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Weevils and fungi infestation of dried fish: A case study of Uyo local government area, Akwa Ibom state, Nigeria

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Abstract
The assessment of the infestation of common weevils and fungi of dried fish in Akwa Ibom State, Nigeria, was studied, between July and December, 2014. Two markets were used as case study, which are the Akpan Andem market and the Anua market. 180 fishes were randomly selected and examined for weevil infestation. Fish samples were opened and checked for adult weevils while light microscope was used for the identification of weevils at the egg stages. The fishes were incubated on Potato dextrose agar (PDA) for five days for fungal infestation. The weevil isolated was *Dermestes maculates with a* total of 343 *Dermestes maculatus* [288 larvae (84%) and 55 adults (16%)] were isolated from fishes obtained from Akpan Andem market; while a total of 385 *Dermestes maculatus* [331 larvae (86%) and 54 adults (14%)] were isolated from fishes obtained from Anua market. The three fungi isolated and identified were *Aspergillus flavus, Penicillium spp* and *Mucor spp.* The highest mean microbial counts for the two markets (42.14×10^{-5}cfu/ml and 52.34×10^{-5}cfu/ml) were isolated in July, while the lowest mean microbial counts (30.18×10^{-5}cfu/ml and 35.2×10^{-5}cfu/ml) were recorded in December. *Aspergillus spp* are known to produce aflatoxins which are carcinogenic (causing hepatoma cancer of the liver) acute hepatitis, reduced red blood cell and decreased immune system in man. Prolonged intake of dried fish with these metabolites may constitute potential public health hazard. Adequate cooking could help in reducing fungi and weevils of dried fish.

Keywords: Infestation, dried fish, weevils, fungi, Akwa Ibom, Nigeria

1. Introduction
Fish is one of the most important sources of animal protein and has been widely accepted as a good source of protein and other elements for the maintenance of healthy body (Ravichandran *et al*, 2012) [42]. Fish is a perishable agricultural product and is highly susceptible to spoilage. Spoilage is a metabolic process that causes food to be undesirable or unacceptable for human consumption due to changes in sensory nutritional characteristics (Doyle, 2007) [9]. Since fish is highly susceptible to deterioration immediately after harvest, and to prevent economic losses, the processing and preservation of fish is of utmost importance (Okonta and Ekelemu, 2005) [37]. Odeyemi (2000) [36] noted that smoke dried fish is one of the highly digestible and respectable sources of proteins and essential minerals in the tropics but it is highly susceptible to insect pest infestation.

Physical disintegration of smoked fish which results from poor handling, packaging and distribution practices aggravates losses and exposes products to the action of bacteria and moulds. Eyo and Mdaihli (1997) [12] stated that the shelf-life of smoked fish ranges from two (2) to twenty four (24) weeks and depends on factors such as dryness of the fish, temperature of storage, degree of smoking and the microbial load. For example, in high moisture, smoked fish microbial spoilage sets in after two (2) to three (3) days after smoking whilst smoked dried lean sardines can store for more than three (3) months without spoilage. Though *Aspergilus spp* and *Penicillium spp* are common moulds, their widespread occurrence on smoked fish is alarming since some species/strains are mycotoxigenic and produce potential carcinogens.

Eyo and Mdaihli (1997) [12] also noted that fragmented fish encourages the rapid development of beetle pests; particularly *Dermestes maculates* and could endanger whole fish staying too long in storage. Some examples of worldwide losses of dried fish due to insect infestation are given by Poulter (1972) [41]. James (1977) [24] estimated weight losses of dried fish due to *Dermestes spp.* damage in a 6-months storage period at 26-34%. The hurry to get improperly dried fish to the market increases the susceptibility of processed fish to weevil and fungal infestation. High humidity not only encourages rapid multiplication of insects but the growth of moulds.

Post-harvest fish losses are a major concern and occur in most fish distribution chains throughout the world (James, 1977) [24]. Not only do losses constitute lost income to fishers, processors and traders, they also contribute to food insecurity- a loss of fish means less fish available to the consumer (Ames *et al,* 1991) [3]. Post-harvest fish losses are often caused by biochemical and microbiological spoilage changes that occur in fish after death. A live fish has natural defense mechanisms that help to prevent spoilage. However, once a fish dies, its defense mechanisms stop, enzymatic, oxidative and microbiological spoilage begins to cause quality deterioration. Weevils and fungi infestation of dried fishes are common issues and they severely affect the quality of dried fishes. Fish weevils, *Dermestes maculates* and *Necrobia rufipes,* and the fungi, *Aspergillus flavus, Aspergillus niger, Penicillium spp, Rhizopus spp and Mucor spp, are the common causes of dried fish infestation in* Nigeria, hence, this study will identify the common weevils and fungi in Akwa Ibom State and suggest possible ways of preventing their infestation.

