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Diversity and Abundance of Associated Insect Pests in Stored Dry Cocoa Beans of Southwest Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Cocoa bean is a vital raw material in the production of beverage, animal feed, medicines and cosmetics which had played significant importance in Nigerian revenue prior to oil discovery. Its production has declined due to a number of factors among which are quantitative and qualitative losses by insect pests. Diverse species of insects attack dry cocoa beans in store and their pest status needs to be determined for effective control. This study examined diversity and abundance of emerging insect pests from collected cocoa samples in locations from Southwestern Nigeria. Four cocoa producing states namely Ekiti, Ondo, Osun and Oyo were chosen for this study. Four towns/villages were selected in each state from where1kg of dry cocoa beans each was collected from four cocoa stores/warehouses and bulked to represent the town/village. 750g of the beans was weighed in improvised culture cage in four replicates for each location. The experiment was laid out in a Completely Randomized Design at the Entomology laboratory of CRIN, Ibadan. Emerging insect species were counted, identified and added at thirty days interval for 120days. *Ephestia cautella* and *Corcyra cephalonica* were more abundant in all locations than populations of *Plodia intepuctuella*, *Araecerus fasciculatus* and *Tribolium casteneum*.

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1. INTRODUCTION

The cocoa plant, *Theobroma cacao* Linn formerly in the Sterculiaceae family and now in Malvaceae has demonstrated significant impact on human health, socio economic and ecological landscape of producing countries [1]. The tree is a major cash crop, mainly cultivated for its beans which serve as major raw material in the production of beverage, animal feed, medicines and cosmetics. Cocoa bean is a major source of revenue and foreign exchange earnings for producing countries. Cocoa is widely cultivated in the tropical rain forest and adjoining rain-fed ecology in Nigeria with her first export reported in 1900. In Nigeria, cocoa is a major export crop with revenue of at least 34 billion derived annually from the export of cocoa beans alone, besides revenue from cocoa by-products like butter, cake, liquor and cocoa powder. Nigeria recorded significant increase in production from about 4000 metric tonnes in 1914 to about 80,000 metric tonnes between1913 to 1930. Cocoa then became a major agricultural export crop and a top foreign exchange earner in the 1950s and 60s [2]. Before the discovery of crude oil in commercial quantities in the 1970s, Nigeria was the second largest cocoa producer in the world with annual production of about 270,000MT constituting 18% of world's production by 1965 [3]. Nigeria contributed 11 per cent of the world's 3.5 million tons of cocoa supplied in 2005, [4] but now ranks the fourth largest producing country after Cote d'Ivore, Ghana and Indonesia, with annual production of about 367,000 to 421,300 tonnes in 2013-14 [5].

The sector remained stagnant during the oil boom decade of the 1970s, and this accounted largely for the declining share of its contributions, [6,7].

An inconsistent downward trend has since been recorded, from about 300,000MT per annum to about 55,000MT per annum with average annual growth rate declining from 8.3% during 1992-1996 period to1.8% during the 1997- 2001 period. This downward trend was attributed to factors like rising costs of production, price and government instability, differences in management systems, ageing trees, loss due to reduction of quality and quantity of cocoa beans caused by pests and disease invasion, and drawbacks in applying some agronomic techniques by the farmers [8].

The problem of insect pests in cocoa both on field and store according to [9] cannot be overemphasized. Of about 1500 species of insect pests that attack cocoa on the field, only 2% is of economic importance [10,11]. About 10 significant storage insect pests of cocoa beans had been reported. The pests are: tropical warehouse moth, *Euphestia cautella*, (Walker 1863) (Lepidoptera: Pyralidae).; rice moth, *Corcyra cephalonica* (Stainton 1866) (*Lepidoptera :Galleriidae)* ; red flour beetle, *Tribolium castaneum,* (Herbst 1797) (Coleoptera: Tenebrionidae) ; cigarette beetle *Lasioderma serricorne* (Fabricius 1792) (Coleoptera: Anobiidae); Corn sap beetle, *Carpophilus dimidiatus* (Fabricius 1792)/ *Carpophilus obsoletus (*Erichson 1843) (Coleoptera: Nitidulidae) ; foreign grain beetle, *Ahasverus advena*, (Walti 1832) (Coleoptera: Silvanidae); rusty grain beetle, *Cryptolestes ferrugineus*, (Steph 1831) (Coleoptera: Laemophloeidae) and coffee bean weevil *Araecerus fasciculatus* (De Geer 1775) (Coleoptera: Anthribidae) [12,13,14]. The rich nutritional component of dry cocoa beans predisposes it to attack by many insect pests in the store. The damage caused by these pests to a large extent depends on pest population, temperature of the beans and relative humidity of the store [15]. Other factors include moisture content of the stored beans (<8% mc optimum), susceptibility of the beans to storage pests and presence of alternate hosts [16,17].

