DOI:36108/NJE/4002/22.0180

NIGERIAN JOURNAL OF ENTOMOLOGY (2004) 21:71-83

Comparative Studies on Insect Pests of Cocoa Beans in Farm and Town Storage Sites and Insecticide Tolerance in the Major Pest, *Corcyra cephalonica* (Stainton)

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(Accepted 01 March, 2004)

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ABSTRACT

A survey was conducted to study the insect pests of dried cocoa beans in farm and town storage sites in Ondo State, South West, Nigeria. Also a glass-vial bioassay was used in estimating tolerance to insecticide in adult *Corcyra cephalonica* (Stainton), the major moth pest found in the storage sites. Laboratory reared *C. cephalonica* were compared with first filial generation of the moths collected from farm and town storage sites in which control with insecticides has been inadequate. Investigations revealed that hygiene practices and storage of cocoa beans improved in the town storage sites than in the farm sites. There were significant differences ($P<0.005$, U-test) in insect populations at both sites. *C. cephalonica* was prominent at the storage sites. *Ahasverus advena* (Walts) was present in the farm sites but absent in the town sites thereby indicating high moisture content in the cocoa beans at the farm level. Mouldiness in cocoa beans was moderate at the farm and town sites in the dry season while there was an increase in the wet season. Significant differences ($P<0.05$) in resistance among adult *C. cephalonica* were found among town, farm and laboratory reared groups using the insecticide, pirimiphosmethyl. Adult moths from the laboratory culture were least tolerant while those from town storage sites were the most tolerant species.

INTRODUCTION

Cocoa, *Theobroma cacao* (Linn) is important as a foreign exchange earner in South-West, Nigeria and some parts of the West African sub-region. The beans are very useful in the production of cocoa beverage, chocolate candies and cocoa butter, which are very rich in proteins, fats, carbohydrates and vitamin B complex (Owolabi, 1972). The Southwestern states have similar ecological factors particularly with respect to climate and vegetation (Ojo, 1977). Cultural practices as regards farming and preservation of agricultural products are the same.

Dry cocoa beans can be stored indefinitely in the temperate countries ut in the tropics, the high temperatures favours the rapid development of stored product pests while the relative humidity which is subject to frequent diurnal changes favours development of moulds (Wood, 1973; Ojo, 1977).

The major insect pest of stored cocoa beans in Nigeria include *Cocyra cephalonica* (Stainton), *Lasioderma serricorne* (F.), *Ahasverus advena* (Walts), *Tribolium castaneum* Herbst, *Ephestia cautella* (Walker) and *Carpophilus* spp. (Cornes and Walker, 1961; Cornes, 1973). Stored product insects generally find the best conditions for development at temperatures between 280C and 300C and humidities between 68 and 80%. Around these perfect conditions, a rapid sequence of generations will lead to mass reproduction.

Monitoring infestation level of cocoa beans in storage sites is not, in itself, a method of pest control. However, detection and survey activities serve as the first step, leading to the application of direct control techniques and therefore are considered essential to the development of any integrated pest management programme (Trivedi et al., 1994). Infested cocoa beans at the farm level are often sold by farmers to unsuspecting cocoa merchants. Subsequently, cocoa processing industries and commercial venture suffer huge monetary losses as a result of damage and contamination caused by insects, mites and microorganisms. The use of organophosphorus insecticides commonly applied to control infestation in cocoa storage is being investigated for insect tolerance. Due to the genetic plasticity of most insect species, differences may be large enough to be of importance (Champ, 1975). So far information is lacking on insect pests infesting cocoa beans in farm and storage sites and level of insecticide tolerance in *C. cephalonica*. This present study brings into focus the insect pests of cocoa in farm and town storage sites and tolerance by *C. cephalonica*, to pirimiphos-methyl, an insecticide used in cocoa storage centers.

