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BIOPESTICIDAL EFFECT OF NEEM PLANT PRODUCTS (*Azadirachta indica A. Juss*) ON THE MORTALITY OF LATE INSTAR LARVAE AND EMERGENCE OF F_1 GENERATION OF DERMESTID BEETLE (*Dermestes maculatus Degeer*) ON DRIED FISH (*Clarias* sp)

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Abstract

This study investigated the efficacy of Neem plant products namely Neem kernel oil (NKO), Neem kernel powder (NKP) and Neem leaf powder (NLP) at the rate of 1ml, 5g and 5g respectively per 35g of dried fish evaluated for their biopesticidal effect on the late instar larvae and F_1 generation emergence of Dermestid beetle on dried fish. NKO (1ml/35g) of dried fish resulted in a high mortality of *Dermestes maculatus* late instar larvae at both 96 hours PTA and 28days PTA than the NKP (5g/35g) and NLP (5g/35g) of dried, and there was significant difference among the treatments. The observed difference among the treatment was significant statistically at (P= 0.01) level of significance. The emergence of F_1 generation (Adult) from the late instar larvae was highly suppressed by the effect of NKO and NKP at 1ml and 5g respectively per 35g dried fish than NLP (5g/35g dried fish) after 8weeks PTA. But NLP (5g/35g dried fish) resulted in the formation of moribund (deformed) and dead F_1 generation of *D. maculatus* from the late instar larvae than the NKO (1ml/35g dried fish) and NKP (5g/35g dried fish) respectively. The result is indicative of the efficiency of the Neem plant products especially NKO (1ml/35g dried fish) for the effective control of *Dermestes maculatus* on dried fish.

***Key words**: Late instar larvae, F_1 generation, Neem plant products, Dermestes maculates, biopesticidal effect.*

Introduction

Fish is an important component of diet for people throughout the world. Total world production of fish has risen from about 20 million tonnes from 1938 to more than 73 million tonnes in 1976 (Clucas and Sutcliffe, 1981). Annual production of dried fish from the Nigerian waters of Lake Chad is about 4,700 tonnes, equivalent to approximately 9800 tonnes of fresh fish and valued at about €1.5 million in retail markets (Giles, 1962).

But indications of the economic survey being conducted by the Federal Resource Service in 1961 are that some 6,000 tonnes of dried fish (15,000 tonnes wet weight) are exported annually from the Nigerian coast of Lake Chad to markets within the Federation, which was estimated at €3 million annually (Rollings and Hayward, 1963). Consequently, the dried fish traffic from lake Chad has far exceeded all predictions, with figures obtained from fish traffic census at Maiduguri, North-Eastern Nigeria which showed that dried fish production rose from 6.4 million kilograms in 1969 to 26.5 million kilograms in 1971, valued at €3.2 million (₦6.4 million) and €12.7 million (₦25.48 million) respectively at the source (Osuji, 1976). Dried fish is a very important item in West African diets. The reason for this is many and varied. The main one, however, is that dried fish is rich in protein, a nutrient essential for health and growth of the body. Twenty percent (20%) of the weight of fish flesh is protein.

Dried fish is a highly favoured item of many traditional dishes; it greatly enriches their flavour and enhances the nutritional status of the dishes by furnishing excellent quality but inexpensive proteins and often a good alternative to fresh fish which in many places is not really available (Osuji, 1976). Dried fish protein compares favourably with egg, milk and meat in its amino acids composition and, infact, often has higher levels of essential lysine and methionine, both of which are lacking in cereal-based diet. The loss of water during fish drying results in an apparent increase in the concentration of its nutritionally important constituents and a greater nutritional value for the weight of fish purchased. Fat is the other major nutrient supplied by fish, which is characteristically high in poly-unsaturated fatty acids (PUFAS) making them important in diets for people requiring to keep low levels of cholesterol in their blood. Dried fish is also a ready source of energy which is valuable in areas where the overall calorie per head is insufficient. Dried fish has a higher keeping quality, and increase the varieties in which it can be presented, because of the release of special flavours and aroma during its processing which improves the general acceptability. The main constraint with dried fish production and making in Nigeria is infestation by the Dermestid beetle (*Dermestes maculatus*) during processing, storage, transportation as well as the marketing stage of dried fish (Osuji, 1974).