Many attempts in the use of synthetic chemicals to control these stored product insect pests had been reported. The challenges now lies with insect pest resistance, food and food product contamination with toxic residues, increased cost of application and handling hazards [18-23].

Research approach aimed at improving cocoa production without considering the identification of associated insect pest of the dry beans at storage level and their abundance in different producing states becomes difficult. Effective control of stored product insect pests depends to a large extent on the knowledge of associated pest and the population pattern over a period of time.

This research determines to know the different species of insect pests that are associated with

cocoa beans samples collected at different locations of cocoa producing states of the South west Nigeria and their abundance over a period of one hundred and twenty days of storage.

2. MATERIALS AND METHODS

2.1 Study Area

Four major cocoa producing states of South-western Nigeria were selected for this study namely Oyo, Osun, Ondo and Ekiti. Four major cocoa producing towns and or villages with stores/warehouses were selected in each of the four cocoa producing states. Also four main stores/warehouses were randomly chosen from each town.

2.2 Experimental Design

The experiment was laid out in a completely randomized design in the laboratory of the Entomology section of Cocoa Research Institute of Nigeria (CRIN), Ibadan, Oyo state.

A kilogram of dried cocoa beans was collected from four different stores/warehouses in each town/village and bulked into total of 4 kg representing collection per town and or village. The bulked samples were brought to laboratory for culture and evaluation. 750g of collected bean was weighed (using China's CAMRY scale, model Z 209278) from each cocoa bean sample and put in an improvised plastic culture cages in four replicates for each town and or village. Emerging insects from each of the collected bean samples were collected on weekly basis and the total for thirty days was done for a period of a hundred and twenty days.

Total number of individual insect species associated with cocoa beans from all locations was analyzed using ANOVA with the aid of SAS version 9.1 software packages and the means were separated using Duncan Multiple Range Test (DMRT).

Percentage abundance was calculated as=
(No of individual specie / Total number of all species) X 100 %

3. RESULTS

Table 1 shows the species diversity and percentage abundance of adult emergent at thirty days intervals for a period of one hundred and twenty days of storage of collected cocoa beans sample from Ondo state. Only two taxas, namely *E. cautella* and *C. cephalonica* emerged from the four locations in Ondo state both of which are lepidopterans. At thirty days of storage, no emergence of both species was recorded from all locations except from Ondo town where a mean of 1.50a of *E. cautella* emerged. At sixty days however, there was no significant difference (P≤ 0.05) in mean emergence of both *E. cautella* and *C. cephalonica* across all locations. Mean emergence of *E. cautella* was 5.75a in collected samples from Ile-oluji while it was not significantly (P≤0.05) low in Owena and Ondo town with 0.50a and 1.00a respectively and sample from Oka-akoko recorded zero emergent. Similarly, 10.50a mean emergent of *C. cephalonica* was recorded from sample collected from ile-oluji, while 0.50a and 0.25a were recorded from cocoa beans from Owena and Oka-akoko respectively. Zero emergent of *C.cephalonica* was recorded in Ondo town collection. A hundred Percentage abundance of *E. cautella* was recorded in sample from Ondo town, while 50.00 and 35.39% were recorded in samples from Owena and Ile-oluji respectively.

At ninety days Ile-oluji dry cocoa beans sample recorded higher mean emergent of *E.cautella* of 26.75a though not significantly higher than Oka-akoko with 12.75ab while it was significantly higher (P≤0.05) than those of Ondo town with 5.00b and Owena with 2.50b. There was no significant difference (P≤0.05) in mean emergent of *C. cephalonica* in all locations at ninety days, though higher mean emergent of *C.cephalonica* of 27.75a was recorded in sample collected from Ile-oluji and 16.75a from Oka-akoko while 4.00a and 1.00a were recorded in samples from Owena and Ondo respectively. Percentage abundance of *E.cautella* was 83.33 in Ondo, 49.08 in Ile-oluji, 43.33 in Oka-akoko and 38.46 in Owena. *C. cephalonica* recorded high percentage abundance of 61.54 in Owena sample, 56.78 in Oka-akoko, and 50.92 in Ile-oluji.

