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EFFECT OF INDIGENOUS PLANTS ON THE PROGENY DEVELOPMENT OF *Dermestes maculatus* (DeGeer, 1774) IN DRIED AFRICAN CAT FISH (*Clarias gariepinus*)

Amadi[1] G.I. and Dimkpa[1], S.O.N

[1]Department of Crop/Soil Science, Rivers State University, Nkporlu Port-Harcourt, Rivers State, Nigeria.

Abstract

Seeds of Alligator pepper (*Aframomum melegueta,* Schumann*)* and African nutmeg *(Monodora myristica,* Gaertn*)* and pods of Aridan fruits *(Tetrapleura tetraptera ,* Schumach and Thonn*),* were ground separately into powder and each tested for their effect on the F1 progeny development of *Dermestes maculatus (*Degeer) in dried *Clarias gariepinus,* Burchell (African catfish). Fifty grams (50g) of the three plant powders were mixed (1:1:1) to also form a fourth treatment for trial against the beetle. Different concentrations of plant powders of 0, 2, 4, 6, 8 and 10g/20g of dried fish (which corresponded to 0%,10%,20%,30%,40% and 50% w/w) were tested against adult male and female (in ratio 2:3) over one month duration in the laboratory with each concentration having three replicates. The results confirmed that progeny development of the beetle larvae was significantly impaired ($P<0.05$) by the plant powders, revealing a host plant resistance mechanism (Antibiosis); as each plant powder interfered with the insect's normal life cycle and prevented immature stages from attaining adulthood. Adult beetle treated with *T. tetraptera* and the mixed powder did not exceed the larval stage, followed by treatment with *M. myristica* which did not exceed the prepupal stage and *A. melegueta* which did not exceed the pupal stage. The progeny development of The order of effectiveness was: *T. tetraptera* > Mixed powder > *M. myristica* > *A. melegueta*. Increasing concentrations of all the tested powders had significant devastating effects.
Key Words: *D. maculatus* beetle, *T. tetraptera*, *M. myristica*, *A. melegueta*, *C. gariepinus* and plant powers.

INTRODUCTION

Smoked or dried fish is a traditional item in the diet of a large section of the world's population (Lale and Sastawa, 1996; Lale, 2001; Azam *et al*., 2004). Dried fish is one of the highly digestible and respectable sources of protein and essential minerals in the tropics (Okoko, 1996; Zakka, 2009; Olayemi *et al.,* 2011; Zakka, 2013). However, the gap between the demand and supply of fish is widening due to increase in human population, poor postharvest handling, lack of efficient processing methods and high insect pest infestation (Lale and Sastawa, 1996).

Dried fish is subject to beetle infestation throughout storage and transportation, and so the potential for losses is great. These beetles proliferate and grow on the dried fish, thus changing its appearance and powdering the fish; making it unfit for consumption and marketing (Luckman and Metclalf, 1978; FAO, 1981). In addition to this, insect pests of fish often transmit *E. coli* mould spores, while heat and moisture produced by heavy infestation can create conditions suitable for mould growth on fish that has previously been dried (Lale and Sastawa, 1996). Financial losses occur to the fisherman whose sole means of sustenance during off-season are the returns from curing activities. Smoked dried fish is readily attacked by several species of insect pests including *Dermestes maculatus, D. fruchii, D. ater and Necrobia rufipes* (Osuji, 1974; Hedges and Lacey, 1996; Chung *et al*., 2002; Brianna and Philips, 2010). These insect-pests infest the stored products during storage, transportation and marketing.

Dermestes maculatus (DeGeer, 1774), class Coleoptera and family dermestidae has been reported as the major pest of the dried African catfish. Both the adults and the larvae of the beetles feed upon the fish leading to fragmentation of the product thereby causing large quantitative losses of up to 50% of edible material (Haines and Rees, 1989), which leads to substantial loss in the nutritive value of fish during storage (Odeyemi *et al*., 2000; Fasakin and Aberejo, 2002).

The life cycle of *D. maculatus* on a suitable substrate of dry-carcass, fish or other animal product requires approximately five to seven weeks, to complete under optimum conditions. Eggs are laid in cracks of the material on which they are feeding (Haines and Rees, 1989). Females are capable of laying eggs continuously (Jones *et al*., 2006). The eggs are laid in batches of 3-20. A single female can lay between 198-845 eggs over a

life time (Hinton, 1945). The larvae pass through 5-11 instars, the number of instars increasing with unfavourable conditions (Haines and Rees, 1989). Within the last 10 days of the final instar, the larvae will find a place to pupate in the substrate or a non-food substance such as wood. Exposed pupae that could not find conducive pupal chambers are eaten up by larvae. Pupation can be slowed down for more than 20 days if there is no conducive place to pupate. This adversely affects the adult body size and increases chances of fatal diseases (Archer and Elgar, 2007). Optimum temperature for *D. maculatus* development is approximately 30°C, where the beetles reach adulthood around 38 days (Richardson and Goff, 2001) with a life span of 4 to 6 months (Richardson and Goff 2001). Emerged adult beetle measures from 5.5 to 10.0 mm in size and can move to other food sources by flying (Haines and Rees 1989).

