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The Relationship between Population Fluctuations of *Helopeltis theivora* Waterhouse, Availability of Cocoa Pods and Rainfall Pattern

RITA MUHAMAD[1] and CHUNG GAIT FEE[2]

[1]*Department of Plant Protection, Faculty of Agriculture 43400 UPM, Serdang, Selangor Darul Ehsan, Malaysia.*

[2]*Ebor Research, Locked Bag No. 7202, Batu Tiga, 40706 Shah Alam, Selangor Darul Ehsan, Malaysia*

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ABSTRAK

Kajian mengenai faktor-faktor yang mempengaruhi fluktuasi populasi daripada Helopeltis theivora *yang berhubungan dengan sumber makanan dan curah hujan telah dilakukan. Hasil kajian menunjukkan bahawa fluktuasi populasi dipengaruhi oleh curah hujan dan jumlah buah-buah koko yang ada dimana terdapat korelasi positif antara mereka. Hasil kajian juga menunjukkan bahawa pengurangan yield yang nyata didapati bersamaan dengan kenaikan populasi mirid. Jumlah cherelles dan buah koko yang didapati pada satu pokok akan menentukan daya tarikannya terhadap infestasi mirid, disebabkan lebih banyak cherelles dan buah koko didapati pada pokok yang diinfestasi oleh mirid apabila dibanding dengan yang tidak diinfestasi.*

ABSTRACT

Investigation on factors affecting the population fluctuations of Helopeltis theivora *in relation to food supply and rainfall in the field was conducted. Results showed that population fluctuations seem to be dictated by rainfall and numbers of available pods as shown by positive correlations between them. The results also showed a significant yield decrease with increased mirid populations. The numbers of cherelles and pods on a tree determine its attractiveness, since significantly more cherelles and pods were found on infested trees than on uninfested trees.*

INTRODUCTION

Helopeltis theivora formerly known as *Helopeltis theobromae* Miller (Stonedahl 1991) is the major pest of cocoa in Peninsular Malaysia. Feeding by the active stages causes lesions on shoots and pods of all ages including the newly formed cherelles. There is some disagreement over factors responsible for seasonal fluctuations in *H. theivora*. In Malaysia, pod production peaks twice a year. The relative scarcity of pods at other times of the year can influence the population dynamics of the species; Azhar (1986) emphasised pod shortage as a limiting factor to population increase. While the fluctuation in pod numbers probably plays an important role in the ecology of *H. theivora* and of other mirids, this role is likely to be moderated or even masked by other factors such as weather. The importance of cocoa pods as a source of food and as an oviposition site for *H. theivora* has been stressed by many workers (Miller 1941; Tan 1974). Cocoa pods are the main source of food for development and play a vital role in the reproductive success of *H. theivora* (Rita and Khoo 1983). Young shoots are not as good as pods for nymphal instars, but can sustain them when pods are scarce. However, pods are critical to adults for optimum survival and reproduction (Alias *et al.* 1988). The feeding and oviposition preferences for pods may be attributed to the suitability of their food value and to their texture for egg laying (Rita 1992). Tan (1974) observed that an increase in the population of *H. theivora* coincided with both increasing numbers of pods and increasing rainfall. A decrease in the numbers of *H. theivora* followed a decrease in rainfall even though the pod numbers remained high. Betrem (1941) also observed that there was a decrease of *H. antonii* Sign. numbers following a dry season. Roepke (1916) also observed that hot and humid weather conditions with sufficient sunshine and intermittent, but not too heavy, rainfall were optimum conditions for *H. antonii.*

In West Africa, *Sahbergella singularis* Hagl. and *Distantiella theobroma* (Dist.) showed well-marked annual population fluctuations which coincided with the main rainy seasons to influence mirid population patterns (Marchart 1969). In Indonesia, *H. antonii* populations decreased following a dry season (Roepke 1916). The importance of cocoa pods and vegetative tissues as food has been stressed for *S. singularis* and *D. theobroma* (Williams 1954).

Food supply and rainfall no doubt contribute to the changes in the pattern of mirid populations. Studies were conducted in the field to further investigate factors which affect the population fluctuations of *H. theivora* to gain a better understanding of the mirid's ecology. These investigations covered a three-year study of population fluctuations in one plantation.

