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Review about the use of the Invertebrates in Pisciculture: Termites, Earthworms and Maggot

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Abstract

The halieutic products have a very significant role in human nutrition. They constitute the most significant animal protein nutrient source for Beninese population. But, the offer of the national production is low compared to the demand population. The problem of the aquaculture is the feed. This is not well justified by ashormentionned points. The object of the study is to set out the background some invertebrates used in pisciculture; earthworms, termites and maggots through their ecology, biology, system of production and their utility in pisciculture.

Keywords: *Aquaculture, invertebrates, feed, termites, earthworm, maggot*

Introduction

The fish and fishery products belong to the basic foodstuffs most exchanged in the world and constitute today a significant source of nutritive food and animal proteins for a great part of the world population (FAO, 2012). The national demand for halieutic production in 2011 was estimated at approximately 37.784 tons while the national request was 120.000 tons (Direction des pêches, 2011).One observes however, an imbalance between supply and fish. Indeed the imported feed is too expensive and cannot allow a profitable pisciculture, the local feed without fish meal are less expensive but low in essential nutriments. It is thus necessary to improve she nutritional quality of local fish feed with no conventional sources of proteins. Termites, maggots and earthworms are very rich in proteins and quite balanced in essential amino acids (V.C. Navarro *et al,* 1989 ; R.A. Dynes, 2003 ; D.M. Miller *et al,* 2010 ;A.O. Sogbessan *et al*,2008). The target of this study is to make a review on biology, ecology, the systems of production and the nutritional values of termites, earthworms and maggots.

Colony Establishment

The swarmers (fig1) are new termite kings and queens that must leave their parent colony in order to mate and establish new colonies of their own. The termite swarmers pair up during their flight, then land and search for a place to begin a family. Their wings break off shortly after landing, and the new king and queen start their colony by excavating a small chamber in a plot of soft soil. When the chamber is large enough, they crawl inside, seal the opening and mate. From this point on, they will spend the rest of their lives underground. The queen lays her first batch (6-12) of eggs within a few days or weeks of mating. Initially, the king and queen tend the young termites. However, as the queen's egg laying capacity increases, the older offspring begin to tend their younger siblings. The colony will now continue to grow with increasing numbers of termites being produced each year. The parental king and queen have the longest life span in the colony. They often survive for a decade or longer and can produce huge colonies with thousands of offspring (D.M.Miller *et al*, 2010).

Figure 1: Swarmer with workers. (D.M. Miller *et al*, 2010)
Subterranean Termite Castes

Primary reproductives

As described above, mature subterranean colonies, at certain times of the year, will produce large numbers of winged swarmers or “alates” that will eventually become king and queen termites. These royal termites are dark-colored and are the only caste with functional eyes. The swarmers lose their wings after a short flight where they select a mate. The new king termite remains virtually unchanged after losing his wings. However, as the new queen begins to produce eggs her abdomen grows larger with the development of her ovaries. As she stretches, the segments of her body pull farther apart showing the white membranes between the segments of her abdomen. This gives the queen a striped appearance. The eastern subterranean termite queen will stretch until she is about 14.5 mm in length. At this point she is an egg laying machine, producing over 500 offspring a year.

Secondary reproductives

The termite colony originates from a single pair of reproductive swarmer termites, the king and the queen. However, if the king or the queen should die, other individuals within the colony will start to develop functional reproductive organs to take their place. These individuals are called secondary reproductives. Secondary reproductives are light in color but they are larger than workers and never develop wings. In mature colonies a secondary reproductive caste can develop even though there is still a producing queen present. When this happens the secondary reproductive caste members will produce the majority of the eggs, causing the colony to grow at a much faster rate. Although no individual secondary reproductive can produce as many eggs as the queen, several hundred of them may exist in a single colony thus producing thousands of eggs. Secondary reproductives may also develop in satellite nests where a group of workers have become separated from the parent colony. This splitting or budding of the nest expands the original colony’s foraging territory.

Worker Caste

Subterranean termite workers are the caste found in infested wood. The workers are responsible for all of the labor in the colony. They care for the young, repair the nest, build foraging tunnels, locate food, feed and groom the other castes, and each other. The youngest termite workers perform the domestic tasks inside the colony like feeding, grooming and caring for the young, while the older, more expendable workers take on the hazardous jobs of foraging and nest building. The termite workers are both male and female but they are functionally sterile. They are milky white in color and have no wings or eyes. The body of the termite worker is soft, but its mouthparts are very hard and adapted for chewing wood.

