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Department of Fisheries, Faculty of Agriculture, University of Maiduguri, Nigeria.
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Laboratory Assessment of Relative Susceptibility of Three Fish Species to *Dermestes maculatus* (Degeer) (Coleoptera: Dermestidae) and *Necrobia rufipes* (Degeer) (Coleoptera: Cleridae) in Maiduguri

[1]Medugu M. A. and [2]Kabir*, B. G. J.

[1]Department of Crop Protection, School of Agricultural and Agricultural Technology, Modibbo Adama University of Technology, P.M.B 2076 Yola, Nigeria
[2]Department of Crop Protection, Faculty of Agriculture University of Maiduguri, P.M.B. 1069 Maiduguri, Nigeria

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ABSTRACT

Experiments were conducted to assess the susceptibility and damage of three fish species (Clarias, Synodontis and Tilapia) by two stored-product beetles (Dermestes maculatus and Necrobia rufipes) under ambient laboratory conditions (25 – 34°C and 28 – 56% relative humidity (r.h.). Losses in weight, quality and susceptibility indices were measured. Fish species deferred significantly ($p \leq 0.05$ in their susceptibility to the two insect pests. In all the three fish species D. maculatus caused greater losses in weight and quality (6.1±0.1 to 13.80±0.20 and 42.80±0.60 to 63.20±0.20 %, than N. rufipes (3.1±0.2 to 7.3±0.4 and 22.4±0.20 to 35.60±0.50 %), respectively. The order of susceptibility to D. maculatus was ranked: Clarias spp>Tilapia spp>Synodontis spp. while to N. rufipes was: Tilapia spp>Clarias spp>Synodontis spp.

Keywords: Fish species, Insect Infestation, Susceptibility, Maiduguri

INTRODUCTION

Fish is a valuable source of high quality protein (Barrie *et al*., 2003; Widjaja *et al*., 2009), comparing favourably with eggs, milk and meat in the nutritional value of its protein (FAO, 1998). Fish contains fat, minerals and it is a minor calorie source (Norman and Joseph, 1996; FAO, 1998). In Nigeria, it serves as an important source of animal protein (Akande, 1997), as well as a source of income (Amusan and Okorie, 2002). Its production, handling, processing and distribution provide means of livelihood for millions of people as well as foreign exchange earnings (Al- Jufaili and Opara, 2006).

The processing and preservation of fresh fish prevents economic losses and deterioration of the fish (Okonta and Ekelemu, 2005). In Borno State, fish curing through smoking or drying are the major methods of preservation. A major source of damage of cured fish is insect infestation. About fifteen insect pest species have been recorded on cured fish. *Dermestes sp.* and *Necrobia rufipes* constitute the major pests (Amusan and Okorie, 2002). Ayuba and Omeji (2006) reported that insect infestation is the

*Corresponding Author: bgbkabir@yahoo.com, Tel: + 234 (0) 8026798714

cause of most prominent losses in quality and quantity of stored dried fish in Nigeria. Larval stages of *D. maculatus* account for infestation of about 93% in dried fish (Amusan and Okorie, 2002). Other reports indicated that about 71.5% of dried fish infestation in most of the producing areas was caused by *D. maculatus* Akinwumi *et al*. (2007) and 28% by *N. rufipes* (Osuji, 1974). Losses of 13-17% during 3 months' storage of dried fish in Nigeria (caused mainly by the skin beetle, *Dermestes maculatus* Degeer, the principal post-harvest pest of dried fish (Lale and Sastawa, 1996). Large tonnage (up to 10,000 tonnes) of fish especially species of *Clarias, Synodontis and Tilapia* are produced annually in the Lake Chad fishing district (Sastawa and Lale, 1998). Most studies concerning these species were devoted to losses in one fish species or due to a single pest species, rather than a comparative one. This study was undertaken to assess losses in three fish species (smoked) due to *D. maculatus* and *N. rufipes* infestation under laboratory conditions.