METHODS

The study was conducted over a period from July 1986 to October 1989 at Seafield Estate, Shah Alam on a block of 49.8 hectares of Sabah mixed hybrid cocoa intercropped with coconuts. In the first four months the area was subject to two rounds of insecticide spraying (Lindane 250 g ai/ha) which killed off most of the *H. theivora* population; subsequently no insecticides were applied. A central plot of 15 rows x 15 trees was used in the study. The numbers of *H. theivora* on each tree in the plot were assessed at monthly intervals by the method known as 'counting to hand height' (Williams 1954). In this method, the trees are invidually numbered, and the numbers of mirids found infesting up to a height of about six feet are counted but not removed. Altogether, assessments were made on thirty-nine sampling occasions. At each count the numbers and sizes of cocoa cherelles and pods on each tree were recorded: sizes were divided into cherelles (<10 cm long), small pods (10-12 cm long), medium sized pods (12.1-14 cm long) and large pods (>14 cm long). Local rainfall and crop yield data (dry bean weight) derived from the 49.8 hectares block were recorded. Subsequently, data from the 15x15 central plot were computed based on the relationship between the numbers of *H. theivora,* the numbers of cocoa pods and yield as based on 'per 100 trees'. Association and tests of significance to determine correlations between the numbers of *H. theivora* per 100 trees, the numbers of cocoa pods and crop yield per 100 trees, and the rainfall were statistically compared using Spearman's rank correlations (Siegel and Castellan 1988). The data for the first 10 months were not included in the analyses to allow for the mirids to recover from the insecticide treatments.

Additional data were obtained for each sampling on the numbers of cherelles and pods on the infested trees, and on the uninfested trees surrounding the infested trees, as well as on the numbers of nymphs and adults of *H. theivora* on the infested trees. These were statistically analysed and the differences between individual means were tested using Duncan's Multiple Range Test. (Table 1).

TABLE 1
Number of pods and *H. theivora* per uninfested and infested tree from May 1987 to September 1989

	Mean number of pods per tree/ per sampling			Mean numbers of *H. theivora* per tree/per sampling		
	Cherelles and small pods	Medium and large pods	Total	Nymphs	Adults	Total
Uninfested tree	1.3 ± 0.2b	1.7 ± 0.2b	3.1 ± 0.3b	0	0	0
Infested tree	4.4 ± 0.6a	5.1 ± 0.4a	9.6 ± 0.8a	1.5 ± 1.6	0.8 ± 0.5	2.4 ± 1.7

Note: About 3% of the uninfested trees are without pods.
Any two means within the column followed by the same letter are not significantly different at 5% level based on Duncan Multiple Range Test

RESULTS

Fig. 1 shows the relationship between the numbers of *H. theivora* per 100 trees, the numbers of pods, the crop yield per 100 trees and the rainfall. In the first 10 months of sampling there were fewer *H. theivora* compared to subsequent periods. This was because it took time for the *H. theivora* population to build up after insecticide treatment was stopped. *Fig. 1* shows that, after the first ten months, the population fluctuated annually with two peaks, in June-July and December-January.

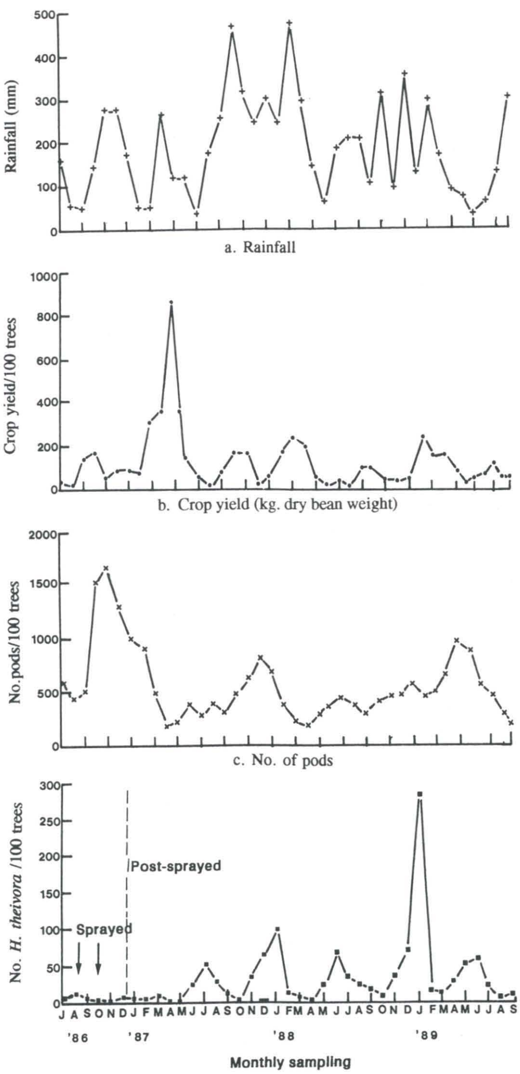

Fig. 1: Relationship between numbers of H. theivora, *numbers of pods, crop yield per 100 trees and the rainfall pattern between July 1986 to September 1989.*

