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Original research article

Dermestes maculatus Degeer infestation impact on market loss of dried fish in Kwara State, Nigeria

Adeyemi Mufutau Ajao*, Segun Olayinka Oladipo, Barakat O. Soliu

Zoology Unit, Department of Bioscience and Biotechnology, College of Pure and Applied Sciences, Kwara State University, Malete, 1530, Nigeria

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ABSTRACT

Dried fish vendors located at three markets in Kwara State, Nigeria were surveyed and *Dermestes maculatus* Degeer-infested specimens of dried *Chrysichthys nigrodigitatus, Heterobranchus bidorsalis* and *Oreochromis niloticus* were analyzed in the laboratory. The dried fish species were exposed to *D. maculatus* larvae and adults for 35 days at ambient laboratory conditions that coincided with their developmental cycle after which the level of damages were recorded. The vendor survey showed that the Ipata market had the most dried fish vendors within the age of 20-30 years (46.66%) and that 60% of the fish vendors had, atmost, 20 years of experience. The weight loss in dried fish due to *D. maculatus* infestations (larval, adult) was *H. bidorsalis* (22.66 ± 1.20g, 29.00 ± 3.05g), *O. niloticus* (14.33 ± 2.96g, 20.00 ± 0.58g), and *C. nigrodigitatus* (14.00 ± 1.53g, 15.00 ± 1.15g) in decreasing order. This suggests that the development of cost-effective methods for pest control in dried fish would greatly reduce market loss of product for dried fish vendors from *D. maculatus* and other pestiferous species, making the dried fish business more profitable in Nigeria.
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1. Introduction

Nigerians consume fish, one of the main animal protein sources, in large quantities. There is little or no religious bias, which gives it an advantage over other animal protein sources, like pork (Eyo, 2001; Ligia, 2002). Despite the large volume of both fresh and marine water that serves as fish habitat in Nigeria, only about 50% of the fish demand is currently met by local supply. The most common method of preserving this fish for optimum supply to smoke it. Smoked or dried fish form a traditional part of the diet for a large protein of the world population. (Ayuba & Omeji, 2006; Okonta & Ekelemu, 2005). Fish, in addition to its nutritional value, is a major source of employment and trad for millions of people living close to water via harvesting, handling, processing and distribution (Bene & Heck, 2005; Al-Jufaili & Opara, 2006; Mufutau, 2012).

Fish near Kwara State, north-central Nigeria belong to taxonomic families including Osteoglossidae, Clariidae, Characidae, Cypriniidae, Mochokidae, Schilbedae, Claroteidae, Cichlidae, Polypteridae, Tetraodontidae, Gymnarchidae, Citharinidae and Centropomidae (Araoye, 2008; Mustapha, 2010; Omotosho, 1998). The family Cichlidae has been identified as the most dominant in terms of species diversity and number, as a result of food presence and its prolific breeding capabilities (Araoye, 2008; Omotosho, 1998). The same reasons also account for the high number of *Tilapia zilli* dominance in Oyun Reservoir, Offa, Kwara state, Nigeria (Mustapha, 2009) while families Osteoglossida, Schilbedae, Gymnarchidae and Cyprinidae were less abundant and showed seasonal variations in the catches by the fishermen along the lake (Araoye, 2008).

Only a small percentage of the fish were sold fresh, which is why preservation methods such as freezing, smoking, drying and heat treatment were applied to extend the shelf-life of the product (Ikenweiwe, Bolaji, & Bolaji, 2010; Babarinde, Adebayo et al., 2016). Preservation was carried out locally as described by Davies, Davies, Inko-Tariah, and Bekibele (2008), who processed fishery products that were stored using traditional storage technologies. The methods of preservation differs between countries and within the same country depending on the species of fish the type of product desired (Ogbonnaya & Ibrahim, 2009). Despite the efforts made to preserve catches, pest infestation were common in most developing countries, including Nigeria. This implies that, the efficiency of any preservation method is very important for insuring the quality, yield and highest possible profits to be achieved in the

* Corresponding author. Kwara State University, Malete, 1530, Nigeria.
E-mail address: adeyemi.ajao@kwasu.edu.ng (A.M. Ajao).

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fishing industry.

