EFFECT OF INSECT PEST ON THE PRESERVATION OF SOME FISH SPECIES SOLD IN EGOR LGA MARKETS

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A PROJECT SUBMITTED TO THE DEPARTMENT OF AQUACULTURE AND FISHERIES MANAGEMENT FACULTY OF AGRICULTURE UNIVERSITY OF BENIN, BENIN CITY

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CERTIFICATION

This is to certify that this project was carried out by Matthew Eseoghene IROREVWO (AGR1700242) in the department of Aquaculture and Fisheries Management in the Faculty of Agriculture, University of Benin, Benin City, Nigeria.

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Dr. O. M Wangboje Date
(Head of Department)

DEDICATION

This project is dedicated to the furtherment and improvement of knowledge. It is a testament to the importance of continuous learning and growth in our personal and professional lives. As we strive to better ourselves, we also contribute to the betterment of society and the world around us.

May this project serve as a reminder of the power of dedication and devotion to learning. Let us continue to seek out new opportunities to expand our knowledge and skills, and to use our talents and abilities to make a positive impact on the world.

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ABSTRACT

A study was conducted in Benin city, located in South South Nigeria, to investigate the insect pest species affecting three distinct fish species: Clarias spp, Tilapia spp, and Synodontis spp, Orechromis niloticus and Hemichromis spp. The common insect pests identified infesting all three fish species included Dermestes spp and Tribolium spp. The data collected included the total count of insect pests infesting each fish species and the distribution of the insects in their two life stages, larvae and adults. Analysis of this data was performed using simple percentage calculations.

The results indicated that Tilapia spp exhibited the highest susceptibility to insect pests. The ranking of susceptibility was as follows: Tilapia > Synodontis > Clarias. Notably, Tribolium spp emerged as the predominant insect pest, with an infestation rate of approximately 61.7% on Tilapia spp and 100% on Clarias spp. Necrobia spp followed with an infestation rate of 31% on Tilapia spp and 80% on Synodontis spp.

Furthermore, the study observed the distribution of adult and larval stages of these insect pests. The findings revealed that the majority of the insects infesting the five species of smoked fish in Benin city, Edo state, Nigeria, were in the larvae stage.

CHAPTER ONE

1.0 INTRODUCTION

One of the most significant sources of animal protein in the world is fish, which also competes favorably with other sources of animal protein due to its high nutritional content and suitability for human dietary demands. (Okonta, and Ekelemu 2005). In rural and fishing communities in Nigeria, fish is known to play a significant role in the diet, providing up to 75% of the total animal protein intake (Department for International Development-Food and Agriculture Organization, 2002). Fish protein contains a higher quantity of necessary lysine and methionine, both of which are deficient in a diet high in cereal, and compares favorably to eggs, meat, and milk in terms of amino acid content (Amusan *et al*., 2002). Because fish fat often contains a lot of polyunsaturated fatty acids, it contributes to low-cholesterol diets. Fat-soluble vitamins, particularly vitamins A and D, are present in the oils at a very high concentration (Okonta, and Ekelemu 2005).

Fish is a food that deteriorates quickly when it is caught or killed. The fish is still vulnerable to numerous types of loss and spoilage even after processing, especially if conventional methods were used (Obasohan *et al.*, 2012). In Nigeria, due in part to the lack of ice for the preservation of fresh fish products, more than 80% of fish captured from artisanal waters are processed by sun drying or smoking (Ashamo *et al*., 2003). Traditional fish processing techniques like smoking effectively control or minimize post-harvest losses. Heat is used to drain the water, and the fish are protected from germs and enzymes by doing so (Kumolu-Johnson *et al*., 2013). Dried fish products have significantly lower oil and moisture contents and more protein per unit of weight

than fresh fish. Due to their aroma and flavor, dried fish is greatly favoured in many parts of the world, especially when it has been smoked (Lale and Sastawa, 1996).

Locally processed fish may get spoiled as a result of bug infestations like blowflies that lay their eggs on exposed fish during the drying process, pestiferous insects, particularly species of beetles from the genera Dermestes and Necrobia, can cause the deterioration of dried fish products to occur very quickly (Tunaz and Uygun, 2004). These insect pests generally infest dried fish during storage, transportation, and marketing. Thus, responsible for extensive damage to marketed fish leading to enormous weight loss due to feeding damage from insect pests (Don-Pedro, 1989; Davies *et al.*, 2014).

Furthermore, poorly dried fish or fish that has adequately dried but reabsorbed moisture may be home to a significant population of Chrysomyia blowflies, which commonly infest dried fish during storage, transportation, and marketing and cause significant damage to marketed fish that results in significant weight loss It has been documented that *Dermestes maculatus* and *Necrobia rufipes* adults and larvae share a habitat, eat on the same dried fish, and harm it (Don-Pedro, 1989). In Nigeria, losses due to beetle infestation of dried fish have been estimated to reach between 22 and 50 percent. Additionally, fish that harbor insect pests have lower protein levels than uninfected fish, according to Omoregie *et al*. (1985).

Pest damage may cause the curing process to break down the fish into smaller pieces, which can lead to quantitative loss of the smaller pieces and value loss due to quality decline. Contaminatio n by pests, whether alive or dead or by their cast skins, may also cause a loss of visual quality. (Davies *et al.*, 2014). Several serious enteric diseases, including cholera and dysentery, have been linked to flies that frequently perch on dried fish. Foodstuffs contaminated by insects

typically result in consumer complaints, and occasionally legal action, which can result in levies and damage to a business. (Busvine, 1980; Osuji, 1985; Eke *et al*., 2008).

1.1 JUSTIFICATION OF STUDY

The fisheries subsector represents a major food source, which is invaluable for the protein they provide and the industrial products they produce. Fish is economically, socially, and culturally important as a global dietary aspect of sustainable food security. Fish are a significant source of food and revenue for both men and women economically, and fishing holds a significant social and cultural status in communities along rivers. Fish marketing can successfully meet the population's needs for fish intake and protein (Na-Nakoru and Brummett, 2009).

To close the supply-demand gap in Nigeria, the distribution and value chain for the country's abundant fish resources needs to be developed and strengthened (Amao *et al*., 2006). However, a deficit of more than 2.17 million metric tonnes is necessary to meet the rising demand, which is further fueled by the enormous importation of frozen fish. This severely depletes the country's foreign exchange revenues. (Federal Department of Fisheries FDF, 2008).

Hence, a systematic survey of the various insect pests infesting traditionally processed fish in Benin City will be of immense benefit to both sellers and consumers of traditionally processed fish in Edo state.

1.2 AIM AND OBJECTIVES OF THE STUDY

The main aim of this study is to identify the insect pests that infest traditionally processed fish in the Benin metropolis of Edo state.

Therefore, the objectives of this study are to:

I. Determine the damage done to fish by insect pests in terms of market value, texture, structure, and acceptability by insect pests;

II. Determine the mode of infestation;

III. Make suggestions based on findings.

CHAPTER TWO

2.0 LITERATURE REVIEW

One of the best sources of protein for us is fish. Fish is a significant source of protein, and the harvesting, handling, processing, and distribution of fish support millions of people's livelihoods and generate foreign exchange for many nations (Al-jufaili and Opara, 2006). Fish must be processed and preserved because it is still quite perishable, especially in the tropics where the high temperatures encourage the growth of spoiling agents (Waterman, 1976).

One of the protein foods that need careful handling is fish (Eyo, 2002). This is because fish degrades quickly after being caught due to the high tropical temperatures, which speed up bacterial, enzyme, and chemical oxidation of fat in fish. In Nigeria, between 30 and 50 percent of the fish collected are lost due to improper handling. By using appropriate handling, processing, and preservation techniques, these losses could be reduced (Bate and Bendall, 2010). The goal of processing and preserving fish is to deliver it to a final consumer in a healthy, usable state. The actions required to achieve this start before the fishing trip and don't end until the fish is consumed or processed (Karube *et al*., 2001).