MATERIALS AND METHODS

Source of fish

The three most commonly smoked fish species were used in the study. These were: *Clarias gariepinus, Synodontis nigrita* and *Tilapia niloticus* species. The smoked fish were obtained from Baga Road Fish Market, Maiduguri.

Establishment of *D. maculatus* and *N. rufipes* cultures

Parent insects were sieved out of infested cured fish obtained from the same market, where the fish substrates were collected. About 300g of sterilized cured fish were placed in a series of 1-litre glass jars and infested with 100 un-sexed adults of the insects from the parent stock. The glass jars were then covered with wire mesh and held in position by perforated screw tops to keep in the insects and also to facilitate ventilation. Three such cultures of each fish species were prepared at a time and placed on inverted Petri dishes in vegetable oil on shallow trays to keep out mites and other unwanted insects. The parent adult insects were then sieved out after two weeks of oviposition. The culture jars were then left undisturbed until adult emerged. Resulting offspring, aged (0-7 days old) were then used for the experiments. The raising of culture and the experiment were conducted under ambient laboratory conditions (25 – 34°C and 28 – 56% relative humidity).

Determination of loss in weight and quality

Loss comprises the reduction in weight of dry matter (weight loss) while fragmentation of intact fish is quality loss. Prior to the experiments, the smoked fish was sterilized thermally by heating at 60^0C for 1 hour in an air circulated oven to kill any insect pest present. The glass jars used for the trials were also sterilized under same condition. In order to assess these losses, one medium sized sterilized fish weighing 80 to 120 g of each of the three species representative were weighed and placed in separate glass jars and their moisture content (Mc) determined: $Mc= (W_1-W_2)/W_1x100$; where, Mc = moisture content (%); W_1= initial weight of the sample before oven drying (g); W_2= final weight of the samples after oven drying (g).

Five pairs (male + female) of adult insects emerging from the breeding cultures were introduced into one separate glass jar containing a separate fish species with the exception of control jars, the content was kept in the laboratory for 68 days. This is considered to be the normal period of storage of cured fish during which the development

of insect pest could be completed (Osuji, 1975). Each treatment was replicated 4 times, arranged on shelves in the laboratory in a completely randomized design. At the end of a 68 days storage period, all infesting insects (both adult and larvae) were extracted from the individual fish samples by slightly heating in an oven to make them restless. These were counted and recorded. The remaining fish bulk together with the resulting frass were collected and weighed. The loss in weight of fish was then determined as the difference in weight of fish sample before and after the insects developed, and expressed in percentage. Percentage weight losses were calculated by direct weighing method (FAO, 1983): $F_1 = W_1$ (100-M1)/100, where: F_1 = Dry weight of fish solid before the experiment; W_1 = Weight of fish solid before experiment; M1 = Moisture content before the experiment. $F_2 = W_2$ (100-M2)/100, where: F_2 = Dry weight of fish solid after the experiment; W_2 = Weight of fish solid after the experiment; M_2 = Moisture content after the experiment. Thus; Effective weight loss of fish = (F_1-F_2)

Loss in quality was assessed only in relation to fragmentation which was expressed as the weight of intact fraction at the end of the experiment to the initial weight of fish and was calculated as: Quality loss = X_1-X_2/X_1 x 100 (%), where, X_1 = initial weight of fish (g); X_2 = Weight of intact fish after the experiment (g).

Determination of susceptibility Index (SI)

Susceptibility index was determined by setting a separate experiment to assess the capacity for progeny production and median length of developmental period. To study these parameters, 100 g of smoked fish of each species (treatments) was placed in 250 ml glass jar and 20 unsexed adult insects aged 0-7 days were introduced into each jar and allowed to oviposit for 7 days after which the insects were removed and the substrate kept under same conditions stated above. The experiments were laid out in completely randomized design, each treatment replicated 4 times.