Common pests that have been commonly found on dried fish in Nigeria are beetles (Coleoptera), flies (Diptera) and mites (Acarina) (FAO, 1989) and genera like Calliphora, Chrysomia, Lucillia and Musca (Diptera), *Dermestes* and *Necrobia* (Coleoptera) have been oberved as pests in dried fish (Mufutau, 2012; Babarinde et al., 2012, Babarinde, Adebayo et al., 2016, Babarinde, Sunnie-Ododo et al., 2016 Osuji, 1985). Beetles of the family Dermestidae invade fish from the earliest stages of drying and breed in the dried product (Abolagba, Akise, & Orukpe, 2015) and are also associated with spread of anthrax and contaminants of insect origin in the foodstuffs of some countries, resulting in market value reduction for fish vendors (Osuji, 1985).

Pest infestation, a lack of adequate handling, processing techniques and good storage facilities contribute significantly to the low fish availability that rural dwellers have, living far away from fish sources that account for three quarters of the population in developing countries, like Nigeria (Ayuba & Omeji, 2006; Osuji, 1973).

The growth and development of dried fish pests are promoted by poor traditional processing methods, storage and packaging. The local dried fish vendors sprinkle water on dried fish to promotes *D. maculatus* growth and provides a suitable breeding ground for several other species of flies and beetles. There are limited studies that focus on the activities of fish vendors, fish sources, processing, level of insect infestation and damage done to many species of dried fishes, especially for Kwara State, north-central Nigeria. This study assess the socio-economic characteristics and activity of dried fish vendors and compares the level of infestation of *D. maculatus* on different fish species.

2. Materials and methods

2.1. Market survey and sample collection

Three markets, noted for their sale of dried fish in Kwara State were surveyed. Questionnaires and interviews were administered to obtain demographic information of the dry fish vendors and their fish processing methods. 50g of fresh, pest infested and dried samples of catfish and tilapia were obtained randomly from the markets in Ipata (Ilorin East LGA), Idi-ape (Ilorin West LGA) and Gbugbu (Edu LGA) Kwara State, north-central Nigeria. Each sample was cut into pieces and insect pest were extracted using a scalpel. Several males and females of *D. maculatus* were obtained for laboratory exposure of the three dried fish species samples.

2.2. Entomological experimental setup

Three fish species *Chrysichthys nigrodigitatus* (Silver catfish), *Heterobranchus bidorsalis* (African catfish) and *Oreochromis niloticus* (Tilapia) were obtained, weighed, oven dried at 60 °C and then allowed to cool at room temperature. 50g of each dried fish sample was weighed and placed in experimental jars with 10 pairs of newly emerged male and female adult *D. maculatus*. In-star larva species were separately introduced and covered with muslin cloth held tightly with a rubber band to allow aeration but prevent the escape of insects. Uninfested fish samples of each species (50g) served as control for the experiment. Jars were examined twice daily between 10:00 and 11:00am, and temperature and relative humidity readings were recorded for 35 days corresponding with the life cycle duration of *D. maculatus*.

The pre-infestation weight of fish, post-infestation weight of fish, weight of frass, pre-infestation weight of *D. maculatus* and post-infestation weight of *D. maculatus* were recorded.

Table 1
Demographic profile of the fish vendors in Kwara State, north-central Nigeria.

Parameter	Market						Total
	IDI-APE		IPATA		GBUGBU		
	F	%	F	%	F	%	
Age (years)							
20–30	4	26.66	7	46.66	2	20.00	13
31–40	6	40.00	3	20.00	3	30.00	12
41–50	3	20.00	4	26.67	3	30.00	10
>50	2	13.34	1	6.67	2	20.00	5
Total	**15**	**100**	**15**	**100**	**10**	**100**	**40**
Experience (years)							
5–10	3	20.00	4	26.67	0	0	7
11–15	5	33.33	6	40.00	1	10.00	12
16–20	5	33.33	2	13.33	6	60.00	13
>20	2	13.34	3	20.00	3	30.00	8
Total	**15**	**100**	**15**	**100**	**10**	**100**	**40**
Level of Education (years)							
No formal Education	5	33.34	6	40.00	6	60.00	17
Primary Education	7	46.66	4	26.67	3	30.00	14
Secondary Education	2	13.34	4	26.67	m	10.00	7
Tertiary Education	1	6.66	1	6.66	0	0	2
Total	**15**	**100**	**15**	**100**	**10**	**100**	**40**

Field survey 2017.
F= Frequency.