Soldier Caste

Subterranean termite soldiers are the defenders of the colony (fig2). They protect the colony against marauding ants and foreign termites. When foraging tubes or galleries are broken in, the soldiers congregate around the break to stand guard against invaders. Soldiers are similar to the termite workers in that they are blind, soft-bodied and wingless. However, the soldiers have an enlarged, hard, yellowish-brown head which has been adapted for fighting. The head has a pair of very large mandibles or jaws that are used to puncture, slice and kill enemies (primarily ants). However, the large mandibles prevent the soldiers from feeding themselves, so they must rely on the workers for food.

Figure 2: Soldier caste (D.M. Miller *et al*, 2010)

Subterranean Termite Behavior

It is not known exactly how subterranean termites locate sources of food. It is thought that the termites simply divide up the territory around the nest and start digging a network of tunnels. As they dig, they come into contact with buried wood in the process. When food is found, other termites are recruited to the food source and non-productive tunnels are closed off. The foraging range of a single termite colony is difficult to predict. Small colonies may forage over only a few yards if food is plentiful. Some larger colonies may forage over areas the size of a football field. However, depending on the season and weather, a colony may not forage over their entire range at all times. It has also been hypothesized that several small related colonies may cover a greater foraging distance than one large colony. Foraging termites produce a variety of chemicals called pheromones that influence their behavior. These pheromones are basically odors that send messages to other termites in the colony. While tunneling underground, the foraging termites lay down a trail of pheromone which they secrete from glands on their abdomen. When a food source is located, the odor trail is intensified to recruit other termites to the feeding site. However, the intensity of the recruitment effort (odor trail) is influenced by soil temperature, moisture and compaction as well as the size and quality of the food source. Subterranean termites also forage above ground for sources of food, like the structural wood in homes and other structures. In order to protect themselves from desiccation and predation from ants while foraging above ground, termites build long tubes out of mud and fecal material. Termite workers travel back and forth inside these tubes between the soil and the structure above ground. These mud tubes are called exploratory tubes. Termite exploratory tubes are very easy to see and are one of the best ways to identify a potential termite infestation. Once a source of wood has been located, the termites establish larger, more permanent utility or working tubes. The utility tubes are highways running from the underground termite galleries directly to the food source. Utility tubes can cover long distances over the foundation of a building or along exterior walls to reach the wood inside. Sometimes subterranean termites build another tube that runs from the structural wood back down to the ground. These tubes are called drop or suspended tubes. Drop tubes are often lighter in color than the utility tubes because they contain more of the wood fiber taken from the structure. Subterranean termites construct a fourth type of mud tube in addition to those that facilitate foraging. These are called swarming tubes. Swarming tubes are built seasonally extending only 4-8 inches above ground. These tubes provide the exit port for winged swarmers leaving the colony.

Moisture Needs

Subterranean termites are constantly at risk of drying out; this is why they must live in the soil. Soil has the capacity to hold water for a long period of time and keep the colony moist. When termites forage above ground, they must maintain their connection to the soil so that the workers and soldiers can return periodically to replenish their body moisture. The mud tubes provide the termites with this soil connection. If a tube becomes damaged, the worker termites will labor desperately to repair it. If the tube is beyond repair, the termites located above ground will often die of dehydration. However, on some occasions subterranean termite colonies do become established above ground. These above ground infestations are almost exclusively found in structures with chronic moisture problems. Chronic moisture problems are usually the result of leaves and moisture accumulation on a flat roof, pipes leaking within the structure, or poor ventilation in crawl spaces. In such cases, the colony can survive above ground indefinitely.

Nutrition and Feeding

Although subterranean termites can chew through and damage many materials, they can only obtain nutrition from cellulose. However, subterranean termites cannot digest cellulose on their own. In order to digest wood, subterranean termites have large numbers of microorganisms in their gut that convert the wood fiber into usable nutrients. If there were no microorganisms in the gut, the termite could eat constantly but still die of starvation. In the colony most food is shared mouth to mouth (a process called trophallaxis). Foraging worker termites feed directly on wood or other cellulose material then store the food in their gut. They then return to the nest and feed the immature termites, soldiers, and reproductives.