The species is also associated with dried meat. In other countries, *D. maculatus* and other species, notably *D. ater* Deg. and *D. frischii K*ug. have been identified with smoked meat, dried fish, bones, hides and skins and other stored commodities of animal origin (Aref et al, 1964). But records from elsewhere indicate *D. maculatus* most frequently encountered (Proctor, 1972). Green (1967) investigated the relationship between the method of curing dried sea-fish on one hand, and insect attack on the other hand, in South-Arabia, and he concluded that these serious damage to dried sea-fish resulting from infestation by *D. frischii* was primarily a result of the primitive conditions of an industry which was totally unsuited to the needs of modern marketing and export. In Nigeria, the methods of dried fish processing,

have remained fully traditional in most places, and storage conditions are haphazard with no quality control or government involvement, and the presence of insect in dried fish is presumed to be normal by both the traders and consumers, and any attempts at control seem obviously irrelevant (Osuji, 1988). Under the hot and generally humid conditions of the tropics, methods of processing have been developed as a means of prolonging shelf-life and getting the fish to distant markets.

But not withstanding such efforts, dried fish are prone to infestation by insects species and mites which can cause considerable losses, with estimates of quantities of fish damaged by insect pests to be marketed are sometimes put as high as 50%, with financial losses which are correspondingly heavy (Rollings and Hayward, 1962; Aref et al 1964). In addition to causing losses in quality and quantity, insect pests are potential carriers of pathogenic bacteria and thus represent a health hazard. Osuji (1974) reported in a survey of infestation carried out in Ibadan market, Nigeria that a high proportion of the dried fish sold in the market harboured beetle infestation mainly *D. maculatus* and *Necrobia rufipes*, with *D. maculatus* been dominant pest accounting for about 71.5% of the observed infestation. These beetles will generally select fish with a lower moisture content in the range of 15 – 30 %, they are typically inhibited by moistures greater than 45% (FAO, 1981), but occasionally can be found on fish with a moisture content as high as 50%.

The longer dried fish are stored, the greater are the losses due to beetle infestation, because these insects will feed and reproduce on dried fish finally reducing it to powder of waste products. Infestation of dried fish by *D. maculatus* commences in the fish producing areas where female adults of the beetle lay their eggs on drying and dried fish usually spread out on mats on the ground (Osuji, 1974), and most of the damage done to dried fish by the beetles has usually been attributed to the larvae of this beetle (Aref et al, 1964). These damages caused to dried fish by these larvae is due to their voracious feeding activity and boring of the edible portion of the dried fish by the late instar larvae during a normal period of storage, thus reducing the fish to mere frass and bones within weeks. This will ultimately result in loss in weight and reduction in nutritional value of the fish (Cutting, 1961).

The fish are often rendered unfit for human consumption because of contamination with faeces and larval exuviae, and aesthetically unacceptable to prospective buyers. Loss in fish weight in the range of 43.0% and 62.7% had occurred respectively as a result of damage by Dermestid beetle larvae (Osuji, 1974). When assessing the loci of infestation by this beetle, (Osuji, 1974) reported that adults and late instar larvae of *D. maculatus* were usually located in various bones in the head capsule and in the eye sockets. Early instar larvae were usually found in muscular tissues in the body wall of the fish. Most of the pupae and pre-pupae of *D. maculatus* were observed in tunnels within thick muscle blocks of dried fish. The concentration of the pest in these loci may be concealment of the individuals as well as availability of essential nutrients. for the adults and advanced instar larvae, concealment would be provided within the bones of the head and vertebrae, whereas the muscle blocks would furnish lipid and protein dietary requirements for the growing larvae instars (Osuji, 1973), the development of the pest species depending directly on changing environmental conditions and the immediate micro-climate of the dried fish itself. The distribution patterns follows series of marketing channels right from the local fish producing area up to the consumer markets in the south depending on method of processing, storage and packaging which contributes greatly to the widespread of the pest.