Larvae of the *D. maculatus* are very destructive to stored products, especially dry fish, hides and skin. Unfortunately, the larvae are hardy with a prolong life developmental time, and could withstand adverse environmental conditions including most available synthetic insecticides compare to many other stored products' insect. Also, the use of insecticides may render the fish unattractive and unpalatable to consumers (Johnson and Esser, 2000; Chung *et al*., 2002; Onu and Baba, 2003; Ayuba and Omeji, 2006).

The frequent use of synthetic insecticide on stored products is not "friendly" on human health, and the environment. Thus lead to biomagnifications, cancers and other serious ailments and also environmental pollutions. To prevent these and other toxic effects on non-target organisms, many natural products of plants origin are currently being investigated (Opender *et al*., 2008; Abolagba *et al.,* 2011). The quest to reduce the use of insecticides on dried fish, have made researchers employ the use of alternative, eco-friendly and cheaper insect-pest management measures involving plant and its products e.g powders and extracts (Gonzalo, 2004; Mwanauta *et al.,* 2014). The inhibitory effect of the extracts may also be an indication that the plant possesses bioactive compounds which are soluble in ethanol, cold and hot water (Facknath and Lalljee, 2000). Many Nigerian medicinal plants species have proven to be very important in pest management of stored grains, legumes and dried smoked fish (Gonzalo, 2004, Ajao, 2012).
The present research therefore determined the effect of some indigenous plant powders on the progeny development of *D. maculatus* as to incorporate them in the efficient management of the pest on dried fish.

METHODOLOGY

Curing of Dried *Clarias gariepinus* (Burchell): The dried catfish (both infested and non-infested) were bought from the Oginigba slaughter market, Trans- Amadi Port-Harcourt, Nigeria. The non-infested fish were oven dried at 60^0C for 4 hours to cure the fish of insect larvae or any microbial infection. This was carried out in the biology laboratory of the department of Applied and Environmental Biology. The fish were left to cool and then weighed out (10g each) into the plastic containers wherein the *D. maculatus* larvae would be introduced and covered.

Rearing of *D. maculatus* (Degeer): Adult beetles were collected from the dried, infested catfish (*C. gariepinus*). The adult beetles were placed in a round transparent plastic container, containing dried fish. A piece of cotton wool was soaked in water (for moisture), and placed at the mouth of the container which was covered with mosquito net and fastened to the container using rubber ring. The beetles mated severally, eggs were laid on and around the fish substrate which hatched into larvae that were used for the experiments. Larvae of uniform age 0-96hrs were isolated from the colony to infest the cured dried fish. Also, some of the larvae were reared to adulthood and then paired for the experiment.

Plant powder preparation: Three different indigenous plant materials were bought at the Rumuokwurusi oil mill market, port-Harcourt, Nigeria; *A. melegueta, M. myristica and T. tetrapleura* were seperately dried in an oven at 40^0C for 2 hrs and cooled before grinding in a hand grinder (Corona Grain Mill). The *T. tetrapleura* pods were cut into small pieces for easy drying.The ground plant materials were seived with a $40mm^2$ hole plastic seive, weighed (each powder weighed 250g) and stored in an air tight plastic container.

Mixture of plant powders: 50g of each of the plant powders were weighed out with a beam balance and mixed (ratio:1:1:1) thoroughly with a plastic spoon to form the fourth treatment.

Adult emergence investigations: Laboratory reared adult *D. maculatus* were severally paired (2 males to 3 females) in similar rectangular plastic containers as stated above and each container was added 20g of the dried fish as food to support their survival. The four (4) test powders (Three different plants and a mixture of the three)

were again tested individually (one test powder at a time) against this paired adults in the same concentrations of 0,2,4,6,8,10g of powder/20g of fish and replicated three (3) times including the control which is the container having adult beetles (2 males and 3 females) without any test powder. Observations were then made at 3-day intervals over a period of one month on the emerging *D. maculatus* juvenile (larvae, prepupae and pupae) and adult populations. The experiments were all under same laboratory conditions of temperature and relative humidity 30±2^{0}C and 65±5% respectively.

