Original Research Article

Infestation and Damage by *Caryedon serratus* (Olivier) on Stored *Tamarindus indica* (Linneaus) in Kano State, Nigeria

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ABSTRACT

A survey was conducted on the infestation and damage *Caryedon serratus* on stored tamarind pods from September to November, 2014 in three local government areas (Doguwa, Gezawa and Kano Municipal) of Kano State in Nigeria. Structured questionnaires were randomly administered to 60 respondents. A total of 27 samples of tamarind pods were purchased for damage analysis. Descriptive statistics were used to analyze the collected data while ordinary least square Regression was used on damage data. Results obtained indicated that un-elevated room storage (in woven sacks) was the preferred (48.3 %) form of tamarind storage practiced (91.7 %), mostly for a period of 1 – 3 months (60 %) of storage before being sold out. More so, about 98.3 % of the respondents were aware of *C. serratus* as pest of tamarind pods. The pods are commonly attacked by such pest (48.3 %) from inception to about 3 months of storage leading to highest damage ~~(36.7 %) levels~~. The regression analysis revealed that the number of perforations were highly significant (*P<.001*) in relation to the total number of tamarind pods, however~~, no significant~~ effects observed on pods' weight loss in any of the three locations. The combined models analysis shows Gezawa recorded significantly ~~(*P<.001*) higher number of perforations~~ compared to others which are similar. On the control measures, 46.7 % have reported the application of a control method against *C. serratus* and that dried pepper (20 %) was the most prevalent. Solarization and airtight polythene storage bags were found statistically similar. Only 5 % of the respondents use synthetic chemicals although very effective. The present study revealed that *C. serratus* is a widespread and damaging pest of tamarind in the study areas. Therefore, there is need for a more advanced, cost effective and safe alternative means of control especially from the first three to six months of storage.

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Keywords: (Infestation, Caryedon serratus, Tamarindus indica, Damage)

1. INTRODUCTION

Tamarind (*Tamarindus indica*) is an important tree distributed worldwide in semi-arid tropical regions. The tree produces edible pod-like fruits which are used extensively in cuisines and medicinal purposes in different tropical countries around the world [1]. Apart from being an important tree crop, is also valued as fuel wood, ornamental, medicinal plant, and livestock feed [3]. The fruit pulp which is sweet in taste is used for serving curries, chutneys and sauces, because of its anti-ascorbic properties the pulp is also used in place of lime or lemon in soups. Tamarind kernel powder (TKP) is used as a sizing material in textile and leather industries [2]. In Northern part of Nigeria, roots of tamarind in combination with other native medicines are used for treatment of leprosy and chest pain [4], also the seeds are used for the treatment of dysentery, ulcer, boils, and diabetes, furthermore, the pulp and

leaves are used in preparation of soups and refreshing drinks, confections, and ice cream [2].

Despite these uses and importance, tamarind is reported to be attacked by more than 40 different species of insect pests, although only few of them are of economic importance [2]. Among these insect pests, fruit borers such as *Paraplis agularis, Corcyra cephalonica*, and most importantly *Caryedon serratus* are of prime importance and responsible for low yields due to their ability to infest the crop at different stages (fruits and seeds) in both the field and store. Borer insect pests feed on the fruit pulp internally and leave behind its excreta which deteriorate the quality and market value of the fruits. Hence, studies on tamarind fruit borer's especially *C. serratus* and their losses are essential particularly in places where tamarind plant contribute immensely to livelihood of people. Thus this study was conducted to determine the level of infestation and damage by *C. serratus* on stored tamarind in Kano state.

2. MATERIAL AND METHODS

2.1 Study Area

The survey was carried out in Gezawa, Doguwa and Kano Municipal Local Government areas of Kano state in 2014. In Gezawa (Gezawa central, Wangara and Jogana villages), Doguwa (Burji and Tagwaye villages) and Kano Municipal (Sharada, Rimi, Kurmi and Sheka markets) were selected for the study.

2.2 Sampling methods

A Purposive sampling technique was used in selecting the three local government areas in order to target mainly farmers dealing with storage and selling of tamarind in the study area. Twenty respondents were randomly selected in each local government area, thus making a total of sixty (60) respondents for the study. Structured questionnaires were administered to the respondents to elicit information from them on their various activities related to tamarind and problems associated with storage of tamarind. In addition, socio-economic characteristics of the respondents were collected. Local interpretation of the questionnaire in Hausa (in north western Nigeria) was made where the farmers had no grasp of English as their first or primary language.

