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Checklists of Field and Storage Insect Pests of Kola Nuts, (*Cola Nitida; Cola Acuminata*) - A Review

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Abstract

Several insect pests attack kola nuts (*Cola nitida*; *Cola acuminata*) both in the field and storage but only twenty common species of economic importance are discussed within the purview of this work. The fecundity, developmental (i.e. Biology/life cycle) stages and damage characteristics including control measures (i.e. chemical, mechanical/physical, and cultural methods, use of natural enemies and botanicals etc) were examined. Insect pests were classified as either minor or major based on the degree of damage caused to kola nuts. Kola nuts do not require further processing before consumption thus any minute chemical residue is deemed unacceptable. Chemical for storage pests are used sparingly hence uses of bio-rational or botanical insecticide are also explored. Moreover, the studies of population dynamics in Kola producing farms have enhanced proper taxonomy and enable formulation of standard integrated packages for insect pest management.

Keywords: Insect pests; *Cola spp*; Damage characteristics; Control measures; Field; Storage pests

Abbreviations: CRIN: Cocoa Research Institute of Nigeria; MOE: Minutes of exposure; DDT: Banned chemical; EU: European Union

Introduction

Kola belongs to order *Malvales* and family *Sterculeacea*. The species, *Cola nitida* (Vent) Schott and Endl. and *Cola acuminata* Schott and Endl. are important economic crops in West and Central Africa, Carribean Islands, Mauritus, Sri Lanka and Malaysia Oladokun [1]. Though *Cola verticillata* is less important due to the nuts' foamy nature when chewed Daramola [2]. However, *Cola acuminata* and *Cola nitida* (Schott and Endl) are the only edible species of kola nuts grown in commercial scale in Nigeria Jacob [3]. Kolanut is used as a masticatory and stimulant by Africans and has numerous other uses in social, religious, ritual and ceremonial engagements which include child naming, installation of chiefs, funerals and sacrifices Opeke [4]; Asogwa [5]. Nigeria accounts for about 70% of the total world production of kola nuts and reported to be contributing 6.8% to Nigeria's GDP and 17.9% to the agricultural sector of Nigeria's GDP Sanusi and Ndubuaku [6]; and FOS [7]. However, about 90% of the kola produced in Nigeria is consumed within the country while 10% is exported Quarco [8]; Sanusi and Ndubuaku [6]; and FOS [7]. The cultivation of kola nuts in Nigeria is ecologically limited to the rain forest zones of the South and riverine areas of the Savannah region of Nigeria. In the same vein, the Kola programme constituted by scientists of multi-disciplinary in Cocoa Research Institute of Nigeria (CRIN) toured at least two local governments in each of the three States, Southern West, Nigeria. The survey was designed to re-assess the distribution and frequency of occurrence of important pests (i.e. *Balanogastris kolae* and *Sophorhinus spp*) of kola nuts within the kola nuts producing states. The population studies of the *Balanogastris kolae* will enhance proper taxonomy of the insect and standard integrated packages formulated for their control.

Kola production in Nigeria is associated with a number of problems principal among these are very low yield and inconsistent pattern of fruit bearing Odegbaro [9] including problem of pest, which has become recurring decimal in Kola production. Therefore, a pest is any form of plant and animal life or any pathogenic agent injurious or potentially injurious to plant, plant product, livestock and man which includes insect and other arthropods, vertebrate, weeds, micro-organism, bacterial, fungi, viruses (Organisation for Economic Cooperation and Development [10]. Thus, for organism to qualify as a pest, it must fulfill one or more of the following conditions:

a) The insect must actively seek for or utilize crop for the food or reproduction.

b) It must have potential ability to inflict injury on the crop.

c) One or more life stages of the pest must be found on the crop.

d) The population must be unbearable (very) high to cause nuisance and economic loss.

However, the role of insect pests which are capable of destroying more than half of the produce cannot be over emphasised Daramola [11] because kola tree is exposed to attack by highly complex insect populations. Insect pests cause damage to virtually every growing plant valued by man mostly through their feeding activities depending on the species and life stages. Daramola [11] identified some of the species as major pests which cause economic damage to the crop. Therefore, these pest complexes are classified into major and minor pests depending on their damage patterns (Table 1).

Table 1: Insect pests associated with Kola nut production.

No	Insect pests (Scientific names)	Common names	Order	Family	Type	Pest category	Plant parts attacked
1	*Balanogastris kolae Desbr*	Weevils	Coleoptera	*Curculionidae*	Field to store	Major	Pods/nuts
2	*Sophrorhinus spp*	Weevils	Coleoptera	*Curculionidae*	Field to store	Major	Pods/nuts
3	*Phosphorus virescens Oliver*	Stem borer	Coleoptera	*Cerambycidae*	Field	Major	Stem
4	*Characoma stictigrapta Hmps*	Pod borer	Lepidopte a	*Noctuidae*	Field	Major	Pods/nuts
5	*Ceratitis colae Silv*	Fruit fly	Diptera	*Trypetidae*	Field	Major	Pods/nuts
6	*Sylepta spp Hmps*	Leaf roller	Lepidoptera	*Pyrallidae*	Field	Major	Leaves
7	*Anomis leona Schaus*	Moth	Lepidoptera	*Noctuidae*	Field	Major	Pods/follicles
8	*Anaphe venata Bulter*	Moth	Lepidoptera	*Notodontidae*	Field	Minor	Leaves
9	*Zonocerus variegatus L.*	Grasshopper	Orthoptera	*Pyrrgomorphi-dae*	Field	Minor	Leaves
10	*Sahlbergella singularis Hagl*	Brown mirid	Heteroptera	*Miridae*	Field	Minor	Pods/follicles
11	*Distantiella theobroma Dist*	Black mirid	Heteroptera	*Miridae*	Field	Minor	Pods
12	*Torma colae China*	Torma	Heteroptera	*Miridae*	Field	Minor	Pods/follicles
13	*Crematogaster buchneri Forel.*	Ants	Hymenoptera	*Formicidae*	Field	Minor	Leaves
14	*Mesohomotoma tessmani Aulum*	Psyllid	Homoptera	*Psyllidae*	Field	Minor	Leaves
15	*Polytichus carter Butt*	Moth	Lepidoptera	*Noctuidae*	Field	Minor	Leaves
16	*Polytichus poliades Jow*	Moth	Lepidoptera	*Noctuidae*	Field	Minor	Leaves
17	*Ancistrotermes spp.*	Termite	Isoptera	*Termitidae*	Field	Minor	Stem/root
17	*Ancistrotermes spp.*	Termite	Isoptera	*Termitidae*	Field	Minor	Stem/root
18	*Amitermes spp*	Termite	Isoptera	*Termitidae*	Field	Minor	Stem/root
19	*Coptotermes spp.*	Termite	Isoptera	*Termitidae*	Field	Minor	Stem/root
20	*Macrotermes spp*	Termite	Isoptera	*Termitidae*	Field	Minor	Stem/root