3. Results

The analysis of survey data from the markets (Idi-ape, Ipata and Gbugbu) showed that Ipata market had the highest fish vendors within the age range of 20–30 years (46.66%), with only 1 above 50 years of age. 60% of the total fish vendors in Gbugbu market had 20 years' experience, with only 1 vendor having 15 years' experience. A majority (90%) of the fish supply at Gbugbu market was supplied from Kwara State, while only 10% were obtained from Niger state. Likewise, 46.66% of the dried fish vendors at Idi-ape market had at least a primary education while 33.34% had no formal education (Tables 1 and 2).

The result of infestation level from the three different markets revealed that there was high infestation level in *O. niloticus*,

Table 2
Fish processing, pest control and fish storage methods by fish vendors in Kwara State, north-central Nigeria.

Parameter	Market						Total
	IDI-APE		IPATA		GBUGBU		
	F	%	F	%	F	%	
Fish processing method							
Smoking	9	60.00	7	46.66	4	40.00	20
Drying	6	40.00	5	33.33	4	40.00	15
Salting	0	0	1	6.66	1	10.00	2
Water sprinkling	0	0	2	13.33	1	10.00	3
Total	**15**	**100**	**15**	**100**	**10**	**100**	**40**
Method of pest control							
Chemical	9	60.00	9	60.00	6	60.00	24
Groundnut oil	3	20.00	2	13.33	1	10.00	6
Used vehicle oil	3	20.00	4	26.66	3	30.00	10
Total	**15**	**100**	**15**	**100**	**10**	**100**	**40**
Storage of fish							
Pack old with new	5	33.33	7	46.66	4	40.00	16
Packed separately	10	66.67	8	53.33	6	60.00	24
Total	**15**	**100**	**15**	**100**	**10**	**100**	**40**
Storage period of fish before disposal							
0–1week	7	46.66	6	40.00	5	50.00	18
2–3weeks	5	33.33	5	33.33	3	30.00	13
>4weeks	3	20.00	4	26.66	2	20.00	9
Total	**15**	**100**	**15**	**100**	**10**	**100**	**40**

F: Frequency.

Table 3
Weight loss in fish species infested with *Dermestes maculatus* after 35 days of infestation.

Species	Mean ± SE Weight Loss	
	Adult	Larva
Chrysichthysnigrodigitatus	27.47 ± 4.44^{bc}	20.04 ± 0.70^{b}
Heterobranchus bidorsalis	36.58 ± 1.82^{c}	29.25 ± 3.67^{b}
Oreochromisniloticus	23.48 ± 2.90^{b}	39.78 ± 4.58^{c}
Control	0.02 ± 0.01^{a}	0.02 ± 0.01^{a}

Means within the same column with different superscripts differ significantly ($P < 0.05$).

Table 4
Weight gain by *Dermestes maculatus* introduced to fish species after 35 days infestation.

Species	Mean ± SE Weight Gain	
	Adult	Larva
Chrysichthysnigrodigitatus	0.48 ± 0.05^{b}	0.41 ± 0.02^{b}
Heterobranchus bidorsalis	0.96 ± 0.05^{c}	0.85 ± 0.05^{c}
Oreochromisniloticus	0.47 ± 0.03^{b}	0.38 ± 0.02^{b}
Control	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}

Means within the same column with different superscripts differ significantly ($P < 0.05$).

H. bidorsalis and *C. nigrodigitatus*. The weight loss of fish species with high level of adult *D. maculatus* infestation resulted in weight reductions of 36.58±1.82 g for *H. bidorsalis*, 27.47±4.44 g for *C.nigrodigitatus*, and 23.48±2.90 g for *O.niloticus*. *D. maculatus* larval infestation in *O. niloticus* resulted in the greatest weight loss, 39.78±4.58 g, while the greatest weight loss was recorded in *C. nigrodigitatus* (20.04±0.70 g) (Tables 3 and 4).

The weight gain of *D. maculatus* adults and larvae after 35 days of infestation was high in *H. bidorsalis* (0.96±0.05 g and 0.85±0.05 g, respectively) when compared to *C. nigrodigitatus* and *O. niloticus* (Table 4). The weight of fish frass from adult *D. maculatus* infestation recorded was 0.67±0.03 g in *H. bidorsalis* and 0.26±0.29 g in *O. niloticus* (Table 5) .

