OPEN ACCESS International Journal of Applied Biology

ISSN : 2580-2410
eISSN : 2580-2119

Susceptibility of *Dermestes Maculatus* Degeer (Coleoptera: Dermestidea) Larvae Infesting Smoked African Catfish (*Clarias Gariepinus*) to *Alchornea Cordifolia* (Schum. & Thonn.) Leaf Powder

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Abstract

The efficacy of the plant powder of *Alchornea cordifolia* was evaluated under laboratory conditions against the larvae of the leather beetle *Dermestes maculatus* which is a major fish pest that cause serious damage when left uncontrolled. The experiment was in concentrations of 0g, 1.0g, 2.0g, 2.5g, 3.0g admixed with 15g of smoked fish powder; while all the treatment containing 0g were without plant powder which served as control, all the treatment were in triplicates. Newly emerged (0 - 72 hours old) larvae of *D. maculatus* were introduced. Evaluation of the potency of the plant powder was based on larvae mortality and the adult emergence. The weight losses in fish muscle in the treated and untreated samples were compared as index of fish damage during storage. The result showed that higher plant powder concentration were significantly ($P<0.05$) effective in killing larvae stage of the insect as well as the larvae at 1st and 2nd weeks after infestation (WAI). Adult emergence was significantly ($P<0.05$) inhibited in the treated fish and weight loss due to insect infestation was greatly suppressed by the higher dosage rate of the plant powder compared to control. The findings showed that efficiency of *A. cordifolia* leaf powder is dosage dependent and is capable of controlling the larval stage of *D. maculatus* in smoked fish (*Clarias gariepinus)* during storage. It is therefore recommended that plant could be used by poor resource fish farmers, processors and marketers in protecting smoked-dried fish against *D. maculatus* during processing, transportation, marketing and storage.

Article History
Received July 18, 2022
Accepted December 14, 2022

Keyword
Alchornea cordifolia;
Dermestes maculatus;
Clarias gariepinus;
Adult emergence;
Efficacy;
Larvae mortality;
Toxicity

Introduction

One of the major and cheapest sources of animal protein is fish. This has been used steadily due to its availability and nutritional values; fish is also used to correct protein deficiency in human diets in the tropic area (Nta et al., 2019). Fish has high protein content, which serves the purpose of natural supplement for meat and cereals in the human diet

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(Nta et al., 2019). The consumption of fish provides essential nutrients to a great number of people globally and thus its significant contribution to nutrition cannot be over-emphasized, a decline in fish availability will have a detrimental effect on the nutritional status in places where fish contributes significantly to the protein intake of the people (Nta et al., 2019).

Stored fish just as any other stored agricultural product is infested by several stored product pests (Babarinde et al., 2016). Notably among them are beetles of the genera, *Dermestes* and *Necrobia* throughout processing, transportation, marketing and storage (Adesina et al., 2014). *D. maculatus* infestation causes enormous losses. These include physical loss whereby the amount of fish available for human consumption is reduced, economic loss whereby the physical loss despite the amount of fish available for sale and or the price commanded for insect damaged fish is below that for undamaged fish, and nutritional loss, which is a direct consequence of the physical and economic loss and causes the retail value of fish to increase beyond the purchasing power of the poor (Moses, 1992).

Attempts at controlling this dreadful insect pest of *Clarias gariepinus* has been overwhelmingly relied upon the use of synthetic insecticides. These synthetic products, however, are not without their hazards to human health and the environment (Babarinde et al., 2008). Apart from the health and environmental hazards posed by synthetic insecticides, mis-use and over-use by applicators have led to serious problems, including development of insect resistant strains to insecticides, toxic residues on stored products, health hazards to handlers, food poisoning and environmental pollution (Ali, 2009). These problems have stimulated research into plants with insecticidal properties grown locally that are readily available, effective, affordable, less poisonous and less detrimental to the environment (Tierto, 1994).