The peak abundance of the pests is normally in the warm dry months of the year (Jan – May and Oct – Dec), while the lowest densities is generally during the wet and cool months (Jun – Sept). According to Osuji (1973), in a survey carried out from the Dugbe market, Nigeria, the highest density of *D. maculatus* was recorded in the months of January – May and October – December in 1971, while in 1972, the months of highest abundance were January, March and May. Lowest values were observed in the months of June – September in 1971 and in June – July in 1972; and the mid-day temperatures recorded within fish specimens, around fish specimens and external temperatures just above ground surface respectively are 25.5^0C, 26.8^0C and 27.5^0C for June 1972 while at the corresponding time in the day in December 1972 he recorded 31.9^0C, 32.8^0C and 33.9^0C.

It will thus be evident that the periods of peak abundance and distribution of *D. maculatus* corresponded generally to the periods of the year (October – December, January – May) when atmospheric and micro-climatic temperatures around the marketed fish were highest. Infestation during drying and storage of fish in the tropics leads to substantial losses, with some estimates as high as 50% (Proctor, 1976). Successful methods of controlling insect pests of drying and dried fish have been developed, but their adoption is far from widespread. The main difficulty is that the greater part of the fish industry in tropical countries is conducted by small traders under relatively primitive conditions, often in remote places. The extension of new techniques in such circumstances presents formidable problems, not the least of which are the lack of trained personnel to pass on information and the reluctance of many people to adopt new ideas. With respect to *D. maculatus,* experiments by previous workers were centered on laboratory investigation of insecticidal treatments on the beetle, and the possible application of the results of such investigations to hides and skins, and similar commodities normally affected by *D. maculatus* (Osuji, 1974). The various methods of controlling these beetles involved physical or non chemical controls and chemical or insecticidal controls respectively.

The only insecticides which have been successfully introduced for the treatment of dried fish have been based on Pyrethrins synergized with Piperonylbutoxide (Proctor, 1976). A dust formulation containing 0.15% w/w Pyrethrins and 2.4% w/w Piperonylbutoxide has given three to four months protection from Dermestid infestation when applied directly to dried fish. Organophosphorus insecticides such as Malathion, Malaoxon, Diethylmalathion and Coumaphos have been used, but considerable natural tolerance by *D. maculatus* for Malathion and Malaoxon were observed. Application of contact insecticides to larvae of *D. maculatus* and *D. lardarius* showed that they were less readily killed, and that such insecticidal treatment subsequently rendered the fish aesthetically unattractive to consumers (Proctor, 1972). It has also been observed that only 3-pyrethrum, lindane and Malathion may be applied directly to food stuffs, but *D. maculatus* is now known to be resistant to Lindane (Golob et al 1987).

Dried *Tilapia spp* dipped for 4 seconds in different insecticide dips, and Deltamethrin (2.5% EC) offers protection against Dermestid infestation for 6 months (Golob et al 1987). Aref et al (1965) tried sulphur dipping and fuming with

poor results. Amorphous silica based dusts which are virtually non-toxic to mammals have been tried on dried fish, but were found to be ineffective because they absorbed oil from the fish (Green, 1967, Proctor, 1972). Alternatively, insecticides have also been applied to containers used for the storage and transportation of dried fish, or to places in which fish are handled. Osuji (1974) suggested that treatments of jute bags and crates used in transporting dried fish with insecticides or suitable fumigant mixtures such as ethylene dichloride or carbon tetrachloride before use. Proctor (1976) recommended regular spraying of internal surfaces of ware houses or fogging with contact insecticide or fumigation under a gas-proof sheet. However, he found that Dermestid beetles penetrated sacks treated with a dust formulation of synergised Pyrethrins and infested contents. Apart from the possibilities of insecticidal resistance in *D. maculatus* as reported by various workers, and that reported by Proctor (1972) regarding the appearance of insecticide-treated fish is of particular relevance to Nigerian Consumers. In view of hazards to health of man and domestic animals, these short comings have emphasized the importance of physical methods for protecting food stuffs from insect pests (Osuji, 1974). The physical methods have not always yielded the spectacular results which we are accustomed to expect from chemical insecticides.