Immature termites are unique in their nutritional needs because like all juvenile insects they must periodically shed their skin (exoskeleton) in order to grow (molting). When they do this they also shed the lining of their hindgut where the wood-digesting microorganisms live. After molting the termites no longer have their microorganisms and are unable to digest food. In order to replenish their microorganism supply, the young termites feed on fluids (which contain the microorganisms) excreted from the hindgut of older termites. This delicious practice of feeding from a nest mate's anus is called proctodeal feeding. Although it may sound disgusting, proctodeal feeding is essential for the survival of the termite colony.

Termite production

The termites can be produced at any place not too dry and containing cellulose. For that, a small broad hole containing the vegetable remains as the deadwood and dry sheets. The termite swamers can be introduced into the hole for sowing. The surrounding must be a little sprinkled in order to give a little moisture to the mixture of wood and the dead sheets.

Nutritionals values and essential amino acids composition

Table 1: Nutritionals values of termites

Elements	Values
Crude protein (%)	46.3±3.2
Crude lipid (%)	30.1±5.1
Crude fibre (%)	7.3±1.2
Ash (%)	3.6±0.6
Nitrogen free extract (%)	19.0
Moisture (%)	3.7
Gross energy(kJ/100g)	2458.0±60.1
Sodium (g/100g)	0.20±0.06
Calcium (g/100g)	0.23±0.04
Potassium (g/100g)	0.38±0.06

Source : (A.O. Sogbessan *et al*, 2008)

Table 2 : Essential amino acids

Element	Values
Arginine	2.87±0.12
Histidine	1.28±0.12
Isoleucine	1.70±0.02
Leucine	3.11±0.013
Lysine	2.82±0.06
Methionine	1.68±0.02
Phenylalanine	1.97±0.013
Threonine	1.67±0.9
Valine	2.26±0.06
Total Essential amino	19.36±0.58
Crude Protein %	46.32±3.2

Source : (A.O.Sogbessan *et al*, 2008)

Use of the termites in aquaculture

The termites are used in aquaculture as no conventional source of protein or source of alternate protein to the fish meal.

(A.O. Sogbessan *et al*, 2008) use termite meal (*Macrotermes subhyalinus)* in the place of fish meal to feed the fingerling of *Heterobranchus longifilis.* Termite meal (*Macrotermes subhyalinus* has been also used to replace soya meal in the died of fingerling of *Heterobranchus longifilis* (S.G. Solomon *et al*, 2007).

Literature on the earthworms and their applications in pisciculture

Earthworm Classification

Earthworms are terrestrial invertebrates with thousands of species grouped into three categories according to their behavior in the natural environment: anecic, endogeic, and epigeic.

Anecic species, represented by the common nightcrawler (*Lumbricus terrestris*), construct permanent vertical burrows as deep as 4 to 6 feet in the soil. They feed on organic debris on the soil surface and convert it into humus. If anecic species are deprived of their permanent homes, they will discontinue breeding and cease to grow.

Endogeic species, such as Aporrectodea calignosa, build wide-ranging, mainly horizontal burrows where they remain most of the time, feeding on mineral soil particles and decaying organic matter. They are the only species of earthworms that actually feed on large quantities of soil. As they move through the soil and feed, they mix and aerate the soil and incorporate minerals into the topsoil.

Epigeic species, represented by the common redworm (*Eisenia fetida*), do not build permanent burrows; instead, they are usually found in areas rich in organic matter, such as the upper topsoil layer, in the forest under piles of leaves or decaying logs, or in piles of manure. Since they don't burrow deeply into the soil and prefer to eat rich organic matter, epigeic worms adapt easily to vermiculture and vermicomposting systems. *Eisenia fetida* and *Eisenia andreii* constitute about 80 to 90 percent of the earthworms raised on a large-scale commercial basis.

Biology of Earthworms

The physical structure of earthworms is similar among the different species. Earthworms belong to the phylum Annelida, which means "ringed." The "rings" around worms are called segments. Redworms have about 95 segments, while nightcrawlers have about 150. Earthworm bodies are streamlined, containing no protruding appendages or sense organs, to enable them to pass easily through soil. Worms have well-developed nervous, circulatory, digestive, excretory, muscular, and reproductive systems.

The head or anterior end of the earthworm has a prostomium, a lobe covering the mouth that can force open cracks in the soil into which the earthworm can crawl. Setae (bristles) on each segment can be extended or retracted to help earthworms move. Lubricating mucous, secreted by skin glands, helps worms move through soil and stabilizes burrows and castings.