Rainfall occurred throughout the year, but with sharp increases in April and May of each year. The wettest months usually occur towards the end of each year, usually from October to December, and may extend into January. The population peaks of *H. theivora* in December-January coincided with months of heaviest rainfall, although a one month gap was observed in the June-July peak. Some cherelles and pods were available throughout the year with most after the onset of the rainy season, especially between October and January. A flow chart of correlations is shown in *Fig. 2*.

increased numbers of pods

↘

increased *H. theivora* (r=0.61)** → decreased crop yield (r=–0.55)**

increased *H. theivora* (r=0.34)* →

↗

increasing rainfall

Fig. 2: Diagram showing relationship between H. theivora *population with availability of food (total numbers of pods), rainfall and crop yield*

Fig. 2 indicates that food in the form of numbers of pods available in the field and the increased rainfall were associated with an increase in the *H. theivora* population since positive correlations were obtained between these parameters. But the *H. theivora* population appeared to reduce the total crop yield at the same time since a negative correlation was obtained when decreased yield of harvested crop and increase in the *H. theivora* population were compared.

The numbers of *H. theivora* were calculated in terms of the numbers per pod, the mean numbers per infested tree and the percentages of infested trees (*Fig. 3*). At the population peaks, the mean numbers of *H. theivora* per infested tree varied from 3 to 10 and the percentages of trees infested during the June-July peak were between 10-20% but increased to about 40% in the December-January peak. It was

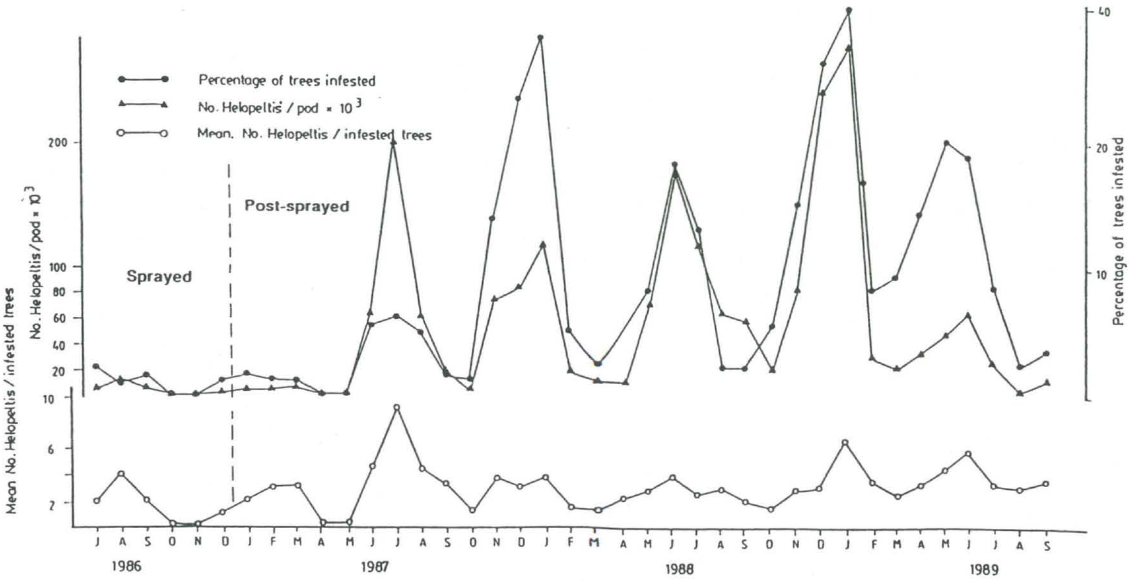

Fig. 3: Mean numbers of H. theivora *per pod, mean numbers per infested tree and percentages of trees infested at each sampling time*

observed that there was a relationship between the percentage of trees infested and the numbers of *H. theivora* per pod; there were fewer *H. theivora* per pod when a greater percentage of trees was infested and more *H. theivora* per pod when a smaller percentage of trees was infested. Although about similar percentages of infested trees (20%) and mean numbers per infested tree (4 insects per infested tree) were recorded in the June-July peaks in 1988 and 1989, about three times more per pod were recorded in 1988 than in 1989. This could be attributed to the fewer pods available during the 1988 peak which was nearly one-third of the numbers found in 1989. In June-July 1987, the mean numbers per infested tree was the highest (10 insects per infested tree) but with about similar numbers per pod as in 1988. This could be attributed to the the fewer trees which were infested (7%). In the December-January peaks of 1987 and 1988, similar percentages (about 40%) of trees were infested but the numbers per pod in 1987 were about one- third of those found in 1988. These differences were mainly due to the fact that the total numbers of *H. theivora* were about three times greater in 1988 than in 1987. The numbers of *H. theivora* per pod or per infested tree were directly related to the total numbers of *H. theivora* and the total numbers of pods available.

