

Original Research Article

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

ABSTRACT

A survey was conducted on the infestation and damage of *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 levels (36.7%). The regression analysis revealed that the number of perforations were highly significant ($P < .001$) in relation to the total number of tamarind pods, however the effect observed on pods'was insignificant on weight loss in any of the three locations. The combined models analysis shows Gezawa recorded significantly higher number of perforations ($P < .001$) 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.

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

27 leaves are used in preparation of soups and refreshing drinks, confections, and ice cream
28 [2].
29

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

43 **2.1 Study Area**

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45
46 The survey was carried out in Gezawa, Doguwa and Kano Municipal Local Government
47 areas of Kano state in 2014. In Gezawa (Gezawa central, Wangara and Jogana villages),
48 Doguwa (Burji and Tagwaye villages) and Kano Municipal (Sharada, Rimi, Kurmi and Sheka
49 markets) were selected for the study.
50
51

52 **2.2 Sampling methods**

53
54 A Purposive sampling technique was used in selecting the **three local** government areas in
55 order to target mainly farmers dealing with storage and selling of tamarind in the study area.
56 Twenty respondents were randomly selected in each local government area, thus making a
57 total of sixty (60) respondents for the study. Structured questionnaires were administered to
58 the respondents to elicit information from them on their various activities related to tamarind
59 and problems associated with storage of tamarind. In addition, socio-economic
60 characteristics of the respondents were collected. Local interpretation of the questionnaire in
61 Hausa (in north western Nigeria) was made where the farmers had no grasp of English as
62 their first or primary language.
63

64 **2.3.- Laboratory damage assessment**

65
66 Tamarind fruits were purchased (2 kg sample) from seven good respondents (who answered
67 all questions) in each of the three Local Government Areas to be used for the laboratory
68 study on extent of damage by the pest on tamarind pods. The 2 Kg samples were divided in
69 5 equal portions (400 g each), thereafter three portions were selected randomly as replicates.
70 These samples were examined for damage levels in the laboratory using a scale of low (less
71 than 15 % of the fruits infested with cocoon), medium (15 to 45 % of fruits infested with
72 cocoon) and high (46 % and above infestation) in damage levels.
73

74 **2.4 Statistical Analysis**

75
76 Data collected were analyzed through descriptive statistics (frequencies and percentages) to
77 generate summaries and tables, using computer statistical software SPSS for windows

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

81

82 3. RESULTS AND DISCUSSION

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85 **Table1: Socio-economic characteristics of the respondents**

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

86 Source: Field survey, 2014

87

88 3.1 Forms and methods of tamarind storage

89 Majority (85 %) of the respondents store tamarind (Table 2), out of this percentage 46.7%
 90 had 1 – 10 years of experience in tamarind storage, 23.3 % had 11- 20 years of experience,
 91 and 11.7 % and 3.3 % had 31- 40 and 45 – 50 years of experience in tamarind storage
 92 respectively. Majority of the respondents (91.7 %) store their tamarind in a **shelled form**
 93 **(figure A)** while only 8.3 % store the **unshelled tamarind (figure B)**.
 94

95 The storage methods for tamarind were observed to be same as those of grains which are
 96 generally being stored in bags (sacks) and packed in well aerated store rooms. Airtight
 97 storage is also found to be effective especially under long-term storage. Six different storage
 98 methods were observed among the respondents out of which majority (48.3 %) were found
 99 to store their tamarind in sacks and inside store rooms (on the floor without an elevation),
 100 while a few of them do store tamarind pods in sacks and place outside under shade without
 101 an elevation. The use of polythene bags inserted inside sacks (11.7 %), was said to be the
 102 most effective method of storage as it is a form of airtight storage which serves as a control
 103 measure commonly used **against other insect** pests (*C. maculatus*, *Sitophilus sp* etc).
 104 Moreover, considering quantity and length of storage, majority (96 % and 60 %) of the
 105 respondents store 1 to 50 bags of tamarind for a period of 1 to 3 **months**, respectively.
 106