In Nigeria, fish is eaten cooked, preserved, or processed (smoked) and form a much–cherished delicacy that cuts across socio-economic, age, religious, and educational barriers (Adedayo *et al*., 2008). Many reasons can cause fish to spoil, but a few that stand out are the health of the fish, the presence of parasites, any bruising or skin wounds, and the method of collection (Omoruyi *et al*., 2015). According to Ayuba and Omeji (2006), insect infestation is to blame for the majority of losses in both quantity and quality of dried fish that are kept in storage in Nigeria. Since fish is very prone to deterioration just after it is caught, preparing and preserving fresh fish is crucial to

avoid financial loss (Okonta and Ekelemu, 2005). Since refrigeration preservation is not always possible, long-distance distribution requires some processing and storage (Agbon *et al*., 2002).

2.1 FISH SPOILAGE

The sight, smell, and texture of raw fish are typically the only factors used in the trade to determine how fresh fish is (Karube *et al*., 2001). These criteria are referred to as sensory or organoleptic because assessment is based on the senses. The most important things to look for in the freshness of fish are:

1. The general appearance of the fish including that of the eyes, gills, surface slime and scales, and the firmness or softness of the flesh.

2. The odour of the gills and belly cavity;

3. The appearance, particularly the presence, and absence of discoloration along the underside, of the backbone.

4. The presence or absence of rigor mortis or death stiffening;

5. The appearance of the belly walls (Bate and Bendall, 2010).

In the high ambient temperatures of the tropics, the rotting process (Rigor mortis) of fish will begin within 12 hours of their capture (Berkel *et al*., 2004). After a few hours of its death, the fish goes through a process known as rigor mortis in which its flexibility is lost as a result of the hardening of fish muscles (Adebowale *et al*., 2008). The two characteristics that need to be described explicitly are spoiled food and freshness (Gram and Huss, 2000). A product is considered to be "fresh" if its original characteristics have not changed. Therefore, spoilage is a

sign of changes after harvest (Hui, 2006). It is possible to categorize this transition as going from absolute freshness to the outer edges of acceptability to unacceptable. Typically, deterioration is followed by physical changes. Some features of rotten fish include a change in colour, odour, texture, the colour of the eyes, the colour of the gills, and the softness of the muscle (Baird-Parker, 2000). The fish's enzymes, bacteria, and chemicals work together to induce spoilage. The following other elements also lead to fish spoilage:

1. High-fat content
2. High moisture content
3. High protein content
4. Weak muscle tissue
5. Ambient temperature
6. Unhygienic handling (Abbas and Saleh, 2009).

Fish spoilage is a critical task caused by the interactions of enzymes, bacteria, and chemical elements. The fish's death triggers the beginning of the spoilage process. (Amos, 2007).

2.1.1 TYPES OF SPOILAGE

2.1.1.1 ENZYMATIC SPOILAGE

Dead fish undergo chemical and biological changes shortly after being captured as a result of the enzymatic degradation of key fish components (FAO, 2005). According to Hansen *et al*. (2003), autolytic enzymes decreased textural quality during the initial stages of deterioration but did not result in the typical off-odours and off-flavours of spoiling. This shows that autolytic degradation can reduce shelf-life and product quality even when spoilage organism populations are relatively low (FAO, 2005). Along with the creation of hypoxanthine and formaldehyde, the textural

quality is most significantly impacted. The considerable autolysis caused by the digestive enzymes softens meat, ruptures the abdominal wall, and drains blood water that contains both protein and oil (FAO, 2005). After the fish is caught, several proteolytic enzymes are discovered in the muscle and viscera. During storage and processing, these enzymes aid in the post-mortem breakdown of fish muscle and fish products. Proteolytic enzymes may lead to a sensory or product-related modification (Engvang and Nielsen, 2001). Proteolysis, which is responsible for the destruction of proteins after inappropriate storage of whole fish, is followed by a process of solubilization (Lin and Park, 2006). On the other hand, the autolysis of fish muscle proteins can result in the formation of peptides and free amino acids, which causes the spoiling of fish meat as a result of microbial development and the production of biogenic amines (Fraser and Sumar, 2008). Proteolytic enzymes from the gut and pyloric caeca flow into the ventral muscle, causing belly popping. The pH range between alkaline and neutral 7 is where proteases function best. According to Martinez and Gildberg (2011), keeping the fish at 0°C and a pH of 5 decreased the rate of breakdown by proteolytic enzymes.

2.1.1.2 MICROBIAL SPOILAGE

The microbial makeup of the water in which the fish dwell affects the microflora of recently caught fish. Bacterial species including Pseudomonas, Alcaligenes, Vibrio, Serratia, and Micrococcus are present in fish microflora (Gram and Huss, 2000). Numerous bacteria are naturally found on the fish's surface, in its gills, and in its guts (Karube et al., 2001). These bacteria often do not damage living fish. However, they quickly proliferate and within two to four days, even a well-iced fish's flesh gets consumed by them as enzymatic digestion starts to soften it. A fish's bacterial load is influenced by its health, environment, and method of capture.

Fish caught in a trawl net and dragged along the bottom of a dirty pond will be less healthy than fish from clean water. Both bacterial decomposition and enzymatic digestion include chemical changes that result in the distinctive odours of spoilage (Putro, 2005). Fish spoilage is primarily caused by microbial growth and metabolism, which generates amines, biogenic amines including putrescine, histamine, and cadaverine, as well as organic acids, sulphides, alcohols, aldehydes, and ketones with disagreeable and undesirable off-flavours (Dalgaard *et al*., 2006; Emborg *et al*., 2005; Gram and Dalgaard, 2002). Gram-negative, fermentative bacteria like Vibrionaceae cause spoiling in unpreserved fish, but cold fish is more susceptible to psychrotolerant Gram-negative bacteria like Pseudomonas spp. and Shewanella spp (Gram and Huss, 2000). Therefore, it's critical to distinguish between non-spoilage microflora and spoiling bacteria as many of the current bacteria don't cause spoilage (Huss, 2005). Trimethylamine (TMA) levels are frequently used to assess the microbial decline causing seafood rotting. To prevent tissue waterlogging in fresh water and dehydration in marine conditions, fish use trimethylamine oxide (TMAO) in osmoregulation. By converting TMAO to TMA, which results in the off-odours that resemble ammonia, bacteria including *Shewanella putrifaciens*, Aeromonas species, psychrotolerant Enterobacteriaceae, P. phosphoreum, and Vibrio species can gain energy. (Gram and Dalgaard, 2002). *Pseudomonas putrifaciens*, fluorescent pseudomonads, and other spoilage bacteria increase rapidly during the initial stages of spoilage, producing many proteolytic and 9 hydrolytic enzymes (Shewan, 2001).

