution pattern of the insect also can be seen from the values of calculate $\chi 2$, which shows that most of observations (30 observations) indicated aggregated distribution as the values > $\chi 2$ table (0.95,58)= 76.8. Six observations with $\chi 2$ values between $\chi 2$ table (0.975, 58) = 76.8 and $\chi 2$ table (0.025, 58) = 41.5, indicated random distribution.

Taylor's power law analysis based on cashew plant phenology showed highly significant relationships between variance (s^2) and mean ($\bar{x}$) of the *H. antonii* population (Table 2). During flushing-flowering seasons, the slope values significantly was greater than 1 (b = 1.78, 1.50 and 1.48 with R^2 = 0.90, 0.86 and 0.96 for flushing-flowering seasons 2004, 2005 and 2006 respectively), indicating an aggregated distribution of *H. antonii* in cashew plantation. Meanwhile during post flowering seasons, *H. antonii* population very low, the gradient values showed below 1 (b=0.86 and 0.94 for post flowering seasons September 2004 – March 2005 and November 2005 – April 2006 respectively), indicating regular distribution. Iwao's patchiness regression based on similar cashew plant phenology eventhough shows highly significant relationship between mean crowding and mean density of *H. antonii*, however, it produced gradient values below 1 (b = 0.03, 0.05 and 0.07 with R^2 = 0.71, 0.49 and 0. 58 for flushing-flowering seasons 2004, 2005 and 2006 respectively, and b = 0.02 and 0.05 with R^2 = 0.99 and 0.89 for post flowering seasons September 2004 – March 2005 and November 2005 – April 2006 respectively), indicating regular distribution.

DISCUSSION

Distribution analysis of *H. antonii* population on cashew plantation showed that most of the observations indicate aggregated distribution particularly during flushing-flowering seasons of cashew plant. Meanwhile during post-flowering seasons the distribution was regular or random. The aggregated distribution was examined through various indices of dispersion and regression models such as the variance to mean ratio ($s^2/\bar{x}$), Lloyd mean crowding, $\chi 2$, Green's coefficient of dispersion and Taylor's power law but not with Iwao's pachiness regression. The Iwao's patchiness regression showed low

Table 2. Linear regression for Taylor's Power Law and Iwao's patchiness regression for seasonal dispersion of *H.antonii* according to plant phenology of cashew plants from April 2004 to May 2006

Tabel 2. Regresi linier sebaran H. antonii *menurut musim menggunakan analisis hukum kekuatan Taylor Power Law dan model regresi dari Iwao berdasarkan fenologi tanaman jambu mete dari bulan April 2004 sampai dengan bulan Mei 2006*

Plant phenology *Fenologi tanaman*	Period *Periode*	Taylor's Power Law [a] *Hukum kekuatan Taylor Power Law*				Iwao's Patchines Regression [b] *Model regresi dari Iwao*			
		Intercept (log a)	Slope (b)	r^2	P	intercept (a)	Slope (b)	r^2	p
Flushing-flowering *Pembentukan tunas dan pembungaan*	April-Sept 2004	1.281	1.78	0.90	<0.0001	0.081	0.03	0.71	<0.0001
Post flowering *Sesudah musim pembungaan*	Sept.-March 2004-2005	0.019	0.86	0.90	<0.0001	0.022	0.02	0.99	<0.0001
Flushing-flowering *Pembentukan tunas dan pembungaan*	March-Sept 2005	0.861	1.50	0.86	<0.0001	0.072	0.05	0.49	0.0052
Post flowering *Sesudah musim pembungaan*	Nov.-April 2005-2006	0.096	0.94	0.84	<0.0001	0.040	0.05	0.89	<0.0001
Flushing-flowering *Pembentukan tunas dan pembungaan*	March-May 2006	0.902	1.48	0.96	0.0004	0.074	0.07	0.58	0.0773
Pooled *Keseluruhan fenologi tanaman*	March-May 2004-2006	0.264	0.95	0.68	<0.0001	0.062	0.038	0.55	<0.0001