2.3.- Laboratory damage assessment

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Tamarind fruits were purchased (2 kg sample) from seven good respondents (who answered all questions) in each of the three Local Government Areas to be used for the laboratory study on extent of damage by the pest on tamarind pods. The 2 Kg samples were divided in 5 equal potions (400 g each), thereafter three portions were selected randomly as replicates. These samples were examined for damage levels in the laboratory using a scale of low (less than 15 % of the fruits infested with cocoon), medium (15 to 45 % of fruits infested with cocoon) and high (46 % and above infestation) in damage levels.

2.4 Statistical Analysis

Data collected were analyzed through descriptive statistics (frequencies and percentages) to generate summaries and tables, using computer statistical software SPSS for windows

version 15.While, damage data obtained from the laboratory samples were subjected to Ordinary Least Squares Regression using "Shazam –Version 9.0" computer statistical software.

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3. RESULTS AND DISCUSSION

Table1: Socio-economic characteristics of the respondents

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Variable	Frequency	Percentage
Age (Years):		
23 – 34	6	10.0
35 – 46	15	25.0
47 – 58	22	36.67
59 – 70	15	25.0
71 – 83	2	3.33
Total	**60**	**100**
Sex:		
Male	53	88.3
Female	7	11.7
Total	**60**	**100**
Marital Status:		
Married	59	98.3
Single	1	1.7
Total	**60**	**100**
Household Size:		
1 – 10	28	46.7
11 – 20	23	38.3
21 – 30	5	8.3
31 – 40	4	6.7
Total	**60**	**100**
Level of Education:		
Religious Education	43	71.7
Primary Education	9	15.0
Secondary Education	4	6.7
Adult Education	4	6.7
Total	**60**	**100**
Major Occupation:		
Integrated Merchant	26	43.3
Farmer	21	35.0

Seller of Agricultural Products	10	16.7
Labourer	1	1.7
Driver	2	3.3
Total	**60**	**100**

Source: Field survey, 2014

3.1 Forms and methods of tamarind storage

Majority (85 %) of the respondents store tamarind (Table 2), out of this percentage 46.7% had 1 – 10 years of experience in tamarind storage, 23.3 % had 11- 20 years of experience, and 11.7 % and 3.3 % had 31- 40 and 45 – 50 years of experience in tamarind storage respectively. Majority of the respondents (91.7 %) store their tamarind in a ~~shelled (Figure A) form~~ while only 8.3 % store the ~~unshelled (Figure B) tamarind~~.

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Comment [m12]: unshelled tamarind (Figure B)

The storage methods for tamarind were observed to be same as those of grains which are generally being stored in bags (sacks) and packed in well aerated store rooms. Airtight storage is also found to be effective especially under long-term storage. Six different storage methods were observed among the respondents out of which majority (48.3 %) were found to store their tamarind in sacks and inside store rooms (on the floor without an elevation), while a few of them do store tamarind pods in sacks and place outside under shade without an elevation. The use of polythene bags inserted inside sacks (11.7 %), was said to be the most effective method of storage as it is a form of airtight storage which serves as a control measure commonly used against other insects pests (*C. maculatus, Sitophilus sp* etc). Moreover, considering quantity and length of storage, majority (96 % and 60 %) of the respondents store 1 to 50 bags of tamarind for a period of 1 to 3 months respectively.

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The quantity of tamarind stored by each of the respondents varies depending on their capital, the highest quantity observed was 250 bags and the lowest was 1 bag being put for storage. ~~Significantly (*P* = .05) highest porcentage (96.7 %) of the respondents~~ are storing from 1 to 50 bags of tamarind pods, while about 3.3 % of the respondents do store over 100 bags (Table 2). Moreover, considering the time of storage, majority of the respondents interviewed (60 %) store tamarind pods for less than 3 months, 15 % for 4 to 6 months while 15 % for 6 to 9 months and only 10 % store for a period of 10 to 12 months. Nonetheless, the highest price recorded was ~~₦~~5000 per bag and the lowest was ~~₦~~1000. Majority of the respondents (46.67 %) have reported purchasing their tamarind at prices ranging ~~₦~~1000 to ~~₦~~2000 per bag while 40 % purchased at prices up to ~~₦~~3000 per bag, 11.67 % of the respondents purchased at prices between ~~₦~~3000 to ~~₦~~4000 per bag and only 1.67 % make purchases at prices above ~~₦~~4000 per bag.