Most plants are rich sources of compounds that have insecticidal properties (Obeng-Ofori et al.; 1997). One of such plants is *Alchornea cordifolia* (Schum. & Thonn.) which is an important medicinal plant in African traditional medicine and much pharmacological research has been carried out into its antibacterial, antifungal and antiprotozoal properties, as well as its anti-inflammatory activities, with significant positive results (Agbor, 2004). The leaves or leafy stems are also believed to be abortifacient, antispasmodic, blood purifier, diuretic, emetic (in large doses), emmenagogue, oxytocic, purgative, sedative and tonic (Agbor, 2004). The crushed fresh leaves or powdered dry leaves are applied externally as a cicatrizant to wounds, to relieve pain, e.g. backache and headache, to fractures to improve healing and to treat eye infections and numerous skin afflictions including venereal diseases, leprosy, sores, abscesses, yaws and filariasis (Agbor, 2004). Koomson and Oppong (2018), Koomson, *et. al*., (2018) as well as Koomson (2020) found out the leaves, bark and roots of the plant was effective in controlling the stored products insect pests through suppressing oviposition and progeny development, contact toxicity and repellency activities. This present study is aimed at determining the larvicidal activity of the leaf powder in order to evaluate its insecticidal potential in suppressing infestation and damage by *D. maculatus* on stored smoke-dried fish.

Materials and Methods

The research was carried out in the Biology Education Department laboratory of the University of Education, Winneba, Central Region, Ghana. Temperature in the laboratory was 30±2°C and relative humidity was 70±5%. The study was carried out from May 2021 to August 2021.

Collection and preparation of plant materials

Leaves of *Alchornea cordifolia* plant were collected from the Gomoa Otapirow area of the Central Region of Ghana early in the morning. They were rinsed in clean water to remove sand and other impurities, air dried at room temperature in the laboratory for 15 days, after which, ground into very fine powder using an electric blender. The powders were further sieved to pass through 1mm^2 perforations. The powders were packed in plastic containers with tight lids to ensure that the active ingredients are not lost and stored in the laboratory prior to use.

Insect culture and maintenance

The initial source of *D. maculatus* culture used for this study was obtained from natural infested smoked catfish *(C. gariepinus*) collected from smoked fish market stall in the Mandela market, Agona Swedru, Ghana. It was maintained in a kilner jar covered with muslin cloth under laboratory conditions and kept at a temperature 30+ 2℃ under relative humidity 70 + 5%. All bioassay jars was disinfected in an oven at 80℃ for 2 hours and was allowed to cool at room temperature. New generations was prepared by removing newly emerged (0-72h old) larvae from a stock culture, and placed on fresh uninfected fish, while the parent adult was removed after 2-3weeks oviposition period. Smoked samples of the fish species (*Clarias gariepinns*) were obtained from smoked fish market stall at the Mandela market at Agona Swedru in the Central Region of Ghana. The fish samples showed no visible presence of neither adult or larvae of *D. maculatus* infestation. The cured fish species were sterilized thermally by heating at 10℃ for one hour in a hot air oven (Gallenkamp Oven) in the laboratory in order to kill any insect pests that may be present (Atijegbe, 2004), and allow to cool at room temperature in the laboratory.

Effect *A. cordifolia* powder on larvae and adult emergence of *D. maculatus*

The toxic effect of *A. cordifolia* on larvae *D. maculatus* was carried out using 250ml plastic containers containing 15g of smoked cat fish with concentration of 1.0g 2.0g, 2.5g and 3.0g *A. cordifolia* leaf powder. The smoked fish in control dish contain no plant powder. The containers were gently shaken for 2 min to ensure homogenous mixture (Adesina et al. 2012) of the smoked fish and treatment powder. Ten newly emerged (0-72h old) larvae of *D. maculatus* was introduced into each treated and control dishes and was covered. Each treatment was in triplicate. Larvae mortality was counted every 24 hours for 7 days. The insects were confirmed dead when there was no response to probing with blunt forceps at the abdomen (Adedire et al., 2011). Daily observation was made until adult emergence. The number reaching adult stages was recorded and percentage weight was also recorded. The percentage reduction in adult emergence of F1 progeny was calculated using the formula:

Percentage adult emergence reduction = 100 × (No. of adult insect emerged in control dish — No. of adult insect emerged in treated dish) / No. of adult insect emerged in control dish.