2. Materials and Methods

2.1 Study Location

Akpan andem market is the major market in Uyo Local government Area of Akwa Ibom State, Nigeria, although there are other smaller markets like the Anua market. Uyo lies on the road from Oron to Ikot Ekpene. It's geographical co-ordinates are $5^{o}3^{1}0^{11}$ North and $7^{0}56^{1}0^{11}$ East. Uyo L.G.A. occupies an expanse of land of about 115 square kilometers. The area is located within the tropical rainforest zone with two distinct seasons, rainy season extending from April to November and dry season from December to March, with an annual rainfall of between 2,500 – 4000 units and a temperature range of about 24-25 ^{o}C (Eyo, 2001) [13]. The area is highly commercial cutting across trading, fishing, arts and crafts. It has deposits of minerals such as crude oil and other natural resources.

2.2 Examination of dried fish for weevil infestation

A total of 180 fish samples were purchased from the two markets were and the samples were thereafter taken to the laboratory for analysis. The fish were simply dissected for weevil isolation, while the serial dilution and plate counting methods were used for isolation of fungi. Fish samples purchased from the markets were opened and checked for weevils. Collection of pests involved taking the samples of infested fish together with the pests and placing in polythene bags. Isolation of the pests involved dissecting the fish with scalpels, and a light weight forcep was used to remove the weevils. The adult and larval stages of *Dermestes maculates* were identified with the naked eye and a simple hand lens respectively. The light microscope was used in case of the egg stages.

2.3 Method of fungal examination of dried fish

Five commonly available dried fish samples (*Clarias gariepinus, Tilapia zilli, Gadus morhua, Ethmalosa fimbriata and Heterotis niloticus*) were randomly purchased from Akpan Andem and Anua markets respectively. The samples were labeled A, B, C, D and E and were carefully packaged in different polythene bags, and taken to the laboratory for analysis.

2.4 Culture media preparation

Potato dextrose agar (PDA) was used for fungi. Twenty-eight gram (28 g) of NA and 37 g of PDA were dispensed differently in 1 litre of distilled water in separate conical flask. Sterilization was done in the autoclave at 121 °C for 15 min after which it was allowed to cool. The culture media was shaken vigorously before use (Taylor *et al*., 1964) [44].

2.5 Isolation

For each fish sample, five test tubes were used for serial dilution. One gram (1 g) of the blended samples was weighed aseptically and mixed thoroughly in 9 ml distilled water. Subsequent tenfold dilution was made up to 10-5 from it. One milliliter (1 ml) of each dilution was dispensed in sterile Petri dishes using pour plate method. The plates were allowed to solidify and were incubated at 35 °C for 24 h (bacteria) and fungi were left on the bench for 3 to 5 days at room temperature. Bacteria and fungi count were done after 24 and 72 h, respectively. The microbial isolates were observed for their cultural and morphological characteristics.

2.6 Data analysis

Data collected were analyzed using descriptive statistics. Data differences were tested for significance using F-test at 95% confidence level (Hull and Nie, 1981) [22]. For multiple comparisons, the Fisher's least significant difference (LSD) was used to separate means at 95% level with the aid of Statistical package for the social sciences (SPSS) 17.0 for Windows Vista on PC.

3. Results

3.1 Quantitative analysis

180 dried fishes (36 each of *Clarias gariepinus, Tilapia zilli, Ethmalosa fimbriata, Gadus morhua* and *Heterotis niloticus)* were examined from Akpan Andem and Anua markets for six months, July to December, 2014, of the 180 fishes examined, 138 (76.7%) were infested by weevil (*Dermestes maculatus)* as shown in Figure 1 and Tables 1 - 2. A total of 343 *Dermestes maculatus* [288 larvae (84%) and 55 adults (16%)] were isolated from fishes obtained from Akpan Andem market; while a total of 385 *Dermestes maculatus* [331 larvae (86%) and 54 adults (14%)] were isolated from fishes obtained from Anua market.

The highest infestation rate was recorded in July for both markets with 68 *Dermestes maculatus* [53 larvae (77.9%) and 15 adults (22.1%)] from Akpan Andem market; and 75 *Dermestes maculatus* [60 larvae (80%) and 15 adults (20%)] from Anua market, as shown in Figure 1 and Table 1 and 2. December recorded the lowest infestation rate with 46 *Dermestes maculatus* [43 larvae (93.5%) and 3 adults (6.5%)] from Akpan Andem market; and 51 weevils [49 larvae (96.1%) and 2 adults (3.9%)] from Anua market, as shown in tables 1 and 2 respectively.

