Distribution of Cocoa Pod Borer (CPB) *Conopomorpha cramerella* (Snellen) (Lepidoptera: Gracillariidae) Egg Population with Respect to the Pod Phenology

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ABSTRAK

Pada tahun 2000 dan 2001, satu kajian mendalam ke atas pensampelan ulat pengorek buah koko (UPBK) telah dijalankan selama 12 bulan di Lembaga Koko Hilir Perak, Sg. Sumun, Perak. Beberapa komponen meliputi penentuan bentuk taburan UPBK berasaskan fenologi buah dan penentuan saiz sampel optimum UPBK menggunakan tiga kaedah pensampelan rawak, sistematik dan strata. Data dianalisis menggunakan dua model pengelompokan, Hukum Kuasa Taylor (pekali b) dan Indeks Pengelompokan Iwao (pekali β). UPBK ditemui berkelompok. Bagi penentuan saiz sampel optimum, dua parameter dihitung, pekali b bagi model Green dan pekali β bagi model Kuno. Model Green didapati paling sesuai bagi menghasilkan pensampelan paling efisien pada kepadatan populasi rendah dan tinggi UPBK bagi kesemua kaedah pensampelan yang digunakan.

ABSTRACT

At the Malaysian Cocoa Board Research Station at Hilir Perak, Sg. Sumun, Perak, an in-depth investigation on sampling of the cocoa pod borer (CPB) was conducted over a period of 12 months from 2000 to 2001. Several components were examined including determining distribution of CPB with respect to pod phenology and determining optimum sample size to produce sampling parameters for CPB using three different sampling techniques, random, systematic and stratified. Data were analysed using two aggregation models; Taylor's Power Law (b coefficient) and Iwao's mean crowding (β coefficient). CPB's egg were found to be highly aggregated. In determining optimum sample sizes, two parameters were calculated; b coefficient of Green's model and β coefficient for Kuno's model. The Green model was suitable to produce the most efficient sampling sizes during low and high population densities for all sampling techniques.

INTRODUCTION

Cocoa is the third most important primary crop in Malaysia providing RM 0.66 billion revenue to the country (MCB 2001). The Malaysian cocoa industry has developed rapidly since the late 1970s with production reaching 240, 000 tons in 1990. It is the most productive crop in the world with a yield of 1 tons/ha/year (MCB 2001). However, in the 1980s the industry was beset with problems of prolonged depressed price and infestation of a serious pest, the cocoa pod borer, *Conopomorpha cramerella* (Snellen) (CPB).

The CPB lays eggs on the pod surface, mostly in the furrows or in pod's morphological depressions. The larvae hatch and bore directly into the pods to feed within the placenta resulting in the formation of malformed beans. These problems if left uncontrolled may result in severe economic loss. Several methods are recommended to control CPB including frequent harvesting, bagging or sleeving, chemical treatment, natural enemies and pheromones. Currently, insecticides are widely used by the growers at biweekly prophylactic applications (Tay *et al.* 1989), often causing additional productivity costs through unnecessary spraying without knowing the exact information on the pest status. Hence, sampling may alleviate this problem through proper estimation of CPB population status which facilitates treatment decisions.

A sampling strategy is the adoption of sequential sampling methodology that will reduce time and labour cost. The objective of this study, was to determine the distribution of CPB eggs population.

MATERIALS AND METHODS

The study was conducted from 2000 to 2001 over a period of 12 months at the Cocoa Research Center, Malaysian Cocoa Board, Hilir Perak, approximately 25 km northwest to Teluk Intan. Three blocks having three different levels of CPB egg densities-high, medium and low- were used. Approximately, 60 trees in each block were randomly selected for sampling pods. Sampling was carried out by recording the number of eggs on pods, time taken for egg counting and the length and diameter of the pod. Three sampling techniques were compared including random, systematic and stratified.

