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Species compositions and relative abundance of insect pests associated with stored dried cassava chips in selected markets in Oyo state, Nigeria

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Abstract
Field survey was conducted in four purposively selected markets; Bodija, Oja-Agbe, Sango and Sabo in Oyo state based on the availability of dried cassava chips (DCC) between April 2016 and March, 2017. Four stores were selected within a market for monthly sampling for insect pest species. 4kg DCC were sampled from the stock in each stores for occurrence and insect pest's determination. Relative abundance in percentage of occurred insect pest species were determined. Data collected were analysed using descriptive statistics. A total of 11174 identified coleopteran insect pest species belonging to Five (5) families; Bostrichidae, Curculionidae, Trogossitidae, Tenebrionidae and Laemophidae grouped into seven species were obtained. The species relative abundance in percentage in decreasing order are: *Prostephanus truncatus (Horn*) 39.61%, *Dinoderus species 25.95%*, *Ryzopertha dominica 24.11%*, *Sitophilus species* 3.62%, *Tenebroides species 0.22%; Tribolium species* 5.82%, *Cryptolestes* species 0.67%. The result also indicates species abundance were more prevalent is Oja-Agbe than other markets investigated. Result also showed that highest abundance of insect pest species was observed in rainy season (85.20%) compared to dry season (14.80%). This study has showed that stored dried cassava chips in, markets are not immune to insect pest infestation with infestation occurring all year round.

Keywords: dried cassava chips, insect species, markets, Oyo state

1. Introduction
Cassava is a staple sustenance crop in Africa, produce in substantial amount by worker and business agriculturists. Nigeria is ranked the largest world producer [1] because it produces around 54 metric tons more than a third of African production [2]. Cassava production is crucial to the economy of Nigeria because it serves as a cheap source of edible carbohydrate and other uses. In Nigeria, cassava is produced in 24 of the country's 36 states, its production rules the southern part of the country, both in terms of area covered and number of farmers growing the crop [3]. The major states of Nigeria which produce cassava are Anambra, Edo, Delta, Benue, Cross River, Imo, Oyo, and Rivers, and to a lesser degree Kwara and Ondo [4]. There are more than 40 cassava varieties in use, which shows a remarkable capacity to adjust to environmental change [Consultative Group On International Agriculture Research [5], with a tolerance to low soil fertility, resistance to drought conditions, pests and diseases, and suitability to store its roots for long periods underground even after they mature [6]. Cassava roots are highly perishable, So, to keep new roots away from decay and wastage, they are changed over to dried chips. The procedure of transformation into chips, trailed by drying and capacity for extensive stretches until needed, opens them to attack by stored insects pests, consequently debilitating sustenance security in Sub-Saharan Africa. Nevertheless, stored product pests are the major post-harvest pest both at the agriculturists' and purchasers' levels in the tropics [7, 8]. The sort of insect pest observed on stored product relies on the commodity, they also depend on their olfactory frameworks to locate their ideal or good sustenance rather than visual signals. Therefore, the purpose of this study, was to survey insect pests species associated with stored dried cassava chips in southwestern Nigeria.

2. Materials and Method
Study Area
The Study was carried out in Oyo state, south western Nigeria, with latitude 8.12° N and longitudes 3.42° E between April, 2006 and March, 2017. The state has an area of 28,454 square kilometers, bounded on the West by Republic of Benin, on the North by Kwara State, on the East by Osun State and on the South by Ogun State. The Climate is equatorial, notably with dry and wet seasons with relatively high humidity. The dry season lasts from November to March while the wet season starts from April and ends in October. Average daily temperature ranges between 25°C and 35°C almost throughout the year. Based on the prevailing climatic and soil characteristics, three vegetation zones are identifiable in the State: forest, savannah and the derived savannah. Agriculture is the main occupation of the people of Oyo State. Its climate favours the cultivation of crops like cassava maize, yam, millet, rice, plantains, cocoa, palm produce, cashew.

Survey of Insect pest on Stored Dried Cassava Chips
Market survey of insect pests in stored dried cassava chips was conducted for one year spanning between April 2016 and March, 2017, to ascertain relative abundance and current pest status. Four markets namely; Bodija, Sabo, Oja-agbe and Sango from Ibadan, Oyo town, Iseyin and Saki in Oyo state

respectively were chosen based on the availability of the products in the markets (Fig 1). Bodija Market is located in a district in Ibadan North local government between latitude 7° 26'. 18" N and longitude 3° 54'. 98" E.; Sabo Market is located in Oyo North, Oyo town between latitude 7° 52'. 67" N and 3° 56'. 68" E; Oja- Agbe market is located in Iseyin Local government area with latitude 7° 58'. 18" N and Longitude 3° 34'. 11" E and Sango market located in Saki west local government with latitude 8° 40'. 70" N and longitude 3° 23'. 60" E.