The earthworm's digestive tract extends the whole length of its body. Worms swallow soil (including decomposing organic residues in the soil) or residues and plant litter on the soil surface. Swallowed matter is mixed by strong muscles and moved through the digestive tract while enzyme-filled fluids are secreted and blended with the materials. The digestive fluids release amino acids, sugars, bacteria, fungi, protozoa, nematodes, and other microorganisms, in addition to partially decomposed plant and animal materials from the food the worms have swallowed. Simpler molecules are then absorbed through intestinal membranes and are utilized by earthworms for energy and cell production.

Earthworms do not have specialized breathing devices. They breathe through their skin, which needs to remain moist to facilitate respiration. Like their aquatic ancestors, earthworms can live for months completely submerged in water, and they will die if they dry out.

A red pigment in earthworms' skin makes it sensitive to ultraviolet rays. Brief exposure to strong sunlight causes paralysis in some worms, and longer exposure kills them. Earthworms seen lying dead in puddles after a rainstorm likely were killed by exposure to light, not by drowning, since they can live submerged in water. However, worms will emerge from their burrows seeking oxygen when unoxygenated rainwater filters down through the soil and squeezes most of the rest of the oxygen from the soil spaces.

Taste cells are located in and near an earthworm's mouth, and worms show definite food preferences. Experiments have demonstrated that they will pass up cabbage if celery is available and shun celery if carrot leaves are offered.

Earthworms are hermaphroditic, meaning each individual possesses both male and female reproductive organs. The eggs and sperm of each earthworm are located separately to prevent self-fertilization. When worms mate, they face in opposite directions and exchange sperm; the eggs are fertilized at a later time. Mature eggs and sperm are deposited in a cocoon produced by the clitellum, a swollen, saddle-shaped structure near the worm's head. Within the cocoon, the sperm cells fertilize the eggs, and then the cocoon slips off the worm into the soil. The number of worms inside each cocoon and the length of time it takes them to hatch varies according to worm species and environmental conditions. Approximately four *Eisenia fetida* baby worms will emerge from a cocoon in 30 to 75 days, and another 53 to 76 days must pass for the newly hatched worms to reach sexual maturity. Earthworm cocoons resemble grape seeds in size and shape, with one end rounded and the other slightly pointed. Cocoons are initially pearly-yellow in color, then deepen to brown as the young inside mature and get ready to hatch. Earthworms can only reproduce using sperm from members of their own species. Claims of hybrid worms are not valid.

Earthworm Production

Earthworms have certain minimum care requirements that must be met on a regular schedule. The key environmental factors affecting earthworm growth, reproduction, and health are temperature, moisture, aeration, pH (acidity-alkalinity), and food material.

Temperature

Earthworms live and breed at temperatures between 55 and 85 degrees Fahrenheit. For commercial earthworm production, the ideal temperatures for growth and activity range from 60° to 80°. Bed temperatures should be between 60° and 70° to facilitate intensive cocoon production and hatching. If bed temperatures rise too high, they may be lowered by adding water, activating fans in or near the system, and reducing the amount of feedstock applied.

Moisture

Earthworms need adequate moisture to help them breathe through their skin. Beds need to sustain a moisture range of 60 to 85 percent and feel crumbly-moist, not soggy-wet. They should be sheltered from direct sunlight so they do not dry out and overheat. One method of increasing cocoon production after worms are fully established is to stop watering the beds for several days or until the top 1 or 2 inches are scarcely moist. Then dampen the beds enough to restore them to their recommended moisture content.

Aeration

Earthworms can survive in relatively low oxygen and high carbon dioxide environments and even stay alive when submerged in water if it contains dissolved oxygen. If there is no oxygen, however, earthworms can die. Oxygen may be depleted if earthworm beds are kept too wet or if too much feed is introduced. By reducing the amount of moisture, cutting back on feed, and turning the pile with a pitchfork or three-prong garden tool, oxygen will be restored. Turning the materials in the beds every two to three weeks will help keep the beds aerobic.

pH (acidity-alkalinity)

The pH of soil indicates whether it is acidic (1 to 6), neutral (7), or alkaline (8 to 14). Earthworms will grow in a pH range of about 4.2 to 8.0. For commercial production, however, earthworm beds should be kept at a pH range of 6.8 to 7.2. Check levels weekly with a pH kit. Take readings at different levels in the bed: the top feed area, 3 inches deep, and 8 inches deep. If an acid condition is detected in an earthworm bed, agricultural lime (calcium carbonate) may be mixed with bedding material to remedy the condition. Sprinkle half a pound of limestone on each 24 square feet of bedding surface, and water the bed. It is far less common for an overalkaline condition to exist. To remedy alkalinity, mix enough dry peat moss into the bedding until pH readings indicate a range of 6.8 to 7.2