4. Discussion

The market survey revealed that the source of dried fish infestation by *D. maculatus* were attibuted to mixing of the old and newly purchased fish in storage; inadequate smoking by the fish catchers and mixing of dried fish with other commodities like hides and skins, grains and groundnuts during transportation. The likelihood of cross-infestation was high (Babarinde, Adebayo et al. 2016, Babarinde, Sunnie-Ododo et al., 2016). The high infestation and corresponding economic damage to dried fish has been acknowledged worldwide (Mufutau, 2012; Osuji, 1973; Hossain et al., 2016). There are different methods being employed to reduce the economic damage which include smoking, sun drying and use of chemical treatment by fish vendors. The results revealed the prominent use of synthetic insecticides and vehicle oil for protecting fish against pest infestation. Many researchers (Mufutau, 2012; Adesina, Jose, & Rajashekar, 2016; Akpotu, Oniye, Abolude, & Yusuf, 2016; Ayeloja & George, 2016; Babarinde, Adebayo et al., 2016) have suggested the use of botanicals as an alternative to the use of poisonous materials such as vehicle oil and synthetic chamicals for protecting dried fish (Babarinde, Pitan, Olatunde, & Ajala, 2015; Abolagba et al., 2015).

Table 5
Weight of fish frass after 35 days of infestation of *Dermestes maculatus*on fish species.

Species	Mean ± SE Weight of Frass	
	Adult	Larva
Chrysichthysnigrodigitatus	0.37 ± 0.02^{c}	0.41 ± 0.04^{b}
Heterobranchus bidorsalis	0.67 ± 0.03^{d}	0.36 ± 0.03^{b}
Oreochromisniloticus	0.26 ± 0.29^{b}	0.41 ± 0.03^{b}
Control	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}

Means within the same column with different superscripts differ significantly ($P < 0.05$).

The poor storage systems used by some dry fish vendors might also pose an infestation risk. Some respondents stored both old and new smoked fish together, which might affect the quality of new product due to cross-infestation. The level of infestation of the smoked fish by *D. maculatus* may be directly related to the storage length of the fish, as the fish vendors purchase smoked fish in bulk and do not buy new stock until the old stock is completely disposed. This observation agrees with Eyo (2001) and Katamssadan, Nukenine, Stahler and Adler (2015), who reported that long storage periods allow insects more time to breed and consume the fish.

D. maculatus adult and larvae infestation of *C. nigrodigitatus, H. bidorsalis* and *O. niloticus* varies for 35 days with no infestation in the control experiment. *H. bidorsalis* proved to be a more suitable substrate for adult *D. maculatus* development because with significant weight reduction in *H. bidorsalis* after 35days' infestation, whereas *O. niloticus* proved to be more suitable for *D. maculatus* larvae. The ability select chemical cues is passed from the larval stage to the adult, triggerring recognition of a substrate (Corbet, 1985). Likewise, *D. maculatus* feeds on any material that has animal steroids (Lale, 2002; Medugu, Kabir, Dauda, & Gambo., 2014). However, when exposed to various animal steroid sources the insect tends to show preference to particular species. The comparatively high weight loss and significantly higher frass generated in *H. bidorsalis* samples suggest the flesh of the species was a more suitable substrate than *O. niloticus* and *C. nigrodigitatus* for the growth and development of *D. maculatus.* The significant differences ($P < 0.05$) observed in the weight reduction in all exposed species shows that the level of pest damage depends on both *D. maculatus* developmental stage and the fish species.

The fish frass weight fromboth *D. maculatus* adult and larvae are significantly different ($P < 0.05$) in relation to fish species. Awoyemi (1991) had earlier assessed fish pest infestation for 60 days and the infested fishes were reduced to mere frass and bones. There is also an incidence of larval stage of *D. maculatus* in the dry fish medium exposed to adult *D. maculatus* which points to the fact that the bulk of damages were done by the larva stage because they infest dry fish in very large numbers and feed on the tissue of the fish for development. This agreed with the report that maintained that adult and larvae of *Dermestes* infest dried fish samples. Both stages cause large quantitative losses of edible material and fragmentation of the remaining product (Johnson & Esser, 2000; Babarinde et al., 2012; Babarinde et al., 2014). This is the reason for the weight gain in *D. maculatus* feeding on *H. bidorsalis, C. nigrodigitatus* and *O. niloticus*.

5. Conclusion and recommendation

In conclusion, this research revealed that *D. maculatus* is the major pest infesting dried fish in Kwara State, north-central of Nigeria and the infestation results in substantial weight losses. Generally, susceptibility depends on insect developmental stage and fish species, but larval stage of *D. maculatus* was most destructive than its adult stage. There is need to look into the pest problems of animal processed food items for the economic aspect of dried fish business through relevant agencies. Further research is recommended on the development of cheap, effective and widely

available dried fish control method to prevent the destructive effect of *D. maculatus* and other pest species.

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