However, the use of ionising radiation of up to 10 – 30krad shortened the life span of *D. maculatus* larvae, pupae and adults, and no offspring resulted, but gamma radiation of up to 6 – 16 Krad have a deleterious effects on the eggs, larvae, pupae with adults being sterile throughout their life (Shokoohian, 1977). Aref et al (1964) while investigating the possibility of controlling Dermestid beetles in dried fish by means of ionizing radiation, found 53,000 to 105,000rad to be lethal to adults, with 23,000rad not killing but probably induced sterilization. However, the capital costs of installing irradiation equipment and the time interval (4wks or more) between treatment and insect death are obvious disadvantages in Nigerian conditions (Osuji, 1974). Toye(1970) suggested heating of dried fish in simple charcoal fired oven for 30 minutes at four day intervals during the storage period to control infestation. Osuji (1974) recommended effective dehydration of fish (to about 8% MC) would create a condition that is unfavourable to beetle development and survival, and the use of post-smoking hot-chambers where fish is kept at temperatures lethal to insect stages for shorter and longer periods in the silo-type storage houses.

Artificial heating of fish above 65 – 70^0C may cause scorching and spoil the colour or flavour of dried fish (Cutting, 1961). The range of temperatures available for killing pests without spoiling fish, is therefore, very narrow and the warm smoking technique (45-60^0C for 4-7 hours) for larger fish is probably the best method to adopt (Osuji, 1973). Well dried fish could be stored for up to one year in sealed polyethene bags without serious loss of quality (Keshvani, 1964). Choice of a chemical to control pests without causing health hazards is of a great importance, and this could possibly be achieved by using the extracts of plants having pesticidal properties, such extracts are comparatively more economical, safer, less toxic and biodegradable (Banerji et al 1982). Although certain plants have already been shown to possess insecticidal properties but very little information on the antifeedants properties of plants is available (Sandhu and Singh, 1975, Pandey et al, 1977).

It has been revealed that various plant products with repellent effect on insects afford protection to stored pulses against the bean weevil (Pandey et al, 1977). Neem tree (*Azadirachta indica:* Meliaceae A. Juss. Synonym: *Melia azadirachta*) products show considerable potential for controlling pest of stored products. Out of 1800 plant species investigated for pest control properties at the East-West Resources Institute in Honolulu, the Neem was the most promising as reported by Seun (1975) in National Research Council (1992). Three feeding inhibitory triterpenoids have been isolated and identified from Neem Kernels (Butherworth and Morgan, 1968), and these compounds are Meliantriol, Salanin and Azadirachtin. These extracts have been found to affect more than 200 insect species (Warthen, 1989; NRC, 1992) including a number of stored product pests. The extracts act on different insect species in various ways including repelling adults and larvae, disrupting developmental processes, inducing adult sterility and disturbing adult behaviour (Warthen, 1989).

