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Insect species of stored cocoa beans in Peninsular Malaysia

(Spesies serangga perosak biji koko dalam penyimpanan di Semenanjung Malaysia)

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Key words: insects, cocoa beans, incidence, estates, buyers, Peninsular Malaysia

Abstrak

Spesies serangga perosak daripada biji koko dari estet dan pembeli koko telah ditentukan. Berdasarkan bilangan serangga yang belum dan sudah dewasa, spesies utama yang dikenalpasti ialah *Tribolium castaneum* (Herbst.), *Oryzaephilus mercator* (Fauvel), *Lasioderma serricorne* (Fabr.) dan *Corcyra cephalonica* (Stainton). Komposisi spesies dan kelimpahan relatif spesies utama adalah sama untuk ladang dan pembeli koko. Bilangan purata serangga dewasa untuk setiap beg seberat 62.5 kg adalah masing-masing 0.74 dan 3.51 untuk ladang dan pembeli koko. Corak taburan serangga dewasa menunjukkan bahawa populasi serangga dalam setiap beg adalah terlalu beragregat. Infestasi sisa dan infestasi silang mungkin berpunca daripada serangga peringkat belum dewasa yang selalunya sukar dikesan semasa pemeriksaan awal. Berdasarkan andaian ini, disarankan supaya semua biji koko yang hendak dieksport, perlu difumigasi terlebih dahulu, tanpa mengambil kira bilangan serangga dewasa.

Abstract

The insect species in cocoa beans were determined for both estate and buyer beans. The major species, based on adult and immature numbers, were *Tribolium castaneum*, *Oryzaephilus mercator*, *Lasioderma serricorne* and *Corcyra cephalonica*. The species composition and the relative abundance of the major species were similar for the estate and buyer beans. The mean number of adults per sack of 62.5 kg nett was 0.74 and 3.51, for estate and buyer beans, respectively. The dispersion pattern of adults in the sacks was highly aggregated for both estate and buyer beans. It was suggested that the immature stages of insects, which are not easily detected during preliminary inspection, could be a source of residual and cross-infestation during shipment. Based on this, it was suggested that all cocoa beans for export be fumigated, regardless of adult insect numbers.

Introduction

Insect infestation affects the quality of cocoa beans during storage. Poor quality beans, resulting from infestations, usually affect the grade and consequently incur low prices. To maintain the reputation of Malaysian beans in the international market, since October 1984 preshipment inspection is carried out by the Federal Agricultural and Marketing Authority

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(FAMA) on beans for export to certify their quality, before the export permit is issued. Based on FAMA's records, rejection of beans due to high insect numbers (≥ 10 insects per sack of 62.5 kg nett) during preliminary inspection (Othman 1986) was consistently high compared to other factors such as moisture content, waste and poor packaging (Sivapragasam 1987). For example, in 1986, rejection of samples due to high insect numbers was about 28% based on total quantity graded in Peninsular Malaysia. Beans rejected as a result of insect infestations have to be fumigated thereby incurring additional costs to the exporter.

Despite the importance of insect infestation on quality, there is a general lack of information on the insect species and their relative abundance in cocoa beans during storage in this country. Although the presence of some insect species was confirmed in earlier studies (Yunus and Ho 1970; Conway 1971), these studies lacked quantitative data on the relative abundance of the various species. This study examines the various species of insect pests and their relative abundance in cocoa beans obtained from the estates and licensed cocoa bean buyers.

Materials and methods

Sources of cocoa bean samples

Cocoa bean samples were obtained from the two FAMA grading centres at Port Kelang, Selangor, and at Johore Bahru, Johore. These centres grade more than 95% of the total beans graded in Peninsular Malaysia. Most (> 81%) of the beans sent to Port Kelang are estate beans whereas those sent to Johore Bahru are from licensed buyers cum exporters (> 84%) whose major source of beans come from smallholders. A total of 81 and 124 cocoa bean samples, were obtained from Port Kelang and Johore Bharu, respectively, for a period extending from June 1986 to September 1987. Each sample was made up of the total residue, which consists of mainly dusts, debris, insects and broken beans, obtained from 16 bags sieved during preliminary inspection of the cocoa beans. Samples were obtained monthly and the number of samples for each month depended on the availability of cocoa beans for grading.