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Figures: A Unshelled and B Shelled tamarind pods showing pupal cocoons with damaging perforations by *C. serratus*

Source:Field survey, 2014

Table 2: Forms and methods of tamarind storage by the respondents

Variables	Frequency	Percentage
Storage of Tamarind:		
Yes	51	85.0
No	9	15.0
Total	**60**	**100**
Years of Experience in Tamarind Storage		
1 – 10	28	46.7
11 – 20	14	23.3
21 – 30	9	15
31 – 40	7	11.7
45 – 50	2	3.3
Total	**60**	**100**
Form of storage:		
Shelled	55	91.7
Unshelled	5	8.3
Total	**60**	**100**
Methods of storage applied:		
Sacks in storage room (without elevation)	29	48.3
Sacks in storage room on elevation	6	10.0
Polythene bag in sacks in storage room (without elevation)	7	11.7
Polythene bag only in storage room (without elevation)	8	13.3
Sacks outside storage room under shade (without elevation)	1	1.7
No storage method applied	9	15.0
Total	**60**	**100**
Quantity of tamarind stored (in bags):		
1 – 50	58	96.67
51 – 100	0	0

101 – 150	0	0
151 – 200	1	1.67
201 – 250	1	1.67
Total	**60**	**100**
Length of storage (in months):		
1 – 3	36	60
4 – 6	9	15
7 – 9	9	15
10 – 12	6	10
Total	**60**	**100**
Price of tamarind per bag (in Naira)		
1000 – 2000	28	46.67
2001 – 3000	24	40
3001 – 4000	7	11.67
4001 – 5000	1	1.65
Total	**60**	**100**

Source: Field survey, 2014

3.2 Knowledge of Pest and Control Measures Applied by the Respondents

Almost all of the respondents interviewed (98.3 %) were aware of *C. serratus* as a pest that attacks tamarind under storage, while 1.7 % does not know anything about the pest (Table 3). ~~Most (48.3 %) of the respondents~~ reported that attack/damage to tamarind pods start at the inception (1-3 months) of storage. More so, about 36.7 % of the respondents have observed that high (70 %) damage to tamarind pods is mostly caused by the insect pests during storage while 33.3 % have observed moderate damage and 30 % have stated the damage to be low. When control measure is been considered only 46.7 % of the respondents use one control measure or another to manage *C. serratus* damage on tamarind pods, out of this proportion only 5 % of the respondents use synthetic pesticides, while the remaining 41.7 % of the respondents uses other control measures such as Solarization, use of air tight method and plant powders (Table 3).

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As presented in Table 3 a proportion of about 46.7 % of the respondents were applying different control measures in an effort to minimize *C. serratus* damage on tamarind pods during storage, while 53.3 % of them were not applying any form of insect pest control measure. Some of the various control measures applied includes the application (sprinkling) of ground red pepper into the bag of tamarind (20 %), sun drying infested tamarind or solarization (10 %), airtight method using polythene bag (10 %). Storage of the pods on an elevation (i.e. a wooden platform) and the application of Gammalin (chemical control) indirectly by applying the powdered formulation on the floor, covering with a mat or sack and spreading the pods on top, the pods are again covered with another mat or polythene sheet and left for about 24 hours.

Table 3: Respondents' knowledge of *Caryedon serratus* as a pest of tamarind pod

Variables	Frequency	Percentage
Awareness of the pest:		
Yes	59	98.3
No	1	1.7
Total	**60**	**100**

Period of Attack:		
At inception of storage (0 – 3 months)	29	48.3
After three months storage	19	31.7
After six months storage	11	18.3
After one year storage	1	1.7
Total	**60**	**100**
Level of Damage Caused:		
Low	18	30
Medium	20	33.3
High	22	36.7
Total	**60**	**100**
Control Measures:		
Yes	28	46.7
No	32	53.3
Total	**60**	**100**
Type of Control Measures Applied		
Ground red pepper	12	20
Solarization	6	10
Good sanitary measure (including elevation)	1	1.7
Air tight method (polythene bag in sack)	6	10
Chemical control (application of Gammalin)	3	5
None	32	53.3
Total	**60**	**100**

Source: Field survey, 2014

3.3 Regression analysis for pod perforation made by *C. serratus* at the three different ~~location~~

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The regression analysis for pod perforations made by *C. serratus* at the three locations among samples were highly significant in the three Local Government Areas, with much higher number of perforations from Kano Municipal Local Government Area than those obtained from Gezawa and Doguwa Local Governments (Table 4).