Sampling Protocols

1kg dried cassava chips were collected monthly from 4 different stores within a market. Thereafter, samples were pooled together to make a composite sample of 4kg per location, these were taken to Entomology Laboratory, Department of Zoology, University of Ibadan (7.44° N, 3.89° E) for analysis. Collected dried chips were split into pieces and sieve using 0.55mm mesh size into a white tray for easy recognition and identification of stored insect pest species. All adult insect pest species found were collected, kept in 70% alcohol, properly identified and counted under microscope using the identification keys of [9]. Thereafter, relative abundance (main variable for assessing insect infestation) was calculated using the method of [10]. This is expressed by the following formula:

$$\text{Relative Abundance} = \frac{\text{Number of insect pest species}}{\text{Total to number of insect pests species}} \text{ X } 100$$

Data Analysis

Data obtained were subjected to descriptive statistics; (mean and simple percentage).

3. Results

A total of 11,174 stored insect pest species belonging to 5 families; Bostrichidae, Curculionidae, Trogossidae, Tenebroinidae and Laemophidae in order coleopteran were encountered. The most abundant species was *Prostephanus truncatus* (Bostrichidae) 4425 (39.6%) while *Tenebroides* species (Trogossidae) 24 (0.2%) recorded the least (Table 1).

In Bodija market, a total number of 1808 insect pest species were recorded. *Dinoderus species* recorded the highest relative abundance of 906 (50.11%), followed by *P. truncatus* 337(18.64%), *Ryzopertha dominica* 285 (15.76%), *Sitophilus* species 67 (3.71%), while *Tribolium species* and *Cryptolestes species* recorded 211 (11.67%) and 2 (0.11%) respectively as the only secondary pests encountered.

Sabo market recorded a total of 2978 insect pest species *P. truncatus* was most dominance with relative abundance 1457 (48.93%). *R. dominica* and *Dinoderus species* recorded 803 (26.96%) and 422 (14.17%) respectively while *Cryptolestes species* (0.07%) recorded the least abundant.

In Oja-Agbe, Iseyin result revealed that 3414 insect pest species were encountered in the stores surveyed. *P. truncatus* and *R. dominica* were the most dominant species with relative abundance of 1589 (46.54%) and 1241(36.35%) respectively, followed by *Dinoderus* species which recorded 276 (8.08%). *Cryptolestes* species recorded 54(1.58%) relative abundance, while the least abundance was recorded in *Tenebroides species*.

Sango market, Saki recorded a total of 2974 insect pests species in which *Dinoderus species* recorded the highest relative abundance of 1294 (43.51%), followed by *P. truncatus* with 1042 (35.04%). *R. dominica* and *Tribolium species* recorded relative abundance of 365 (12.27%) and 158 (5.31%) respectively. *Sitophilus* species recorded 101 (3.40%), while *Tenebroides species* recorded 13 (0.44%). *Cryptolestes* species recorded the least relative abundance of 0.03%.

Generally, on monthly basis assessment of insect species abundance, rainy season between the month of April and September recorded the highest percentage of insect pests species (85.2%) than the dry season (October –March) 14.8% (Table 2).

Table 1: Relative Abundance of Stored Insect Species in 16kg Dried Cassava Chips from Selected Markets, Oyo State.

Species	Order	Family	Number Occurred	Relative Abundance (%)
Prostephanus truncatus	Coleoptera	Bostrichidae	4425	39.6
Dinderus speceies	Coleoptera	Bostrichidae	2899	25.9
Ryzopertha dominica	Coleoptera	Bostrichidae	2693	24.1
Sitophilus species	Coleoptera	Curculionidae	408	3.7
Tribolium species	Coleoptera	Tenebroididae	650	5.8
Tenebroides species	Coleoptera	Trogossitidae	24	0.2
Cryptolestes species	Coleoptera	Laemophidae	75	0.7
Total			11174	100

Table 2: Monthly Relative Abundance of Insect Species on 16kg Dried Cassava Chips in Selected Markets, Oyo State

	Insect Pest Species							
Sampled Months	***Prostephanus truncatus***	***Dinoderus species***	***Sitophilus species***	***Tribolium species***	***Ryzopertha dominica***	***Tenebroides species***	***Cryptolestes species***	**% Relative Abundance**
April' 16	133 (1.19)	372 (3.33)	6 (0.05)	95 (0.85)	295 (2.64)	3 (0.03)	0 (0.00)	904 (8.09)
May	993 (8.89)	587 (5.25)	13 (0.12)	49 (0.44)	275 (2.46)	0 (0.000	41(0.3)	1958 (17.52)
June	742 (6.64)	341 (3.05)	16 (0.14)	55 (0.49)	307 (2.75)	0 (0.00)	1 (0.01)	1462 (13.08)
July	906 (8.11)	572 (5.12)	55 (0.49)	61 (0.55)	578 (5.17)	4 (0.04)	2 (0.02)	2178 (19.49)
August	901 (8.06)	393 (3.52)	12 (0.11)	80 (0.72)	407 (3.64)	0 (0.00)	11(0.1)	1804 (16.15)
Sept.	342 (3.06)	331 (2.96)	140 (1.25)	87 (0.78)	290 (2.59)	4 (0.04)	18(0.1)	1212 (10.85)