Source: Asogwa [64].

Major pests of kola nuts

Balanogastris kolae (Debrs.) and *Sophrorhinus spp*

I. Importance

Kola weevils, *Balanogastris kolae (Debrs.)* and *Sophrorhinus spp* have a wide geographical distribution in the kola belt majorly in Africa and in fact all trees are usually infested. Therefore, the kola weevils are the most destructive pests of kola nuts in West Africa Daramola [12,11]. They attack nuts from the field to storage, thus caused percentage infestation ranges from 30-100% depending on the sanitary condition on the farm and time of harvest Daramola [12]; Daramola and Famuyiwa [13].

II. Biology

The mature adults of the weevils, *B. kolae* and *Sorphrorhinus spp.,* are dark brown beetles, 3-4 mm long and 1.5-2 mm wide Castner [14]. The female lay eggs 1 cm deep in the nuts or in other parts of the fruit through wounds and holes made by other insects such as *Ceratitis colae Silv.* or through cracks on the husk created when the follicles dehisce before harvest. Incubation lasts for

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about 4-6 days. Larval stage takes 17-20 days and the larva feeds extensively reducing the kola to brown powdery mass. Pupation lasts for about 5-6 days NRI [15]. Furthermore, several researchers have underscored the reports that the weevils are field to store pest of kola nuts and their eggs are usually laid inside the nuts or pods during the feeding entry or exit points made by other insect or directly with pods or nuts Esther [16]. Breeding was noted to continue throughout the year on left-over nuts and nuts produced between the main harvest seasons Daramola [17]; NRI [18]. The average period from oviposition to the emergence of the adults of *B. kolae* is 29 days and 31 days for Sorphrorhinus spp.

III. Damage characteristics

The kola weevils, *Balanogastris kolae* Desbr. and *Sophrorhinus spp* (Coleoptera: Curculionidae) are the most destructive pest of kola nuts in West Africa Daramola [11,12]. They attack nuts from the field to storage thus caused percentage infestation ranges from 30-100% depending on the sanitary condition on the farm and the time of harvest Daramola [12], consequently accounts for a loss of about 60% of the produce Quarco [8]. The larvae feed inside the nut leaving tunnels filled with frass, leaving circular holes behind in the nuts by emerging adults. Adults weevils also feed on the nuts and the damages caused destroy the nuts thereby lowering its market value NRI [15,18].

IV. Control measures

a) Cultural/physical method

Daramola [19] observed that early harvests of mature pods greatly reduced the level of weevil damage, removal of fallen nuts including pods still on the trees at the end of main fruiting season and also unripe pods produced between crops. Furthermore, sanitation of the farm like destruction and proper disposal of all debris from the nuts and packing materials Daramola and Taylor [13]. Idowu and Ojelade [20,21] reported the percentage of weevil damage recorded on kola nut from timely harvested pods (35.42%) and pods whose harvest were delayed (58.25%-83.3%). During the first few weeks of storage, nuts usually stored in baskets lined with leaves should be examined once a week and all infested nuts should be removed Ndubuaku [22]. Ndubuaku [23] also advocated that since the kola weevil exhibit positive geotaxis (movement of weevils towards the bottom of the storage containers), the farmers should concentrate on the physical removal of adult weevils from the bottom of the baskets and that the crevices at the bottom of the baskets should be thoroughly inspected during regular replacement of banana leaves to ensure that the weevils hiding at the bottom of baskets were not overlooked. Generally, good hygiene such as timely harvest, proper cleaning of the store, selection of good nuts etc should be practised to have insect free kola nuts.

b) Chemical method

Only kola nuts with mean moisture content of 56.9 + 2.2% will attain 46% moisture level after about three weeks of storage in the dry season and about 4-6 weeks in the wet season Ivbijaro [24]. Nuts should therefore be stored for more than six weeks before fumigation to avoid the development of taint. Ivbijaro [25] successfully controlled weevil infestation in storage by dipping freshly harvested kola nuts (with testa removed) for 10 min in 0.003% gamma BHC emulsion. Many scientists have carried different chemical control trials against the kola weevils. These include fumigation of the nuts with phostoxin; dipping of weevil-infested nuts in concentration of 0.03% gamma BHC emulsion Ivbijaro [25]. Furthermore, irradiation of kola nuts using gamma radiation generated from cobalt 60 Daramola [11,12]. Daramola [12] observed that dosage rates between 10-15 krads of gamma radiation were sufficient for the control of weevils in infested nuts. Germination was zero in nuts irradiated but no undesirable changes were produced in the nuts when chewed. Daramola [11] concluded that since the effective dosage rates for disinfecting kola nuts (8-15 krads) fall well below the dosage rates of 30-70 krads approved for agricultural products in other countries, it is reasonable to assume that the irradiated kola nuts are safe for consumption. Total control of the insect pest by treating kola nuts with one tablet of phostoxin (Aluminium phosphide) in 100-litre airtight drums for 14-16 hrs at 26^{o} to 28^{o}C was achieved in the past.