107 The quantity of tamarind stored by each of the respondents varies depending on their
 108 capital, the highest quantity observed was 250 bags and the lowest was 1 bag being put for
 109 storage. **Significantly, at ($P = .05$) the highest percentage of the respondents (96.7 %) are**
 110 **storing from 1 to 50 bags of tamarind pods**, while about 3.3 % of the respondents do store
 111 over 100 bags (Table 2). Moreover, considering the time of storage, majority of the
 112 respondents interviewed (60 %) store tamarind pods for less than 3 months, 15 % for 4 to 6
 113 months while 15 % for 6 to 9 months and only 10 % store for a period of 10 to 12 months.
 114 Nonetheless, the highest price recorded was **\$13.88 (~~₦5000.00~~) per bag (Naira/Doller**
 115 **exchange rate at ₦360/1\$Dollar)** and the lowest was **\$0.36 (~~₦1000~~)**. Majority of the
 116 respondents (46.67 %) have reported purchasing their tamarind at prices ranging **\$0.36**
 117 **₦1000 to 0.18 (~~₦2000~~) per bag** while 40 % purchased at prices up to ~~₦3000~~ per bag, 11.67
 118 % of the respondents purchased at prices between ~~\$8.33 ₦3000~~ to **\$11.11 (~~₦4000~~)** per bag
 119 and only 1.67 % make purchases at prices above **\$11.11 (~~₦4000~~)** per bag.
 120



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122 **Figures: A Unshelled and B Shelled tamarind pods showing pupal cocoons with**
123 **damaging perforations by *C. serratus***
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125 *Source:Field survey, 2014*
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144 **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

145 Source: Field survey, 2014

147 **3.2 Knowledge of Pest and Control Measures Applied by the Respondents**
 148

149 Almost all of the respondents interviewed (98.3 %) were aware of *C. serratus* as a pest that
 150 attacks tamarind under storage, while 1.7 % does not know anything about the pest (Table
 151 3). Most of the respondents (48.3 %) reported that attack/damage to tamarind pods start at
 152 the inception (1-3 months) of storage. More so, about 36.7 % of the respondents have
 153 observed that high (70 %) damage to tamarind pods is mostly caused by the insect pests
 154 during storage while 33.3 % have observed moderate damage and 30 % have stated the
 155 damage to be low. When control measure is being considered only 46.7 % of the
 156 respondents use one control measure or another to manage *C. serratus* damage on
 157 tamarind pods, out of this proportion only 5 % of the respondents use synthetic pesticides,
 158 while the remaining 41.7 % of the respondents uses other control measures such as
 159 Solarization, use of air tight method and plant powders (Table 3).
 160

161 As presented in Table 3 a proportion of about 46.7 % of the respondents were applying
 162 different control measures in an effort to minimize *C. serratus* damage on tamarind pods
 163 during storage, while 53.3 % of them were not applying any form of insect pest control
 164 measure. Some of the various control measures applied includes the application (sprinkling)
 165 of ground red pepper into the bag of tamarind (20 %), sun drying infested tamarind or
 166 solarization (10 %), airtight method using polythene bag (10 %). Storage of the pods on an
 167 elevation (i.e. a wooden platform) and the application of Gammalin (chemical control)
 168 indirectly by applying the powdered formulation on the floor, covering with a mat or sack and
 169 spreading the pods on top, the pods are again covered with another mat or polythene sheet
 170 and left for about 24 hours.
 171
 172
 173

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

174 Source: Field survey, 2014

175 **3.3 Regression analysis for pod perforation made by *C. serratus* at the three different**
 176 **locations**

177
 178 The regression analysis for pod perforations made by *C. serratus* at the three locations
 179 among samples were highly significant in the three Local Government Areas, with much
 180 higher number of perforations from Kano Municipal Local Government Area than those
 181 obtained from Gezawa and Doguwa Local Governments (Table 4).
 182

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

Variable	Estimated coefficient	Standard Error	T-ratio	<i>P-value.</i>	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

186
 187 *SWT* = Sample Weight, *NOH* = Number of Holes, *TNPG* = Total Number of Pods in Gezawa,
 188 *TNPD* = Total Number of Pods in Doguwa, *TNPK* = Total Number of Pods in Kano Municipal
 189