Oct.	167 (1.49)	131 (1.17)	84 (0.75)	153 (1.37)	305 (2.73)	12 (0.11)	1 (0.01)	853 (7.63)
Nov.	69 (0.62)	24 (0.22)	24 (0.22)	9 (0.08)	99 (0.89)	1 (0.01)	0 (0.00)	226 (2.02)
Dec.	51 (0.460	27 (0.24)	7 (0.06)	18 (0.16)	76 (0.680	0 (0.00)	1 (0.01)	180 (1.61)
Jan '17	59 (0.53)	23 (0.21)	11 (0.09)	14 (0.13)	54 (0.48)	0 (0.00)	0 (0.00)	161 (1.44)
Feb.	20 (0.18)	46 (0.41)	19 (0.17)	18 (0.16)	1 (0.01)	0 (0.00)	0 (0.00)	104 (0.93)
March	42 (0.38)	52 (0.470	21 (0.170	10 (0.09)	7 (0.06)	0 (0.00)	0 (0.00)	132 (1.18)
Total	4425 (39.61)	2899(25.94)	408 (3.65)	650 (5.82)	2693(24.10)	24 (0.22)	75 (0.67)	11174 (100)

Fig 1: Map of Oyo State Showing the Study Area

Total number of insect species (N) =1808

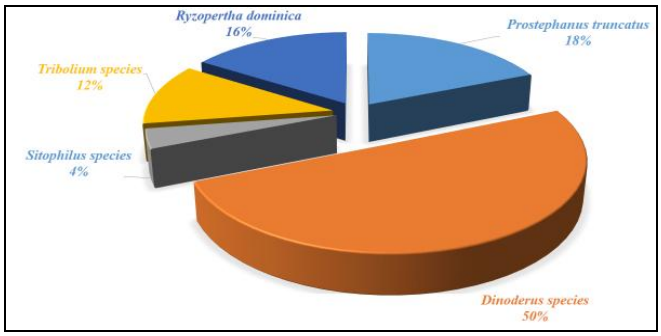

Fig 2: Percentage (%) abundance of individuals' insect pest species in 4 kg stored dried cassava chips in Bodija market.

Total number of insect species (N) =2978

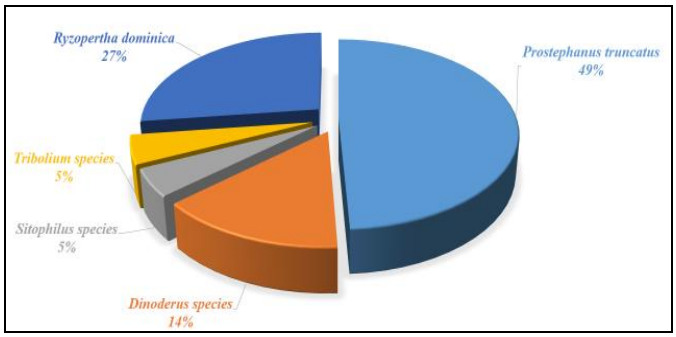

Fig 3: Percentage (%) abundance of individuals' insect pest species in 4 kg stored dried cassava chips in Sabo market, Oyo town, Oyo state

Total number of insect species (N) = 3414

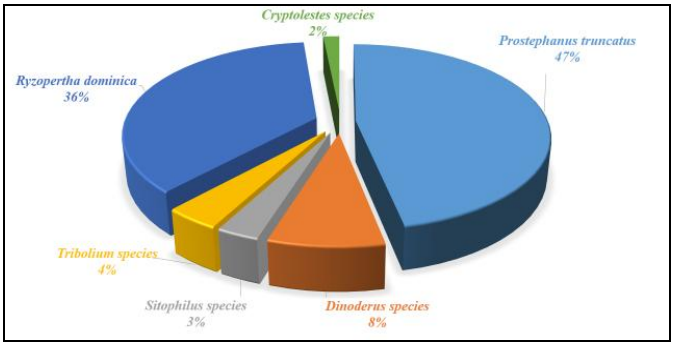

Fig 4: Percentage (%) abundance of individuals' insect pest species in 4 kg stored dried cassava chips in Oja-agbe market, Iseyin, Oyo state