Accordingly, the fishes were examined for fungal infestation from July to December, 2014. The species of fungi isolated were *Aspergillus flavus, Penicillium spp and Mucor spp.* Tables 7 – 8 shows the microbial colony count on monthly basis for both markets. The highest mean microbial count values of 42.14×10^{-5}cfu/ml and 52.34×10^{-5}cfu/ml were recorded in July, while December recorded the least mean microbial count values of 30.18×10^{-5}cfu/ml and 35.2×10^{-5}cfu/ml for both Akpan Andem and Anua markets respectively. Table 5 – 8 shows result of qualitative analysis of Weevil and fungi recorded between July and December 2014 in Akpan Andem and Anua Markets, Uyo in Akwa Ibom State.

Table 1: Result of Quantitative analysis of infestation of Weevil Recorded between July and December, 2014 in Akpan Andem Market Uyo in Akwa Ibom State.

Fish Species	July					August					September					October					November					December				
	Number of fish examined	Number of fish infested (%)	Number of weevils isolated		Total number of weevils isolated	Number of fish examined	Number of fish infested (%)	Number of weevils isolated		Total number of weevils isolated	Number of fish examined	Number of fish infested (%)	Number of weevils isolated		Total number of weevils isolated	Number of fish examined	Number of fish infested (%)	Number of weevils isolated		Total number of weevils isolated	Number of fish examined	Number of fish infested (%)	Number of weevils isolated		Total number of weevils isolated	Number of fish examined	Number of fish infested (%)	Number of weevils isolated		Total number of weevils isolated
			Larvae (%)	Adult (%)				Larvae (%)	Adult (%)				Larvae (%)	Adult (%)				Larvae (%)	Adult (%)				Larvae (%)	Adult (%)				Larvae (%)	Adult (%)	
C. gariepinus	3	3 (100)	4 (66.7)	2 (33.3)	6	3	2 (66.7)	5 (62.5)	3 (37.5)	8	3	3 (100)	4 (57.1)	3 (42.9)	7	3	3 (100)	6 (75)	2 (25)	8	3	2 (66.7)	5 (83.3)	1 (16.7)	6	3	2 (66.7)	11 (100)	0 (0)	11
T. zilli	3	2 (66.7)	30 (85.7)	5 (14.3)	35	3	3 (100)	27 (93.1)	2 (6.9)	29	3	1 (33.3)	25 (96.2)	1 (3.8)	26	3	2 (66.7)	20 (100)	0 (0)	20	3	3 (100)	20 (100)	0 (0)	20	3	1 (33.3)	6 (100)	0 (0)	6
E. fimbriata	3	3 (100)	8 (72.7)	3 (27.3)	11	3	3 (100)	4 (80)	1 (20)	5	3	3 (100)	6 (75)	2 (25)	8	3	3 (100)	4 (66.7)	2 (33.3)	6	3	2 (66.7)	3 (50)	3 (50)	6	3	1 (33.3)	12 (100)	0 (0)	12
G. morhua	3	3 (100)	5 (83.3)	1 (16.7)	6	3	2 (66.7)	9 (69.2)	4 (30.8)	13	3	3 (100)	7 (70)	3 (30)	10	3	3 (100)	10 (90.9)	1 (9.1)	11	3	3 (100)	10 (90.9)	1 (9.1)	11	3	2 (66.7)	4 (100)	0 (0)	4
H. niloticus	3	3 (100)	6 (60)	4 (40)	10	3	3 (100)	8 (80)	2 (20)	10	3	2 (66.7)	5 (83.3)	1 (16.7)	6	3	1 (33.3)	7 (70)	3 (30)	10	3	1 (33.3)	7 (77.7)	2 (22.2)	9	3	1 (33.3)	10 (76.9)	3 (23.1)	13
Total	15	14 (93.3)	53 (77.9)	15 (22.1)	68	15	13 (86.7)	53 (81.5)	12 (18.5)	65	15	12 (80)	47 (82.5)	10 (17.5)	57	15	12 (80)	47 (85.5)	8 (14.5)	55	15	11 (73.3)	45 (86.5)	7 (13.5)	52	15	7 (46.7)	43 (93.5)	3 (6.5)	46
Mean	3	2.8	10.6	3	13.6	3	2.6	10.6	2.4	13	3	2.4	9.4	2	11.4	3	2.4	9.4	1.6	11	3	2.2	9	1.4	10.4	3	1.4	8.6	0.6	9.2

Table 2: Result of Quantitative analysis of Infestation of Weevil Recorded between July and December 2014 in Anua Market Uyo in Akwa Ibom State.