The % loss in weight was determined and recorded using the method described by Odeyemi and Daramola (2000).

% Weight loss = 100 × (initial weight of fish sample —final weight of fish sample) / initial weight of fish sample.

Experimental Design and Data Analysis

The experiment was laid out in Complete Randomised Design (CRD) and each treatment was replicated three (3) times. Data were subjected to analysis of variance and where significant differences existed, treatment means were separated using Least Significant Difference (LSD) at 5% probability level. Data in percentage were arcsine transformed, before analysis.

Results

Table 1 presents the mortality rate of *D. maculatus* larva over a period of 120h after infestation. The results showed that the plant powder exert significant (P<0.05) larva mortality with increase in application rate over the time of exposure. Fish treated with 2.5g and 3g *A. cordifolia* had the highest larval mortality, while fish protected with 1g and 2g had the lowest mean values of larval mortality.

Table 2 shows the larval mortality week after infestation. There was significant difference (P<0.05) at the first and second weeks after infestation (WAI) with 3g treated having the highest larval mortality of 86.47% and 94.87% respectively while 1g treatment had the lowest of 25.63% and 48.36% for both the first and second WAI.

Weight loss as a result of the activities of *D. maculatus* showed a trend that reflected the number of surviving larvae and adult that emerged from the respective treatment dishes. Dish treated with *A. cordifolia* powder had significantly (P<0.05) suppressed adult emergence and lower weight loss as can be found in table 3 and 4 respectively.

Table 1. Percentage larval mortality of *D. maculatus* treated with different concentration of *A. cordifolia* powder

Treatment	**Hours after infestation**				
Conc./ 15g fish	24h	48h	72h	96h	120h
0g	0.0	0.0	12.21	13.12	17.94
1.0g	12.68	23.41	41.45	51.34	64.32
2.0g	14.87	25.34	46.32	58.35	68.35
2.5g	15.98	32.01	46.10	62.34	70.32
3.0g	29.45	39.48	56.32	74.98	84.02
LSD	5.21	10.21	14.23	14.98	13.21

The data above (Table 1) is summarized in the figure below:

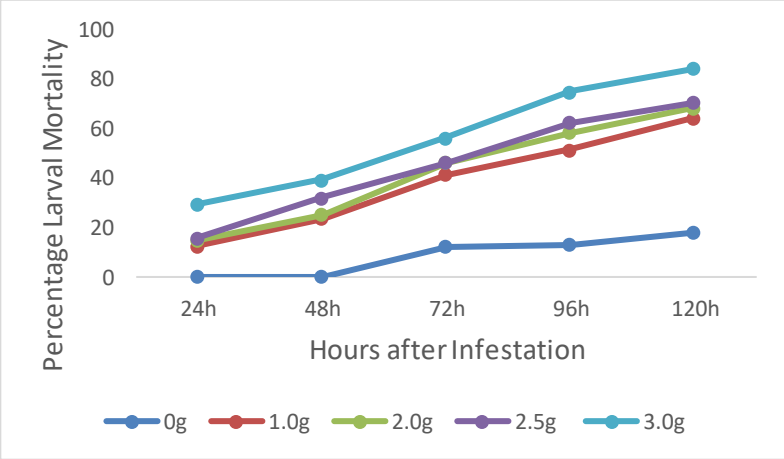

Figure 1. Percentage Larval Mortality of *D. maculatus* Treated with Different Concentration of *A. cordifolia* Powder

Table 2. Percentage larval mortality of *D. maculatus* treated with different concentration of *A. cordifolia* powder weeks after infestation

Treatment	Weeks after infestation	
Conc./ 15g fish	1st	2nd
0g	8.20	5.3
1.0g	25.63	48.36
2.0g	59.48	75.48
2.5g	78.69	83.94
3.0g	86.47	94.87
LSD	5.02	6.21