MATERIALS AND METHODS

Survey

A survey of dried cocoa beans was conducted in 7 selected farm and town storage sites in Ondo State. Three samples of 500g each were collected from each site. A total of 42 samples were collected on each survey. Samples were collected in labeled polythene bags and taken to the laboratory for analysis. The storage methods used were observed at each site. Visits were made at 4-weekly intervals from August to February during the cocoa season. Insecticides were not applied in the storage sites throughout the survey period.

Population count and Identification

From the samples collected, insect population was assessed as the number of insects present in 500g of sample weight. Identification of insects was done by using the keys provided by Halstead (1963) and Haines (1991). All larvae present were incubated till they emerged as adult. Data was analysed statistically using the Kruskal-Wallis test for pest population. Further grouping was done using the Mann-Whitney, U-test.

Damage and Quality Assessment

Each sample collected was visually examined for damage done by insect and moulds. For each sample, 100 cocoa beans were selected randomly. Insect damage was assessed based on number of holes made by feeding insects. Gradng was done by classifying the damage level into four categories; A – none (no insect hole); B – light (1 – 2 insect holes); C – moderate (3 – 4 insect holes); D – Heavy (5 – 10 insect holes). The degree of insect damage, the Damage Index (DI) was determined using a modification of the method of Shibao et al (1993).

$$DI = 100x\ (B + 3C+6D/6x(A+B+C+D).$$

The presence of mould in the cocoa samples was assessed by splitting each bean longitudinally into two halves using a sharp pen knife and observing each testa for mouldiness. The level of mouldiness was calculated by counting mouldy beans present in 100 cocoa beans randomly picked from the sample.

The moisture content of the samples was estimated using the method of Anon (1975). The free fatty acid (f.f.a.) value was determined by the method of Anon (1970). Total ash of cocoa was determined using the procedure of Anon (1984).

Bioassay Test

Glass vials (50 ml) were treated with pirimiphos methyl dust (Actellic) diluted in acetone in dosages of 0.5 ml, 1.0 ml and 1.5 ml. Each vial was rolled on its side on an electric hot plate until an even layer of the insecticide dried on its inner surface (Plapp and Vinson, 1977). Vials in control treatment received only the equivalent volume of acetone. Adult *C. cephalonica* from a laboratory culture used for the test had been in continuous culture for eight months and were reared and allowed to inbreed without insecticide selection pressure. The first filial generation of moths collected from farm and town storage sites, cultured in the laboratory were used for the test. Adult moths from the three groups were sexed by the method of Haines (1991) and also by using size differences; males were usually smaller than females in newly emerged adults.

Adult moths were tested at the ages of, 1-2, 4-5 and 6-7 days per insecticide dosage. Two sexed moths were placed per treated glass vial in 5 replicates per sex at each age. Since adults do not feed, food was not provided. Cotton ball was used

to seal vial, which was held in upright position. Mortality was determined after 24 hours. In all tests, insecticide was applied to the vial on the same day the test was performed. Tests were carried out at ambient laboratory conditions of 28-300C and humidity of 70-75% r.h. Data were analysed by analysis of variance (ANOVA) and means were separated using a least significant differences test (LSD).

RESULTS

Insect Population

Table 1 shows the mean number of insects found per 500g cocoa beans. In the farm storage sites, insect infestation increased from August to February. A mean number of 4.21 insects per 500g were collected in August while 16.61 insects were collected for February. There was a significant difference ($P<0.005$, U-test) in insect population during the survey period. *Corcyra cephalonica* was the most prominent insect on the farm sites but was absent during the months of August and October. In the town storage sites, there was significant difference ($P<0.005$), U-test) in insect population from August to February of the following year. Infestation was low in October and November with values of 6.20 and 6.81, respectively. *C. cephalonica* was present throughout the survey period in town sites.

Table 1. Population of insects in cocoa beans storage sites surveyed for 7 months.