At one hundred and twenty days, Ile-oluji recorded 25.25a mean emergent of *E.cautella*, oka-akoko had 14.50ab, Ondo town had 3.50b and Owena had 2.50b. Mean emergent *of C.cephalonica* in Ile-oluji was 69.25a,while Oka-akoko recorded 35.25ab, Owena had 4.00b and Ondo town had 2.75b. Higher Percentage abundance of 56.00 *E.cautella* was recorded in Ondo town, while Owena, Oka-akoko and Ile-oluji recorded 38.46, 29.15, and 26.72 respectively. *C.cephalonica* had high percentage abundance of 73.28 in sample from Ile-oluji, 70.85 in Oka-akoko, 61.54 in Owena and as low as 44.00 in Ondo sample.

Table 2 shows the number of insect species that emerged from dry cocoa bean samples collected from locations in Ekiti state at thirty days intervals over a period of one hundred and twenty days. Varying numbers of taxa emerged from the four locations while a total number of 5 taxa were recorded in the state.

At thirty days, *E. cautella* emerged only from the dry cocoa sample collected from Igede with mean number of 0.50a and percentage abundance of 66.67. Also, *C. cephalonica* emerged from Igede and Aramoko samples only, both with 0.25a mean abundance each, with 33.33 and 100 percentage abundance respectively. *P. interpunctella* emerged from Ado cocoa sample only, at 30 days with mean number of 1.75a and 100.00 percent abundance. At sixty days after storage, Oode sample recorded mean number of 8.75a *E. cautella* emergent with percentage abundance of 45. 45, Aramoko recorded 6.25ab with 59.52 percentage abundance, Ado had mean number of 5.50ab and 53.66 percentage abundance with a low mean number of 2.00b and percentage abundance of 27.59 from Igede sample. *P. interpunctella* emerged from Ado and Oode samples at sixty days. Ado sample recorded mean number of 2.75a and percentage abundance of 26.83 while 0.25a mean number and percentage abundance of 1.30 were recorded in Oode sample.

At ninety days there was no significant difference (P≤ 0.05) in the mean number of *E. cautella* emergent from all locations, percentage abundance was however high in Ado sample, with 59.34 and as low as 15.65 in Aramoko sample. The mean emergent of *C. cephalonica* in Aramoko sample was 24.00a which was significantly higher than 1.50b obtained in Igede sample, but not significantly different (P≤ 0.05) from 12.00ab and 8.00ab emergent from Oode and Ado samples respectively. Percentage abundance was also high in Aramoko sample with 83.48 while Igede had 54.55, Oode and Ado had 48.98 and 35.16 respectively. Emergent of *P. interpunctella* was 2.50a in Oode sample, 1.00a in Ado sample, and 0.25ab in Aramoko sample. Percentage abundance was however low across the locations, 10.20 in Oode, 4.40 in Ado and 0.87 in Aramoko. Emergent of *A. fasciculatus* were found in all locations except Aramoko at ninety days of storage. While both Igede and Ado samples recorded 0.25b mean, Oode sample recorded significantly high (P≤ 0.05) mean number which is 3.00a.Percentage abundance was 12.25 in Oode which is relatively higher than 1.10 obtained from Ado and 9.09 from Igede sample.

At a hundred and twenty days of storage, mean number of *E.cautella* emergent from all locations were not significantly different (P≤ 0.05). Oode sample recorded 15.50a, Aramoko had 12.00a, Ado recorded 8.00a,Igede had 6.75.Percentage abundance was 59.26 in Ado, 56.25 in Igede both of which are higher than that obtained from Oode which is 22.06 and Aramoko with 18.39. Significantly higher (P≤ 0.05) mean number of *C.cephalonica* emerged from Aramoko sample with 52.75a and 39.50a in Oode sample while 5.00b was recorded from Ado and 4.75 from Igede samples. Percentage abundance was also high at Aramoko with 80.84 and in Oode sample with 56.23 compared with 39.58 and 37.04 from Ado and Igede samples respectively. Mean number of *P.interpunctella* emergent from Oode sample was 4.75a and 0.50ab each from Ado and Aramoko samples. Percentage abundance was however low in all locations, 6.76 in Oode 3.70 in Ado and 0.77 in Aramoko. Mean number of 8.00a emergent of *A.fasciculatus* was recorded from Oode sample while 0.50ab emerged from Igede sample, while percentage abundance was 11.39 from former and 4.17 from the latter. Emergent of *T.castaneum* was found only in Oode sample with mean number of 2.50a and percentage abundance of 3.56.