Azeez [26] reported from a field survey and personal communication that a phostoxin tablet was cut into four and one quarter was enclosed in perforated envelop and placed in a basket full of kola nuts. The preferable position of placing the perforated envelop is at the middle of the basket filled kola nut. Therefore, this would enhance adequate diffusion fumigant coverage effect against kola weevil infestation. Hence, the perforated envelop avoided contact between the nuts and phostoxin tablet. However, phostoxin is poisonous and it is advisable farmers/traders should spread the stored kola nuts meant for sale in a ventilated environment so that the concentration of the chemical would diffuse into the air. Kola nuts should be handled with care because it does not require further processing before it is consumed and mindful of application rates Azeez [27]. It is worthy to note that irrespective of all these trials, there has been no categorical recommendation of chemical control of kola weevils. This is due to the fact that kola nuts need no further processing before consumption hence no level of chemical residue on it will be acceptable.

Phosphorus virescens Olivier

I. Importance

The stem borers, Phosphorus virescens Olivier is the most destructive of all known kola insect pests. The species is found throughout the cola growing areas in Nigeria NRI [18]. The other species found in Nigeria is *P. gabonator* which is observed to be restricted to the higher rainfall areas of Nigeria. *P. virescens* is the dominant among the two species and is more prevalent in kola plantations in the lowland rain forest with a rainfall of 2,000 mm-5,000 mm. It also appears to a lesser extent in the gallery forests in the derived savanna Ndubuaku [28]. Distribution of *P. virescens*

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was observed within the top, the middle and lower sections on the entry points into young kola plants. He also noted that the larval tunnel was prevalent in the pit and under the bark of young and woody stems Ndubuaku [29].

II. Biology

Phosphorus virescens measures 2 - 3.5 cm in lenght and 0.8 - 1.2 cm in width with a striking yellow and black pattern. The female deposits eggs in the dead tip of the shoot from the month of August to November, which it had earlier ring barked Asogwa [5]. On emergence from the egg, the larva bores into the dead shoots and feeds its way towards the green tissue, then sinks drainage shafts from the burrow to the outside to drain the mucilage discharged from the tissue. The larval stage lasts for about 6 months while the pupation takes 20-46 days. The life cycle in areas of high rainfall appears to be more complicated with much overlapping of the various stages NRI [15,18].

III. Damage characteristics

Phosphorus virenscens attacks trees of all ages, though severe on young trees and particularly devastating, causing severe stunting and malformation and resulting often times in death of the plant. However, attack seldom results in the death of the old trees but as they are riddled with borers, they barely fruit and remain living reservoirs of infestation and a menace to neighbouring trees and groves Asogwa [5]. The larval tunnel was prevalent in the pit and under the bark of young and woody stems Ndubuaku [29], while the adult beetles feed on the leaves, shoots, young branches and chupons. Consequently, the destruction of the bark on new growth causes very serious die-back associated with infection by the fungus, *Calonectria spp*. New growth arises at the base of the damaged shoots only to be attacked in turn. Attack on young trees is so severe making it almost impossible to establish kola trees in areas where Phosphorus spp is active Ndubuaku [28]. Studies on the distribution of *P. virescens* showed that about 63% of the entry points into young kola plants (3-4 yrs old), were observed within the top section (> 1.5 m) of the young plants. The middle (1.5 m-0.5 m) and lower (< 0.5 m) sections each had about 18% of the entry points.

IV. Control measures

a) Cultural method

Ndubuaku [28] reported that if canopy of an infested kola tree is shaken or beaten early in the morning, adult stem borers tend to drop to the ground and sometimes feign death. This should be followed by hand picking and immediate crushing of stem borers, *P. viriscens*. However, hand picking is therefore less labourious and more efficient as a control measure when carried out early in the morning. Daramola [11] and Ojo [30] also recommended poking of larvae of *P. viriscens* in the tunnel with long wires and cutting or removal of stems containing the larva. The method is labour intensive though found to be effective.

b) Chemical method

Larval mortalities ranging from 14 to 16% for Dimeathoate and 2 to 91% for Morphothion were recorded on treated kola, consequently Dimeathoate (0.2% a.i.) and Morphothion (0.2% a.i.) are effective against *P. viriscens*. Similarly, Ojo [31] reported less than 50% larval mortality due to the application of Lannate 20 E.C. and Nuvacron 50 E.C. when sprayed to drench infested branches Asogwa [5].

Characoma stictigrapta Hmps

I. Importance

The kola pod borer, Characoma stictigrapta Hmps has a very wide distribution in tropical and sub-tropical regions of Africa. Besides *Cola spp*., they also attack Theobroma cacao and Sterculia tragacantha Daramola [11]. In Nigeria they are more prevalent during the dry season (December-March) when the larvae are most numerous NRI [18].

II. Biology

Characoma stictigrapta has a body length ranging from 9-10 mm and a wingspan of 22 mm. The forewing is grey with black dots, while the female moth has one large black spot near the inner margin of the forewing Castner [14] and usually lays its eggs on the follicles NRI [15]. Incubation period is between 4-5 days and the larval development lasts 25-30 days. Colour changes during larval growth range from white to pale green with pink tinge Ndubuaku [32]. At full growth, the larvae eat their way to the surface of the pod where pupation takes place. Pupal period lasts 13-15 days. The adult life span is between 2-8 days Ndubuaku [32].