2.1.1.3 CHEMICAL SPOILAGE

For pelagic fish species with high oil/fat content stored fat in their flesh, such as mackerel and herring, lipid oxidation is a key cause of deterioration and spoilage (Fraser and Sumar, 2008). A

three-stage free radical pathway called initiation, propagation, and termination is involved in lipid oxidation (Frankel, 2005; Khayat and Schwall, 2003). Through catalysts like heat, metal ions, and radiation, lipid free radicals are created throughout the initiation process. Peroxyl radicals are created when these free radicals combine with oxygen. The peroxyl radicals interact with other lipid molecules to produce hydroperoxides and a fresh free radical during propagation (Fraser and Sumar, 2008; Hultin, 2004). When a concentration of these free radicals interacts to produce non-radical products, termination takes place. Oxygen usually reacts with the double bonds of fatty acids during oxidation. Fish lipids made of polyunsaturated fatty acids are therefore very vulnerable to oxidation. For oxidation to take place, molecular oxygen must be activated. Molecular oxygen is primarily activated by transition metals (Hultin, 2004). Lipid oxidation in fish can happen either enzymatically or nonenzymatically. Lipolysis is the word for the enzymatic hydrolysis of fats by lipases (fat deterioration). Lipases divide the glycerides during this process, creating free fatty acids that are responsible for (a) the common rancid flavour and (b) reducing the oil quality. (Huis and Veld, 2006; FAO, 2005). The lipolytic enzymes could either be endogenous to the food product (such as milk) or derived from psychrotrophic microorganisms (Huis and Veld, 2006). The enzymes involved are the lipases present in the skin, blood, and tissue. The main enzymes in fish lipid hydrolysis are triacyl lipase, phospholipase A2, and phospholipase B (Audley *et al*., 2008; Yorkowski and Brockerhoft, 2005). Non-enzymatic oxidation is caused by hematin compounds (hemoglobin, myoglobin, and cytochrome) catalysis producing hydroperoxides (Fraser and Sumar, 2008). The fatty acids formed during the hydrolysis of fish lipids interact with sarcoplasmic and myofibrillar proteins causing denaturation (Anderson and Ravesi, 2009; King *et al*., 1962). Undeland *et al*. (2005)

reported that lipid oxidation can occur in fish muscle due to the highly pro-oxidative Hemoglobin (Hb), specifically if it is deoxygenated and or oxidized.

2.2 FISH PRESERVATION

According to Akinola *et al*. (2006), several preservation techniques include drying, smoking, freezing, chilling, and brining. However, smoke-drying is Nigeria's most well-known traditional method of fish preservation. This might be explained by the lack of electricity in the majority of fish settlements, which prevents them from freezing their catch. Electricity is rapidly losing its reliability as a source of energy for processing and preserving fish. Despite the crudeness of conventional methods, Akinola *et al*. (2006) found that lack of control over the drying rate can occasionally cause under-drying or over-drying, exposing the fish to unanticipated breezes, dust, filth, insect infestation, and pollutants like flies. These techniques are still widely used in Nigeria.

2.2.1 METHODS OF PRESERVATION

It is possible to preserve anything for both a short and long time (Eyo, 2002). Chilling is a form of short-term preservation, whereas long-term preservation methods include salting, drying, smoking, and canning fish.

2.2.1.1 CHILLING

Keeping fish cold is the first and most basic way to both preserve and process it. Fish that has been chilled keeps longer than fish that have not, although, both will deteriorate in a matter of hours (Tawari and Abowei, 2011). The fish is covered in several layers of ice to achieve this. Ice itself, however, is ineffective for long-term preservation because water melting causes a type of

leaching of valuable fish flesh contents that are responsible for its flavour. Ice, on the other hand, is useful for short-term preservation, such as for transporting fish caught to neighboring markets or canning plants. By reducing the temperature, autolytic enzymic activities are monitored (FAO, 2007). In some steps of processing, ice is used to preserve the majority of fish that are captured. In most cases, well-iced fish maintained for fewer than six or seven days cannot be distinguished from fresh fish. However, adding antibiotics to the ice can somewhat prolong storage life. Ice operates in two ways: (Idachaba, 2001).

1. It reduces the growth rate of bacteria by reducing the temperature of the fish; and

2. It also washes the bacteria and slime away as it melts. Because of this, it is important to keep meltwater drained away from the fish.

2.2.1.2 SALTING

There are many different types of salt, some of which are better for curing fish than others. However, on islands or remote locations, there frequently isn't a choice, and whatever salt is available must be utilized, whether it is purchased in a store, produced on the spot, or extracted from the earth. There must be a differentiation between the two main salting methods: wet salting and dry salting (FAO, 2005).

I. **Wet Salting**: The idea is to brine the fish for an extended period. The necessary tools are a waterproof container, which can be made of tin, a drum, a canoe, or a barrel, among others. Four parts of clean water (freshwater or seawater) and one part of salt are combined to create the brine. The salt must first be crushed or pounded if it is coarse (Tys and Peters, 2009). The water is then stirred while it is dissolved. A fish must float in the brine for it to be good.

Depending on the type of fish that will be salted, the next step will vary. The fish should ideally be cleaned, and gutted, before being salted, though small fish can be salted whole. Large fish must be cut open, and the backbone should preferably be removed. The fish must be washed and placed in the brine after being prepared for its size. To ensure that the fish is completely submerged in brine, a plank or mat is placed over it and weighted with rocks. This salted fish can be kept for a long time in the dark or at least in a shady place (Leistner and Gould, 2002). The remaining brine can be used three times, but water and salt must be added every time until a fish can again float on the liquid. In any case, fresh brine is always best.

II. **Dry Salting**: In this method, the fish is salted but the juices, slime, and brine are allowed to flow away. Dry salting can be done in an old canoe, or on mats, leaves, boxes, etc. In any case, the brine formed by the fish juices and the salt must be allowed to run away. Layers of fish must be separated by layers of salt. It is a valuable method when one has no containers. This method is used to salt down flying fish in open fishing boats while at sea, and the fish in this case is kept whole. Some people like the salty taste of fish prepared in this way, but it is always possible to wash the salt away by soaking it in freshwater before use (FAO, 2005).

2.2.1.3 DRYING

. Drying is regarded as a traditional, low-cost, and simplest method of preservation of fish and it plays a vital part in developing countries (Basu and Gupta, 2004). If brought in early enough in the morning, very small and thin fish can be dried immediately in the sun (and if, of course, the sun is shining). The fish must be placed in brine or dry salt for one night if these requirements are not met. The next morning, they may be dried (Deepchill, 2010). It is required to wait until the weather has cleared up, which might take a few hours to a few days if it happens to be

raining the next day. In this latter case, it will be necessary to wash the salt away from the fish by soaking it in fresh or sea water for a couple of hours before drying it; this depends again on the tastes of the consumers and on the purpose for which the fish is cured (Huss, 2009). Small fish are mostly sun-dried on mats, or suspended. When it rains the fish must be kept dry by covering or transferring them under shelter. If fish are laid on mats or other material to dry, it is best to turn them over every two hours so that they will dry quickly and not become maggoty. In the case of large fish, hanging is better if they are merely split (Ananoui *et al*., 2007). Dry salted fish can also be dried, but they should first be cleaned in water. Normally the fish will be dried after three days. If a great quantity of fish has been dried and is to be kept for some time, the best way is to pile it up in a dark place, off the ground, and preferably on wooden boards. It should then be covered with a sack or mat. After a fortnight the fish should again be laid in the sun for one or two hours and then put away as before. These are only indications of the main principles of fish drying; variations are possible (Leister and Gould, 2002).

2.2.1.4 SMOKING

Any kind of fish can be smoked. There are three main methods of smoking: (a) Smoking and roasting; (b) hot smoking; (c) long smoking.

I. **Smoking and Roasting**: This is a simple method of preservation, for consumption either directly after curing or within twelve hours. Re-smoking and roasting can keep the product in good condition for a further twelve hours (Kauffeld *et al*., 2005). Fresh unsalted fish is put over a wood or coconut husk fire. This should be kept very small and the fish turned over every five minutes. The fish is ready for consumption in approximately 30 minutes, or it should be placed in an aerated container if it will be kept for a while. (Tys and Pieters,

2009). Even on open fishing boats, fish may be kept in this technique, although smoking must take place in a tin or a half-drum. This method can also be used to smoke salted fish, although it's more frequently employed to prepare food for immediate consumption or to transport it to a local market.