Significant level at $P \leq 0.05$

a - $y = \log(s^2)$, intercept = $\log(a)$, gradient = b and $x = \log(\bar{x})$ of $\log(s^2) = \log(a) + b \log(\bar{x})$

b - $y = x^* = [\bar{x} + (s^2/\bar{x}) - 1]$, intercept = a, and gradient = b of $x^* = a + b\bar{x}$

values of index of aggregation. It was also showed low relationship between mean crowding and mean density with gradients of regression, R^2 were 0.71, 0.49 and 0.58 on flushing-flowering seasons in 2004, 2005 and 2006 respectively. The aggregation index of Taylor's power law, may reflect the behavioural interaction between organism and environment (TAYLOR, 1961 ; ZIMMERMAN and GARRIS, 1987). It was observed in this study, aggregated distribution occurs during flushing-flowering seasons and less aggregated during post-flowering seasons. The distribution analysis suggests that when the population of *H. antonii* is high, the insects tend to aggregate on cashew plants, meanwhile when the population is low the insects tend to distribute randomly or regularly. This trend of distribution is quite common in insect. On the contrary, KARMAWATI *et al*. (1999) found randomly distribution using negative binomial analysis. SOUTHWOOD (1978) mentioned that changes in density of the insect often lead to changes, or at least apparent changes, in the distribution. POOLE (1974) stated that the most obvious cause of aggregation is probably habitat heterogeneity or an intrinsic part of the behaviour of a species. ANDREWARTA and BIRCH (1954) also mentioned heterogeneity of nature of habitat in space and in time that makes the dispersal of species. The aggregation of *H. antonii* possibly due to attraction towards food sources in the form of cashew flushes or shoots, inflorescences and young fruits which was abundant during flushing-flowering seasons. The aggregation may be determined by the females laying eggs on certain plants which preserve food sources, since *H. antonii* fed and oviposit on the same cashew plant parts. The aggregation of *H. theivora* on cocoa were determined by their attractiveness to the numbers of cherelles and pods on a tree (MUHAMAD and CHUNG, 1993). Meanwhile, WRATTEN and FRY (1980) summarized that aggregated distribution on aphid occur as a result of a combination of true gregariousness, where the presence of one species attracts others, and spatial heterogeneity of the environment causing some areas inherently more suitable for survival and reproduction.

Results obtained during the studies indicated that abundant shoot, inflorescence and fruit on cashew trees determined the attractiveness to *H. antonii*. Aggregation of the insect pest on trees which harboured food in abundance also occurred in *H. theivora* on cocoa (YOUDEOWEI and TOXOPEUS, 1983; MUHAMAD, 1992). Monitoring of the insect should be done during flushing-flowering season with sample trees bearing large number of shoots, inflorescences and young fruits which are chosen systematically. The census could be based on fresh or recent damage symptoms apart from the number of insect population. Fresh and recent damage of *H. antonii* shows watery soak symptom with greyish to brown colour lesions, whereas old damage symptoms show dried up spots with blackish to black colour lesions. Based on population fluctuation results, monitoring on *H. antonii* should be initiated when plant have produced a lot of flushes or shoots, at the end of the rainy season, that is, around March until the end of the flushing-flowering season. Monitoring interval could be weekly or biweekly depending on pest intensity. When control action is needed, it should be taken as tree-by-tree spraying which harbour *H. antonii* damaged since the insect showed aggregated distribution. Control action should be taken soon after large number of young nymphs are detected.

CONCLUSION

Distribution analysis using various indices of dispersion and regression models indicate aggregated distribution when the population is high during flushing-flowering seasons of cashew plants, and regular or random when the population is low during post-flowering season. The aggregation possibly was caused by their attractiveness to food sources of the cashew plant in the form of flushes/shoots, inflorescences and young fruits. For sampling and monitoring of the insect should be carried out during flushing-flowering seasons with sample trees bearing large number of shoots, inflorescences and young fruits which are chosen systematically.

ACKNOWLEDGEMENT

This work was supported by funds from IPMSECP (Integrated Pest Management for Smallholder Estate Crop Project) and AARD (Agriculture Agency for Research and Development) under Agricultural Department of Indonesia.

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