III. Damage characteristics

The kola pod borer, Characoma stictigrapta is the most destructive of kola moth and the insect pest is known to attack only kola follicles and cacao cherelles and pods in Nigeria. Percentage infestation of the insect in some growing areas ranges from 37% to 48% Daramola [29]. Percentage infestation during periods of out-breaks of the insect on kola ranges from 60-75% Daramola [28]. Daramola [28] and Daramola [29] also reported that C. stictigrapta Hmps is the most destructive kola moth in Nigeria. The pest is known to attack only kola follicles and cocoa cherelles and pods in Nigeria. According to him, the percentage infestation of the pest in some kola growing areas ranges from 37%-48% and during the period of outbreaks this could be as high as 60%-75%. The larva bores into and feeds inside the follicles and then damage together with secondary fungal infection, cause the death of the follicles. The exit holes of the larvae also enhance weevil infestation of the nut Daramola [28,29]; Ndubuaku [33].

IV. Control measures

a) Cultural method

According to Daramola [29], dehusking of pods far away from kola grooves and burying of pod husks which harbour developing

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larvae will reduce the level of the kola pod borer Asogwa [34].

b) **Chemical method**

Dioxocarb was recommended for the kola pod borer, C. stictigrapta NRI [18]. Daramola [28] recommended the selective spraying of kola fruits that are produced in-between seasons of main production and the destruction of wild kola hosts in around cacao and kola plantations as well as reducing the attack by the insect pest on kola.

Ceratitis colae Silv

I. Importance

The kola fruit fly, Ceratitis colae has been recorded on *C. acuminata*, *C. nitida*, and *C. verticillata* in Ghana, Guinea, Nigeria and Cameroun Daramola [12].

II. Biology

Adult deposit eggs within the skin of the fruit and hatch in 2-4days. Oviposition holes allow the entry of pathogenic organisms which cause rotting. There are three larval instars that feed on the fruit flesh. Also, it burrows through the pod husk and feed on the succulent and sugary testa of the kola seed. Larval development takes 10-14 days to complete. The exit holes of the mature larvae of the fruit fly serve as entry-point for kola weevils and facilitate weevil attack Daramola and Ivbijaro [35]. It was also reported that the emerging larva of kola fruit fly, *C. colae* Silv. burrow through the pod husk and feed on the cotyledons. Pupation takes about 14 days. Adults can live for 5-6 months providing they are able to feed on sugary foods during this time. There can be 8-10 generations for fruit fly in one year.

III. Damage characteristics

Ceratitis colae Silv. (kola fruit fly) causes damage by laying eggs inside the developing kola fruits. The *C. colae* larvae burrow through the pod husk and feed on the succulent and sugary testa of the kola seed, leaving purple marks on the cotyledons, and making the nuts unmarketable. Infestation of 67-95% of kola pods have been recorded and the exit holes of the mature larvae of the fruit fly serve as entry-point for kola weevils and facilitate weevil attack Daramola and Ivbijaro [35]; NRI [18]. Also, the discolouration accompanying infestation by emerging larva of kola fruit fly constitutes serious damage thereby making the nuts unattractive.

IV. Control measures

a) **Cultural method**

Early harvests of mature pods greatly reduced the level of damage, removal of fallen nuts including pods still on the trees at the end of main fruiting season and also unripe pods produced between crops Daramola [19]. Infested fruits that have fallen should be collected and destroyed. Furthermore, sanitation of the farm, like destruction and proper disposal of all debris from the nuts and packing materials Daramola and Taylor [35].

b) **Chemical method**

A spray made from extract of the neem tree is effective. Chemical sprays can be applied to kill the adults before egg laid, however expert advice should be sought.

Sylepta semilugens, S. polycymalis Hmps, S. retractalis (Hmps)* and *S. derogata

I. Importance

The defoliators have wide distribution throughout the kola belt of tropical Africa, even though some have been recorded in Namibia, S. Africa and Malagasy. They were as serious pests in the kola producing forest region of W. Africa, stretching from Guinea to the Republic of Congo. However, *S. semilugens* has the widest geographical distribution and the injurious effect of its attack on kola foliage were reported in Guinea and Cote d'ivoire NRI [15]. Their larvae and pupae were abundant in the dry season with the peak in December, January and February and the population declined with the outset of the rains Daramola [11]; NRI [18].

II. Biology

The kola leaf roller, *Sylepta spp* lays its eggs on the underside of leaves. The eggs of *S. semilugens* are whitish while those of *S. derogata* and *S. polycymalis* are pink. Eggs may be laid singly or in groups on either surface of the leaf. The incubation period is between 2-4 days and after hatching the young larvae move into the shelters which they have made from the curled leaves. Therein they feed until they pupate either in the leaf curl or in leaf litter on the ground. The larval period last 18 -22 days and pupation takes 9-14 days Ndubuaku [36]; NRI [15,18].

III. Damage characteristics

The kola leaf roller, *Sylepta semilugens*, *S. polycymalis* Hmps and *S. derogata* are harmful insect pests in Nigeria. They feed on kola foliage causing extensive damage. Mature leaves are rolled, and the leaves eaten up become not-like. Extensive defoliation by the larvae may seriously check growth especially in seedlings Daramola and Famuyiwa [37]. *Sylepta spp* was reported to feed on kola foliage causing extensive damage. Mature leaves are rolled and eaten up and similarly extensive defoliation by the larvae may seriously check growth especially in seedlings NRI [15].

IV. Control measures

a) **Cultural method**

Handpicking of sheltered rolled leaves for insect and destroyed to give some protection against mild attacks. Farm sanitation entails regular weeding and rogueing of the weeds that served as the abode for the insects.

b) **Chemical method**

Application of cypermethrin and lambda-cyhalothrin are effective against infestation of the insect pests. It has knocked down effect on the insect pest population.

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Anomis leona Schaus

I. Importance

Anomis leona is a serious lepidopterous insect pest of *Cola spp* in Nigeria. It is found majorly in the tropics.

II. Biology

The lepidopterous moth, Anaphe venata emerges during the dry season. The female of *A. leona* lays 300-500 eggs and eggs hatch 4-5 days later. The eggs are deposited on kola leaves and take approximately one month to incubate NRI [18]. The larval period is 14-22 days, however live in large nests and trees may be defoliated by the middle of the rainy season. During the rainy season the larvae start making daily migrations to other plants. Pupation takes 8-10 days, while it takes place in large communal cocoons about mid-August NRI [18].