Month	Farm sites		Town sites	
	*Mean total insects	% *C. cephalonica* (larvae)	*Mean total insects	% *C. cephalonica* (larvae)
August	4.21b	-	20.82a	10.41b
September	4.80b	5.22b	21.42a	8.92b
October	2.64b	-	6.20b	6.31b
November	3.11b	6.81b	6.81b	19.12b
December	14.43a	8.24ab	18.60ab	41.24b
January	13.82a	10.80a	22.32a	61.21a
February	16.61a	15.31a	26.71a	61.15a

Means followed by same letter within a column are not significantly different. ($P<0.005$, Mann Whitney, U-test). *Counts made from 500g cocoa beans (n = 42)

The insects identified from the storage sites are shown in Table 2. In the farm site, *A. advena* featured throughout though not in high percentage as *C. cephalonica* but was absent in town sites. *Tribolium castaneum* and *Cryptolestes ferrugineus* featured only in the town sites and were absent in farm sites. *Ephestia cautella* and *C. cephalonica* were present in samples only in the larval stages.

Table 2: Insect species that infest stored cocoa in Farm and Town storage sites surveyed for 7 months.

Month	Farm sites	Town sites
August	Ahasverus advena (Walts), *Lasioderma serricorne* (Fabricius)	*Ephestia cautella* (Walks), Corcyra cephalonica (Stainton), *Tribolium castaneum* (Herbst), *Crystolestes ferrugineus* (Stephen)
September	*A. advena, E. cautella, C. cephalonica*	*E. cautella, T. castaneum, L. serricorne, C. cephalonica*
October	*E. cautella, A. advena*	*E. cautella, T. castaneum, C. cephalonica*
November	*A. advena, E. cautella, C. cehalonica*	*T. castaneum, E. cautella*
December	*L. serricorne, A. advena, C. cephalonica*	*C. ferrugineus, C. cephalonica*
January	*A. advena, E. cautella, C. cephalonica*	*E. cautella, C. ferrugineus, C. cephalonica*
February	*E. cautella, A. advena*	*E. cautella, C. cephalonica*

Table 3 shows the mean level of infestation of the seven samples. Bangui... of cocoa beans from the farm sites had no evidence of insect... infestation throughout the storage period. In the town sites some samples had heavy infestations in the months of August, September, October and February. The degree of damage, Damage Index, for the infested cocoa beans is shown in Fig. 1. Damage was low for the months of November, December and January in the town sites. The degree of damage in the farm storage sites was generally low throughout the survey period.

Table 3: Damage assessment of infected cocoa beans in Farm and Town Storage sites surveyed for 7 months.

Month	*Mean Level of infection (%)							
	Frm Site				Town sites			
	None A (no holes)	Light B (1-2 holes)	Moderate C (3-4 holes)	Heavy D(5-10 holes)	None A (no holes	Light B (1-2 holes	Moderate C (3-4 holes)	Heavy D 10 holes
August	98.20	0.94	0.86	-	92.26	4.26	2.62	0.86
September	99.16	0.60	0.24	-	92.04	3.48	2.68	1.20
October	99.82	0.18	-	-	96.46	1.86	0.88	0.80
November	99.46	0.32	0.22	-	99.42	0.58	-	-
December	98.71	0.80	-.49	-	99.08	0.92	-	-
January	99.20	0.62	0.18	-	98.02	0.96	0.52	-
February	98.64	0.94	0.42	-	96.18	1.82	1.26	0.74

*Counts made from 100g seeds selected randomly per 500g cocoa beans (n = 42)

Fig 2 shows the percentage variation in mouldiness of cocoa samples from farm and town storage sites. In the months of August and September mouldiness of cocoa was high in the town sites with the highest value of 14.12% in September. In the farm sites, mouldiness was 12.50% in August, 6.25% in September and 4.45% in February.