Table 3 shows the numbers of insect species that emerged from dry cocoa bean samples collected from locations in Osun state at thirty days intervals over a period of one hundred and twenty days. Total number of two taxa emerged from the four locations in the state which are lepidopterans - *Euphestia cautella* and *Corcyra cephalonica*. At thirty days, emergent of *E. cautella* was found only from dry cocoa sample collected from Ipetu with a mean number of 0.25a and percentage abundance of 100. Similarly *C. cephalonica* emergent was found in Ilesa sample only, with mean number of 0.25a and 100 % abundance.

At sixty days however, neither of the two species emerged from the four locations in Osun state. At ninety days, *E. cautella* emerged only from Iwo sample with a mean number of 1.75a and 87.50 % abundance. However, emergent of *C. cephalonica* was found in Ife sample with mean number of 0.25a and 100 percent abundance; in Ilesa with 0.75a mean number and 75.00% abundance; in Ipetu sample with 1.00a mean number and 100 percent abundance; and in Iwo

sample with mean number of 0.25a and 12.5 % abundance.

At a hundred and twenty days of storage, 7.50a mean emergent of *E.cautella* were found in Iwo samples with 50% abundance, 3.25ab mean emergent in Ipetu sample with 72.22% abundance, 1.00ab mean emergent in Ilesa sample with 30.77 % abundance and 0.50ab mean emergent in Ife sample with 50% abundance. Emergent of *C. cephalonica* were found in Iwo sample with mean number of 7.50a and 50% abundance while in Ilesa a mean number of 2.25ab and 69.23% abundance recorded. Ipetu sample recorded a mean number of 1.25b and 27.78% abundance of C. *cephalonica* and Ife sample recorded 0.50b mean number and 50% abundance of the specie.

Table 4 shows the mean number of insect species that emerged from dry cocoa bean samples from four locations in Oyo state and their percentage abundance. Varying number of taxa emerged from different locations with a total number of 5 taxa from the entire state, three of which are lepidopteran - *Euphestia cautella*, *Corcyra cephalonica* and *Plodia interpunctella*, the remaining two being coleopteran which are *Tribolium castaeneum* and *Araecerus fasciculatus*.

Over the whole one hundred days of storage, no insect species emerged on dry cocoa bean sample from Idi-ayunre. At thirty days, only sample from one location recorded emergent of only one insect species which was 0.50a mean number of *C.cephalonica* emergent in Igbo-ora sample with 100% abundance.

At sixty days, emergent of *E.cautella* was significantly higher (P≤0.05) in Igbo-ora sample than the other two locations with a mean of 19.50a and 30.47% abundance, while Oyo/Ilora sample recorded mean number of 7.50b and 68.18% abundance; Omi-adio sample recorded mean number of 3.50bc and 33.33% abundance. Also emergent of *C. cephalonica* was significantly higher (P≤0.05) in sample collected from Igbo-ora than other locations. While *C. cephalonica* mean emergent was 44.25a and 69.14% abundance in Igbo-ora, mean number was 7.00b in Omi-adio with 66.67% abundance, and in Oyo/Ilora 3.50b mean number and 31.82% abundance. Mean emergent of 0.25a *T.castaneum* was also found in Igbo-ora sample with 0.39% abundance.

At ninety days, mean emergent of *E.cautella* was 18.75a with 23.96% abundance in Igbo-ora sample, Omi-adio recorded 3.75ab mean emergent with 34.88% abundance, and Oyo/Ilora sample also recorded 3.75ab but 20.27% abundance. In a similar vein, Igbo-ora sample recorded significantly higher (P≤0.05), mean number of 58.75a emergent of *C. cephalonica* with 75.08% abundance while Oyo/Ilora recorded mean emergent of 13.25b and 71.62% and Omi-adio sample recorded mean emergent of 6.75b with 62.79% abundance. Few numbers of *A. fasciculatus* were recorded in Oyo/Ilora sample with mean number of 1.00a and 5.40% abundance, while Igbo-ora sample had 0.50a mean number and 0.64% abundance; and Omi-adio had 0.25a mean number with 2.33% abundance. Emergent of *P. interpunctella* was found in sample from Oyo/Ilora only with a mean number of 0.25a and 0.32% abundance.