Total number of insect species (N) = 2974

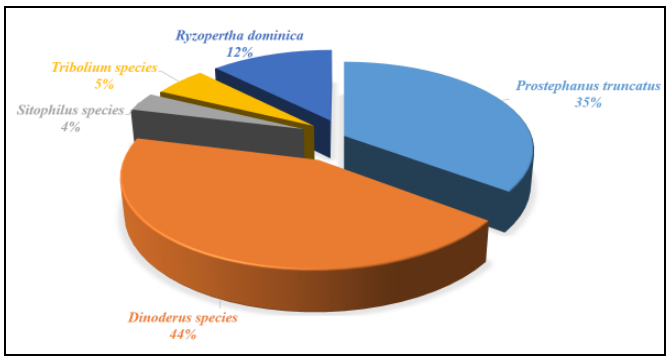

Fig 5: Percentage (%) abundance of individuals' insect pest species in 4 kg stored dried cassava chips in Sango market, Saki, Oyo state.

4. Discussion

Insect pest infestations are the most important constraint to stored dried cassava chips, causing low quality and quantity to the crop because of its hygroscopic nature, which increases its susceptibility to damage by insect pests [11]. The knowledge of occurrence and abundance of insect pest is an integral part for pest management. Therefore, insect pest species detection, monitoring of the spread and seasonal dynamics is one critical activity in management of the pest. According to [12], the knowledge of pest spectrum, distribution and relative seasonal abundance is very vital in implementing any pest management strategy in the stored product environment especially, using the integrated pest management fashion [13-15].

From this study, stored dried cassava chips from markets in Oyo state, Nigeria are not immune to insect pest infestation which were both primary and secondary stored pest beetles from the order coleopteran. This agrees with the findings of [16, 17], who stated that stored pests that are devastating insects of the order coleopteran of which both the larvae and the adults does the damage. The presence of secondary pests *Tribolium species* and *Cryptolestes species* is an indicative of high infestations of primary pests since the produce samle were stored dried cassava chips. This findings is in line with the work of the general believe that secondary pest are more prevalent on products that are partly damaged by other species (primary pests) [18] or processed into its products [7]. This study also indicated that both the traders and the farmers are prone to experience some serious loss in produce due to insect infestation. This corroborates with the findings of [19], stated that infestation by some insect pests may commence from the field just before harvest and the pests continues to reproduce and destroy the produce even in stores.

In all the stores sampled across the state, it was obvious that other products apart from dried cassava chips were stored together with dried cassava chips which could result into cross infestation in the stores houses attributed to residual populations from old stock, unclean storage containers, unhygienic condition of the warehouse and flour with high moisture content. From this study, it is established that seasonal variation affects the population dynamics of insect pests of stored dried cassava chips. The relative abundance of 85.18% pests observed from samples collected in rainy season between April and September compared to those sampled in dry season between October and March which recorded relative abundance of 14.82% across the sites could partly be explained by the meteorological differential between the periods in the period and time of harvest and the length of time it took in storage. This finding concurs with the studies of [20] on bruchids in which they indicated that beetles developed better in the raining season which was characterized by high temperature and humidity. Also [21], recorded the highest infestation of stored grains by the stored pests during rainy season (77.50%) followed by dried season (62.50%) [22]. also confirmed that, maximum number of insect damaged grains is found in wheat during the rainy season followed by the summer. According to the research work by [23] on "A survey of pests of stored Ginger in some selected markets in Rivers State, Nigeria" their result also indicated that seasonal variations greatly influences the relative abundance of these insect pests and that time of harvest and storage duration affect the number and species abundance of such insect pests.

In the findings, insect infestation during the dry season could have been reduced due to the marketers or store owners cultural habit of spreading and drying infested chips in scorching sun which reduce number of pest found compared to rainy season when the chance of drying infested chips is limited. This observation is in line with previous studies which showed that temperature influences various biological characteristics of insects such as sex-ratio [24], adult life-span, survival, fecundity, and fertility [25, 26]. As a result, temperature profoundly affects colonization, distribution, abundance, behavior, life history, and fitness of insects [27]. Also, [28] reported that, abundance of stored product insects pests in any locality is to some extent determined by prevailing climatic conditions and types of stored product; and always greater in the tropical storage environment. This research also revealed that Oja-agbe market, Iseyin had the highest dominance of insect pest species over other markets surveyed. This is in accordance with the work of [29] Echendu and Ojo (1997) who reported catches of *P. truncatus* were heaviest in the traps set at Okeho/Iseyin, Oyo State. This result is very similar to research work of [30] Pike *et al.* (1992) who recorded 60% of their total survey catch from this area alone. While Bodija market had the highest species diversity which was evenly distributed. Oja-agbe market recorded the lowest species diversity but was also evenly distributed.

5. Acknowledgement
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