Traditionally, Neem leaves are mixed with grain kept in storage for 3 – 6 months, and treating jute sacks with Neem oil extracts prevent pests, in particularly weevils (*Sitophilus spp*.) and flower beetles (*Tribolium spp*.) from penetrating for several months (Cobbinah and Appiah-Kwarteng, 1989). Neem has also been used to protect stored roots as well as tubers against the potato moth, and small amount of Neem powder are said to extend the storage life of potatoes for three months (Schmutterer, 1990). Neem leaf or seed powder mixed with stored maize have effectively reduced the progeny production of S*itophilus oryzae* and *S. zeamais* by disrupting the larval development and adult fecundity (Pereira and Wohlygemut, 1982). Dry ground Neem seed reduce fecundity, prolongs pre-imaginal developmental period and considerably reduces emergence of progeny (Ivbijaro, 1983), adults are rarely affected. Ogunwolu and Idowu (1994) showed that powdered root bark of *Zanthoxylum zanthoxyloides* (Lam)(Fagara) and seeds of *Azadirachta indica* A. Juss at the rate of 2.5% of the treated seed weight were toxic to the cowpea seed bruchid C*allosobruchus maculatus* (F) with consequent reduction in loss in seed weight of 55 – 93% by *A. indica* and 83 – 85% with *Z. zanthoxyloides* after three months of storage. Jotwani and Sircar (1965) reported that wheat seed is protected against *S. oryzae, Rhyzopertha dominica* and *Torgoderma granarium* for nearly a year when mixed with powdered Neem seed kernel at 1% or 2% weight of seeds. Jotwani and Sircar(1967) also showed that seeds of Mung, Bengal grain, Cowpeas and Peas can be effectively protected from damage by the bruchid (*C. maculatus*) by mixing the seed with crushed neem seed at 1% or 2% of the seed weight, and the germination of the treated seed was not impaired. Organoleptic test carried out after washing and cooking the seeds showed that they were devoid of taste and odour. Powdered Neem seed kernel at 1.5 and 2% mixed with maize and cowpea seeds gave good protection against *S. zeamais* and *C. maculatus* for 8 months as compared to 89% damage in control (Sowunmi and Akinnusi, 1983). Saramma and Verma (1971) also shows that powdered drupes of Dharek, Neem seeds and Costus roots as well as Magnesium carbonate were tested as protectants of wheat seed against attack of *Trogoderma* grabs with Neem seed powder offering the best protection from Khapra grubs at 1% or 2% for about 8 months. Neem oil also is an extremely effective and cheap protection for stored beans, cowpea and other legumes, and it keeps them free of bruchid- beetle infestations for at least 6 months regardless of whether the beans were infested before treatment or not. Pereira (1983)

found that Neem Kernel oil at 8ml/kg cowpea seed gave good protection for up to three months against the cowpea beetle by reducing oviposition. Therefore, the objective of this study is to evaluate the biopesticidal effects of three Neem products namely NKO, NKP and NLP on the larvae mortality and F_1 generation (adults) emergence on treated dried fish.

Materials and Methods

The study was conducted at the Storage Entomology Laboratory of Crop Protection department of the Institute for Agricultural Research, Ahmadu Bello University (IAR/ABU) at Samaru ($11^0 11'$N and $07^0 38'$E) Zaria, Nigeria. Medium-sized dried fishes variety cat fish (*Clarias Sp.*) were purchased from Sabon-Gari market ($11^0 13'$N and $07^0 52'$E) Zaria and the Neem products were obtained from the available pure-line Neem trees in the premises of IAR/ABU Samaru. Kilner jars Electric oven, weighing balance, basin, carmel hair brush, pipette, fish cutter, forcep, mortar and pestle, late instar larvae and adult of Dermestid beetle. The population of test insects for the experiment was obtained from the infested dried fish materials from the market and sub cultured in the laboratory using dried fish media at 25-27^{0}C ambient temperature and 60 – 75% relative humidity for six weeks in order to have enough test insects. Neem Kernel Oil (NKO) was obtained by air-drying the collected Neem seeds which were then decorticated to separate the kernel from the seed coat. The decorticated kernels were then grinded and boiled in water to form paste which was then squeezed in a cheese cloth to extract the oil. Neem Kernel Powder (NKP) was obtained by air-drying decorticated kernels which were then grinded with the aid of pestle and mortar, and it was then thoroughly sieved with a fine-mesh sieve. Neem Leaf Powder (NLP) was obtained by air-drying Neem leaf leaves which were later grinded into fine powder with the aid of a pestle and mortar using a fine mesh sieve.