Fish Species	July					August					September					October					November					December				
	Number of fish examined	Number of fish infested (%)	Number of weevils isolated		Total number of weevils isolated	Number of fish examined	Number of fish infested (%)	Number of weevils isolated		Total number of weevils isolated	Number of fish examined	Number of fish infested (%)	Number of weevils isolated		Total number of weevils isolated	Number of fish examined	Number of fish infested (%)	Number of weevils isolated		Total number of weevils isolated	Number of fish examined	Number of fish infested (%)	Number of weevils isolated		Total number of weevils isolated	Number of fish examined	Number of fish infested (%)	Number of weevils isolated		Total number of weevils isolated
			Larvae (%)	Adult (%)				Larvae (%)	Adult (%)				Larvae (%)	Adult (%)				Larvae (%)	Adult (%)				Larvae (%)	Adult (%)				Larvae (%)	Adult (%)	
C. gariepinus	3	3 (100)	8 (72.7)	3 (27.3)	11	3	2 (66.7)	7 (77.7)	2 (22.2)	9	3	3 (100)	8 (72.7)	3 (27.3)	11	3	3 (100)	8 (72.7)	3 (27.3)	11	3	3 (100)	10 (90.9)	1 (9.1)	11	3	2 (66.7)	11 (100)	0 (0)	11
T. zilli	3	3 (100)	28 (93.3)	2 (6.7)	30	3	2 (66.7)	30 (96.8)	1 (3.2)	31	3	2 (66.7)	30 (96.8)	1 (3.2)	31	3	2 (66.7)	30 (100)	0 (0)	30	3	2 (66.7)	30 (100)	0 (0)	30	3	2 (66.7)	13 (100)	0 (0)	13
E. fimbriata	3	3 (100)	7 (87.5)	1 (12.5)	8	3	3 (100)	6 (75)	2 (25)	8	3	3 (100)	7 (77.7)	2 (22.2)	9	3	1 (33.3)	2 (66.7)	1 (33.3)	3	3	1 (33.3)	8 (80)	2 (20)	10	3	1 (33.3)	11 (100)	0 (0)	11
G. morhua	3	3 (100)	8 (61.5)	5 (38.5)	13	3	3 (100)	8 (72.7)	3 (27.3)	11	3	3 (100)	4 (57.1)	3 (42.9)	7	3	2 (66.7)	3 (60)	2 (40)	5	3	1 (33.3)	5 (62.5)	3 (37.5)	8	3	2 (66.7)	5 (100)	0 (0)	5
H. niloticus	3	3 (100)	9 (69.23)	4 (30.77)	13	3	3 (100)	4 (66.7)	2 (33.3)	6	3	2 (66.7)	3 (75)	1 (25)	4	3	3 (100)	7 (70)	3 (30)	10	3	2 (66.7)	12 (85.7)	2 (14.3)	14	3	1 (33.3)	9 (81.8)	2 (18.2)	11
Total	15	15 (100)	60 (80)	15 (20)	75	15	13 (86.7)	55 (84.6)	10 (15.4)	65	15	13 (86.7)	52 (83.9)	10 (16.1)	62	15	11 (73.3)	50 (84.7)	10 (15.3)	59	15	9 (60)	65 (89)	8 (11)	73	15	8 (53.3)	49 (96.1)	2 (3.9)	51
Mean	3	3	12	3	15	3	2.6	11	2	13	3	2.6	10.4	2	12.4	3	2.2	10	1.8	11.8	3	1.8	13	1.6	14.6	3	1.6	9.8	0.4	10.2

Table 3: Results of qualitative analysis of Weevil Recorded between July and December 2014 in Akpan Andem Market Uyo in Akwa Ibom State.