Statistical Analysis

Distribution data of eggs for all sampled trees were used to calculated the means, variances, negative binomial parameter k (Long and Theroux 1979) and index mean crowding (Llyod 1967). Frequency histogram and simple linear regression (Woolf 1968) were used to indicate relationship between statistical and observed mean densities.

Distribution Indices

Taylor's Power Law relates variance (s^2) to mean densities (x) at $\log s^2 = \log a + b \log x$. The parameter a is the intercept which is considered as the factor related to sample size while the parameter b is an index value of aggregation, which is a constant species. When the b value < 1, it describes uniform distribution, $b=1$ for random distribution and $b > 1$ for aggregated distribution (Taylor 1961).

Iwao's model (1968) showed a regression of mean crowding $\overset{*}{x}$ on the mean ($\bar{x}$), where $\overset{*}{x} = x + [(s^2/x) -1]$ (Lloyd 1967) and the linear regression model is $\overset{*}{x} = A + Bx$. Intercept A is the basic contagion while B represents the individual distribution. $B<1$ shows uniform distribution, $B=1$ shows random distribution and $B>1$ shows aggregated distribution pattern.

RESULTS AND DISCUSSION

A frequency histogram based on the sampling technique describes CPBs egg population throughout the sampling program (*Figs. 1 to 3*). The proportion of pods without eggs in each block was inversely related to the overall egg population density in the block. The levels of CPB egg density were very low, where trees were not attacked randomly but certain trees were more likely to be infested than the others. The results from this finding are similar to the finding of Azhar and Long (1993). Since the number of trees examined was large, and therefore, the degree of freedom was high, a small number of trees with high CPB egg density was sufficient to reject the hypothesis of randomness. One of the reasons why aggregated spatial distribution describes CPB egg population is that the adults

TABLE 1
Distribution parameter obtained using TPL based on different sampling techniques.

	Log a	SE	B	SE	r²	t	p
Random	2.391	0.166	1.716	0.092	0.902	18.748	0.005
Systematic	2.072	0.174	1.678	0.091	0.900	18.49	0.005
Stratified	2.099	0.222	1.684	0.118	0.842	14.236	0.005

TABLE 2
Distribution parameter obtained using Iwao's based on different sampling techniques.