III. Damage characteristics

The defoliator, Anomis leona Schaus poses a threat to kola establishment as their larvae feed mainly on foliage, attacking young seedlings of kola and new flushes of mature trees NRI [18]. Larvae may move around the plant and can cause damage several shoots. Consequently, the pest may pose a threat to the establishment of Kola.

IV. Control measures

a) Cultural method

As there is diapausing stage the insect can be controlled effectively using a closed period of two months when the crop is not grown. Avoid growing Kola nut in the same plantation with tree crops that could serve as alternative host for the insect pest.

b) Chemical method

Dichrotophos and Fenitrothion were found to be effective for the control of the insect pest, *A. leona*. Effective control was achieved with these insecticides by directing the spray to under surface of the leaves and immature pods NRI [18].

Anaphe venata Bulter

I. Importance

It is found mainly in Southern Nigeria though recently recorded from the North. However, gregarious larvae can be a serious pest. It may attack other crops such as cocoa, maize, banana and vegetables.

II. Biology

Moths emerge during the dry season. Eggs are deposited on kola leaves and take approximately one month to develop. Larvae live in large nests and trees may be defoliated by the middle of the rainy season. During the rainy season the larvae start making daily migrations to other food plants. Pupation takes place in large communal cocoons around mid-August.

III. Damage characteristics

The caterpillars of Anaphe venata Butler, are gregarious and when prevalent defoliates the kola plant. The trees may be wholly defoliated by the caterpillars Ndubuaku [36]; NRI [18]. The larvae (caterpillars) are gregarious and when prevalent defoliate the host plants. Trees may be wholly defoliated by the caterpillars which then spread to food crops in the neighbourhood, especially maize.

IV. Control measures

a) **Chemical control**

These insect pests can be effectively controlled using Dichrotophos and Fentrothion insecticides by spraying on the surface of the leaves NRI [18]. Dichrotophos and Fenitrothion were found to be effective for the control of A venata in kola. Effective control was achieved with these insecticides by directing the spray to under surface of the leaves and immature pods NRI [18].

Zonocerus variegatus L.

I. Importance

Zonocerus variegatus L. is found throughout West Africa, South of the Sahara spreading Eastwards of Uganda and northwards into Sudan Page [38]. Youdeowei [39] has produced a map of the distribution of the two species of *Zonocerus* (*Z. variegatus* and *Z. elegans*), which occurs in Africa. According to Page [38], *Z. variegatus* is largely distributed between the Tropic of Cancer and the Tropic of Capricorn, with a predominant occurrence in the West African Sub region. In Nigeria, Toye [40] reported that *Z. variegatus* usually occurs in cultivated land with nymphs and adults sharing the same habitat and its habitat extends from the lowland Rain forest zone to the Guinea savannah in the north. Two distinct populations of *Z. variegatus* exist in southern Nigeria Toye [40]; Taylor [41]; Anya [42] and Youdeowei [39]. These are typically referred to as the dry and wet season populations. In South West, Ibadan area, the populations of *Z. variegatus* may be found throughout the year. The population found during the wet season (April-October) is small, while the dry season population (November-March) can be very large Page [38].

II. Biology

In South West, Nigeria, adult *Zonocerus* variegatus becomes sexually mature with the onset of the rains. Their eggs `are laid from the middle of march to April, with the majority of the laying occurring during the first week in April, but do not hatch until late October or November with embryonic development, which includes diapauses taking 6-7 months Entwistle [43]; Page [38]; Omole [44]. In Eastern Nigeria, there is one annual generation but two definite broods, most eggs being laid in March/April and August/ September. Each female lays 1-4 egg pods, which is 40-45 mm long, each containing 20-90 eggs. The pods are buried 5-8 cm deep in the soil. As many as 3,500 pods have been found on a site of 16 m^2 Toye [45]. This shows that egg pods are normally

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concentrated in selected egg-laying sites. The egg development is dependent on high level of soil moisture and takes place at the end of the wet season. *Zonocerus* variegatus generally has six nymphal instars in the field although a small percentage of the insect will have only five instars Chapman [46]. The nymphal development proceeds during the dry season and adults are dead before the next rain or at the onset Entwistle [43]; Toye [45]. Lee and Wood [47] stated that as plant tissue is either directly or indirectly the source of food for termites, vegetation must be an important factor in determining their distribution and abundance.

III. Damage characteristics

In Nigeria, various species have been reported to cause serious damage on virtually all the economic crops across the Mangrove and Fresh water swamp forest, Rain forest, Guinea savannah and Sudan savannah Harris [48]; Malaka [49-51]. The polyphagous pests: *Zonocerus variegatus L.*; Brachytrypes membranaceus Dury and Gryllotalpa africana Beauv, were not left behind as they were seen feeding on kola foliage and young stems causing excessive defoliation and death of seedling plants Daramola [11]. The females deposit egg capsules in the soil during the rainy season. The eggs hatch and nymphs appear in November, while adults emerge in late January to March Daramola [11]; Toye [45]. The nymphs of the variegated grasshopper, *Z. variegatus* are gregarious, and often very numerous and it is at this stage that most damages are done. They are sluggish and migrate only slowly by walking and hence attack tends to be patchy. The adult grasshoppers are less gregarious than the nymphs, which eat up the leaves, leaving the veins intact, especially of seedlings. Both the nymphs and adults feed on new flushes, moving from one plant to the other after stripping the former bare. Their feeding activities always result in severe damages to young kola stands. Grasshoppers are known to feed on wide range of plants, showing preference to various annual herbs. Field observations on the damage caused to economic crops in Nigeria by *Z. variegatus* have been recorded by several authors Toye [52,53]; Anya [42]; Youdeowei [39]; COPR [54,55]; Page [38]; Omole [44]. They all have illustrated accounts of the nature of damages to important economic crops such as banana, plantain, cassava, citrus, cocoa, kola, cotton, cashew, cowpea, tea etc.