II. **Hot Smoking**: The fish can be kept in the hot smoking system for up to 48 hours or immediately consumed. Small fish can first be salted for 30 minutes. After being salted, they are placed on iron spits and dried for an additional 30 minutes in the sun and wind. To create the smoking stove, an oil drum is required. The top of the drum is removed, and spit placement holes are formed 8 inches below the rim. A rectangular hole is built to regulate the flames towards the bottom. This opening should be closed with a small door or piece of steel plate. A fire of hardwood or coconut husks is made in the stove, and once it is well started it is regulated to give no flames (Tys and Pieters, 2009). The fish are then placed over the spits. During the smoking operations, the top of the drum must be covered with a sack or with palm fronds laid as close together as possible; the fire control opening should also be closed. The fire must be watched from time to time. The fish will be ready in about one hour. An indication that they are done will be found in the golden yellow colour of the skin. For big fish, l to 2 feet long, the best method is to split them into halves, to the right and left of the backbone. Each half-fish is fixed between two flat bamboo slats or sticks. These halves are then rested head down on racks built four feet above the ground. Several split fish can be lined up next to each other. A fire of hardwood or coconut husks, or several separate fires, is then lit under the rack. The number of fires depends on the quantity of fish one has to smoke. There should be a slow fire for about half an hour followed by a brisk one for one hour. A small fire is then kept going for six hours (just smoking) (Alasalvar *et al*.,

2011). After this treatment, the fish is ready for transport and will keep in good condition for two to three days under tropical conditions. This method is used in particular in the Celebes for skipjack and other tunas (Ananou *et al*., 2007).

III. **Long Smoking**: If fish must be kept in good condition for a long time, for instance, two or three months or even longer, it can be done by smoking, provided the fish is not oily. For this purpose, a small closed shed made of palm leaves or other local materials can be used. The dimensions of the shed depend, of course, on the quantities of fish to be smoked, but the height should in no case be less than six feet. In this shed, racks are built to hang the fish from or to lay them upon. Hanging the fish on spits is the best method, but they can also be laid on loosely-woven matting. One can start hanging fish three feet from the bottom up to the roof (Deepchill, 2010). The preservation of fish is affected by smoke only in this method, and it is best to use coconut husks which should burn very slowly so that the fish is dry-smoked after 48 hours. After such a treatment the flesh is dried throughout. If it is necessary to transport these fish to other islands, they should be packed in small packages wrapped in dry leaves and reinforced with bamboo or sticks. In Eastern Indonesia, packages of smoked fish are sent over great distances (Idachaba, 2001).

2.2.1.5 CANNING

This procedure involves heating fish in tightly closed tin plates, aluminum cans, or glass containers until the food is completely sterilized (Idachaba, 2001). All heat-sensitive bacteria and spores should be eliminated, the enzymes should be activated, and the fish should be cooked throughout the canning process to ensure that the product is cooked and still edible after a lengthy period of storage (FAO, 2005). Thermal processing uses the term "commercialized sterilization" to refer to a heat treatment intended to essentially eliminate all bacteria and spores

that are present and capable of thriving in the product (FAO, 2008). By being kept in an almost airtight container, the canned food fish is also protected from harmful microbial taint. If heat treatment is done properly, canned fish can be kept for years without refrigeration (Leistner and Gould, 2002). Small pelagic fish species, such as anchovies (Engraulis spp.), herrings (Clupea spp.), sardines (Sardinella sp.), mackerels (Scomberomerus sp.), tuna (Thunnus sp.), and Bonga (Ethmalosa sp.) are used to produce traditional canned fish (Gopakumar, 2010). Fish that is going to be canned has to be in excellent shape and treated hygienically to lower the microbial load on the fish. Poor quality fish will result in canned fish with an unpleasant flavour and odour as well as a poor texture. (Burt, 2003).

2.3 INSECT PESTS OF FISH

The larval stage is mostly responsible for the harm in dry fish (Flowra *et al*., 2013). According to (Bala, 2000), a significant beetle infestation of unsalted dried fish in tropical regions under extremely humid conditions may result in up to a 30% loss of the goods. Odeyemi *et al*. (2000) reported that storage of smoked fish products resulted in losses of roughly 50%. Insect attacks and spoiling in dried fish processing were the sources of the quantitative and qualitative losses. (Doe, 1977; Ahmed, 1978).

Ajayi *et al*. (2006), reported that beetles (*Dermestes maculatus* and *Necrobia rufipes*) are the most common species of insect that infest traditionally (smoked and dried) processed fish. Also, according to Eke *et al*. (2008), mites (Lardoglyphus spp.) and flies (Calliphora spp.) have been reported as insect pests that infest dried fish.

2.3.1 NECROBIA

Necrobia rufipes is a beetle of the family Cleridae and is the commonest species of Necrobia found on cured fish. Two related species, *N. ruficollis*, and *N. violacea* are only rarely found on this commodity (Haines, 1989; Singh et al., 2018).

2.3.1.1 Life-cycle

Adult beetles feed on the surface of dried fish, and they lay their eggs in crevices in the fish. The larvae burrow deeply into the flesh; as well as feed on the fish. They are predatory on the larvae of some flies and the eggs and larvae of Dermestes spp. (Haines, 1989; Singh *et al*., 2018). The larvae pass through three or four instars. The last instar larva spins a cocoon in which pupation occurs: this may be within the fish flesh, or the larva may leave the fish and pupate in any dark crevice. Depending on the type of diet and physical circumstances, the lifecycle can last up to 6 weeks. The population grows at a pace of around 25 times every month under ideal circumstances. The adults can quickly disperse to other food sources since they actively fly (Haines, 1989; Singh et al., 2018).

2.3.1.2 Damage caused to cured fish

Due to contamination from insect bodies and cast skins, feeding by *N. rufipes* larvae and adults results in a quantitative loss of dried cured fish as well as fragmentation and quality losses. Both in the lab and the field, the size and cost of the losses brought on by *N. rufipes* infestation of dried fish have not been determined, but they will undoubtedly be closely correlated with how long the fish was kept in storage. *N. rufipes* is often in the minority when connected to Dermestes infestations, although it might make a sizable contribution to the overall beetle damage. (Haines, 1989; Singh *et al*., 2018).