Table 4: Regression analysis for pod perforation made by *C. serratus* at the three sites

Variable	Estimated coefficient	Standard Error	T-ratio	~~P-value~~	Partial correlation	Standardized coefficient	Elasticity at means
SWT	19621	0.1266	1.550	0.135	0.314	0.1467	0.6697
NOH	28.597	3.246	8.809	0.000***	0.883	0.8761	0.7393
TNPG	-10800	3729	-2.896	0.008**	-0.525	-0.3027	-0.1239
TNPD	-6657.3	3455	-1.927	0.067*	-0.380	-0.1927	-0.0859
TNPK	-5143.6	0.1084	-0.4743	0.640	-0.101	0.0000	-0.1992

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SWT = Sample Weight, NOH = Number of Holes, TNPG = Total Number of Pods in Gezawa, TNPD = Total Number of Pods in Doguwa, TNPK = Total Number of Pods in Kano Municipal

4. DISCUSSION

The low occurrence of women tamarind marketers was as a result of the fact that according to the Hausa and Fulani tribes which are predominant tribes in all of the study areas, males are confined to the most tedious activities of harvesting, bagging, storing and transportation, while females are mostly confined to home retail business and minor storage [5]. However, most of the women still carry out marketing activities in their various homes; these women were met and interviewed within their homes. Majority of the female tamarind marketers sell the tamarind not in its raw form, but rather use it as an important ingredient in the traditional "*kunun tsamiya"* which is prepared and sold in the morning, afternoon or evening depending on the season and location. In a survey in Kebbi State ~~by~~ [6], similar result was obtained that women in Northern Nigeria are mostly confined to the domestic area, where their main responsibility is cooking and taking care of ~~the~~ young. It is the responsibility of a male head of the household to procure and manage grain when needed by women for cooking, with the exception of widows who manage their own grain supplies.

Relatively higher percentage of the respondents had observed damage on their stored tamarind pods. "High damage" connotes 70 % damage and beyond, "moderate damage" connotes about 50 % damage while "low damage" connotes 30 % damage or less. A research conducted ~~by [7]~~ on damage potential and loss caused by *C. serratus* showed that there was up to 90 % damage and more than 60 % weight loss. Similar results were also reported ~~by~~ [8, 17] that infestation rates of *C. serratus* are so high that farmers stocks are often completely destroyed within months. In Northern Nigeria, insects pierce 30 to 40 % of the pods, and up to 80 % especially in dry conditions [9].

~~The survey results indicate~~ that higher proportion of loss caused by storage pests is related to the system of storage practiced, for instance, method of processing before storage. Although a greater proportion of respondents (91.7 %) stored their tamarind unshelled, in spite of the evidence that unshelled grain/crops had lower infestation levels. Further investigation is needed to discover why so many farmers store their tamarind in the shelled state. The observation that grain/crop stored in an unshelled form is less susceptible to insect attack is supported ~~by~~ [6; 10, 11 and 18]. However, this depends on the insect species and the host grain or crop [12]. Since threshed grains/crops are more susceptible to pest attack, these group of farmers may need proper treatment with effective control measures.

The period of attack reported by most of the respondents begins at the inception of storage to the first 3 months of storage this was also confirmed ~~by~~ [9]. Elsewhere, extensive pre-season survey of groundnut post-harvest process and storage premises in Zambia indicated that primary infestation from the field was critical in establishment of the bruchid; *C. serratus* in the stores [13, 18] and that the groundnuts lifted early and dried for longer period than usual in the field received consistently higher insect infestation. In compliance with the aforementioned study, the early infestation period observed may be as a result of long storage period. More so, [14] reported that infestation of tamarind pods was recorded right from the field. He also reported that the only possible source of field infestation by *C. serratus* might have been due to its laying of eggs on new harvested pod of tamarind (or groundnut) kept for drying in the field and during storage.

Moreover, the ~~length~~ of storage depends on the season which in turn determines the demand and affects levels of pest infestation during storage. The survey results indicate that

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majority of farmers stored their tamarind for three months and only 15 % for 4 to 6 and 7 to 9 months respectively. Although, the level of insect infestations were reported to significantly affect grains and dried fruits stored for seven to ten months compared to that stored for three months [6, 17]. The period of maximum demand for tamarind occurs during the Muslims' fasting period and during this period storage ~~length~~ is relatively low. The variation in purchase price of the tamarind depends on the season, marketers' proximity to the site of production (farm or wild) and whether or not the marketer owns the tree i.e. presence or absence of middlemen. Those who own the tree or purchase the tamarind directly from wholesalers tend to purchase and sell it at a lower price**.**

Nonetheless, the use of pepper is the most popular control measure among the farmers and greater percentage are using ground pepper (20 %). [16] had reported a study in Thailand that in addition to being used as foods flavourings; spices have been used from ancient times to protect stored products pests. Traditionally, pieces of dried spices or ground spices were used to sprinkled over or mix with stored foods. Among the most common spices used in storage food protection are black pepper (*Piper nigrum*), ginger (*Zingiber officinale*) and cloves (*Syzygium aromaticum*). More so, [17] reported in a study on the Indigenous Pest Management Practices among Hill Farmers in India that grains to be stored are first sundried by the farmers and this kills most insect pests.