IV. Control measures

a) Cultural control

Toye [45] however reported that control operations on grasshopper should be carried out in November and early December when young nymphal aggregations are dense. A drastic reduction of the *Zonocerus* population could be achieved by digging up the egg laying sites and exposing them to high surface temperatures so that the eggs are killed. If all or nearly all the sites in a large area are cleared in this way the population of the grasshoppers can be reduced well below the damage threshold at no financial cost and with very little labour Page [38]; Toye [45]. According to the COPR [56], it is possible to reduce a *Zonocerus* population by 90% through this method. Also, studies carried out in two egg-laying areas showed that potential hatches were reduced by 83-91% through exposure of dug egg pods to desiccation Page [38].

b) Chemical method

All instars of *Z. variegatus* can be killed easily by the common insecticides (Fenitrothion) using solutions of 0.1% wt/vol. a.i., though 0.5% a.i. could equally achieve effective control on the target. The best time for spraying is in the early mornings or late afternoons when the insects are less active and preferably on the highly aggregated early instars of the insect. However, due to the well dispersal and high mobility of later instars of the insects, spraying them would be uneconomical unless the crop is of high economic value, in which case spraying at regular intervals according to the rate of re-invasion, would be worthwhile Page [38]; Toye [45]. Ndubuaku [36] effectively controlled nymphal aggregations on weeds with kerosene applied using a motorised mist blower.

Sahlbergella singularis Hagl., and *Distantiella theobroma Dist.*

I. Importance

The brown and black cocoa mirids, *Sahlbergella singularis Hagl.*, and *Distantiella theobroma Dist*. respectively attack kola follicles and pods in Nigeria though latter is common in Ghana.

II. Biology

The female inserts eggs into the host stem or pod tissue and laid about 200 eggs. Eggs hatched in 13-18 days and the nymphs feed by piercing the host plant tissues to suck sap. Nymphs passed through five instar stages over a period of about 4 weeks. Their populations are highest in August, September and October, but decrease in severe dry periods. The life cycle of the mirid is usually completed in 4-5 weeks.

III. Damage characteristics

Sahlbergella singularis usually attack young shoots and follicles of *Cola spp* due to serious outbreaks on young fruits of *C. nitida* in a kola belt of Africa. Daramola [11], reported that the piercing and sucking feeding injury of both the nymphs and adults of the mirids, *S. singularis Hagl*. and *D. theobroma Dist*. causes the death of follicles and older pods and often results in stunting, pod malformation and poor yield. However, serious out-break of *S. singularis* infestation of almost 100%, Daramola [11], may result in secondary fungal invasion of pods. Also, the piercing and sucking feeding injury of a similar insect pest, Helopeltis bergrothi Reut. caused yellowing and die back of new growth and pod drop Daramola [11].

IV. Control measures

a) Chemical method

During periods of mirid out-break on kola, gamma BHC (0.25% a.i., hexachlorocyclohexane) and Unden 20 (0.25% a.i.,

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methylcarbamic acid and 2-isopropoxyphenol) both which effectively control mirids on cacao can be used for the control of the insect pest on kola. Spot applications can be made during the dry spell of November and December if the need arose.

b) Cultural method

Shade management and pruning of infested parts may help reduce the severity of mirid attack. The shade management prevent shade created by the canopy of the tree seems to give some protection from insect pests.

Torma colae China

I. Importance

It is a minor insect pest of kola though found everywhere the tree is grown.

II. Biology

Adult female lays eggs on the host tissue and hatched in 10-15 days and the nymphs feed on the host plant flower for pollen grains. Nymphs pass through instar stages over a period of about 4 weeks before adult emerged NRI [18].

III. Damage characteristics

The larvae of Torma colae China was noted to feed on the sepals and androecium but apparently does not damage kola. It has been considered to be a possible pollinator of kola but remains to be proved Ndubuaku [57]; Ndubuaku [22].

IV. Control measures

a) **Cultural method**

Handpicking and proper sanitation could be employed to reduce infestation level.

b) **Chemical method**

Spray of cypermethrin and lambda-cyhalothrin are effective against the insect pest.

Crematogaster buchneri Gorel

I. Importance

Ants are general nuisance pests, building nests in trees, biting aggressively and making harvesting difficult.

II. Biology

Ant colonies have some fertile males called drones and one or more fertile females called queens.

III. Damage characteristics

Eguagie [58] reported that the ant, Crematogaster buchneri Gorel scrapes off the epidermis of the leaves and follicles of kola. The damage usually results in the shedding of leaves and the premature dropping of shrivelled follicles. The associated beneficial insects like scale insect, Stictococcus sjostedti CKII has large colonies whose piercing and sucking feeding injuries cause stunted growth and pod drop. Also, the feeding injury of the mealybugs, Planococcus citri Risso; Planococcus njalensis Laing; Ferrisiana virgata CKII on the kola flowers, flower stalk and pods, impair fruit development Ndubuak [36]. The mutual beneficial insects however produced honey dew that attracted ants to the kola nut trees.

IV. Control measures

a) **Cultural method**

Farm sanitation like pruning and shade management is effective in insect management.

b) **Chemical method**

Aldrex 40 is proven effective for the control of insect.

Mesohomotoma tessmani Aulum

I. Importance

Adult cocoa psyllids are found throughout the cocoa producing areas of Nigeria. They move over the plants by hopping and gliding. Large colonies of wax-covered nymphs are visible on the young stem and the base of flower buds Asogwa [5].

II. Biology

The eggs of the West African cocoa psyllid, Mesohomatoma tessamanni are oval and white, have a small basal hook and are implanted beneath the epidermis of soft host tissue. The Mesohomotoma tessmani oviposits and feeds on vegetative buds, developing leaves and petiolar swellings. Though during the peak flowering period, psyllids are more commonly found on flowers and very young fruit on which they both feed and lay eggs Asogwa [5]. The incubation period varies from 4-10 days. The nymphal stages are passed in 7-20 days and the adult may live up to 19 days.