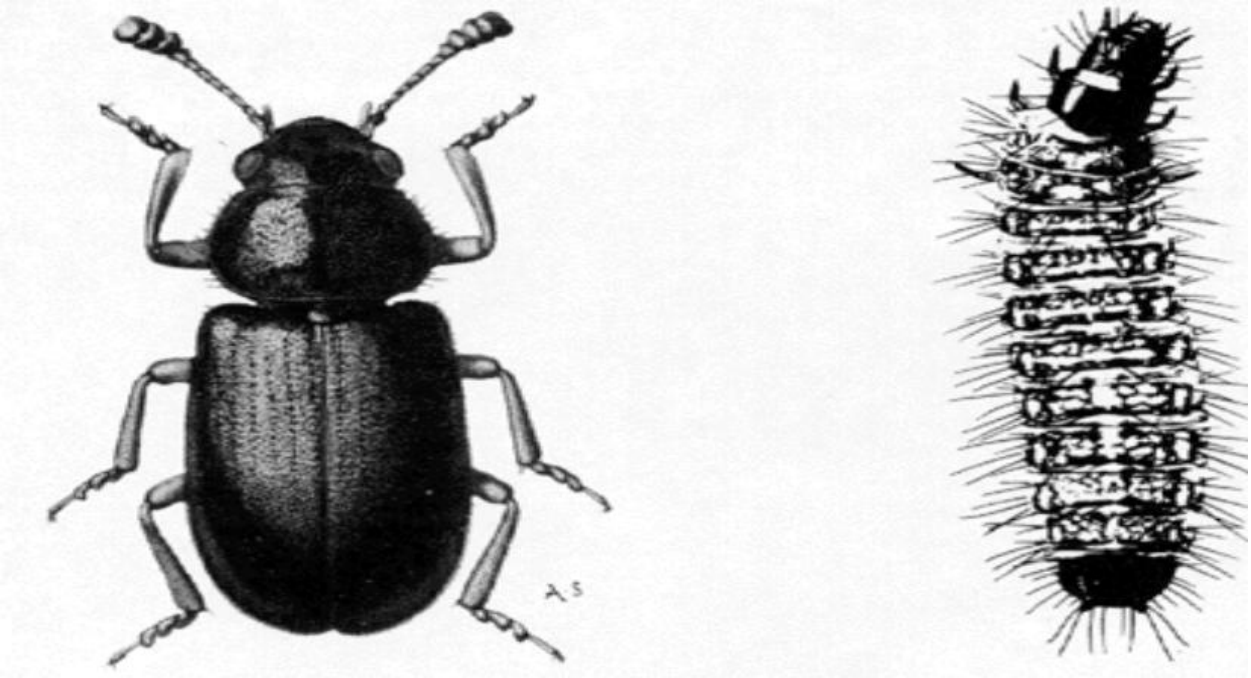

Figure 1: Dorsal views of adult (left) and larva (right) of *Necrobia rufipes*.

Table 1: Description and recognition features

Life Stage	Description
Adult	Shape as in fig. 1 (left). The upper surface of the body (head, thorax, elytra) entirely shining metallic bluish-green. The underside of the abdomen is entirely dark blue. Legs bright reddish-brown or orange. antennae are mainly reddish-brown but with a dark brown or black club at the tip. Sides of the thorax (especially) and elytra with stiff bristle-like hairs. Distinguished from adults of similar species by the coloration described above *N. violacea* has black or bluish legs and antennae, and *N. ruficollis* has a reddish-brown thorax and base of elytra.
Larva	Appearance as in fig. 1 (right). Typical beetle larva with three pairs of jointed legs; moderately hairy. Most of the body is ceramic-grey with mottled violet-grey markings on the upper surface. Head, and upper surfaces of the 1st thoracic segment and the last large abdominal segment (the ninth), with brown hardened plates; 2nd and 3rd thoracic segments also with tiny brownish plates. Plate on the last large abdominal segment with two horn-like protuberances which curve strongly upwards. Very difficult to distinguish from closely-related species of

	Cleridae, but easily distinguished from dermestes larvae by coloration and normal amount of hairs, and from fly larvae by the presence of legs and obvious head.

2.3.2 DERMESTES

Species of Dermestes belong to the beetle family Dermestidae. Several species have been recorded infesting dried fish: *D. maculatus, D. frischii, D. carnivorus Fabr, D. lardarius, D. haemorrhoidalis,* and *D. peruvianus* (Haines, 1989; Singh *et al*., 2018).

2.3.2.1 Life-cycle

The females deposit their eggs in holes in the flesh of the fish, while the adults feed on drying or dried fish. If water is available for the female to drink, the rate of egg-laying is significantly increased. As they consume the meat, the larvae burrow inside it (Haines, 1989; Singh *et al*., 2018). The larvae typically go through five, six, or seven instars, although under poor circumstances, the number of moults increases. Fish with infestations frequently have cast larval skins, which might be mistaken for larvae. The last instar larvae dig into solid material before pupating; this may be fish flesh, but it is typically the wood of drying racks or storage buildings. The burrowing may badly degrade the wood (Haines, 1989; Singh *et al*., 2018). The major pest species have a life cycle that lasts anywhere from 5-7 weeks, depending on the type of food and environmental factors. The rate of population growth for *D. maculatus* and *D. frischii* under ideal circumstances is roughly 30 times every month. Adult Dermestes can fly, making it simple for them to spread to new food sources. (Haines, 1989; Singh *et al*., 2018).

2.3.2.2 Damage caused to cured fish

The feeding of Dermestes spp. larvae and adults result in significant quantitative loss of dried cured fish as well as fragmentation. Additionally, the presence of insect corpses and cast skins may result in quality degradation (Haines, 1989; Singh *et al*., 2018). The adult larvae's harm to wooden drying racks and store buildings may result in additional expenses.

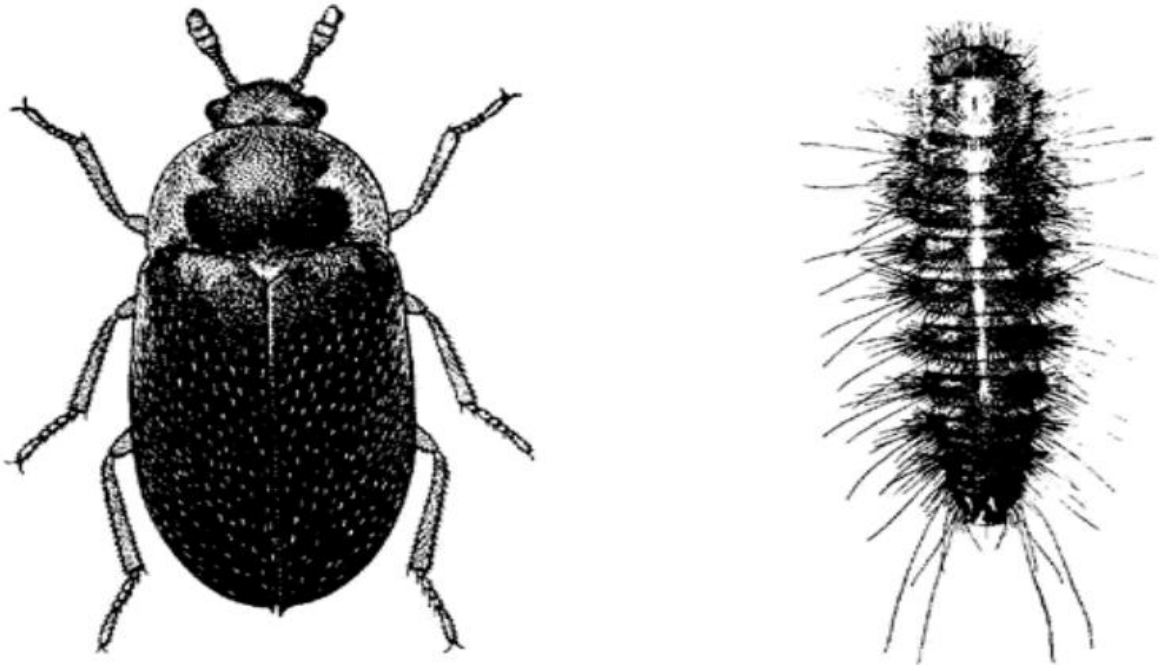

Figure 2: Dorsal views of adult (left) and larva (right) of *Dermestes maculatus*

Table 2: Description and recognition features

Life Stage	**Description**
Adult	Shape elongate-oval, as shown in fig. 2 (left). The Cuticle of the upper surface of the body is black or dark brown, covered with black, whitish-grey, brown, or yellowish hairs, which form a distinct pattern in some species. The underside of the abdomen with black, whitish, brown, or golden hairs, often forming a distinct pattern. Antennae are rather short but with an obvious club at the tip. Distinguished from necrobia spp. by the lack of metallic coloration, and larger size.

Larva	Appearance as in fig. 2 (right). Thoracic segments with three pairs of jointed legs. Body densely covered with hairs of various lengths. The underside of the body is usually yellowish-brown, but the upper surface of the body is mainly dark brown, often with a central yellowish line. The upper surface of the last large abdominal segment (the ninth) with two long pointed horn-like protuberances, which may be partly hidden by surrounding hairs. Dermestes larvae are easily distinguished from all others found on cured fish by their hairiness and dark colour.