At one hundred and twenty days, *E. cautella* emergent from Igbo-ora sample was significantly higher (P≤0.05) than Oyo/ Ilora and Omi-adio samples, while Igbo-ora sample recorded mean number of 38.50a with 17.19% abundance, Oyo/Ilora sample had 10.75b mean number and 23.12% abundance; and Omi-adio had 8.00b mean number and 21.77% abundance.

Similarly, *C. cephalonica* recorded significantly higher (P≤0.05) mean number of 184.00a emergent in Igbo-ora sample with 81.96% abundance unlike 34.50b mean number recorded in Oyo/Ilora sample with 74.19% abundance and 28.75b mean number recorded in Omi-adio sample with 78.23% abundance. Igbo-ora sample recorded 1.50a mean number of *A.fasciculatus* emergent with 0.67% abundance while Oyo/Ilora had mean number of 1.00a and 2.15% abundance. *T.castaneum* emergent was found only in Oyo/Ilora sample with a mean of 0.25a and 0.54% abundance.

From Fig. 1, the population of *Corcyra cephalonica* and *Euphestia cautella* was higher in ile-oluji than the other three locations. Order of abundance of *C. cephalonica* in Ondo state is Ile-oluji > Oka-akoko > Owena > Ondo town while the order for *E. cautella* is Ile-oluji > Ondo town >Oka-akoko > Owena.

Fig. 2 shows that higher population of both insect species that is *E. cautella* and *C. cephalonica* emerged from cocoa beans sample collected from Iwo than the three other locations in Osun state. Order of abundance of *E. cautella* in the state is Iwo > Ipetu > Ilesa > Ife and that of *C. cephalonica* is Iwo > Ilesa > Ipetu > Ife.

Table 1. Mean number and percentage abundance of insect in cocoa samples from Ondo state

Location / Specie	Number in ≤30days	% ABD	Number in ≤60days	% ABD	Number in ≤90days	% ABD	Number in ≤120days	% ABD	Taxa
Owena									
E.cautella	0.00b	0.00	0.50a	50.00	2.50b	38.46	2.50b	38.46	
C.cephalonica	0.00a	0.00	0.50a	50.00	4.00a	61.54	4.00b	61.54	2
Oka-akoko									
E.cautella	0.00b	0.00	0.00a	0.00	12.75ab	43.22	14.50ab	29.15	
C.cephalonica	0.00a	0.00	0.25a	100.00	16.75a	56.78	35.25ab	70.85	2
Ile-oluji									
E.cautella	0.00b	0.00	5.75a	35.39	26.75a	49.08	25.25a	26.72	
C.cephalonica	0.00a	0.00	10.50a	64.61	27.75a	50.92	69.25a	73.28	2
Ondo town									
E.cautella	1.50a	100.00	1.00a	100.00	5.00b	83.33	3.50b	56.00	
C.cephalonica	0.00a	0.00	0.00a	0.00	1.00a	16.67	2.75b	44.00	2

Means with the same letters are not significantly different (P≤ 0.05) for same insect species at same duration. % ABD – Percentage Abundance

Table 2. Mean number and percentage abundance of insect in samples from Ekiti state

Location / Specie	Number in ≤30days	% ABD	Number in ≤60days	% ABD	Number in ≤90days	% ABD	Number in ≤120days	% ABD	Taxa
Aramoko									
E.cautella	0.00a	0.00	6.25ab	59.52	4.50a	15.65	12.00a	18.39	
C.cephalonica	0.25a	100.00	4.25b	40.48	24.00a	83.48	52.75a	80.84	
P.interpunctella	0.00a	0.00	0.00a	0.00	0.25ab	0.87	0.50ab	0.77	3
Igede									
E.cautella	0.50a	66.67	2.00b	27.59	1.00a	36.36	6.75a	56.25	
C.cephalonica	0.25a	33.33	5.25ab	72.41	1.50b	54.55	4.75b	39.58	
A. fasciculatus	0.00a	0.00	0.00a	0.00	0.25b	9.09	0.50a	4.17	3
Ado									
E.cautella	0.00a	0.00	5.50ab	53.66	13.50a	59.34	8.00a	59.26	