Sample No.	Month	Clarias gariepinus		Tilapia zilli		Ethmalosa fimbriata		Gadus morhua		Heterotis niloticus	
		Weevil (D. maculatus)		Weevil (D. maculatus)		Weevil (D. maculatus)		Weevil (D. maculatus)		Weevil (D. maculatus)	
		Larvae	Adult	Larvae	Adult	Larvae	Adult	Larvae	Adult	Larvae	Adult
1	July	+	+	+	+	+	+	+	+	+	+
2		+	+	+	+	+	+	+	-	+	+
3		+	-	-	-	+	+	+	-	+	+
4	August	+	+	+	+	+	+	+	+	+	+
5		+	+	+	+	+	-	+	+	+	+
6		-	-	+	-	+	-	-	-	+	-
7	September	+	+	-	-	+	+	+	+	+	+
8		+	+	+	+	+	+	+	+	+	-
9		+	+	-	-	+	-	+	+	-	-
10	October	+	-	-	-	+	+	+	+	+	+
11		+	+	+	-	+	+	+	-	-	-
12		+	+	+	-	+	-	+	-	-	-
13	November	+	+	+	-	+	+	+	+	+	+
14		-	-	+	-	+	+	+	-	-	-
15		+	-	+	-	-	-	+	-	-	-
16	December	+	-	+	-	+	-	+	-	+	+
17		+	-	-	-	-	-	+	-	-	-
18		-	-	-	-	-	-	-	-	-	-

Table 4: Results of qualitative analysis of Weevil Recorded between July and December 2014 in Anua Market Uyo in Akwa Ibom State.

Sample No.	Month	Clarias gariepinus		Tilapia zilli		Ethmalosa fimbriata		Gadus morhua		Heterotis niloticus	
		Weevil (D. maculatus)		Weevil (D. maculatus)		Weevil (D. maculatus)		Weevil (D. maculatus)		Weevil (D. maculatus)	
		Larvae	Adult	Larvae	Adult	Larvae	Adult	Larvae	Adult	Larvae	Adult
1	July	+	+	+	+	+	+	+	+	+	+
2		+	+	+	+	+	-	+	+	+	+
3		+	-	+	-	+	-	+	+	+	+
4	August	+	+	+	-	+	+	+	+	+	+
5		+	+	+	+	+	+	+	+	+	+
6		-	-	-	-	+	-	+	+	+	-
7	September	+	+	-	-	+	+	+	+	+	+
8		+	+	+	+	+	+	+	+	+	-
9		+	+	+	-	+	-	+	+	-	-
10	October	+	-	+	-	+	+	+	+	+	+
11		+	+	-	-	-	-	+	+	+	+
12		+	+	+	-	-	-	-	-	+	+
13	November	+	+	+	-	+	+	+	+	+	+
14		-	-	+	-	-	-	-	-	+	+
15		+	-	-	-	-	-	-	-	-	-
16	December	+	-	+	-	+	-	+	-	+	+
17		+	-	+	-	-	-	+	-	-	-
18		-	-	-	-	-	-	-	-	-	-

Table 5: Results of qualitative analysis of Fungi Recorded between July and December 2014 in Akpan Andem Market Uyo in Akwa Ibom State.

Sample No.	Month	Clarias gariepinus			Tilapia zilli			Ethmalosa fimbriata			Gadus morhua			Heterotis niloticus		
		A. flavus	Penicillium spp	Mucor spp	A. flavus	Penicillium spp	Mucor spp	A. flavus	Penicillium spp	Mucor spp	A. flavus	Penicillium spp	Mucor spp	A. flavus	Penicillium spp	Mucor spp
1	July	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
4	August	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
5		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
6		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
7	September	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
8		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
9		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
10	October	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
11		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
12		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
13	November	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
14		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
15		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
16	December	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
17		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
18		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Table 6: Results of qualitative analysis of Fungi Recorded between July and December 2014 in Annual Market Uyo in Akwa Ibom State.

Sample No.	Month	Clarias gariepinus			Tilapia zilli			Ethmalosa fimbriata			Gadus morhua			Heterotis niloticus		
		A. flavus	Penicillium spp	Mucor spp	A. flavus	Penicillium spp	Mucor spp	A. flavus	Penicillium spp	Mucor spp	A. flavus	Penicillium spp	Mucor spp	A. flavus	Penicillium spp	Mucor spp
1	July	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
4	August	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
5		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
6		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
7	September	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
8		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
9		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
10	October	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
11		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
12		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
13	November	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
14		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
15		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
16	December	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
17		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
18		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Table 7: Microbial Colony Count of Dried Fish Sample between July and December, 2014 in Akpan Andem Market Uyo in Akwa Ibom State.