2.3.3 LARDOGLYPHUS

Species of Lardoglyphus belong to the family Acaridae in the mite group Astigmata. Three species have been found infesting cured fish: *L. konoi*, *L. zacheri,* and *L. angelinae*. The commonest species is *L. konoi* (Haines, 1989; Singh *et al*., 2018).

2.3.3.1 Life-cycle

Lardoglyphus adults and nymphs consume drying or dried fish as food. The adult female lays eggs on the fish, and the six-legged larvae that result evolve into the eight-legged protonymph and tritonymph stages before becoming adult mites (Haines, 1989; Singh *et al.,* 2018). This growth can happen extremely quickly. The life cycles of *L. konoi* and *L. zacheri* last just 9–11 and 10–11 days, respectively, at a temperature of 23°C and 87 % relative humidity; at optimal conditions, growth may be even more rapid. These mites' potential growth rates have not been calculated, although, under ideal circumstances, they would likely be on the order of thousands of times every month. Due to the ease with which modest populations of Lardoglyphus can be neglected in such circumstances, the mites can multiply to enormous numbers in a matter of

days, and a significant infestation may appear to happen very quickly (Haines, 1989; Singh *et al*., 2018).

2.3.3.2 Damage caused to cured fish

There will be a quantitative loss of dried, cured fish due to feeding by the adults and nymphs of Lardoglyphus species. Contamination by living and corpses, which might be rather numerous, may result in quality deterioration. Both in the lab and the field, the scope and cost of the losses caused to dried fish by Lardoglyphus spp. have not been determined (Haines, 1989; Singh *et al.*, 2018).

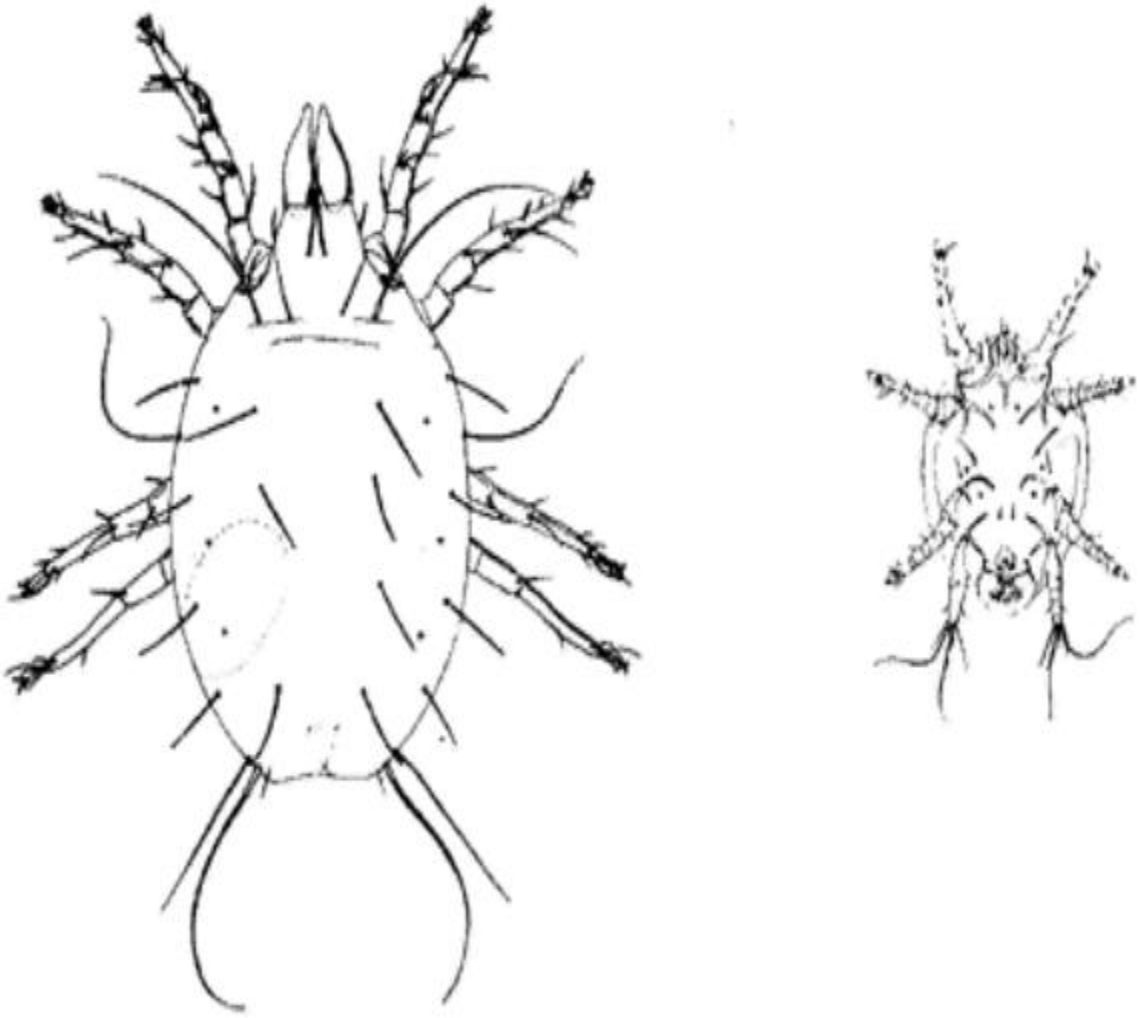

Figure 3: Dorsal view of adult female of *Lardoglyphus konoi* (left) and ventral view of hypopus of *L. zacheri* (right).

Table 3: Description and recognition features

Life Stage	Description
Adult	Appearance as in Fig. 3 (left). Oval-bodied with four pairs of legs. females larger than males. As in most acarid mites, the body is smooth and translucent ceramic-white with several pairs of hairs, which are only visible under a good hand lens or a low-power microscope. The females differ from other acarid mites found on stored food in having paired (rather than single) claws, and the males are distinctive because the third legs end in two blunt spines instead of claws: these characteristics of Lardoglyphus spp. are only visible with a high-power microscope. Precise identification of specie requires specialist microscopic techniques and knowledge.
Larva	Appearance as in Fig. 3 (Right). Legs are rather stouter than those of adults. The body hairs are short and are sometimes thickened into small spines. There are no functioning mouthparts. The underside of the body has numerous small suckers, especially concentrated on a sucker plate behind the bases of the fourth legs.

2.3.4 DIPTERA

The subfamilies Calliphorinae and Sarcophaginae of the family Calliphoridae contain the majority of the flies observed on cured fish. Several species of Chrysomia are the most prevalent among them, although Calliphora, Lucilia, Sarcophaga, and Wohlfartia have also been recorded (Haines, 1989; Singh *et al*., 2018). The families Muscidae, Piophilidae, Milichidae, Phoridae, and Ephydridae are also mentioned in reports of flies infesting cured fish. Although they exhibit a range of sizes and colors, these flies are all very similar in overall appearance, making expert identification necessary (Haines, 1989; Singh *et al*., 2018).

2.3.4.1 Life-cycle

On the flesh of fish, adult female flies often deposit batches of eggs (or, in some species, small larvae). Fly families Milichidae, Phoridae, and Piophilidae can infest both partly and completely infest cured fish, but Calliphoridae, Ephydridae, and Muscidae can only infest damp fish in the early stages of curing (Haines, 1989; Singh *et al*., 2018). The larvae, commonly referred to as maggots, feed on the flesh's surface and have the potential to eat deeply through it. Burrowing, in particular, can seriously damage fish that are damp. The larvae of the Calliphoridae and Muscidae frequently gather in certain locations, where they do significant harm. The varieties of flies observed on cured fish have just three larval instars. The main flies that attack damp fish grow into larvae in as little as three days. The final larval skin is kept and changed during pupation to create a tough protective puparium (Haines, 1989; Singh *et al*., 2018). Infested damp fish larvae typically leave the fish to pupate and frequently dig holes in the ground beneath drying racks or mats. Naturally, the newly emerged adults have great flying abilities and quickly find new sources of acceptable food. Under ideal circumstances, the life cycle of the primary pest species of damp fish (namely Chrysomia spp. and other Calliphoridae) may be finished in around seven days. The species that infest dried fish grow more slowly (Haines, 1989; Singh *et al.,* 2018).