Location / Specie	Number in ≤30days	% ABD	Number in ≤60days	% ABD	Number in ≤90days	% ABD	Number in ≤120days	% ABD	Taxa
C.cephalonica	0.00a	0.00	2.00b	19.51	8.00ab	35.16	5.00b	37.04	
P.interpunctella	1.75a	100.00	2.75a	26.83	1.00ab	4.40	0.50ab	3.70	
A. fasciculatus	0.00a	0.00	0.00a	0.00	0.25b	1.10	0.00a	0.00	4
Oode									
E.cautella	0.00a	0.00	8.75a	45.45	7.00a	28.57	15.50a	22.06	
C.cephalonica	0.00a	0.00	10.25a	53.25	12.00ab	48.98	39.50a	56.23	
P.interpunctella	0.00a	0.00	0.25a	1.30	2.50a	10.20	4.75a	6.76	
A. fasciculatus	0.00a	0.00	0.00a	0.00	3.00a	12.25	8.00a	11.39	
T.casteneum	0.00a	0.00	0.00a	0.00	0.00a	0.00	2.50a	3.56	5

Means with the same letters are not significantly different (P≤ 0.05) for same insect species at same duration. % ABD – Percentage Abundance

Table 3. Mean number and percentage abundance of insect in samples from Osun state

Location / Specie	Number in ≤30days	% ABD	Number in ≤60days	% ABD	Number in ≤90days	% ABD	Number in ≤120days	% ABD	Taxa
Ile-ife									
E.cautella	0.00a	0.00	0.00a	0.00	0.00a	0.00	0.50b	50.00	
C.cephalonica	0.00a	0.00	0.00a	0.00	0.25a	100.00	0.50b	50.00	2
Ilesa									
E.cautella	0.00a	0.00	0.00a	0.00	0.25a	25.00	1.00b	30.77	
C.cephalonica	0.25a	100.00	0.00a	0.00	0.75a	75.00	2.25ab	69.23	2
Ipetu									
E.cautella	0.25a	100.00	0.00a	0.00	0.00a	0.00	3.25ab	72.22	
C.cephalonica	0.00a	0.00	0.00a	0.00	1.00a	100.00	1.25b	27.78	2
Iwo									
E.cautella	0.00a	0.00	0.00a	0.00	1.75a	87.50	7.50a	50.00	
C.cephalonica	0.00a	0.00	0.00a	0.00	0.25a	12.50	7.50a	50.00	2

Means with the same letters are not significantly different (P≤ 0.05) for same insect species at same duration. % ABD – Percentage Abundance

Table 4. Mean number and percentage abundance of insect in samples from Ekiti state

Location / Specie	Number in ≤30days	% ABD	Number in ≤60days	% ABD	Number in ≤90days	% ABD	Number in ≤120days	% ABD	Taxa
Omi-adio									
E.cautella	0.00b	0.00	3.50bc	33.33	3.75ab	34.88	8.00b	21.77	
C.cephalonica	0.00b	0.00	7.00b	66.67	6.75b	62.79	28.75b	78.23	
A. fasciculatus	0.00a	0.00	0.00a	0.00	0.25a	2.33	0.00a	0.00	3
Igbo-ora									
E.cautella	0.00b	0.00	19.50a	30.47	18.75a	23.96	38.50a	17.19	
C.cephalonica	0.50a	100.00	44.25a	69.14	58.75a	75.08	184.00a	81.96	
T.casteneum	0.00a	0.00	0.25a	0.39	0.00b	0.00	0.00b	0.00	
A. fasciculatus	0.00a	0.00	0.00a	0.00	0.50a	0.64	1.50a	0.67	5
P.interpunctella	0.00a	0.00	0.00a	0.00	0.25a	0.32	0.50a	0.22	
Oyo/Ilora									
E.cautella	0.00b	0.00	7.50b	68.18	3.75ab	20.27	10.75b	23.12	
C.cephalonica	0.00b	0.00	3.50b	31.82	13.25b	71.62	34.50b	74.19	
T.casteneum	0.00a	0.00	0.00a	0.00	0.50a	2.70	0.25a	0.54	
A. fasciculatus	0.00a	0.00	0.00a	0.00	1.00a	5.41	1.00a	2.15	4

Means with the same letters are not significantly different (P≤ 0.05) for same insect species at same duration. % ABD – Percentage Abundance