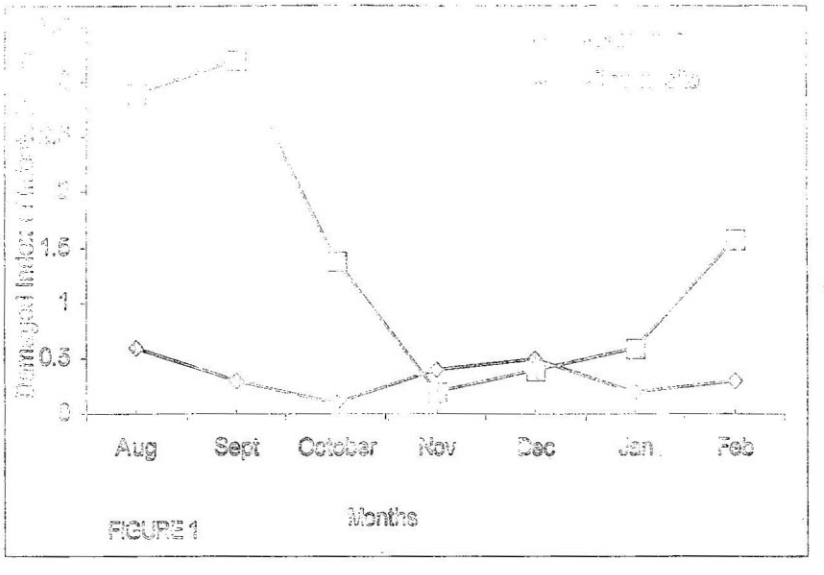

Fig. 1. Comparative Damage Index for infected cocoa beans in Farm and Town Storage sites sampled for 7 months.

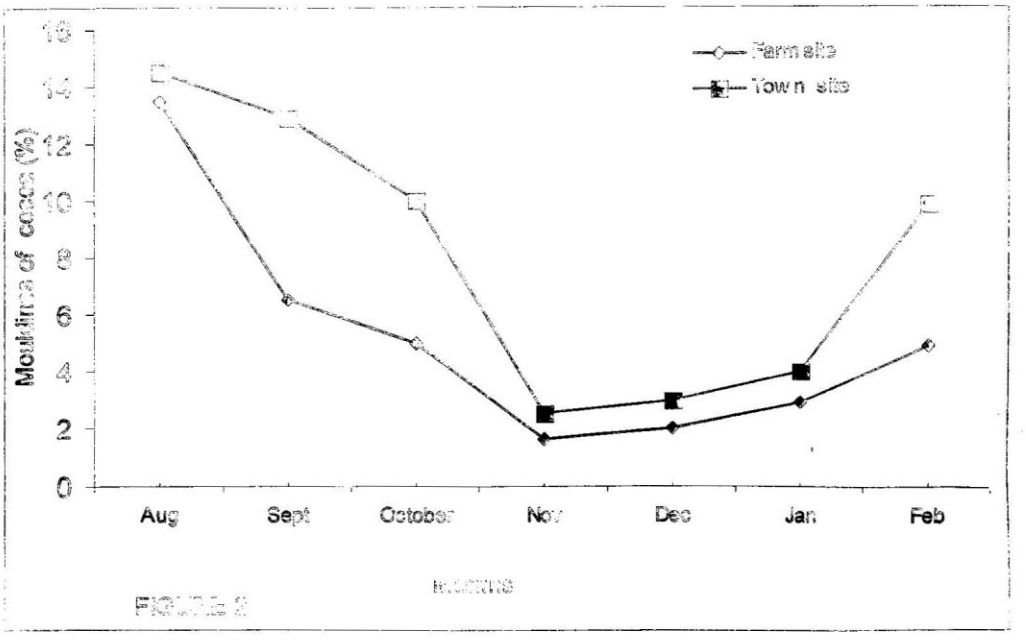

FIGURE 2

Comparative moulding of cocoa beans in Farm and Town Stores after sampled for 7 months

Fig 2 shows variations in the moisture content, fungi counts and the [illegible] of cocoa samples stored for 7 months. Tolerance of [illegible]