190 **4. DISCUSSION**

191
 192 The low occurrence of women tamarind marketers was as a result of the fact that according
 193 to the Hausa and Fulani tribes which are predominant tribes in all of the study areas, males
 194 are confined to the most tedious activities of harvesting, bagging, storing and transportation,
 195 while females are mostly confined to home retail business and minor storage [5]. However,
 196 most of the women still carry out marketing activities in their various homes; these women
 197 were met and interviewed within their homes. Majority of the female tamarind marketers sell
 198 the tamarind not in its raw form, but rather use it as an important ingredient in the traditional
 199 "*kunun tsamiya*" which is prepared and sold in the morning, afternoon or evening depending
 200 on the season and location. In a survey in Kebbi State as described by [6], similar result was
 201 obtained that women in Northern Nigeria are mostly confined to the domestic area, where
 202 their main responsibility is cooking and taking care of their young. It is the responsibility of a
 203 male head of the household to procure and manage grain when needed by women for
 204 cooking, with the exception of widows who manage their own grain supplies.
 205

206 Relatively 70 % damage and beyond were observed by the respondents on their stored
 207 tamarind pods. A research conducted on damage potential and loss caused by *C. serratus*

208 showed that there was up to 90 % damage and more than 60 % weight loss [7]. Similar
209 results were also reported [8, 17] that infestation rates of *C. serratus* are so high that farmers
210 stocks are often completely destroyed within months. In Northern Nigeria, insects pierce 30
211 to 40 % of the pods, and up to 80 % especially in dry conditions [9].
212

213
214 Survey results indicated that higher proportion of loss caused by storage pests is related to
215 the system of storage practiced, for instance, method of processing before storage.
216 Moreover, greater proportion of the respondents (91.7 %) stored their tamarind unshelled
217 due to the fact that unshelled grain/crops had lower infestation levels. Further investigation is
218 needed to discover why so many farmers store their tamarind in the shelled state. The
219 observation that grain/crop stored in an unshelled form is less susceptible to insect attack is
220 supported [6; 10, 11 and 18]. However, this depends on the insect species and the host
221 grain or crop [12]. Since threshed grains/crops are more susceptible to pest attack, these
222 group of farmers may need proper treatment with effective control measures.
223

224 The period of attack reported by most of the respondents begins at the inception of storage
225 to the first 3 months of storage this was also confirmed [9]. Elsewhere, extensive pre-season
226 survey of groundnut post-harvest process and storage premises in Zambia indicated that
227 primary infestation from the field was critical in establishment of the bruchid, *C. serratus* in
228 the stores [13, 18] and that the groundnuts lifted early and dried for longer period than usual
229 in the field received consistently higher insect infestation. In compliance with the
230 aforementioned study, the early infestation period observed may be as a result of long
231 storage period. More so, [14] reported that infestation of tamarind pods was recorded right
232 from the field. He also reported that the only possible source of field infestation by *C.*
233 *serratus* might have been due to its laying of eggs on new harvested pod of tamarind (or
234 groundnut) kept for drying in the field and during storage.
235

236 Moreover, the long period of storage depends on the season which in turn determines the
237 demand and affects levels of pest infestation during storage. The survey results indicate that
238 majority of farmers stored their tamarind for three months and only 15 % for 4 to 6 and 7 to 9
239 months, respectively. Nonetheless, the level of insect infestations was reported to
240 significantly affect grains and dried fruits stored for seven to ten months compared to that
241 stored for three months [6, 17]. The period of maximum demand for tamarind occurs during
242 the Muslims' fasting period and during this period storage period is relatively low. The
243 variation in purchase price of the tamarind depends on the season, marketers' proximity to
244 the site of production (farm or wild) and whether or not the marketer owns the tree i.e.
245 presence or absence of middlemen. Those who own the tree or purchase the tamarind
246 directly from wholesalers tend to purchase and sell it at a lower price.
247

248 Nonetheless, the use of pepper is the most popular control measure among the farmers and
249 greater percentage are using ground pepper (20 %). [16] had reported a study in Thailand
250 that spices are being used since ancient times as food flavourings and stored products
251 insect pests protectant. Traditionally, pieces of dried spices or ground spices were used to
252 sprinkled over or mix with stored foods. Among the most common spices used in storage
253 food protection are black pepper (*Piper nigrum*), ginger (*Zingiber officinale*) and cloves
254 (*Syzygium aromaticum*). More so, [17] reported in a study on the Indigenous Pest
255 Management Practices among Hill Farmers in India that grains to be stored are first sundried
256 by the farmers and this kills most insect pests.
257