2.3.4.2 Damage caused to cured fish

Quantitative losses result from Calliphoridae larvae feeding on damp fish. When the right circumstances for fly growth are present, such as when unsalted or inadequately salted fish dries slowly due to rain or excessive humidity, fly larvae can result in weight losses of 10–30% (Haines, 1989; Singh *et al*., 2018). Fish fragmentation brought on by the fly attack may result in quality loss and raise the possibility of beetle and mite damage. Significant weight losses from

fish fragmentation during processing have been documented, but the blowfly damage's role in these losses has not been separately evaluated. Fly-related expenses are associated with their function as disease transporters and myiasis-causing agents (Haines, 1989; Singh *et al*., 2018).

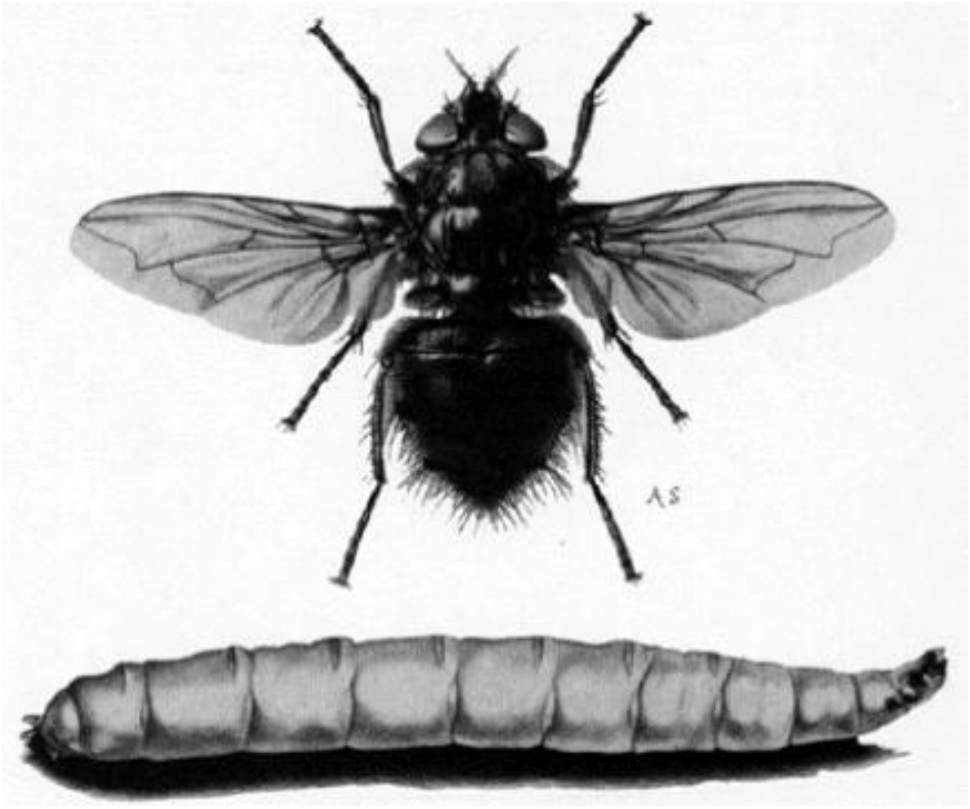

Figure 4: Dorsal view of the adult of *Calliphora vicina* (top) and lateral view of the larva of *Piophila casei* (bottom).

Table 4: Description and recognition features

Life Stage	Description
Adult	The many different species of fly found on cured fish all have the same general form. as shown in fig. 4 (top). Colour of the body is often black and grey but many of the common species have a metallic green. The blue or purple sheen on the upper surface. The eyes are large and the two fore-wings are membranous and transparent, but the hind wings are modified into small club-like halters. Identification of the many species requires specialist knowledge.
Larva	The general form is usually as shown in fig. 4 (bottom). The body is generally cylindrical, but often tapering towards the head and sometimes with numerous protuberances that may act as false legs (not present in the species illustrated in fig. 4). Colour is usually grayish-white or ceramic. They are distinguished from all other pests found on cured fish by their lack of jointed legs, their very small head, and their reduced mouthparts (mainly consisting of two hook-like mandibles). Differentiation of the species is very difficult, even with specialist knowledge, and specimens of fly larvae collected for identification should therefore be kept alive until they become adults.

CHAPTER 3

3.1 MATERIALS AND METHODS

3.2 Study Area

This study will be conducted in Benin City, located in the southern part of Edo State, Nigeria. The area is made up of seven local government areas (Oredo, Egor, Ikpoba-okha, Uhunmwode, Orhionmwon, Ovia South West, and Ovia North East). It is located between latitudes 6°10′10.49″N to 6°28′10.38″Nand longitudes 5°46′46.42″E and5°59′55.42″E. The study covers rural, suburban, and urban areas. This southern part of Edo is typified by a low land rain forest ecosystem. The soil samples from the zone have high levels of organic matter. It experiences both wet and dry seasons; the wet season lasts from April to November while the dry season lasts from December to March (Egwenomhe *et al*., 2020)

Figure 5: Fig.1. Map showing major markets in Benin (Source: Google map, 2023)

3.3 COLLECTION OF SAMPLES

Five species of fish that have been traditionally processed (smoked and or dried) will be purchased from a popular market in Egor local government Area. Four markets are found in Egor LGA which include Uselu, Egor, Uwelu and Ogida markets. Uselu market is chosen as the collection site because of it is the most frequently visited and populous among the other markets. The samples (*Clarias gariepinus, Orechromis niloticus, H. orechromis and Synodontis spp*) were wrapped tightly in polythene bags and were conveyed to the wet lab of the Department of Aquaculture and Fisheries Management, university of Benin, for observation and analysis.

Three samples of each fish species will be purchased from three sellers randomly positioned in the market giving a total of thirty-six (36) samples from each market.

3.4 Experimental Design

The experiment was made up of two main factors, which are;

a. Five (5) fish species (*Clarias gariepinus, Orechromis niloticus, H. orechromis and Synodontis spp*).

b. Three (3) random sellers in Each markets.

c. Eight (8) weeks of storage.

The experiment was carried out with five dried fish species (*Clarias gariepinus, Orechromis niloticus, H. orechromis and Synodontis spp*) × four (4) samples each × Three sellers × Eight (8) weeks of storage. It was also conducted as a factorial experiment laid out in a Completely Randomized Design (CRD).

3.4 COLLECTION OF DATA

The collected fish samples were stored in a polythene bag separately for a period of 8 weeks.

3.4.1 Screening of insect pests from different species of smoked fish

The Samples were analysed using a hand lens to check for larvae of insect pests at two weeks intervals. The samples were analysed by placing them on different shallow trays each for a particular species and there after spread in the open under closed observation in order to exposed the various insect pests.

Hand lens was used to view each of the fish species in order to locate and extract the pests using a fine brush and plastic container. Both the larval stage and adult were preserved in a labeled specimen bottles with 70% alcohol for preservation.

3.4.2 Counting and identification of insect pests

The adult Insect pests or larvae collected from the different fish species were identified using taxonomic key. The different species of insect pests found were counted and recorded. The adult and larval forms were counted separately for each species of the insect pests on the smoked fish and recorded.