Fungi Isolated/ Fish Species	**July**				**August**				**September**				**October**				**November**				**December**			
	A. flavus ×10^{-5}cfu/ml	**Penicillium spp ×10^{-5}cfu/ml**	**Mucor spp ×10^{-5}cfu/ml**	**Mean ×10^{-5}cfu/ml**	**A. flavus ×10^{-5}cfu/ml**	**Penicillium spp ×10^{-5}cfu/ml**	**Mucor spp ×10^{-5}cfu/ml**	**Mean ×10^{-5}cfu/ml**	**A. flavus ×10^{-5}cfu/ml**	**Penicillium spp ×10^{-5}cfu/ml**	**Mucor spp ×10^{-5}cfu/ml**	**Mean ×10^{-5}cfu/ml**	**A. flavus ×10^{-5}cfu/ml**	**Penicillium spp ×10^{-5}cfu/ml**	**Mucor spp ×10^{-5}cfu/ml**	**Mean ×10^{-5}cfu/ml**	**A. flavus ×10^{-5}cfu/ml**	**Penicillium spp ×10^{-5}cfu/ml**	**Mucor spp ×10^{-5}cfu/ml**	**Mean ×10^{-5}cfu/ml**	**A. flavus ×10^{-5}cfu/ml**	**Penicillium spp ×10^{-5}cfu/ml**	**Mucor spp ×10^{-5}cfu/ml**	**Mean ×10^{-5}cfu/ml**
C. gariepinus	41	53	46	46.7	40	49	44	44.3	37	45	42	41.3	35	45	38	39.3	33	40	35	36	30	35	31	32
T. zilli	37	40	36	37.7	35	36	32	34.3	30	35	31	32	27	32	29	29.3	26	30	26	27.3	25	28	26	26.3
E. fimbriata	38	51	55	48	37	50	53	46.7	35	48	49	44	34	46	45	41.7	34	45	42	40.3	32	41	36	36.3
G. morhua	33	35	40	36	32	34	37	34.3	30	30	33	31	28	29	28	28.3	25	27	26	26	25	25	25	25
H. niloticus	39	55	33	42.3	35	51	29	38.3	32	50	37	36.3	30	50	25	35	27	48	25	33.3	26	43	25	31.3
Total	188	234	210	210.7	179	220	195	197.9	164	208	182	184.6	154	202	165	173.6	145	190	154	162.9	138	172	143	150.9
Mean	37.6	46.8	42	42.14	35.8	44	39	39.58	32.8	41.6	36.4	36.92	30.8	40.4	33	34.72	29	38	30.8	32.58	27.6	34.4	28.6	30.18

Table 8: Microbial Colony Count of Dried Fish Sample between July and December, 2014 in Anua Market, Uyo in Akwa Ibom State.

Fungi Isolated/ Fish Species	**July**				**August**				**September**				**October**				**November**				**December**			
	A. flavus ×10^{-5}cfu/ml	**Penicillium spp ×10^{-5}cfu/ml**	**Mucor spp ×10^{-5}cfu/ml**	**Mean ×10^{-5}cfu/ml**	**A. flavus ×10^{-5}cfu/ml**	**Penicillium spp ×10^{-5}cfu/ml**	**Mucor spp ×10^{-5}cfu/ml**	**Mean ×10^{-5}cfu/ml**	**A. flavus ×10^{-5}cfu/ml**	**Penicillium spp ×10^{-5}cfu/ml**	**Mucor spp ×10^{-5}cfu/ml**	**Mean ×10^{-5}cfu/ml**	**A. flavus ×10^{-5}cfu/ml**	**Penicillium spp ×10^{-5}cfu/ml**	**Mucor spp ×10^{-5}cfu/ml**	**Mean ×10^{-5}cfu/ml**	**A. flavus ×10^{-5}cfu/ml**	**Penicillium spp ×10^{-5}cfu/ml**	**Mucor spp ×10^{-5}cfu/ml**	**Mean ×10^{-5}cfu/ml**	**A. flavus ×10^{-5}cfu/ml**	**Penicillium spp ×10^{-5}cfu/ml**	**Mucor spp ×10^{-5}cfu/ml**	**Mean ×10^{-5}cfu/ml**
C. gariepinus	58	71	58	62.3	57	68	55	60	55	67	51	57.7	52	65	50	55.7	50	62	45	52.3	40	51	37	42.7
T. zilli	40	43	54	45.7	39	42	51	44	36	41	47	41.3	33	39	45	39	30	35	40	35	28	30	27	28.3
E. fimbriata	55	57	59	57	54	56	56	55.3	51	53	55	53	49	52	53	51.3	47	49	51	49	29	42	49	40
G. morhua	39	48	45	44	37	45	40	40.7	33	39	37	36.3	30	37	34	33.7	29	35	32	32	27	32	32	30.3
H. niloticus	55	60	43	52.7	52	59	38	49.7	49	55	35	46.3	45	54	30	43	42	51	28	40.7	32	45	27	34.7
Total	247	279	259	261.7	239	270	240	249.7	224	255	225	234.6	209	247	212	222.7	198	232	196	209	156	200	172	176
Mean	49.4	55.8	51.8	52.34	47.8	54	48	49.94	44.8	51	45	46.92	41.8	49.4	42.4	44.54	39.6	46.4	39.2	41.8	31.2	40	34.4	35.2