Processing and examination of samples for insects

The cocoa bean samples, mean weight of ca 162 g and ranging from 60 g to 270 g, were kept in sealed polythene bags and brought to the laboratory at MARDI, Hilir Perak. The samples were sieved manually using a 10-in mesh rectangular sieve, and then inspected for living and dead adult and immature insects. Based on preliminary studies, it was found that this method of examination was generally biased towards obtaining beetle numbers and excluded adult moths. But, since the majority of the insects obtained were beetle species, the sieving method was considered sufficient for determining the relative abundance of the various species. The identification of the species was done by comparing with insect specimens in the taxonomy unit, Central Research Laboratories, MARDI, and by the staff of the C.A.B. International Institute of Entomology (CIE).

Number of insects per sack and determination of residual infestation

The number of insect species per sack was obtained by recording in situ the insect numbers during grading of beans. The total number of sacks sampled were 516 and 519 for estate and buyers, respectively.

An understanding on the dispersion of insects between the sacks is important as it influences, among others, the sampling programme, e.g. determining the number of samples to be taken with a fixed degree of precision, and the manner

in which sacks are selected for inspection. The dispersion of insects per sack was described using the negative binomial distribution which is characterised by two parameters, the mean and the exponent k, (the measure of dispersion). The smaller the value of k the greater the extent of aggregation, whereas a large value (about 8) indicates that the distribution is virtually random (Southwood 1978). The value of k was derived based on the third method using equation 1 (Southwood 1978). The iteration was done using a computer programme.

$$N \ln (1 + \varkappa/\hat{k}) - \Sigma[A_{\varkappa}/(\hat{k} + \varkappa)] = 0 \ldots 1$$

where $A_{\varkappa}$ = sum of observed frequencies of sampling units containing more than $\varkappa$ individuals, N = total number of samples and $\varkappa$ is sample mean. k values for equation 1 were estimated using equation 2 (first method) (Southwood 1978):

$$k = \varkappa^2/S^2 - \varkappa \ldots\ldots 2$$

where $\varkappa$ and S^2 are the sample mean and variance, respectively.

To elucidate the relative abundance of moth population, and to determine the source of residual insect population, some of the samples were kept, after removing all adults from each sample, and observed at subsequent dates for adult emergence. Each sample, weighing ca 200 g, was kept in a bottle (16 cm x 7.0 cm x 5.5 cm diam.) sealed at the top by a filter paper disc held in position with paraffin wax. The bottles were examined at weekly intervals and any adult insects present was removed before resealing the sample. At the end of the period, i.e. when no adults emerged for one week, the total number of insects per sample was determined.

Results

The relative frequency of adults per sample in both locations is shown in *Table 1*. The insects obtained were mostly beetles with two important species of moths. The major beetle species, based on relative numbers, were *Tribolium castaneum*, *Oryzaephilus mercator*, and *Lasioderma serricorne*. These species comprised ca 88% and 77% of the total numbers obtained in Port Kelang and Johore Bahru, respectively. The rice moth *Corcyra cephalonica* was obtained in almost all samples, with *Ephestia cautella* obtained in only one of the samples. In *Table 1*, the numbers of *C. cephalonica* was relatively low, if based on adult numbers, probably due to poor recovery of moths during sampling of the bags. However, the importance of this moth was implicit from results of studies to determine the sources of residual

Table 1. Relative frequency of adult insects in cocoa bean samples collected from FAMA grading centers