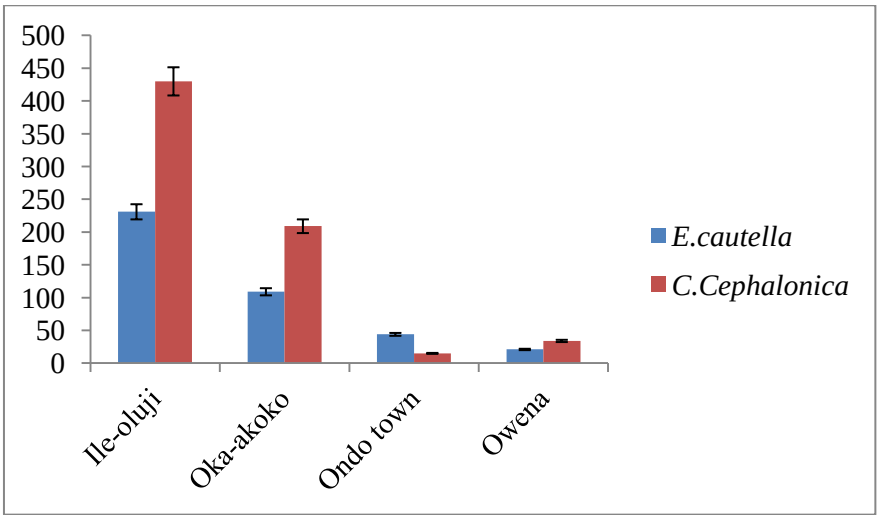

Fig. 1. Diversity of insect species associated with cocoa beans sample from Ondo state at one hundred and twenty days

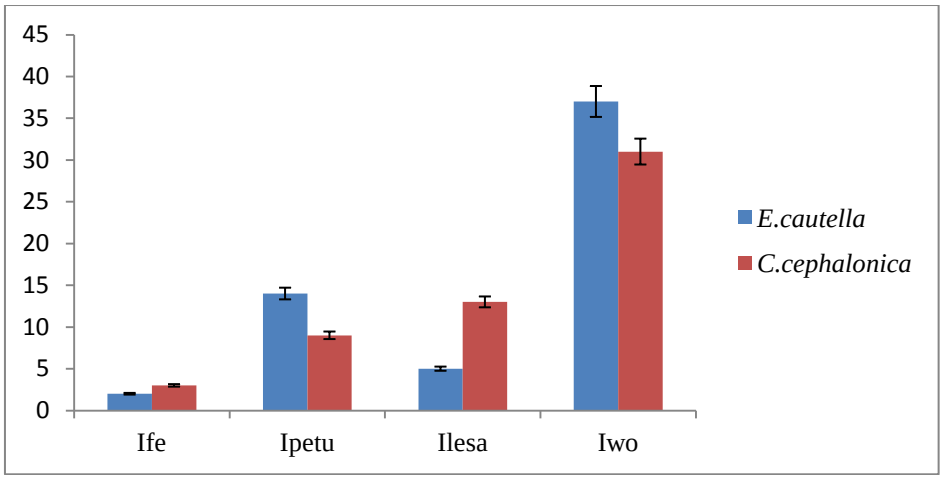

Fig. 2. Diversity of insect species associated with cocoa beans sample from Osun state at one hundred and twenty days

Fig. 3 shows that more insect species emerged from Ekiti state. Higher population of *C.cephalonica* emerged from cocoa beans sample collected from Aramoko while higher population of other insect species emerged from Oode sample. Order of abundance of *E.cautella* is Oode>Ado>Aramoko.Igede. Order of abundance for *C. cephalonica* is Oode>Aramoko>Ado>Igede. Order of abundance for *A. fasciculatus* is Oode>Ado>Igede while *T.castaneum* emerged from Oode sample only.

Fig. 4 shows high emergence of *E. cautella* and *C.cephalonica* in Igbo-ora cocoa sample than Oyo/Ilora and Omi-Adio samples. Negligible number of *P.interpunctella* emerged from Igbo-ora and so are *T.castaneum* and *A.fasciculatus* from Oyo/Ilora.