3.4 ANALYSIS OF DATA

Data obtained will be analysed using descriptive statistics and according to Spiegel (1987), these includes the employment of bar charts and pie chart.

CHAPTER FOUR

4.0 RESULTS

At the end of the research duration, Some categories of insect pests were identified. The populations of adults and larvae of insect pests infesting fish samples are presented in Table 1, which indicates that there were more insect larvae than adult.

Two major categories of insect pest were identified; *Dermestes spp* and *Tribolium spp.* Other insect pest identified at the end of the study include *Necrobia spp*,

According to results presented in table 1, Dermestes spp occured more than other insect pest. Table 1 also indicates that there were more dermestid larvae in the fish samples than there were adults. However there was no significant ($p<0.05$) differences between the abundance of the two species of beetles at the time of purchase of the fish samples although there were significant ($p> 0.05$) differences among the population of the larvae and adult Insect pest recorded.

Table 1 showed that there was no significant ($p< 0.05$) difference in the initial number of adult and larvae of Dermestid and Tribolium spp as all fish species have the same initial number of insect pest (0.00). However as the time duration increases, the number of the insect pest also increases.

At the end of the study period (week 8), it was observed that there was a significant ($p> 0.05$) difference in the number of adult and larvae of Dermestid. O. niloticus had the highest (35 and 54) number of Dermestes spp adult and larvae respectively while H. orechromis had the lowest (14, 15) number of Dermestes spp adult and larvae respectively.

At the end of the study period week 8), it was observed that there was a significant ($p > 0.05$) difference in the number of adult and larvae of Tribolium spp. C. gariepinus had the highest (27 and 09) number of Tribolium spp adult respectively, while Synodontis spp had the lowest (07 and 03) number of Tribolium adults and larvae respectively.

A total of 00 (zero) adults and 00 (zero) larvae of Dermestid was recorded at the first week while 103 (one hundred and three) adults and 163 (one hundred and sixty-three) larvae of Dermestids were recorded at the end of the study period. It was observed that the number of Dermestid increased progressively with time.

Similarly, a total of 00 (zero) adults and 00 (zero) larvae of Tribolium spp was recorded at the first week while a total of 80 (eighty) adults and 32 (thirty-two) Larvae of Tribolium spp was recorded at the end of the study period. It was also observed that the number of Tribolium spp increased progressively with time.

Table 1: Mean number of initial and final of adults and larvae of D. maculatus and Tribolium spp infesting five species of smoked fish sold in the market, Benin, Nigeria.

	Dermestes maculatus				*Tribolium spp*			
Fish species	Wk1 A L	Wk2 A L	Wk4 A L	Wk8 A L	Wk1 A L	Wk2 A L	Wk4 A L	Wk8 A L
C. gariepinus	00 00	02 15	23 40	18 33	00 00	03 00	06 10	27 09
Tilapia spp	00 00	00 03	04 11	16 18	00 00	13 00	14 00	13 05
H. orechromis	00 00	01 04	09 05	14 15	00 00	05 02	08 05	15 07
O. niloticus	00 00	05 28	25 10.7	35 54	00 00	02 07	02 07	18 08
Synodontis spp.	00 00	03 00	15 40	20 43	00 00	00 00	07 00	07 03
Total	00 00	11 50	76 106.7	103 163	00 00	23 00	37 00	80 32
SED (0.05)	NS NS	7.30. 24.21	5.82 9.40	3.02. 26.79	NS. NS	2.13. 0.63	1.10. 0.856	1.21. 0.76

SED= Standard Error Deviation (0.05). NS= No significance.

CHAPTER FIVE

5.0 DISCUSSION

The research findings indicate that there were multiple categories of insect pests identified in the study, with a notable prevalence of Dermestes spp and Tribolium spp. Table 1 presents data on the populations of adult and larval insect pests infesting fish samples. Notably, it was observed that there were more insect larvae than adults, suggesting a lifecycle pattern.

In terms of prevalence, Dermestes spp appeared to be the most common insect pest, with higher numbers (103 adults and 163 larvae at the end of the study) than other species. Table 1 also shows that there was a notable abundance of dermestid larvae in the fish samples compared to adults. Interestingly, there were no significant differences between the abundance of the two species of beetles at the time of purchase of the fish samples. However, significant differences were observed among the populations of larvae and adult insect pests recorded during the study. This was in agreement with those recorded by Ajayi *et al.*, (2006) who reported that minimal amount of insect pest are found on fish after processing but this increases with storage duration.

As the study progressed to week 8, significant differences emerged in the numbers of adult and larval Dermestid and Tribolium spp. O. niloticus had the highest number (35 and 54) of Dermestid adults and larvae, while H. orechromis had the least (14 and 15) numbers. This was in agreement with the findings of Ajayi *et al.*, (2006) who recorded high numbers of Dermestid adult (7.8) within seven days.

Similarly, in the case of Tribolium spp, there were variations in numbers among different fish species. However, C. gariepinus recorded the highest (27, 09) number of Tribolium spp adult and

Larvae respectively in line with the reports of Wahedi and Kefas (2013) who recorded 100% infestation rate of Tribolium spp on C. gariepinus. Given that the extent of infestation increases with longer storage periods, it is plausible to state that the duration of storage will contributed to the reduction in nutritional content in the preserved fish species as hypothesized by Wahedi and Kefas (2013)

This implies that the presence of beetles in fish samples could lead to substantial declines in the nutritional quality of all five fish species, with particularly significant losses observed in C. gariepinus, especially when the infestation is severe. Previous findings have indicated that when fish become infested with Dermestes and Tribolium species, they have the potential to consume the flesh and tissues of dried fish unless adequate protection measures are in place (Ajayi *et al.,* 2006).

CHAPTER SIX

6.0 SUNMARY, CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY

The project's results highlight the presence of insect pests, primarily Dermestes spp and Tribolium spp, in fish samples. Notably, there were more insect larvae than adults, suggesting a lifecycle pattern. Dermestes spp were the most prevalent, with a higher abundance of larvae. While there were no significant differences in initial pest numbers, significant variations emerged over the study period.

In week 8, C. gariepinus showed the highest Dermestes spp infestation, while O. niloticus and Tilapia spp had the lowest. For Tribolium spp, O. niloticus had the highest infestation, with O. niloticus and Synodontis spp having the lowest numbers.

These findings suggest that beetle infestation could significantly reduce the nutritional quality of fish, especially in heavily infested C. gariepinus. Furthermore, it's noted that Dermestes and Necrobia species can consume fish flesh and tissues if proper protection measures are not in place. This research underscores the importance of monitoring and managing insect pests in fish to maintain their quality and safety.

6.2 CONCLUSIONS

In conclusion, the research confirms the presence of insect pests, Dermestes spp and Tribolium spp, within stored fish samples. It is observed that there is a higher prevalence of insect larvae compared to adult insects in the fish samples, indicating the potential existence of a lifecycle

pattern and that different fish species displayed varying levels of infestations, with C. gariepinus being particularly susceptible to Dermestes spp, and O. niloticus showing a higher susceptibility to Tribolium spp. The severity of infestations appears to be directly proportional to the length of storage, suggesting that extended storage periods contribute to increased insect pest presence.

6.3 RECOMMENDATIONS

Based on the result of the results of this study, the following recommendations are made;

1. Given the direct relationship between infestation severity and storage duration, it's crucial to enforce stringent storage practices. This includes ensuring that fish products are stored in a manner that minimizes exposure to insect pests, such as using sealed containers or proper packaging.
2. Educating fishermen and suppliers about the risks of insect infestations and the importance of proper storage practices. This awareness can contribute to better handling of fish from the source.
3. Further analysis and investigation should be conducted to understand the factors influencing the population dynamics of these pests and their implications for fish quality.

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