Beginning from the 22nd and 35th days after infestation, for *N. rufipes* and *D. maculatus,* respectively, daily counting and removal of adults was conducted till there was no emergence for five consecutive days.

Progeny production was calculated as the mean number of F_1 progeny on a given fish species. Length of developmental period was calculated as the period from the middle day of the oviposition period (4^{th} day) until 50% of adult have emerged. Susceptibility Index (SI) of each fish species to *D. maculatus and N. rufipes* was calculated as described by Dobie (1986): $SI = \log^e F_1/D$ x100; where, F_1 = mean number of adults emerging from substrate; D = length of developmental period in days.

Data analysis

All data were subjected to one-way analysis of variance and differences between means were compared using Tukey-Kramer Honestly Significance Difference test at 5% probability level.

RESULTS

There were significant differences in the mean percentage weight loss due to the activity of *D. maculatus* ($F_{2, 9}$ =266, P≤0.001) and *N. rufipes* ($F_{2, 9}$ =71.8, P≤0.001) among fish species. *Clarias* spp sustained the highest weight loss, followed by *Tilapia* spp. and the least was in *Synodontis* species. Similar order was observed for *N. rufipes*, although in this case in all the fish species, weight loss was lower than that in *D. maculatus* (Table 1).

Table 1: Percent weight loss (mean ±SE) in three Fish species caused by *D. maculatus and N. rufipes* over 68 days storage period.

Fish species	Insect species	
	D. maculatus	*N. rufipes*
Clarias	13.80±0.20[a]	7.30±0.40[a]
Synodontis	6.10±0.10[c]	.10±0.20[c]
Tilapia	10.30±0.30[b]	6.00±0.20[b]
SED	0.05	0.08

Means followed by the same letter(s) within a column are not significantly different according to Turkey- Kramer HSD test at 5% level of probability

Table 2 shows the quality losses resulting from fragmentation of fish substrate due to infestation by the two insect pest species. Significant differences d *N. rufipes* (were noted among fish species. With *D. maculatus,* ($F_{2, 9}$ =402, p≤0.001) *Clarias sp.* sustained significantly higher level of fragmentation, with more than half of samples fragmented, than *Synodontis* and *Tilapia* spp., but the differences between the two were not significant. On any given fish species infested by *N. rufipes,* $F_{2, 9}$ =218, p≤0.001) quality loss did not exceed 36%. On Tilapia which was significantly higher than those recorded in *Clarias* and *Synodontis* spp.

Table 2: Percent fragmentation (quality loss) (mean ±SE) of three fish species caused by *D. maculatus and N. rufipes* over 68 days storage period.

Fish species	Insect species	
	D. maculatus	*N. rufipes*
Clarias	63.20±0.20[a]	22.8±0.60[b]
Synodontis	42.8±0.60[b]	22.40±0.20[b]
Tilapia	44.0±0.60[b]	5.60±0.50[a]
SED	0.06	0.07

Means followed by the same letter(s) within a column are not Significantly different according to Tukey- Kramer HSD test at 5% level of probability

The Susceptibility indices of the three fish species to infestation by *D. maculatus* and *N. rufipes* are presented in Table 3. Significant differences in susceptibility to *D. maculatus* ($F_{2, 9}$ =83.2, P≤0.001) and *N. rufipes* ($F_{2, 9}$ =25.8, *P*=0.002) were noted. The order of susceptibility to *D. maculatus* was ranked: *Clarias* spp>*Tilapia* spp>*Synodontis* spp., while to *N. rufipes*: *Tilapia* spp>*Clarias* spp>*Synodontis* spp.

Table 3: Susceptibility indices (mean ±SE) of three fish species to *D. maculatus and N. rufipes*

Fish species	Insect species	
	D. maculatus	*N. rufipes*
Clarias	3.30±0.03[a]	3.80±0.10[b]
Synodontis	2.60±0.05[c]	3.30±0.20[c]
Tilapia	3.10±0.03[b]	4.70±0.10[a]
SED	0.06	0.05

Means followed by the same letter(s) within a column are not significantly different according to Tukey- Krammer HSD test at 5% level of probability.