The mean numbers of cherelles and pods and *H. theivora* recorded per uninfested and infested tree per sampling from May 1987 to September 1989 are shown in Table 1. There were 1.3 ± 0.2 cherelles and small pods per uninfested tree which was significantly less than 4.4 ± 0.6 per infested tree. Similarly, there were 1.7 ± 0.2 and 5.1 ± 0.4 per uninfested and infested trees respectively on medium sized-large pods. The numbers of cherelles and pods were therefore significantly higher on infested trees (9.6 ± 0.8 pods per tree) than on uninfested trees (3.1 ± 0.3 pods per tree). The average number of nymphal and adult *H. theivora* was 2.4 ± 1.7 per infested tree comprising 1.5 ± 1.6 and 0.8 ± 0.5 nymphs and adults respectively.

DISCUSSION

The results show that *H. theivora* population fluctuations seem to be influenced by rainfall and by the numbers of available pods as are shown by positive correlations between mirid numbers, rainfall and numbers of pods. Hot and humid weather conditions with sufficient sunshine and intermittent but not too heavy rainfall are considered to be optimum for *H. antonii* (Roepke 1916). Pods play a vital role as feeding and oviposition sites for *H. theivora* (Alias *et al.* 1988). Their greatest role recurs in an annual pattern when mirid species rely on them for food (Entwistle 1972). The *H. theivora* population was not directly affected by the availability of pods, or rainfall alone, but by an interaction of rainfall availability of food as suggested by Tan (1974). Our results also strongly suggest that *H. theivora* decreases yield, since a significant overall yield decrease was observed with increased mirid populations.

Patches, or pockets of *H. theivora*, have been observed, where individual trees harbour relatively large populations of *H. theivora*. The results show that the numbers of cherelles and pods on a tree determine its attractiveness, especially as significantly more cherelles and pods were found on infested trees than on uninfested trees. Aggregation also occurs with West African mirids such as *D. theobroma* and *S. singularis*. This happens either in open areas of cocoa where there are many young fans and chupons in incomplete parts of an otherwise closed canopy (Youdeowei 1965; Lodos 1969; Johnson 1971; Entwistle 1985). In *H. theivora*, a heavy localised attack on pods of certain trees is the result of heavy egg-laying and nymphal feeding by *H. theivora* related especially to cherelle and pod abundance at the time of infestation (Rita 1992). In this study, no evidence was obtained that particular trees have cherelles or pods that are resistant to or deter the pest. Sometimes a tree with many pods remained unattacked for several months; but this was probably because it was not found, since, once detected, it was heavily attacked as were other trees (Rita 1992). Mirid aggregation as well as the ability to build up rapidly to assume destructive proportions was evident in this study in the January 1989 peak (*Fig. 1*). This rapid build- up necessitates regular monitoring which can provide a basis for chemical control (Youdeowei and Toxopeus 1983; Ho 1986; Wills 1986).

In Malaysia, census systems for *H. theivora* have been formulated such as the early warning system (EWS) and plot and threshold response system (Wills 1986; Wood and Chung 1989). Results obtained in this study could help in improving the census systems by incorporating an additional criterion involving selection of certain suitable sampled trees. These sampled trees chosen in the census system, for example, might be those bearing large numbers of cherelles and small to medium sized pods as these will attract possible infestations. Knowledge of the population fluctuations of *H. theivora* could help in reducing the amounts of insecticide used. Populations of *H. theivora* have been shown to have two annual peaks coinciding with the wet seasons; insecticide spraying would normally be done preferably during these peak periods which coincide with peaks of cherelle production. Insecticide spraying in wet seasons is less effective and more difficult to organise, but it has been shown that spraying during peak periods is effective in reducing the mirid population (Chung and Wood 1989). However, damage can occur earlier at the cherelle stage; therefore to prevent loss, it would be better to spray before *H. theivora* population increases. Mirids also feed on shoots causing dieback and affect vegetative growth which eventually cause canopy dieback (Alias *et al.* 1988; Chung and Wood 1989). For a long-term strategy, it would be better to have a monthly census and to control *Helopeltis* activity above 10 - 15 % threshold as suggested by Wood and Chung (1989). This strategy could be used in population management to ensure healthy cocoa growth and good yield.

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