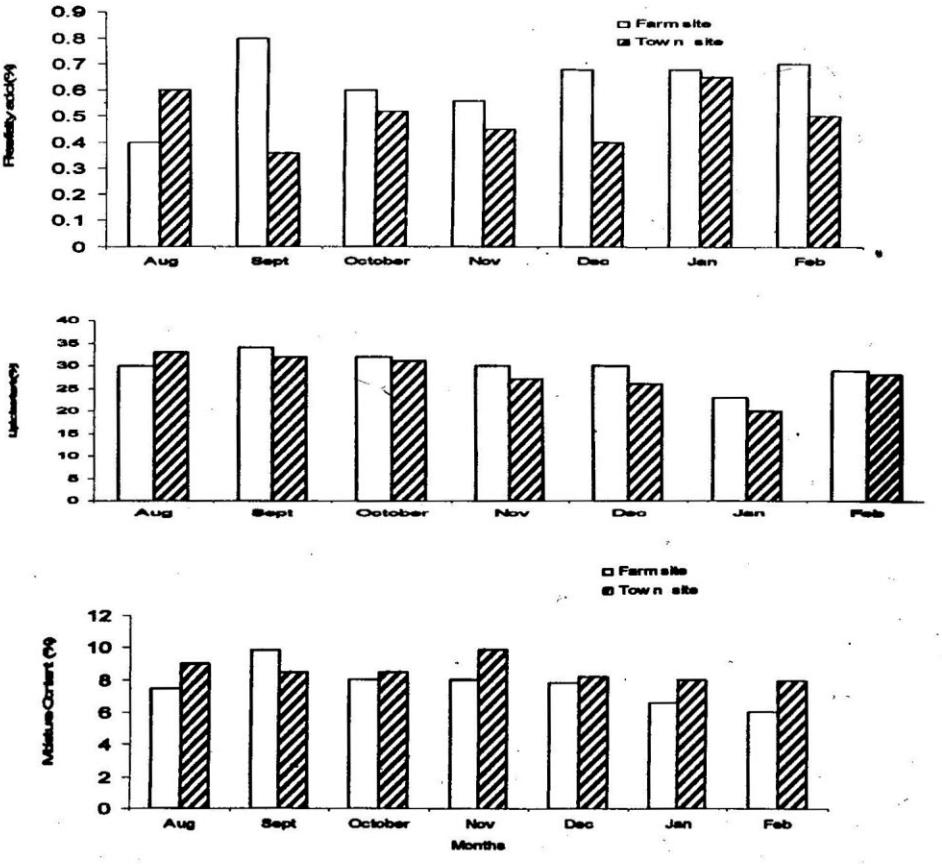

FIGURE 3:

Fig. 3. Variations in the quality parameters of cocoa samples stored in the Farm and Town sites for 7 months.

Insecticide tolerance

There was no significant difference ($P>0.05$) in the tolerance level of adult male and female moths exposed to pirimiphos-methyl (Table 4). However, age of adult moths did significantly influence the results. Adults tested at 6-7d old had significantly ($P<0.05$) higher mortality than those tested when 4-5d or 1-2d. Mortality was low in moths that were 4-5d old. There was also significant difference ($P<0.05$) in susceptibility of adult moths from the 3 group to pirimiphos methyl. Adult moths from the laboratory culture were generally more susceptible to

the insecticide tested than those from the farm and town storage sites. The town storage moths were more tolerant of the insecticide. Mortality in the control, which contained only acetone, was less than 4% and this occurred in the 6-7d old adult moths.

Table 4: Mortality of adult moths in glass vials treated with pirimiphos methyl at different dosages for 24 hours.