Insect species	Relative frequency of adult insects (%)		
	Port Kelang	Johore Bahru	Both locations
Tribolium castaneum	44.95	48.00	45.75
Oryzaephilus mercator	20.76	27.02	22.39
Lasioderma serricorne	21.98	1.74	16.75
Carpophilus dimidiatus	3.39	3.27	3.36
Necrobia rufipes	0.71	2.35	1.14
Cryptolestis ferrugineus	0.71	0.51	0.67
Lophocaterus pusillus	0.36	0.00	0.26
Corcyra cephalonica	0.18	0.20	0.90
*Others + unknown**	6.92	16.89	9.47

*Include mostly (ca 95%) larvae of *C. cephalonica* and *T. castaneum* in both locations. Other species recorded included adults of *Ahasverus advena*, *Silvanus* sp. *castaneus*, *Typhae stercorea* (sp?), *Thaneroclerus buquet*, *Alphitobius laeviqatus*, *Monomorium destructor* and *Ephestia (Cadra) cautella*.

populations *(Table 2)*. Based on location *(Table 1)*, for the major beetle species, there was only slight difference in numbers although their status remained generally unchanged, with the exception of *L. serricorne*. The number of *Carpophilus dimidiatus* was quite similar in both locations, but relatively higher numbers of *Necrobia rufipes* was found in the Johore Bahru samples compared to those from Port Kelang.

The number of samples with *T. castaneum* dominated both sample locations with 84% and 68% of the samples containing this insect. This was followed by *O. mercator* with 67% and 28%; *L. serricorne* 36% and 7.26% and *C. dimidiatus* with 23% and 12% respectively. The number of samples with *C. cephalonica* was 10% and 5%, respectively, suggesting that the majority of this insect was found in a few samples, unlike *T. castaneum*.

Table 2. Assessment of insects in bags, after adults were removed during the previous sampling period

Insect species	Number of insects (mean ± S. D.)*
Corcyra cephalonica	70.00 ± 90.27
Tribolium castaneum	21.80 ± 18.47
Oryzaephilus mercator	26.00 ± 42.64
Lasioderma serricorne	25.40 ± 23.61
Carpophilus dimidiatus	0.40 ± 0.55
Necrobia rufipes	0.40 ± 0.55

*Mean of 5 replicates

The relative frequency of insects between sources is given in *Table 3*. The major insect species were *T. castaneum*, *O. mercator* and *L. serricorne*, for both estates and buyers. However, the population numbers of *T. castaneum* and *O. mercator* were much higher for buyer samples compared to estate, the exception being *L. serricorne*.

Figure 1 shows the distribution of adult insects per sack (62.5 kg) for estate and smallholder sources. The mean number of insects per sack was 0.74 ± 1.99 and 3.51 ± 4.40 for estate and buyer beans, respectively. In addition, the number of sacks with no infestation was relatively much higher in estate than in buyer beans. The dispersion pattern of adults per sack, as described by the exponent *(k)* of the negative binomial distribution, was 0.14 and 0.54, for estate and buyer beans, respectively.

The results of studies on residual infestation are shown in *Table 2*. The high residual infestation was obvious in the case of *C. cephalonica, T. castaneum, O. mercator* and *L. serricorne*.

Discussion

The major coleopterous insect pests recorded in this study are also common stored product pests of other commodities in storage (Yunus and Ho 1978). However, this study provided the first record of *O. mercator* and *L. serricorne* as a pest of cocoa beans in Malaysia. This

Table 3. Relative frequency of adult insects in cocoa bean samples collected from estates and buyers

Insect species	Relative frequency of adult insects (%)	
	Estates (N=66)	Buyers (N=50)
Tribolium castaneum	43.12	62.41
Oryzaephilus mercator	20.00	25.80
Lasioderma serricorne	24.16	3.93
Necrobia rufipes	0.68	1.72
Carpophilus dimidiatus	3.72	0.98
Cryptolestis ferrugineus	0.64	0.98
Lophocaterus pusillus	0.36	0.25
Corcyra cephalonica	0.16	0.25
Others + unknown	7.16	3.69