III. Damage characteristics

Mesohomotoma tessmani attacks young, shaded plants more than ones exposed to full sunlight. However, more of the plants were attacked towards the end of the wet season (September-October) while minimal attack occurred during the dry season Asogwa [5]. The reverse is the case in Ghana with higher attacks during the dry season (December-February) but falls with the early rains. The attacked flowers and young pods are atrophied fall and have been described as being replaced by twisted bracts arranged in a spiral. Also the affected stems swell and the internodes are unusually short and foliage consequently bunched. Serious attack by psyllids can result in extensive inhibition of flush tissues, apical die-back and bunching of leaves as a result of shortened internodes Ndubuaku [36].

IV. Control measures

a) Biological control

The use of natural enemies of this pest may be effective at control.

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b) Chemical control

The nymph should be cleansed of white fluffy wax covered and honey dew that attracted ants to the tree and served as a barrier to chemical control. Spray of cypermethrin and lambda-cyhalothrin are effective against the insect pest.

Polytichus carteri Butt

I. Importance

Daramola [11] reported that the sphingid moth, Polytichus carteri is more common and has a wider geographical distribution in West and Central African countries than *P. poliades*. An outbreak of *P. Carteri* was first observed between June and August, 1973 on *C. nitida* at the Gambari Experimental Station though a very low incidence of the pest was observed between June and September, 1983 at CRIN Headquarters, Ibadan Ndubuaku [59]. However, outbreaks of *P. Carteri* had earlier been observed in Cote'divoire in August and September and Sierra-Leone in October. He also reported serious damage by *P. Carteri* on cocoa trees in Cote'divore and injurious to kola trees.

II. Biology

Ndubuaku [59] reported that a female adult of the leaf defoliator, Poytichus carteri Butt can lay up to 130 eggs. The female lays its eggs singly on both fresh and dry leaves and branches. The larval period ranges from 9-13 days. Mating takes place after about 16 hours of adult emergence and egg laying commences 12 hours later. The adult sex ratio is approximately 1:1 although males tended to predominate sometimes.

III. Damage characteristics

Larvae feed on leaves and other greenish parts of the plant. Young plants may be defoliated if attack occurs early in the season. The larvae (caterpillars) are gregarious and when prevalent defoliate the host plants and defoliated wholly the tree NRI [18].

IV. Control measures

a) Cultural method

Pest populations can be partially controlled by destroying places where the insect can breed. This includes burning crop wastes (rotten and decayed pods) and removing weeds.

b) Chemical method

The insecticides like endosulfan, cypermethrin, lambda-cyhalothrin and fenitrothion have been recommended for effective control of larvae.

Ancistrtermes spp*, *Amitermes spp*, *Captotermes spp* and *Macrotermes spp

I. **Importance**

Ancistrtermes spp, *Amitermes spp*, *Captotermes spp* and *Macrotermes spp* (Termite) colonies are started by the sexual forms, which fly from the nests at the start of the rainy season and lose their wings before re-entering the soil or other hiding places NRI [18]. Termite, Macrotermes bellicosus, is however an emerging pest of Kola/Cocoa tree plantation.

II. **Biology**

Termites undergo incomplete metamorphosis; the younger instars of their nymphs greatly resemble the adults and take on important functions in the nest at an early stage Kranz [60]; Malaka [51]; Pearce [61]. Copulation is eventually accomplished, and eggs laid into excavated initial cell which terminated courtship in termites. In an established colony, the queen lays egg and the eggs may be carried by the workers to other chambers or to a separate part of the royal chamber during incubation for hatching. The larvae are translucent with large setae. They can be assisted in hatching by workers who pull off, eat the eggshell and clean the larvae thoroughly to remove any remains. The larvae on hatching, remain in the brood chamber with the reproductives who looks after and clean them, until the first workers develop to take on the role of foraging for food and looking after the young ones.

III. **Damage characteristics**

Termites cause damages on the field by attacking the trunks and pods of cocoa/kola tree causing the plant and the pods to dry up after severe infestations. They feed on dead vegetation and tunnel into the roots and stems of trees of any age resulting in destruction by weakening of the tree structure causing them to collapse or giving access to the entry of pathogenic organism (fungus and other diseases). The fungal pathogen is responsible for rot infection. Other insect damage activities included bark nibbling and scraping, which can cause the death of seedling and even mature plants. Damage is most severe in stands which are under severe water stress, old stands and those subjected to bad pruning which leaves dead and dying tissue on the plant NRI [18].

IV. **Control measures**

a) **Cultural method**

Crop rotation or rotational cropping system is effective in the control of the subterranean insect pest. Avoid continuous cultivation on the same area of land to prevent the termite population build up.

b) **Chemical method**

Termites could effectively be controlled by the application of insecticides (Methidathion, Carbofuran, Endosulfan, Pyrinex, Dursban, Termicid, Endocarp and Fenitrothion) to the soil around the base of the kola seedlings and mature plants or coppiced stems just before the outset of the dry season NRI [18]; Adejumo and Asogwa [62]. Oyedokun [63] reported that the aqueous extracts of Phyllanthus amarus, Acassia albida and Tithonia diversifolia caused 40-56%, 24-60% and 42-88% mortality of termite, after 140 minutes of exposure (MOE) to the extracts. Similarly, ethanolic

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extracts of the P. amarus, A. albida and T. diversifolia resulted in a significantly ($P<0.05$) higher percentage mean mortality of 64-91%, 36.4-76% and 36-68% respectively.