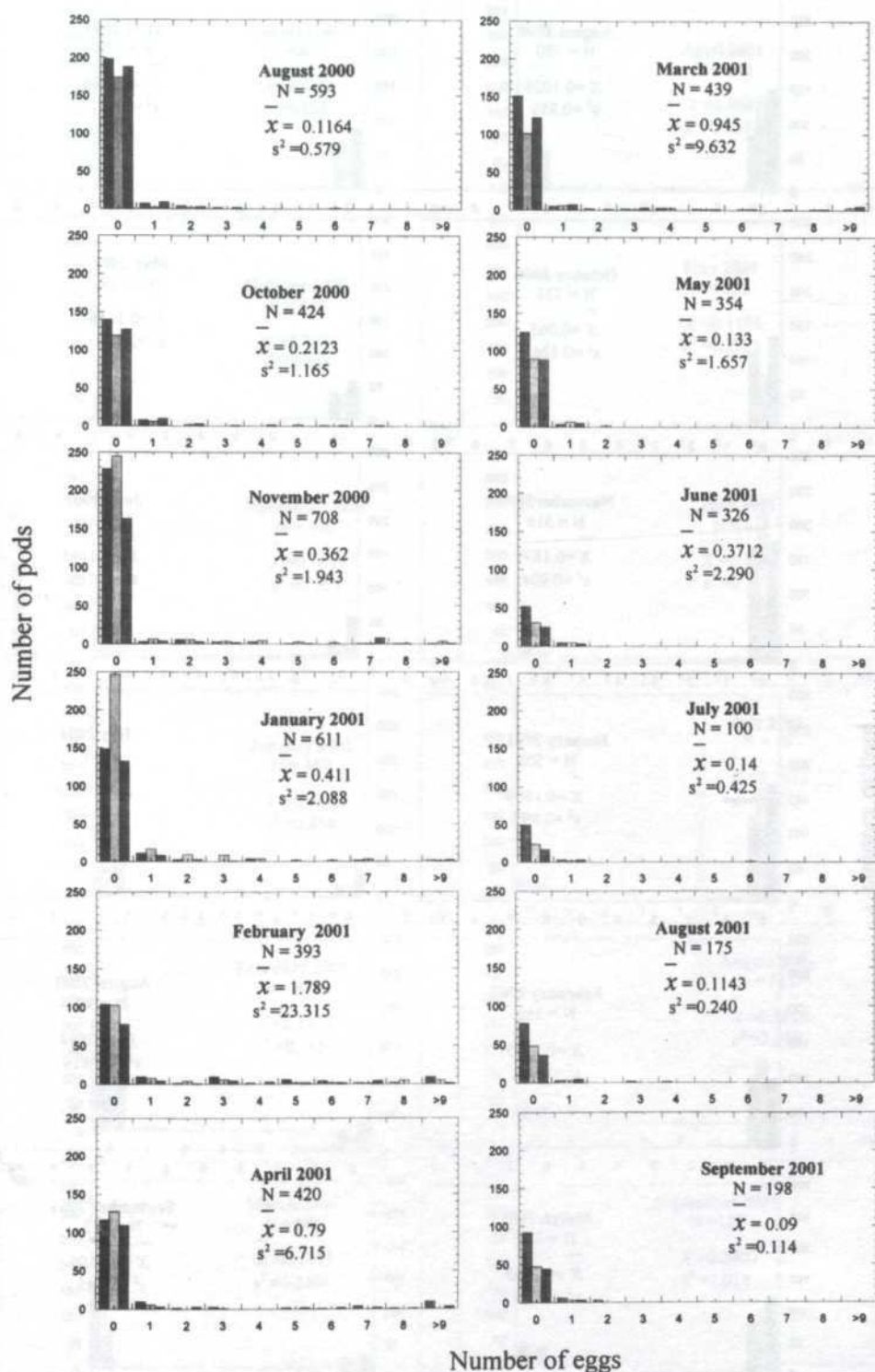|	A	SE	ß	SE	r2	t	p
Random	0.731	0.934	2.897	1.433	0.097	2.023	0.005
Systematic	0.323	0.418	8.623	0.831	0.739	10.388	0.005
Stratified	0.667	0.568	8.637	1.341	0.522	6.439	0.005