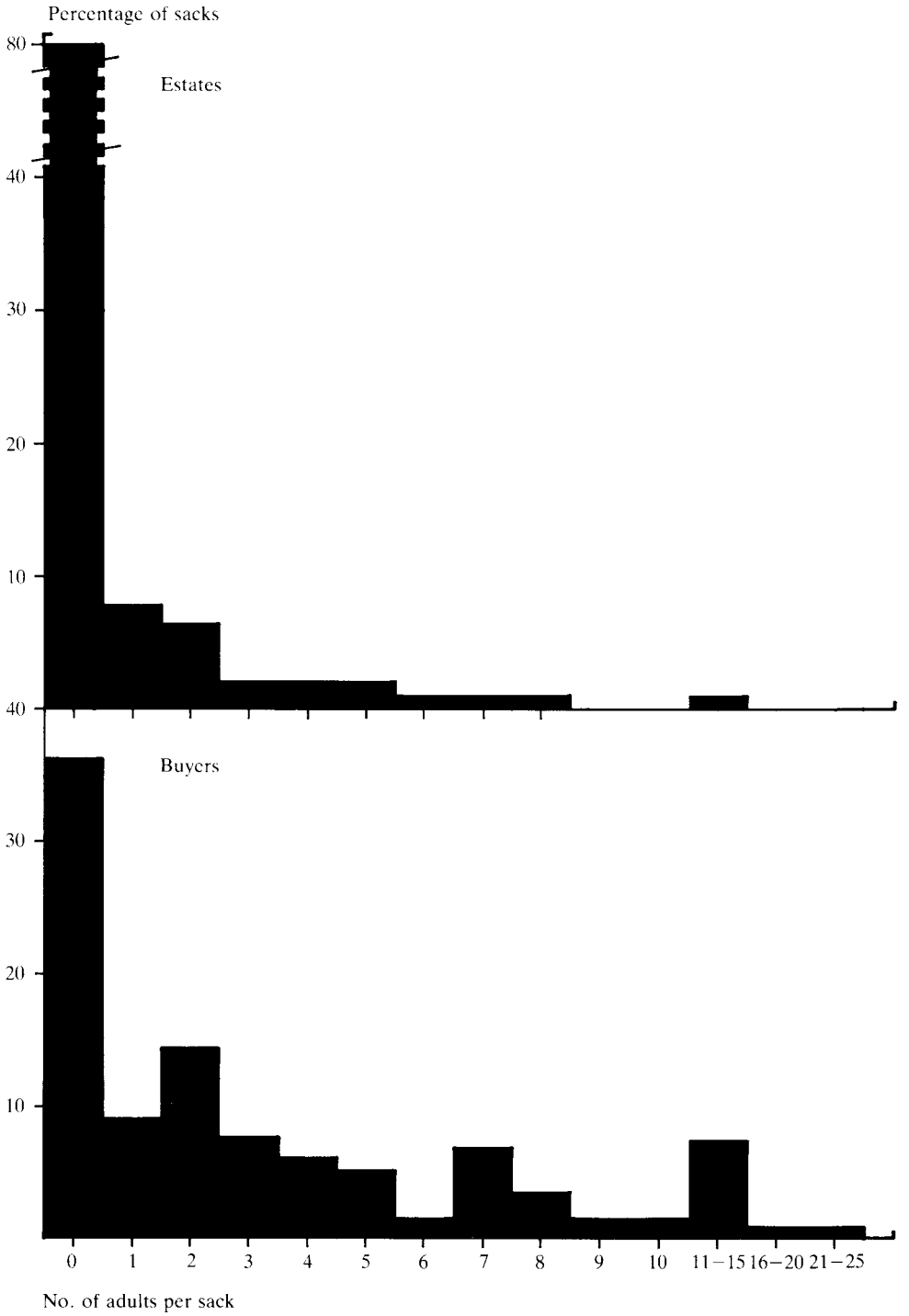

Figure 1. The percentage of sack containing cocoa beans with different number of adult insect population inside them