Experimental Design and Treatments

Twelve medium-sized dried fishes weighing 35g averagely were disinfested in an electric oven set at 50^{0}C for 2-3 hours. The Neem products NKO,NKP and NLP were measured/weighed into a lot of 1ml, 5g and 5g respectively on to each fish placed inside the Kilner jars and then divided into the three treatments plus the control and replicated three times were added the pre-weighed Neem products except the control that were not treated, with the aid of a camel-hair brush, and they were allowed to stand for 5 minutes following which four late instar larvae of *D. maculatus* measuring about 13-15mm in length (Osuji, 1973 and Haines, 1991) were introduced into each treated fish in the jars and then covered with perforated plastic caps lined with muslin cloth. The entire experimental set up and the controls were arranged on a laboratory table with temperature fluctuating between 25 – 27^{0}C and 60 – 67%RH in a Completely Randomized Design(CRD).The contents of the jars were examined at 24, 48, 72 and 96 hours to assess level of larval mortality. This was also repeated at 7, 14, 21 and 28 days post treatment application (PTA). At 4 and 8 weeks PTA, the number of F_1 generation (adult) of *D. maculatus* formed from these late instar larvae was also assessed. Percentage loss in weight of the dried fish from each treatment was determined after 8wks PTA. The data obtained from the study were transformed using Square Root Transformation (SQT) (Steel and Torrie, 1960) with 0.5 as constant i.e.

$$SQT = \sqrt{X_1 + 0.5} = X_2$$

Where X_1 = Initial data or value
X_2 = Final or transformed data or value
0.5 = a constant in the equation
The transformed data were statistically analysed using Analysis of Variance (ANOVA), and the mean of the treatments were separated using Least Significance Difference at both 5% (P=0.05) and 1% (P=0.01) levels of significance respectively.

Post Treatment Residual Effect of Neem Products

Palatability test was carried out on the dried fishes treated with the three Neem products after 12wks of the study to determine if there would be post-treatment residual effect on the taste and odour of the dried fishes after cooking. The test was carried out for 3days with 11 respondents that were randomly selected among staff of IAR/ABU from the Crop Protection department. The retrieved dried fished from each treatment were bulked and cooked separately without onion so as not to mask the effect of the treatments. The respondents were then served the cooked dried fishes separately at different times so that they do not influence one another in their observations and comments. The respondents were asked if there was any unpleasant taste and odour in the cooked dried fishes from any of the three Neem products and their comments were noted.

Results and Discussion

The rate of larval mortality of *D. maculatus* recorded at 24hours interval and 7days intervals respectively are shown in Table I and Table II. Neem Kernel Oil (NKO) at the rate of 1ml/35g of dried fish resulted in high larval mortality of *D. maculatus* at 24, 48 and 96 hours PTA, with the highest larval mortality at 48 and 96 hours PTA. However there was no significant difference in larval mortality recorded at 24 and 96 hours PTA which were not also different from the larval mortality due to Neem Kernel Powder (NKP) and Neem Leaf Powder (NLP) during these periods. But larval mortality due to NKO at 48 hours was statistically higher (P=0.05) than larval mortality due to NKP and NLP, but NKP and NLP do not differ statistically during the same period in the number of larval mortality. However the cumulative larval mortality values recorded after 96hours PTA showed higher mortality of *D. maculatus* larval from NKO and this was significantly different from the values obtained from NKP and NLP, both of which are statistically similar. The high toxicity of NKO observed on the larval of *D. maculatus* may be due to poisoning of the larval when they came in contact with the treated dried fishes. Butterworth and Morgan (1968); attributed the toxicity

of NKO to the presence of some antifeedants and interfering agents such as the triterpenoids which includes Azadirachtin, Salanin and Meliantriol. This present observation corroborates those made by Kilonzo (1991), Jackai and Oyediran, (1991) using NKO having high toxicity on the larvae of fleas and *Maruca testullalis* under laboratory conditions. Gerard and Ruf (1995) also used NKO on the larvae of Keratinophagous insect and found it to have a negative effect on their feeding and survival. The low toxicity of NKP and NLP observed on the larvae of *D. maculatus* could be as a result of low amount of insecticidally active ingredient in the kernel and leaf powder compared to NKO. It could also be attributed to the settling down of the powders at the bottom of the jars thus excluding them from the area of intense larval activities where the control is desired.