3.2 Qualitative analysis

Table 5 – 6 show result of qualitative analysis of Weevil Recorded between July and December 2014 in Anua Market Uyo in Akwa Ibom State. Out of 180 fish species examined, a total of 138 showed infestation; 25 *C. gariepinus,* 31 *T. zilli,* 27 *E. fimbriata,* 25 *G. morhua* and 25 *H. niloticus.*

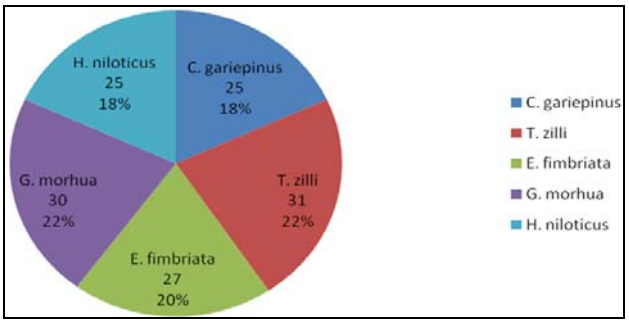

Fig 1: Pie Chart shows the prevalence of infestation in the different fish species in Akwa Ibom State Nigeria.

4. Discussion

Results presented in Figure 1 and Table 1and 2 and Table 3 – 4 shows the quantitative infestation of Weevil and Fungi Recorded between July and December, 2014 in Akpan Andem and Anua Market Uyo in Akwa Ibom State. *D. maculatus* adult and larvae of weevils infesting *Clarias gariepinus, Tilapia zilli, Ethmalosa fimbriata, Gadus morhua* and *Heterotis niloticus.* The weevil isolated was *Dermestes maculates with a* total of 343 *Dermestes maculatus* [288 larvae (84%) and 55 adults (16%)] were isolated from fishes obtained from Akpan Andem market; while a total of 385 *Dermestes maculatus* [331 larvae (86%) and 54 adults (14%)] were isolated from fishes obtained from Anua market. Kevin 2002, stated that weevils are known to be among the economically important insect pests of food crop in Nigeria. These insects bore into maize kernels in the field or in storage and lay eggs. The young insects grow to maturity inside the kernels, eating them from the inside out. This causes loss in the maize's nutritive value and weight. A contaminated supply of seed will most likely contaminate other stores within a certain range. This sort of damage is especially severe on subsistence farmers, who may depend on one year store of grain to provide germinating seeds for the next. While boring through the seed, the insects create powder and kernel fragments that encourage infestation by other secondary storage pests

Table 7 and 8 shows Microbial Colony Count of Dried Fish Sample between July and December, 2014 in Akpan Andem and Anua Market Uyo in Akwa Ibom State. The three fungi isolated and identified were *Aspergillus flavus, Penicillium spp and Mucor spp.* The highest mean microbial counts for the two markets (42.14×10^{-5}cfu/ml and 52.34×10^{-5}cfu/ml) were isolated in July, while the lowest mean microbial counts (30.18×10^{-5}cfu/ml and 35.2×10^{-5}cfu/ml) were recorded in December. *Aspergillus spp* are known to produce aflatoxins which are carcinogenic (causing hepatoma cancer of the liver) acute hepatitis, reduced red blood cell and decreased immune system in man. Prolonged intake of dried fish with these metabolites may constitute potential public health hazard. Adequate cooking could help in reducing fungi and weevils of dried fish. The number of fungi in the present study less than the number isolated in the work of Srivastava, et al., (2014) [34] who isolated fourteen species from the kernels of *Buchanania lanzan* during all three seasons. Nine, seven and seven species were isolated during rainy, winter and summer seasons respectively.

Aspergillus flavus, *A. Niger* and *Rhizopus nigricans* were found associated with the kernels in all the seasons while fungi like *Aspergillus fumigatus, A. ochraceus* and *A. tamarii* were restricted to any two of the seasons. *Aspergillus aculeatus, A.nidulans, Cladosporium herbarum, Eurotium amstelodami, Penicillium purpurogenum, P. citrinum and Syncephalastrum racemosum* infested the kernels in any one of the seasons. *Aspergillus Niger* was the most frequent fungus followed by Rhizopus nigricans during all the three seasons. The third frequent species was Aspergillus flavus. However Penicillium purpurogenum and Aspergillus fumigatus showed almost equal frequency ranking third during winter and summer respectively.