A) Pesticides considered safe for protection of Kola nuts/ Cocoa

The following synthetic insecticides such as Actara 25 WG, Esiom 150 SL, Proteus 170 0-TEC, Avesthrin, Termicid, Capsida, Phostoxin, Zap, Confidor etc. were screened against attacks of kola weevils/mirids. This is to determine biodegradability of the insecticides with little or no residue effect that may pollute the environment Asogwa [64]. Among the chemical insecticides screened, Actara 25 WG, Esiom 150 SL and Proteus 170 0-TEC passed through all the stages and considered effective, and thus recommended for use on Kola/Cocoa tree or their products. However, Phostoxin is recommended as a fumigant in controlling storage pests. Other chemicals aside recommended ones are still under investigation Asogwa [64]. Though, there is need to check or monitor the influx of banned or adulterated insecticides in the country, equally enlighten farmers/traders on the use of currently approved insecticides and involved modern techniques Azeez [65].

B) Sociological effect and perception of farmers towards banned pesticides

Farmers are fond of using DDT and other banned pesticide on their plantation and curing of kola nuts during storage based on recent survey conducted by several scientists Uwagboe [66]; Azeez [27]. The reasons adduced by farmers for the use of the banned chemical (DDT) included no adequate awareness on the status of the banned insecticides, it is cheap, they could procure the banned chemicals easily because it is readily available in the market and they do not have information on detrimental effect of the banned insecticides Uwagboe [66]; Azeez [27]. Consequently, the adulterate chemical/banned insecticides are sold in the market by accessible retailers with unapproved small measurements. However, farmers are ignorant of the side/detrimental effects of the chemical used on their health and the environment. Moreover, Azeez [66] reported that there is death of information on the efficient and economical methods of handling pests problems facing kola traders in Nigeria. Asogwa & Dongo [67] reported the new European Union (EU) Legislation on MRLs allowed on cocoa beans and products, some of the pesticides still undergoing screening and the previously recommended pesticides were banned. This new regulation, which came into effect in September 1, 2008, has left very few pesticides for use on cocoa both on farm and post farm activities in Nigeria. However, some pesticides are recently banned by European Union, but more are still under further investigation against Kola/Cocoa production. The banned pesticides included Acephate, Amitraz, Aldrin, Azinphos-methyl, Cabaryl, Cabofuran, Carbosulfan, Cartap, Terbufos, Cyhexatin, DDT, Dichlorvos, Dieldrin, Dioxacarb, Endosulfan, Lindane, Methyl-Parathion, Methonmyl, Monocrotaphos, Profenfos, Promecarb, Propoxur etc Asogwa [64].

C) Assessment of botanicals as natural chemicals for the storage of Kolanuts

Natural plant pesticides are active principles derived from plants for the management of human and animal pests organisms or it can be said to be biologically active ingredients, principally derived from plants, for the management of human and animal pest organisms. This informed recent direction of research towards the use of aqueous or ethanolic phyto-chemical insecticides in the control of insect pest of kola nut. According to Azeez [65] who reported that the ethanolic extract of Lycopersicon esculentum, Hyptis suaveolens, Cymbogon citratus, Loranthus braunii, Alstonia boonei and Sarcocephalus latifolius gave quick knock down effect and achieved high weevil mortality during exposure periods. Therefore, the botanicals with any of the tested application strategies (contact or fumigant action) could provide effective control of kola weevils Azeez [65]. With the growing global demand for environmentally sound pest management strategies; there is a need to develop alternative pesticides with minimal or non-ecological hazards. Concerted effort so far on the development of botanicals has resulted in the commercialization of "azadirachtin", a highly potent allelochemical from the tropical neem plant, Azadirachta indica A Juss. This is in agreement with the findings by Nisbet [68] that compounds like aztin and azadirachtin, a limonoid extracted principally from the seeds of the neem and thus attributed the insecticidal properties to an ecdysone-like type of action. In the same vein, Enobakhare & Azeez reported that there was an appreciable reduction in oviposition and adult bruchid emergence on neem treated cowpea seeds liken to reported studies on behavioural and developmental stages of kola weevils Azeez [65].

Natural chemicals (botanicals) prepared from parts of the plant such as Azadirachta indica L. (neem), Cymbopogon citratus (DC ex Nees) stapf (tea), Alstonia boonei DeWild (stool wood), Gmelina arborea L.Gmelina etc were used in protecting kola nuts against devastating effect of kola weevils Azeez [65]; [69]. Though the plants used are not only to protect the nuts against the insect attack but rather to retain high percentage of moisture. This agreed with findings reported by Azeez [69] that plant of leaves (Azadirachta indica, Tectonia grandis, Musa paradisiacal and Alchornea cordifolia) could serve dual purpose of nuts protection as well as keeping the nut crispness during and after storage. Asogwa [34] found storage of kola nitida at 2.5 x 103 ppm of five plants (Cederela odorata, Khaya spp, Azadirachta indica, Chromolena odorata and Chrysophyllum albidum) ethanolic extract adequate against kola weevils damage. Therefore, the various extracts could be proffered as alternatives to kola farmers, so as to reduce their total dependence on synthetic insecticides for kola nut storage.

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Conclusion

The knowledge of ecology combined with life cycles of insect pest would enhance better understanding of the best option of pest management strategies to employ. Therefore, the sparingly use of chemical (0.025 ml) with other control options in a compatible manner achieved effective and sustainable pest management. Some chemicals have been banned but the information is yet to reach those who buy in ignorance and apply without knowledge. In the foregoing, the approved and prohibited pesticides are provided to make producers to take right decision. Accredited sources in Nigeria have been provided so that fake chemicals are avoided and recognized Asogwa [65]. Some of these chemicals must be used at specific times and locations in the value chain of the crop. Consequently, it is important to use the right chemicals so that the quality of the farm products would not be affected when used for food items Asogwa & Dongo [34]. It is worthy to note that irrespective of previous storage trials, there has been no categorical recommendation of chemical control of kola weevils [71-73]. This is due to the fact that kola nuts need no further processing before consumption hence no level of chemical residue on it will be acceptable.

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