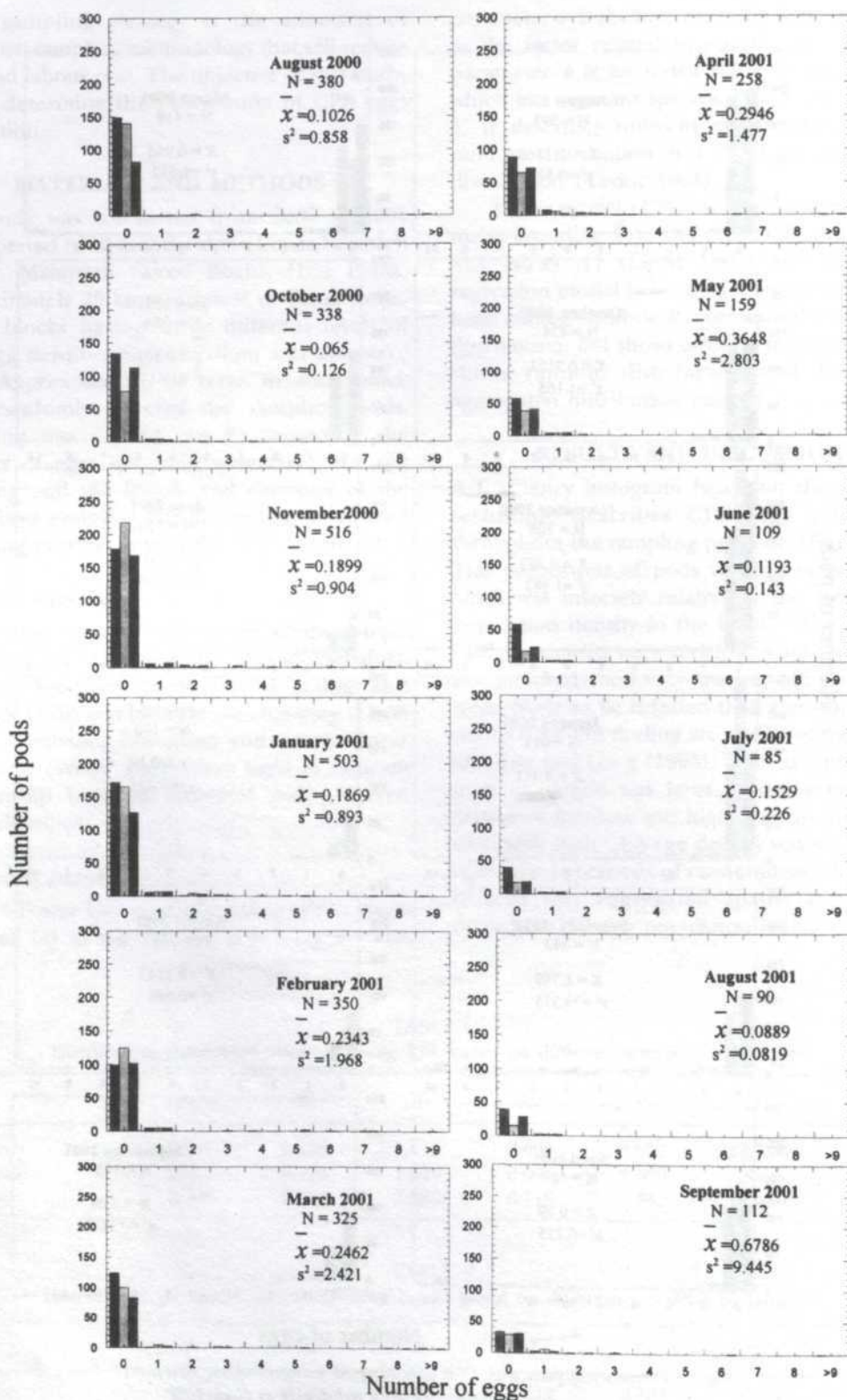Fig. 1: Frequency of pods with CPB eggs sampled using random, systematic and stratified sampling techniques at block 12D