4. DISCUSSION

Findings of this study showed that five taxa of insect were prominent in the study area, three lepidopterans and two coleopterans. The lepidopterans were *Euphestia cautella*, Walker (tropical warehouse moth), *Cocyra cephalonica*,Stainton (rice moth) and *Plodia interpunctella*, Hubner (indian meal moth). The two coleopterans were *Araecerus fasciculatus* De Geer, (coffee bean weevil) and *Tribolium castaneum,* Herbst (red flour beetle). Of the lepidopteran, *E.cautella* and *C.cephalonica* were more abundant in many of the cocoa sample while *P. interpunctella* was less abundant even in

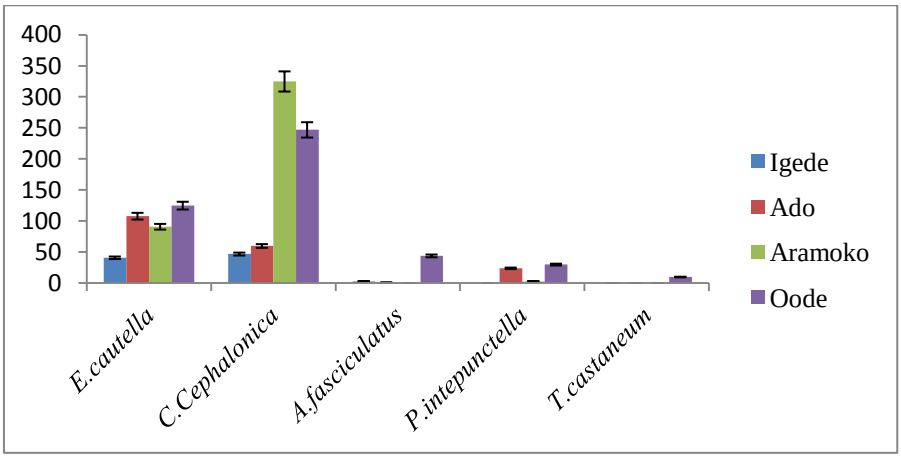

Fig. 3. Diversity of insect species associated with cocoa beans sample from Ekiti state at one hundred and twenty days

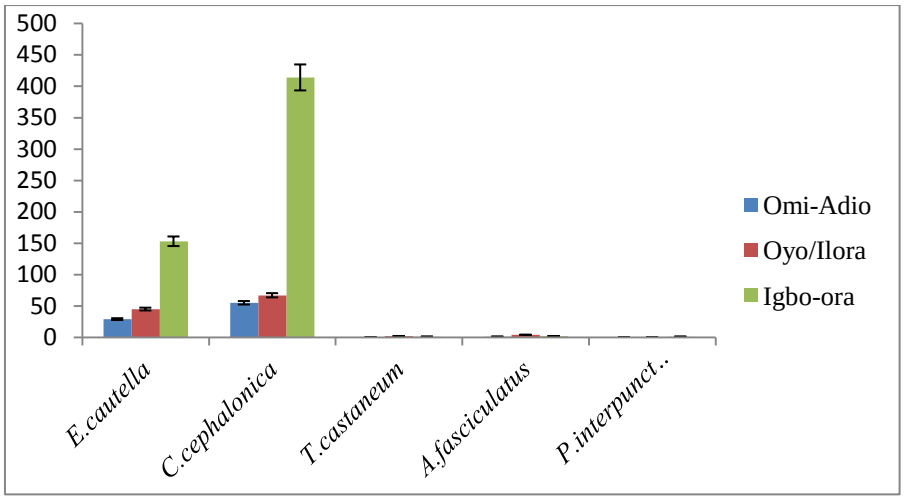

Fig. 4. Diversity of insect species associated with stored cocoa bean sample from Oyo State at one hundred and twenty days

few cocoa samples. This resonates with the findings of [14] that *E.cautella* had high fecundity in dry cocoa bean. [24] reported *C.cephalonica* as the most important pest of stored cocoa beans in Ghana as it was more abundant than the cocoa moth *E. cautella*. Larvae of these moths have been reported to feed extensively on the beans and cause critical damage by webbing of the beans.

The result of this study also revealed that the coleopterans, *A.fasciculatus* and *T.castaneum* had low abundance, also in few areas. Authors have reported *T.castaneum* and *A.fasciculatus* as important pests of cocoa beans in storage [12]. Oyedokun, [13] identified *C. cephalonica, E. cautella, T. castaneum* and *L. serricorne* as major storage insect pests in dry cocoa bean in a declining order of abundance in Osun state of Nigeria.

5. CONCLUSION

A study on the population of *Euphestia cautella* and *Corcyra cephalonica* that could result to economic damage is necessary due to the high abundance of both species recorded in most of the study area. An Integrated Pest Management (IPM) method needs to be developed to control the larvae of the two moths, since this is the stage of growth during which maximum damage is done to cocoa beans through extensive feeding on them and webbing as they metamorphose into pupa.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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