Furthermore, 20 % of the respondents use ground pepper as protectant against *C. serratus*, suggesting the opportunities to document, screen and improve plant products for use as protectants for small-scale farmers in the study areas [6]. However, it was obvious that most farmers in the surveyed area did not have a standard method for preparing and applying repellent plant material to their tamarind stores, which could explain why botanicals did not appear to be very effective in reducing insect infestations. This could also be the reason for disagreements among the farmers as to whether botanicals are effective or not. Similarly, [15, 18] had reported that the efficacy of plant materials depend on the pest species, the environmental location of the stores, the plant species and part of the plant used and the method of preparation and application used. Hence, further investigation on the optimal methods of preparation and application of locally available plant botanicals is imperative in order to establish more promising, effective and standard methods. Moreover, the use of chemical insecticide also reported by the respondents to be very effective. This method was said to be very effective in eliminating all insect pests affecting tamarind however, the method is not practiced by most farmers and traders as the chemicals are so expensive and dangerous to handle. More so, none of the respondents reported to employ the use of integrated management by using 2 or more of the aforementioned methods simultaneously, similar report was reported ~~by~~ [6].

The period from which *C. serratus* begins its attack on tamarinds pods differ as observed by the different respondents that most of the attack occurred at the inception of storage a period of between 0 to 3 months. Therefore, the insect pest could have probably begun its damaging activities on the pods either from the mother tree or the period between 1 to 3 months of storage. This could have taken place after 6 months of storage because only 1.7% reported to have observed infestation after 1 year of storage. This has contradicted with the findings ~~of~~ [6] that the survey findings indicates that farmers stored their grain between four months and one year (i.e., from one crop season to another), with the majority storing their grains for seven months.

The study indicated that the population of *C. serratus* was higher in Kano Municipal Local Government area than in Doguwa and Gezawa Local Government ~~Areas~~, which in a way production centers are indicating that pest number and damage increases with transportation and subsequent storage. Suggesting that pulses need continuous monitoring

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and protection at all stages of storage as they are prone to attack by several insect pests [6, 9]. Pulses stored in farm storage facilities have greater likelihood of pest infestation than storage at a processor's location [6]. Moreover, several factors could also contribute to higher infestation especially in Kano Municipal that the stored tamarind might be poorly treated or not treated at all. Nonetheless, the peak ~~in infestations~~ could coincides the rainy season, which reaches its peak in July and August for instance, ~~[6 and 15]~~ reported a combination of high temperature, relative humidity and moisture content provides favourable conditions for insect perpetuation and development. The major problem arises from the fact that most farmers use inadequate storage methods immediately after harvest and before processing this aggravates infestation and damage during transportation and long-term seasonal storage causing an estimated overall loss of over 30 % [9]. Such situation is greatly magnified in regions where the relative humidity is high, while at temperature of about 32^{o}C the rate of multiplication monthly could increase to about 50 times the original number [6]. This means that 50 insects at harvest time could multiply to about 312 million in just four months.

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5. CONCLUSION

The present study has revealed that *C. serratus* is categorized as major pest of tamarind in Kano State, Nigeria with an increasing number of perforations within the first three months of storage in all the three study areas. Hence, tamarind pods need to be protected against infestation and subsequent damage by *C. serratus* from field to the first three months of storage. It has also shown that adoption of modern tamarind storage and processing facilities as well as sound market structures will reduce the colossal losses usually encountered by the producers, marketers and users of the tamarind in Kano State, Nigeria.

Disclaimer:

This paper is based on preliminary dataset. Readers are requested to consider this paper as preliminary research article, as authors wanted to publish the initial data as early as possible. Authors are aware that difference in the infestation level between shelled and unshelled tamarind the respondents is required to get a scientifically established conclusion. Readers are requested to use the conclusion of this paper judiciously as this parameter is absent. Authors also recommend the same for similar future studies.

This manuscript was presented in the conference.

Conference name: - 48th conference of the Entomological Society of Nigeria

6. COMPETING INTERESTS

Authors have declared that no competing interests exist.

Disclaimer: - This manuscript was published in the conference.

Yes, the paper was presented at the 48th conference of the Entomological Society of Nigeria held at Awka, Anambra State, Nigeria. The title presented is Infestation and Damage by *Caryedon serratus* (Olivier) on Tamarind Pods in Three Local Government Areas of Kano State

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