Fig. 2: Frequency of pods with CPB eggs sampled using random,
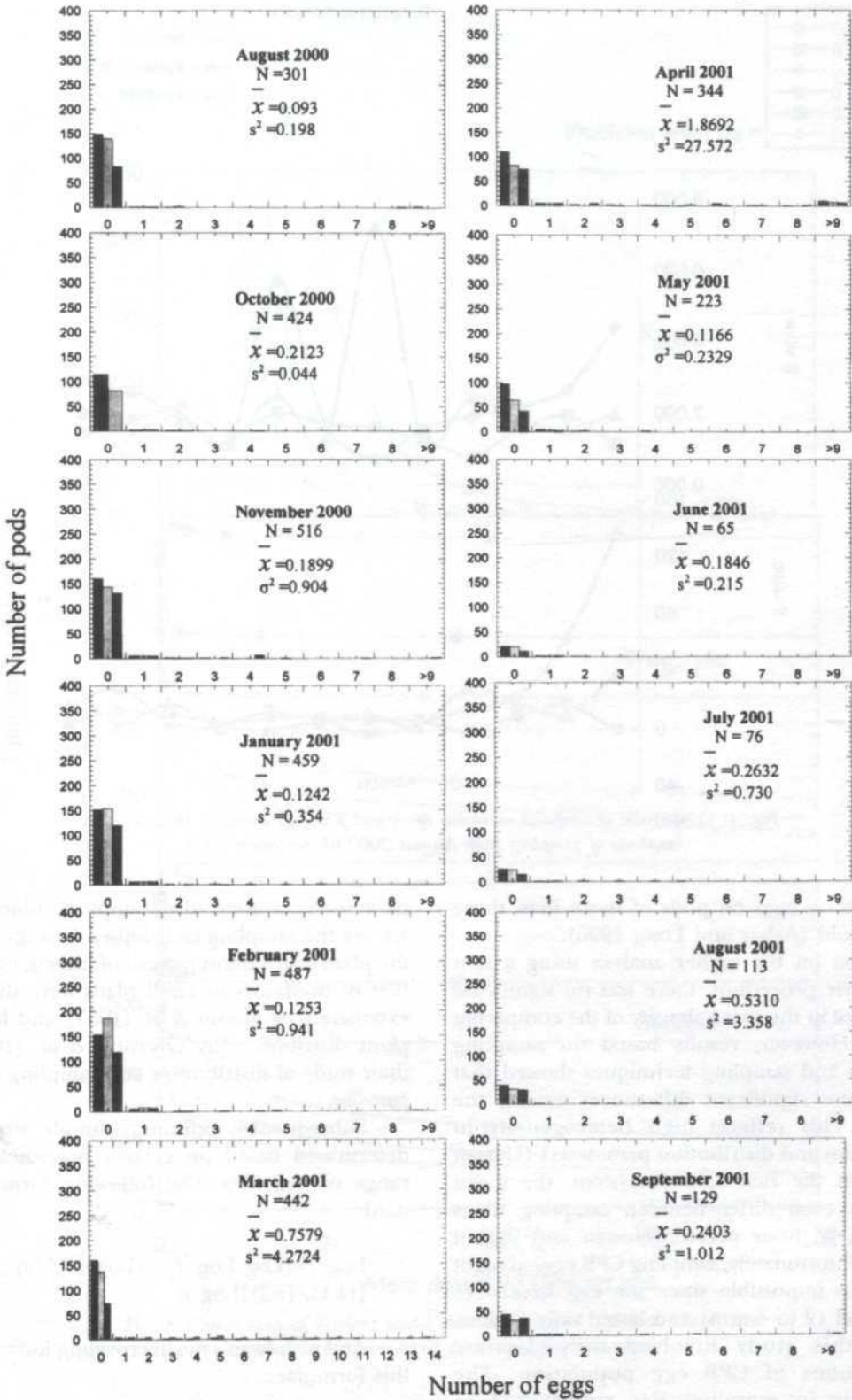systematic and stratified sampling techniques at block 10A