Srivastava, *et al*., (2014) [34] reported a total of 19 species of fungi encountered on the endosperm of *Cocos nucifera* during all the three seasons. The total number of species recorded in rainy, winter and summer were 6, 11 and 11 respectively. *Aspergillus flavus, A. niger* and *Syncephalastrum racemosum* were invariably found in all the seasons while *Rhizopus nigricans* was not isolated during rainy season. However, rest of the fungi were found associated in any one of the seasons only .*Aspergillus niger* ranked first followed by *Aspergillus flavus* during all three seasons; though the per cent occurrence of *Penicillium meleagrinum* and *P. purpurogenum* was slightly more than *Aspergillus flavus* during winter. *Syncephalastrum racemosum* was the third frequent fungus during winter and rainy seasons; though the per cent occurrence of *Cladosporium herbarum* was equal to that of *Syncephalastrum racemosum* during winter.

Makun *et al*., (2010) [29] exhibits that all 22 species infested the dried fruits of *Phoenix dactylifera* during the three seasons but the number of species varied with the seasons; 14, 16 and 3 during winter, rainy and summer respectively. *Aspergillus flavus, A. Niger* and *Syncephalastrum racemosum* were associated during all the seasons while *Aspergillus fumigatus, A. ochraceus, A. terreus* and *Rhizopus nigricans* during two seasons viz. rainy and winter. Rest of the species were restricted either to rainy or to winter only. *Aspergillus niger* was most frequent species followed by *A. flavus* in all the three seasons. Besides *A. orhraceus*, *P. oxalicum*, *P. purpurogenum*, *Cladosporium herbarum* and *Syncephalastrum racemosum* were some frequent species isolated in rainy, winter and summer seasons.

The present work shows that Anua market had higher infestation rates than Akpan Andem market. This is because Anua market is a small and not well known market in Uyo, therefore the fish traders have lesser consumers to buy their products thereby making the products to stay for a longer period of time. The fungal isolates encountered in this study are the most common microbes associated with dried fish. These fungi species have also been isolated from salted and dried meat and fish products (Graikoski, 1973) [19]. Lin *et al* (1976) [28] detected aflatoxins B1 and G1 concentrations ranging from 1.5-8.10µg/kg. This finding is instructive as consumption of contaminated dried fish could pose serious health problems. Aflatoxins have been implicated in cases of acute hepatitis in man and they are also known to be carcinogenic causing hepatoma (Eaton *et al,* 1994) [10]. Some of the fungal isolates like *Aspergillus flavus* and *Mucor spp* recovered from dried fish in Akpan Andem and Anua markets, Uyo were also found on dried fish from Oja-Oba market, Ago-Iwoye, Ogun State, Nigeria (Fafioye *et al,* 2002) [15]. This

shows that the processing environment and market environment for dried fishes in different parts of Nigeria are comparable and any method or technology developed for better fish handling and processing may have general application and comparative success level. Applying appropriate measures to reduce external and processing risk factors can enable individual processors to limit the root causes of infestation at their own processing sites, thereby achieving effective control.

5. Conclusion

This study has identified the poor microbiological quality of dried fish in Akpan Andem and Anua markets. This raises public health concerns about safety in consuming dried fish products from these markets. The likelihood of infestation occurring is thought to be influenced by the interaction of many factors. Some, such as site, season, climate and site location are largely beyond the control of processors. Others, however appear to be associated with processing practices and procedures. In the course of this study, it was discovered that weevil and fungi infestation were subjected to seasonal variations, as July had the highest infestation due to either exposure to rain or cold weather while December, which begins the dry season recorded the least infestation, as shown in tables 1 – 2 and 3 – 4 respectively.

This infestation is also attributed to poor handling by processors and traders who expose dried fish to unsanitary and poor storage conditions. The hurry to get dried fish to the market causes it to be improperly dried, thereby increasing the susceptibility of processed fish to weevil and fungi infestation. Also, the indiscriminate method of mixing wet fish with properly dried ones encourages cross infestation of fish being packaged for distant consumer markets. Consequently, products are usually moved into storage with a high level of infestation. High humidity not only encourages rapid multiplication of insects, but also the growth of moulds.

From this study, it was observed that some of the dried fish sold in Akpan Andem and Anua markets in Uyo Local Government Area of Akwa Ibom State, were infested with weevils and fungi. This has both public and health implications. It is also deduced that fish are highly infested with weevils and fungi especially when not properly dried. Therefore, fish processors and vendors should improve handling hygiene to minimize early infestation, and consumers should also cook dried fish properly to avoid possible health hazards.

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