TABLE I: EFFECT OF NEEM PLANT PRODUCTS ON LARVAL MORTALITY OF *Dermestes maculatus* Deg. ON DRIED FISH AT 24 HOUR INTERVAL.

		Mean of Dead Larvae Per Observation				
TREATMENTS		**Hours Post Treatment Application (HPTA)**				
Neem Plant Products	**Rate/35g Dried Fish**	**24**	**48**	**72**	**96**	**Cumulative Mean**
Neem Kernel Oil (NKO)	1ml	0.88	1.06a	0.71	1.06	3.71sa
Neem Kernel Powder (NKP)	5g	0.71	0.71b	0.71	0.88	3.01b
Neem Leaf Powder (NLP)	5g	0.71	0.71b	0.71	0.71	2.84b
Control		0.71	0.71b	0.71	1.06	3.19b
SED±		0.12	0.12	0.00	0.22	0.22
LSD		0.28	0.28	0.00	0.51	0.51
SIGNIFICANCE		NS	*	NS	NS	*

Mean followed with the same alphabet on the same column d o not differ statistically.
* Significant Difference at (P= 0.05)
** Significant Difference at (P = 0.01)
SED = Standard Error Difference
LSD = Least Significant Difference
NS = Not Significant

From Table II NKO at 7days PTA resulted in a significant higher (P=0.01) larval mortality of *D. maculatus* than NKP and NLP. But larval mortality from NKP and NLP during the same period does not differ statistically. NKO also resulted in higher larval mortality of *D. maculatus* at 14, 21 and 28 days PTA than NKP and NLP, although these observed differences were not significant statistically. The cumulative larval mortality after 28days PTA showed NKO with a significantly higher (P=0.01) larval mortality of D. maculatus than NKP and NLP. However NKP resulted in a high larval mortality of *D. maculatus* than NLP which was statistically different after 28 days PTA.

TABLE II: EFFECT OF NEEM PLANT PRODUCTS ON LARVAL MORTALITY OF *Dermestes maculatus* Deg. ON DRIED FISH AT SEVEN DAYS INTERVAL

		Mean of Dead Larvae Per Observation				
TREATMENTS		**Days Post Treatment Application (DPTA)**				
Neem Plant Products	**Rate/35g Dried fish**	**7**	**14**	**21**	**28**	**Cumulative Mean**
Neem Kernel Oil (NKO)	1ml	1.46a	0.88	0.88	1.00	4.22a
Neem Kernel Powder (NKP)	5g	1.06b	1.27	0.71	0.71	3.75b
Neem Leaf Powder (NLP)	5g	0.71b	0.71	0.71	0.71	2.84c
Control		1.46a	0.88	0.71	0.71	3.76b
SED±		0.16	0.29	0.20	0.20	0.14
LSD		0.37	0.67	0.46	0.46	0.32
SIGNIFICANCE		**	NS	NS	NS	**