RESULTS

The results of the *D. maculatus'* emergence or progeny development (larvae to prepupae to pupae and adults) are shown in the Table 1. The control which is the container having adult beetles (2 males and 3 females) without any test powder experienced a significant ($P<0.05$) uninterrupted, complete developmental cycle from larva to adult stages. The progeny development of the insects in the treated fish suffered some significant ($P<0.05$) serious impairment. Progeny development on fish treated with *T. tetraptera* powders and mixed powders, did not go beyond larval stages as shown in the table 1. The observed larvae were also characteristically weak and eventually died for the mixed powder and *T. tetraptera* respectively. For those treated with *M. myristica*, the development progressed up to prepupal stage; and it got up to pupal stage for those treated with *A. melegueta* but never progressed beyond that stage into adult stage. Increasing concentrations of the test powders had significant devastating effects.

DISCUSSION

The results from this study significantly and vividly confirmed the effectiveness and biopesticidal nature of these tested plants as they all notably suppressed F1 development of *D. maculatus* and hindered its adult emergence. Also, Increasing concentrations of all the tested powders had significant devastating effects on the development of *D. maculatus*. *T. tetraptera* and the Mixed powder (combination of the three plants' powder) were particularly more outstanding in inhibiting the beetle from developing beyond the larval stage which agrees with the work of Ileke *et al.*, (2011). Similar findings were reported by Akinkurolere (2012), with *C. maculatus* on cowpea in western Nigeria. It is noteworthy that *M. myristica* and *A. melegueta* allowed development up to prepupal stages only and not beyond. In all the trials, adults emerged only in the control which were the container having adult beetles without any test powder treatment. These findings clearly revealed the phenomenon of Antibiosis in these plant powders: a plant resistance mechanism with adverse effect on a pest's reproductive biology and survival, by its host (Lale, 2006). Generally, *T. tetraptera* was the most effective of all the plant powders evaluated in inhibiting adult emergence. Other authors have reported similar successes on inhibition of pests' adult emergence, using other different plant powders. Ileke *et al.* (2011) reported that the powders of *Azadirachta indica* (A. Juss) and *Alstonia boonei* (De wild) prevented 100% F1 progeny emergence of *Sitophilus. zeamais* in wheat grain. Shukla *et al.* (2007) successfully prevented *C. maculatus* adult emergence in Chickpea (*Cicer arietinum*) using *Murraya koenigii (*L) and *Eupatorium cannabinum* (L) plant products. While Tanpoudjou *et al.* (2002) used powder of *Chenopodium ambrosoides* (L) leaves to control adult emergence of six stored product pests, namely: *Sitophilus zeamais; S. granaries; Callosobruchus maculatus; Prostephanus truncatus* and *Acanthosceleides obtectus.*

Table 1. Effect of Plant Powders and Concentration on *D. maculatus* Adult Emergence at 1 MAT*

Test powder	Concentration (g/10g fish)	Larva	Prepupa	Pupa	Adult	Efficacy Ranking
	0.0	20	95	68	50	
A. melegueta	2.0	30	83	40	0	
	4.0	29	74	47	0	**4th**
	6.0	30	70	40	0	
	8.0	25	54	30	0	
	10.0	13	26	21	0	
	0.0	20	95	68	47	
	2.0	40	80	0	0	
M. myristica	4.0	38	60	0	0	**3rd**
	6.0	30	40	0	0	
	8.0	30	25	0	0	
	10.0	20	20	0	0	
	0.0	30	87	65	52	
	2.0	40	0	0	0	
T, tetraptera	4.0	25	0	0	0	**1st**
	6.0	20	0	0	0	
	8.0	15	0	0	0	
	10.0	9	0	0	0	
	0.0	24	72	60	37	
	2.0	46	0	0	0	
Mixed Powders	4.0	39	0	0	0	
	6.0	30	0	0	0	**2nd**
	8.0	17	0	0	0	
	10.0	11	0	0	0	

MAT* Month after treatment.

CONCLUSION AND RECOMMENDATIONS

The biopesticidal effect on the progeny developement of *D. maculatus* was in this order: *T. tetraptera>mixed powders>M. myristica>A. melegueta.* These plant powders can be used to stop the development of *D. maculatus* in already infested dried catfish thereby bringing the existence of subsequent beetle generations to an end. Also, since *T. tetraptera* kills better than the mixed powder, there may not be need of mixing the three powders for

treatment since it's not economical. Also, Increasing concentrations of all the tested powders had significant devastating effects on the development of *D. maculatus.*

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