study also suggested the importance of *C. cephalonica* as a pest of cocoa beans, vis a vis, the cocoa moth, *E. cautella*. This could be due to the greater competitive ability by *C. cephalonica* in warmer regions compared with *E. cautella* (Allotey and Kumar 1985). The nitulid, *Carpophilus dimidiatus* is usually associated with damp areas or in beans which are wet and have high moisture content and therefore present when beans are stored under wet conditions for a long period. The copra beetle, *Necrobia rufipes* was relatively higher in the Johore Bahru samples because in this region a number of major buyers stored beans together with copra. This might have resulted in cross-infestations. It has also been recorded to attack cocoa beans (Lever 1969) although the latter may not be the preferred host.

Although *T. castaneum* and *O. mercator* preponderate in the samples, based on severity of damage on cocoa beans both *L. serricorne* and *C. cephalonica* are relatively important; the former two species are usually surface feeders compared with *L. serricorne* and *C. cephalonica* which cause both quantitative and qualitative loss of the beans. Consequently, *L. serricorne* in Nigeria (Riley 1957) and *C. cephalonica* in Ghana (Allotey and Kumar 1985) have been considered very serious pests of cocoa beans in storage.

There was not much difference in species composition between estate and buyer beans. However, there was numerical difference in the number of insects, with estate beans having low population of insects than buyer beans. This could have arisen due to the relatively better control measures, such as regular fogging of storage areas with insecticides, advocated in the estates compared with that of buyers who generally do not advocate to such measures, except for some irregular cleaning of stores, even under relatively poorer storage conditions. The number of insects per sack was therefore higher (4.5 times) in buyer beans than those in estate beans.

The dispersion pattern of adults in sacks from both sources was highly aggregated, suggesting that most of the insects were found in a few sacks. This finding might have an implication on the current inspection practice of FAMA whereby only 16 sacks are selected randomly from a usual consignment of 160 sacks for preliminary inspection of insects. In any case, this aspect should be investigated further in future.

The reasons for the relatively lower k value for the estate beans than that of the buyer beans are not known although the use of various control measures in the former could result in most of the sacks without any insects inside them.

The observations on residual infestations suggested that the adults appearing during the subsequent sampling of the beans developed from the immatures which were not detected in the earlier samplings. This might have an important implication with regard to grading of beans whereby currently only the adults in a sample are counted during preliminary inspection of cocoa beans. More important, the undetected immatures could cause cross-infestations of shipments or build-up to a level conducive to rejection by importers at the port of entry, especially when adequate control measures are not carried out during freight on board. Residual infestation in the shipholds may become a source of infestation to fresh beans in the importing country. This has been well documented by Monro and Thompson (1929). One way to overcome this problem in the future is to fumigate all beans, irrespective of the number of insects present, before the issuance of the export permit. This would naturally avoid unnecessary problems in deciding whether a consignment should be fumigated,

particularly in certain cases when insect population in each of the 16 sacks do not exceed 10 per sack, but based on their total numbers in 16 sacks could result in serious damage to the beans during freight or incur rejection at the port of entry.

Currently, only a few insect species are considered serious enough to cause damage to cocoa beans. This might be due to the relatively low moisture content of the beans (< 8%) which might not be optimal for the development of many potential pests, and the short storage period (< 1 month). Other things been equal, insects usually thrive well at ca 15% moisture content (Anon. 1984). But, with the potential increase in acreage of cocoa planted in Malaysia and the anticipated longer storage periods, the insect complex and their severity may increase. This is particularly true for the tropics which usually provide a conducive environment for development of most insects. Further studies on the ecology of the insect pests and the conditions under which they thrive should be continued to counter any unnecessary problems resulting from insect infestation on cocoa beans.

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