DISCUSSION

The results of this study indicated that a substantial loss in smoked fish occur due to infestation by *D. maculatus* and *N. rufipes*, although fish species differ in their susceptibility to insect species. Loss in weight is the result of damage caused by the scarification of the fish tissues and the partial or complete consumption of the fish tissues. Damage and weight loss are mostly caused by the tunnelling and feeding activities of the larvae and adults (FAO, 1998). Weight losses recorded in this study were greater and ranger from 3.1 to 13.8% with *D. maculatus* causing greater weight loss than *N. rufipes*. This level falls within the FAO estimate of 15-50% losses in cured fish in Nigeria (FAO, 2004).

Lowest and highest weight loss was recorded on *Synodontis* and *Clarias* spp, respectively. This may be attributed to inherent qualities that affect their susceptibility to damage by *D. maculatus* and *N. rufipes*. Similar findings were also reported in previous investigations. Osuji (1974) found some

evidence that different fish genera may vary in their susceptibility to attack by beetles. *D. maculatus* and *N. rufipes* infested *Clarias* spp more heavily than *Citharinus* spp., with *Heterotis* spp. being infested to an intermediate extent. Proctor (1972) also found *Clarias* spp. and *Tilapia* spp. to be relatively susceptible to *Dermestes* spp. infestation while *Synodontis* spp. and *Hydrocyon spp.* were less so. Further, Osuji (1974) found some indication that at least in some cases high lipid content may increase susceptibility to insect infestation.

The three fish species differed in their susceptibility to both *D. maculatus* and *N. rufipes* with susceptibility indices in the three fish species being higher due to *N. rufipes* than *D. maculatus*. This was despite the fact that *D. maculatus* caused greater weight and quality losses. This may be explained due to the relatively shorter development period of *N. rufipes* compared to *D. maculatus*. The shorter the development period, the lower the damage caused by developing larva.

Losses in quality of cured fish due to fragmentation have an important commercial implication. Our results showed that the activity of *D. maculatus* over 68 day's storage period caused 44 to 63.2% fragmentation of the fish commodity. The figures for *N. rufipes* ranged from 22.4 to 35.6%. This, coupled with losses in weight constitutes a substantial commercial loss. The findings of this study regarding fragmentation are in agreement with the finding of other workers. For instance, Mills (1979) found marked differences in susceptibility to fragmentation among different fish species, *Tilapia* spp being more fragile than *Heterotis* spp. and "tonkosa". Watanabe and Cabrita (1971) suggested that large oily fish were particularly susceptible to fragmentation if hot smoked. In addition, differences in composition, texture and size may clearly affect the levels of losses (FAO, 1980).

Based on the weight and quality losses as well as susceptibility index, the result show that *Clarias and Tilapia* spp. were the most susceptible fish to *D. maculatus* and *N. rufipes*, respectively, at least under the conditions the tests were conducted.

In the light of the objectives of this study, the most important aspect of the results was the susceptibility of fish species particularly to *D. maculatus*. This ranking matches ranking of the three fish species according to popularity and abundance in this locality. *Clarias* spp is the most popular, widely cultivated and mostly smoked fish in the Lake Chad District and Nigeria (Akinwumi and Akinwumi, 2011). It supersedes the other two species both in terms of volume of harvest and commercial value (Lale and Sastawa, 1996). And *D maculatus* is the most abundant and serious pest of stored fish (Egwunyenga *et al*., 1998). In addition to weight and losses, infestation by insects can cause mould development, loss in nutritional and aesthetic values (Osuji, 1974, Adedire and Lajide, 2000).

From this study, it can be concluded that infestation of smoked fish by *D. maculatus* and *N. rufipes* result in substantial weight and quality losses. *D. maculatus* causes much higher losses than *N. rufipes*, but general susceptibility depend on fish species.

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