The data above (Table 2) is summarized in the figure below:

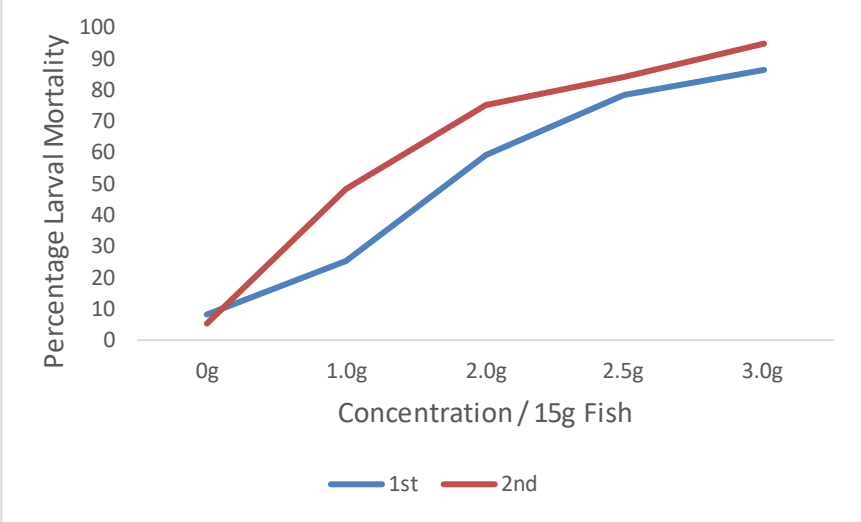

Figure 2. Percentage Larval Mortality of *D. maculatus* Treated with Different Concentration of *A. cordifolia* Powder Weeks after Infestation

Table 3. Percentage adult emergence of *D. maculatus* treated with different concentration of *A. cordifolia* powder

Treatment	Adult emergence
Conc. / 15g fish	1 week after infestation
0g	3.20
1.0g	0.87
2.0g	0.71
2.5g	0.58
3.0g	0.31
LSD	0.02

The data above (Table 3) is summarized in the figure below:

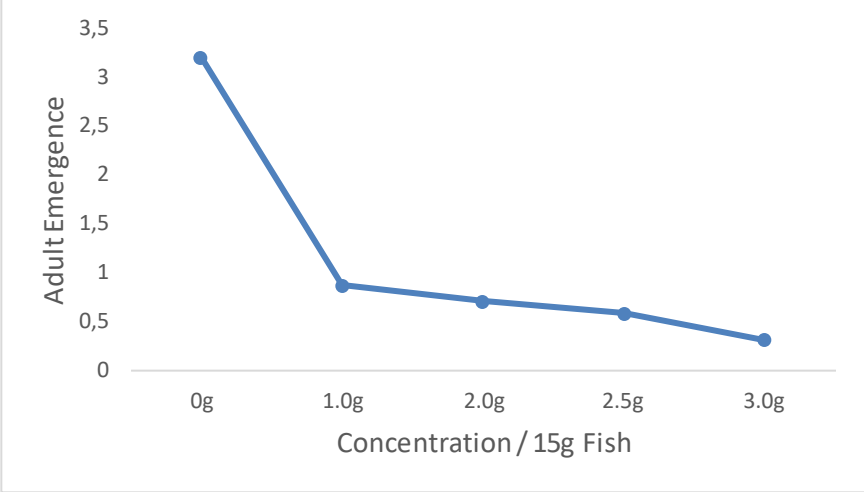

Figure 3. Percentage Adult Emergence of *D. maculatus* Treated with Different Concentration of *A. cordifolia* Powder

Table 4. Percentage weight loss due to fish infestation on samples treated with different concentration of *A. cordifolia* powder

Treatment	**Adult emergence**
Conc. / 15g fish	1 week after infestation
0g	13.42
1.0g	6.11
2.0g	5.23
2.5g	5.01
3.0g	4.06
LSD	1.05

The data above (Table 4) is summarized in the figure below:

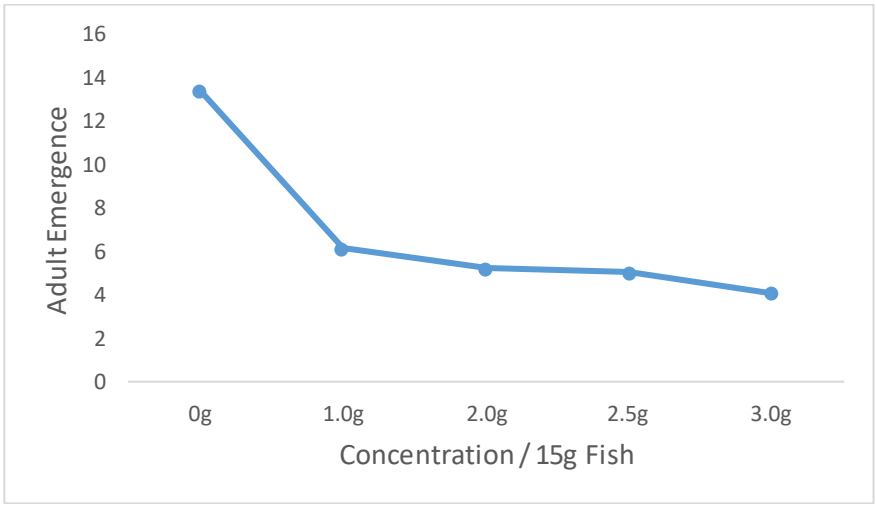

Figure 4. Percentage Weight Loss due to Fish Infestation on Samples Treated with Different Concentration of *A. cordifolia* Powder

Discussion

The use of botanicals to control *Dermestes* species is not new especially in developing countries where these botanicals are cheaply available (Babarinde, 2016). The powdered plant material was very potent in controlling the various stages of *D. maculatus* in smoked, *C. gariepinus*. The plant powder possesses high potency in killing the larvae of *D. maculatus* in smoked *C. gariepinus* during storage. The result is in agreement with many other researchers on the use of botanicals against suppression of *D. maculatus* infestation on smoked-dried fish (Mufutau, 2012; Ahmed *et al*., 2013 and Adesina 2014). The study clearly indicated that the higher dosage level of the treatment was the most effective in the application rates compared to the untreated control. The emergence of F1 adult from all the treated dishes can also be attributed to the hairs found on the larvae which prevent direct contact of the powder on the body surface of the larvae as compared to the adult with smooth cuticle (Kemabota et al., 2013).

Furthermore, plants have phytochemicals which act as chemical defense against other organisms (such as insect) in the environment (Ogunwenmo et. al., 2007). It is therefore possible that the strong pungent odour produced by the plant prevented *D. maculatus* from normal feeding, hence resulting in starvation and subsequent death (Nta et al., 2014) and impairing the development of the immature stage of the insect pests. Fasakin, 2003 reported similar scenario when he used the extract from *Piper guineense, Monodora myristica, Aframomum melegueta, Tithona diversifolia and Nicotiana tobaccum* as surface protectants against the different stages (adults stage to the eggs) of fish beetle (*Dermestes maculatus*) (De geer). Similar case of weight loss in both the treated and untreated fish muscles (which are used as indexes for calculating the rate of fish damage during storage) was also observed in the present study, and the percentage weight loss in fish during storage was significantly reduced ($p<0.05$) in fishes treated with the plant powder than the control. The higher percentage of weight loss recorded in untreated fish suggests that the larval stage of the beetle is more destructive than the adult (Nwankwo *et al*., 2011). Alam (2004) reported that if *D. maculatus* are left undisturbed, they can consume all the flesh and soft tissue of dried fish until only bone and some hard tissue remain.

This study revealed that smoked *C. gariepinus* is susceptible to *D. maculatus* infestation and thus has to be protected well during storage by technique that are environmental friendly and safe if nutrient loss is to be avoided. The use of *Alchornea cordifolia* among poor resource fisher farmers, processors and marketers should be advocated since the plant is widely distributed and used among rural folks for its ethno medical importance.

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