Fig. 3: Frequency of pods with CPB eggs sampled using random, systematic and stratified sampling techniques at block 3A
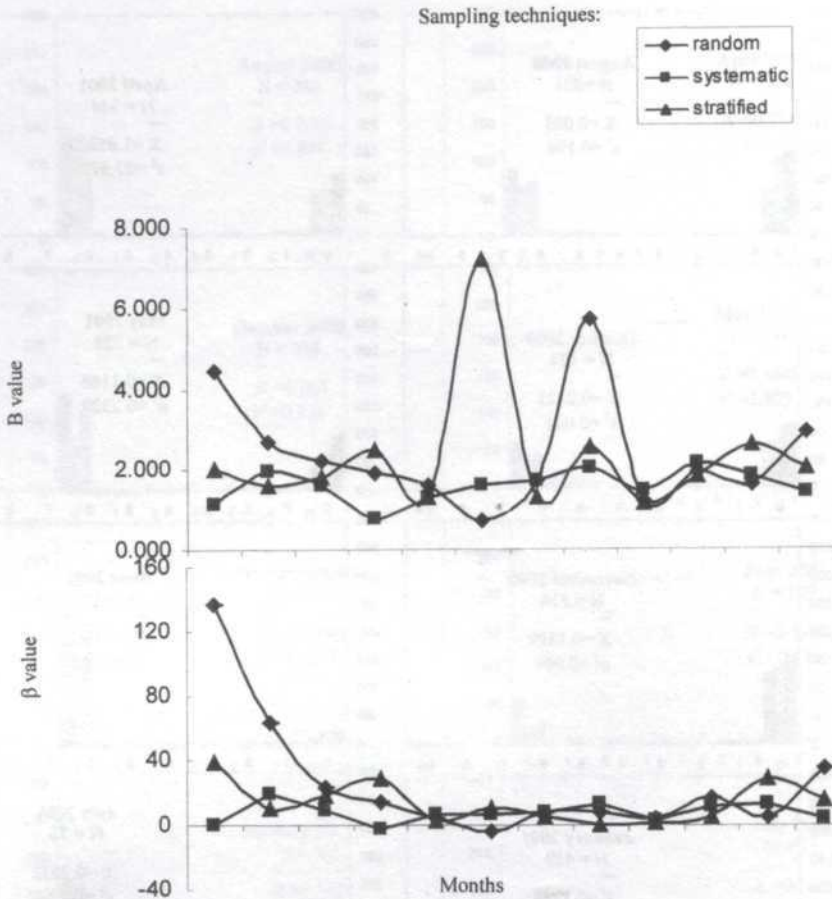
Fig. 4: Comparison of temporal variation of b and β values based on three different methods of sampling from August 2000 till September 2001

prefer to lay eggs on pods of more than three months old (Azhar and Long 1996).

Based on the earlier analysis using a non parametric procedure, there was no significant difference in the mean density of the comparing blocks. However, results based on sampling duration and sampling techniques showed that there were significant differences among the means. This reflects high heterogeneity in population and distribution parameters (Hassan 1996). In the rice field ecosystem, the mean densities even differ between sampling times within a 24 hour period (Hassan and Rashid 1997). Unfortunately, sampling CPB eggs at night times was impossible since the egg sizes were very small (2 to 4 mm) and lasted only 4 days. Thus, this study involved only daytime observations of CPB egg population. The variability in sampling size contributed to variation of the b and β values. Consequently, there might have been differences in distribution

parameters among the sampling blocks and among the sampling techniques. Changes within the plant distribution pattern of insects, especially that of predators in chilli plant were discussed extensively by Maisin *et al.* (1997) and between plant distribution by Overholt *et al.* (1994) in their study of distribution and sampling of *Chilo partellus.*

Subsequently, optimum sample sizes were determined based on certain precisions for a range of densities. The following formula was used:

Log T=[Log Log T = [Log (D_0^2/a) / b-2] + [$(b$-1$)/(b$-2$)$]Log n

And with Iwao's mean crowding indices using this formulae:
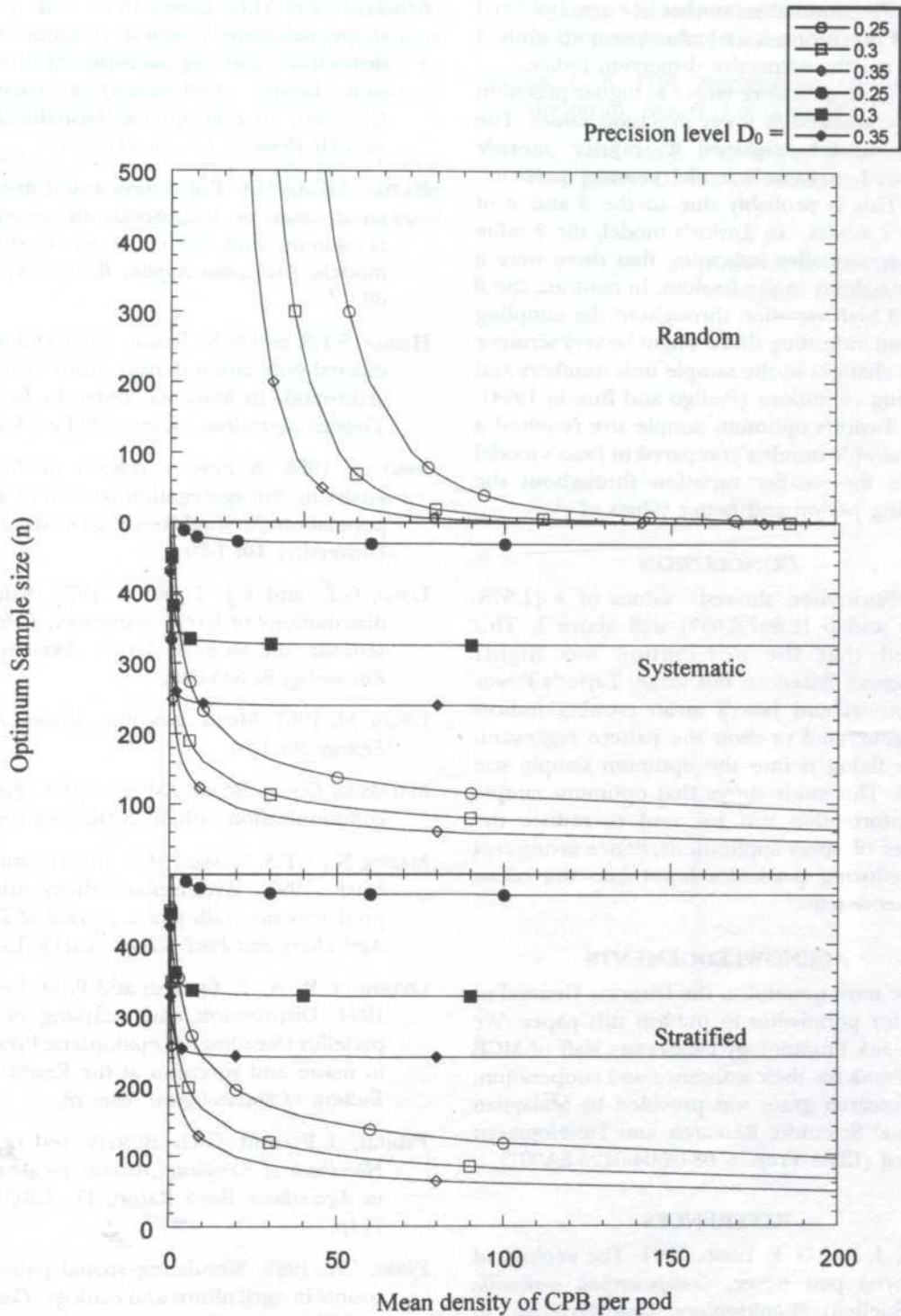
$T = (A+1)/ [D_0^2- (B$-1$)/n).$

Fig. 5: Comparison of Taylor's model and Iwao's model optimum sample size at various precision levels for three different method

where T= cumulative number of eggs, D_0= fixed level of precisions, n = number per pods while A and B are the respective dispersion indices.

Sample sizes were larger at higher precision values compared to lower precision values. The green model required a smaller sample compared to Kuno's model at every presicion level. This is probably due to the b and a of Taylor's model. In Taylor's model, the b value range was smaller indicating that there were a higher stability in the b values. In contrast, the β showed high variation throughout the sampling program indicating that it might be very sensitive to any changes in the sample unit numbers and sampling conditions (Pedigo and Buntin 1994). Thus, Taylor's optimum sample size required a lower sample number compared to Iwao's model due to the smaller variation throughout the sampling period and better values of r^2.

CONCLUSION

CPB distribution showed values of b (1.678-1.716) and β (2.897-8.637) well above 1. This showed that the distribution was highly aggregated. Based on this value, Taylor's Power Law model and Iwao's mean crowing indices were generated to show the pattern regression before fixing it into the optimum sample size model. This study shows that optimum sample size information can be used to reduce the number of spray applications, hence saving cost and reducing pesticides input into the cocoa agro ecosystem.

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