258 Furthermore, 20 % of the respondents use ground pepper as protectant against *C. serratus*,
259 suggesting the opportunities to document screen and improve plant products for use as
260 protectants for small-scale farmers in the study areas [6]. However, it was obvious that most

261 farmers in the surveyed area did not have a standard method for preparing and applying
262 repellent plant material to their tamarind stores, which could explain why botanicals did not
263 appear to be very effective in reducing insect infestations. This could also be the reason for
264 disagreements among the farmers as to whether botanicals are effective or not. Similarly,
265 [15, 18] had reported that the efficacy of plant materials depends on the pest species, the
266 environmental location of the stores, the plant species and part of the plant used and the
267 method of preparation and application used. Hence, further investigation on the optimal
268 methods of preparation and application of locally available plant botanicals is imperative in
269 order to establish more promising, effective and standard methods. Moreover, the use of
270 chemical insecticide also reported by the respondents to be very effective. This method was
271 said to be very effective in eliminating all insect pests affecting tamarind however, the
272 method is not practiced by most farmers and traders as the chemicals are so expensive and
273 dangerous to handle. More so, none of the respondents reported to employ the use of
274 integrated management by using 2 or more of the aforementioned methods simultaneously,
275 similar report was reported [6].
276

277 The period from which *C. serratus* begins its attack on tamarinds pods differ as observed by
278 the different respondents that most of the attack occurred at the inception of storage a period
279 of between 0 to 3 months. Therefore, the insect pest could have probably begun its
280 damaging activities on the pods either from the mother tree or the period between 1 to 3
281 months of storage. This could have taken place after 6 months of storage because only
282 1.7% reported to have observed infestation after 1 year of storage. This has contradicted
283 with the findings reported [6] that the survey findings indicate that farmers stored their grain
284 between four months and one year (i.e., from one crop season to another), with the majority
285 storing their grains for seven months.
286

287 The study indicated that the population of *C. serratus* was higher in Kano Municipal Local
288 Government area than in Doguwa and Gezawa Local Government areas, which in a way
289 production centers are indicating that pest number and damage increases with
290 transportation and subsequent storage. Suggesting that pulses need continuous monitoring
291 and protection at all stages of storage as they are prone to attack by several insect pests [6,
292 9]. Pulses stored in farm storage facilities have greater likelihood of pest infestation than
293 storage at a processor's location [6]. Moreover, several factors could also contribute to
294 higher infestation especially in Kano Municipal that the stored tamarind might be poorly
295 treated or not treated at all. Nonetheless, the peak of infestation could coincides the rainy
296 season, which reaches its peak in July and August for instance, several authors reported a
297 combination of high temperature, relative humidity and moisture content provides favourable
298 conditions for insect perpetuation and development [6, 15]. The major problem arises from
299 the fact that most farmers use inadequate storage methods immediately after harvest and
300 before processing this aggravates infestation and damage during transportation and long-
301 term seasonal storage causing an estimated overall loss of over 30 % [9]. Such situation is
302 greatly magnified in regions where the relative humidity is high, while at temperature of
303 about 32°C the rate of multiplication monthly could increase to about 50 times the original
304 number [6]. This means that 50 insects at harvest time could multiply to about 312 million in
305 just four months.
306

307 5. CONCLUSION

308
309 The present study has revealed that *C. serratus* is categorized as major pest of tamarind in
310 Kano State, Nigeria with an increasing number of perforations within the first three months of
311 storage in all the three study areas. Hence, tamarind pods need to be protected against
312 infestation and subsequent damage by *C. serratus* from field to the first three months of
313 storage. It has also shown that adoption of modern tamarind storage and processing

314 facilities as well as sound market structures will reduce the colossal losses usually
315 encountered by the producers, marketers and users of the tamarind in Kano State, Nigeria.

316

317 Disclaimer:

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

324 This manuscript was presented in the conference.

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

326

327 6. COMPETING INTERESTS

328

329 Authors have declared that no competing interests exist.

330

331 **Disclaimer: - This manuscript was published in the conference.**

332

333 **Yes, the paper was presented at the 48th conference of the Entomological Society of Nigeria**

334 **held at Awka, Anambra State, Nigeria. The title presented is Infestation and Damage by**

335 ***Caryedon serratus* (Olivier) on Tamarind Pods in Three Local Government Areas of Kano**

336 **State**

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