The result in Table III showed the level of emergence of F_1 generation (adults) of *D. maculatus* from the late instar larvae at 4 and 8 weeks PTA due to Neem products treatments. At 4 weeks PTA NKO and NKP suppressed the emergence of F_1 generation of *D. maculatus* than NLP, although the observed differences were not significant statistically. At 8 weeks PTA, NLP resulted in a significantly higher (P=0.01) level of deformed (Moribund) and dead F_1 generation of *D. maculatus* than NKO and NKP, both of which resulted in the suppression of emergence of F_1 generation of the insect. The level of F_1 generation that emerged from NKO and NKP do not differ statistically. the cumulative emerged F_1 generation observed after 8 weeks PTA showed NKO and NKP completely suppressed the development of F_1 generation of *D. maculatus* while NLP resulted in a significantly higher (P = 0.01) formation of deformed and dead F_1 generation of *D. maculatus* from the late instar larvae of the insect than the other two Neem products. The non-emergence of F_1 generation of *D. maculatus* on dried fishes treated with NKO and NKP could be as a result of the toxicity of the two products on the late instar larvae development. According to Warthen (1989) and NRC (1992) various Neem extracts have been found to cause disruption and/or inhibition of eggs, pupae and adult development of insects. The observed moribund (deformed) F_1 generation of *D. maculatus* from dried fish treated with NLP suggests that the product was not effective in outright killing of *D. maculatus* larvae, however, it was effective in disrupting the normal development of these larvae. Similar observations have been made by several authors on the disruptive effect of various Neem products on developmental stages of various insects such as Desert locust

(Schmutterer, 1990) and Colorado potato beetles (Radcliffe, 1992) with their adults having malformed wings and sterile. The development of deformed adults observed in this study due to NLP could lower the fecundity of the insect that may subsequently infest dried fish through migration to other areas.

TABLE III: EFFECT OF NEEM PLANT PRODUCTS ON THE RATE OF EMERGENCE OF F_1 GENERATION (ADULT) OF *Dermestes maculatus* Deg. FROM THE LATE INSTAR LARVAE ON DRIED FISH.

		Mean Number of Emerged F_1 Generation		
TREATMENTS		**Weeks Post Treatment Application (WPTA)**		
Neem Plant Products	**Rate/35g Dried fish**	**4**	**8**	**Cumulative Mean**
Neem Kernel Oil (NKO)	1ml	0.71	0.71c	1.42c
Neem Kernel Powder (NKP)	5g	0.71	0.88c	1.59c
Neem Leaf Powder (NLP)	5g	0.88	1.95a	2.83a
Control		0.88	1.46b	2.34b
SED±		0.18	0.16	0.16
LSD		0.42	0.37	0.37
SIGNIFICANCE		NS	**	**

The palatability test carried out by the selected respondents on the cooked fishes treated with the three Neem products after 12 weeks post experimental periods showed that out of the three Neem products, only NKO treated dried fish was found not to have any unpleasant or bitter taste on the dried fishes. These fishes gave good taste and aroma as the untreated dried fishes. NKP and NLP treated dried fishes were found to induce mild bitter taste on the treated dried fishes and this bitterness was more pronounced on those fishes with NLP. And this could be due to high dosage of the two products used. However, the three Neem products were found not to impart any unpleasant odour in the treated dried fishes following cooking and consumption by the respondents.

Conclusion and Recommendation

The result of this finding revealed that, effect of Neem Kernel Oil (NKO), Neem Kernel Powder (NKP) and Neem Leaf Powder (NLP) at the rate of 1ml, 5g and 5g/35g of dried fish respectively were evaluated for the control of late instar larvae and emergence of F_1 generation of *D. maculatus* on the treated dried fishes, with NKO at the rate of 1ml/35g of dried fish found to cause higher mortalities of the larvae. NKP and NLP were not as effective as NKO in terms of their toxicities to the larvae. Both NKO and NKP suppressed the emergence of the F_1 generation (adults) from the late instar larvae of the insect than NLP. However, NLP was found to result in the formation of moribund (deformed) and dead adults of the insect from the late instar larvae. Based on the results from this study, the use of NKO at the rate of 1ml/35g dried fish is therefore recommended because of its biopesticidal potential for effective control of *D. maculatus* larvae and adult emergence on dried fish as alternative to synthetic insecticides which are very expensive and could constitute hazard to man and his environment.

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