Moth culture	Pirimiphos methyl dosage (mls)	Insect age (days	% Mortality*		
			Male	Female	Average
Laboratory	0.5	1-2	61.6a	62.4a	62.0a
		4-5	58.1a	54.6a	56.4a
		6-7	80.8b	78.3b	79.6b
	1.0	1-2	68.2a	67.1a	67.1a
		4-5	62.1a	60.4a	61.3a
		6-7	72.2b	70.3b	71.3b
	1.5	1-2	80.1a	78.4b	79.3b
		4-5	66.2a	64.6a	65.4a
		6-7	86.1b	82.5b	84.3b
Farm site	0.5	1-2	64.2a	63.8a	64.0a
		4-5	60.4a	58.1a	59.3a
		6-7	72.4b	70.2b	71.3b
	1.0	1-2	69.1a	67.6a	68.4
		4-5	64.4a	60.6a	62.5a
		6-7	76.6b	74.8b	75.7b
	1.5	1-2	78.4b	76.2b	77.3b
		4-5	68.1a	66.6a	67.4a
		6-7	81.6b	80.3b	81.0b
Town site	0.5	1-2	58.4a	54.2a	56.3a
		4-5	47.8a	46.6a	47.2a
		6-7	65.7a	62.4a	64.5a
	1.0	1-2	62.2a	60.8a	61.5a
		4-5	58.2a	55.8a	67.0a
		6-7	68.1a	67.8a	68.0a
	1.5	1-2	68.4a	65.1a	66.8a
		4-5	62.2a	60.4a	61.3a
		6-7	72.8b	70.2b	71.0b
Control	1.0 (acetone)	1-2	-	-	-
		4-5	-	-	-
		6-7	3.8	2.6	32.

Means followed by same letter within a column are not significantly different ($P<0.05$).
*Mortality determined after 24 hours of exposure in the vials.

DISCUSSION

Quality deterioration in cocoa beans is related to the storage method and management practice (Owolabi, 1972; Wood, 1973). In the farm sites, dried cocoa beans were stored in baskets and old jute sacks on the floor and close to the walls.

Hygiene practices were very low and the beans are thus subjected to infestation. In town storage sites, cocoa beans are graded, dried before being stacked in stores and warehouses. Although hygiene practices improved over that of farm sites, stacking of the beans provided the required conditions for development of insects when adequate control measures are lacking since the cocoa beans had previous infestation from the farm sites.

C. cephalonica was prominent in both the farm and town storage sites. The low infestation recorded in some months was probably due to addition of new cocoa beans to the old stock. *C. cephalonica* commonly known as the rice moth, infests stored commodities in the tropics (Chittendenm 1919; Ayar, 1934; Rao, 1954). Previous studies carried out in Ghana established the status of *C. cephalonica* as one of the dominant pests in cocoa storage sites (Allotey and Kumar, 1985). Presently the prominence of this moth in cocoa storage sites in Nigeria reveals the spread of the moth in stored cocoa.

The presence of *A. advena* in the farm storage sites denotes high moisture content of the beans [illegible] *T. castaneum* and *C. ferrugineus* [illegible] among [illegible] (1978), highlighted the effect of insect infestation on the quality of cocoa beans. Apart from boring holes into the beans, they also consume the seed cotyledons. *C. cephalonica* and *E. cautella* were found to serve as primary invaders, [illegible] by living off the [illegible] infesting [illegible] [illegible] [illegible]

According to *C. cephalonica* exhibited tolerance to pirimiphos-methyl, the insecticide commonly used in the cocoa storage sites. This is indicated by the increase in the tolerance level of *C. cephalonica* obtained from the town storage site than those from the farm site and laboratory. The adult moths from the town storage sites were least susceptible to the insecticide applications over the years during storage period. This reveals that the changing levels of tolerance in insects exposed to insecticides require measurement as checks of effectiveness of insecticides used in control measures. Champ (1975) observed that regular monitoring of the tolerance status of the major insect pests is a valuable means of early detection of resistance and can provide unequivocal evidence of the contribution of resistance in control failures.

ACKNOWLEDGEMENT

Research fund was partly provided by the University Research Grant (URG-03-94/95) of the Federal University of Technology, Akure, Nigeria. This support is hereby acknowledged with thanks.

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