Feeding Worms

Earthworms will consume animal manures, compost, food scraps, shredded or chopped cardboard or paper, or almost any decaying organic matter or waste product (R. Sherman, 2003). Horse, rabbit, swine, dairy, or steer manures are excellent feeds. Poultry manure is not recommended as it is too high in nitrogen and mineral.. If feeds are low in nutrients, they must be supplemented with high protein or nitrogen materials such as grains, mashes, and cottonseed meal. Feeds containing high amounts of carbohydrate or woody residues should be composted beyond the heating stage. The feed and supplements can be applied straight or mixed with 20 to 30 percent horse manure or aged pine sawdust or shavings and spread on top of the bedding about 1 inch deep.

When using manure as feedstock or bedding, always test its suitability for the earthworms. The same goes for any organic material in question. Place the material in a container along with about a dozen worms and observe their behavior over the next 12 to 24 hours. If the worms consume the material, it's fine, but if they crawl away or die, it's not suitable. Composting the material may solve the problem. Continue to experiment with the substance until deciding whether it should be fed to the worms.

Feed the worms regularly, once or twice a week. Set the feeding schedule and amount of feed according to the rate of consumption of the last feeding and the condition of the worms and beds. When most of the feed has been consumed, it is time to feed again. If too much feed is added, the beds may overheat or become anaerobic (oxygen-deprived) or too acidic. Adding calcium carbonate and mixing the bedding can alleviate these problems. If the worms do not appear to be growing bigger or producing offspring, more protein may be needed in the feed. Add grains, mashes, or cottonseed meal.

Compared nutritional values of the earthworms and profile in acid amino

Many studies were carried out on the use of earthworm in aquaculture. Authors recognized the high feed value of the worms. However the nutritional values vary between species (table 3).The profile in amino acid is presented in table 4.

Table 3: Compared nutritional values of the earthworms

Species	Protéin	Fat	Ash	NFE	Références
Earthworms	6	11	6	19	Safarkhanlo and *al*. (2009)
Eisenia Foetida	59	9	17	15	Shakorian. (1991)
Dendrobaena veneta	45	11	29	3	Safarkhanlo and *al*. (2009)
Tubifex tubifex	65	14	15	-	Shakorian (1991)
En chytraeus albidus	46	14	7	-	Taebideraz (1997)
Chironomid mirei	51	12	13	18	Safarkhanlo and. (2009)
Bomby mori	72	19	3	5	Safarkhanlo and *al*. (2009)
Tenebrio molitor	58	29	4	2	Safarkhanlo and *al*. (2009)

Source : (F.Roghaye, 2012)

Table 4 : Profile in essential amino acid

Element	Values
Arginine	2.83±0.12
Histidine	1.47±0.23
Isoleucine	2.04±0.012
Leucine	4.11±0.11
Lysine	6.35±0.23
Methionine	5.30±0.05
Phenylalanine	6.26±0.06
Threonine	4.43±0.2
Valine	4.43±0.6
Total Essential amino	37.11±2.31
Crude Protein %	63.04±4.5

Source : (A.O. Sogbessan *et al*, 2008)

Use of the earthworms in aquaculture

The substitution, of the fish meal by the earthworms meal (*Tenebrio molitor)* in the feed of *Clarias gariepinus* was carried out by to feed the fingerlings of *Clarias gariepinus* (W.K. Ng *et al* , 2001). That of the substitution of the fish meal by the earthworms meal (*Eudrilus eugeniae)* in the feed of *Hétéroclarias longifilis* also consisted in substitute the fish meal by the earthworms meal (*Eudrilus eugeniae)* to feed the fingerlings of Hétéroclarias (C.O. Monebi *et al*, 2012). Moreover *Perionyx excavatus* was to produce and to introduce like aquacole ingredient into the feed of *Oxyeleotris marmoratus* and *Pangasius hypophthalmus* (H.Y.N. Nguyen, 2010). Just as *Eudrilus eugeniae* was used to feed the fingerlings of *Heterobranchus isopterus* (B.Y. Hawa, 1991).

Maggot and their applications in pisciculture

The common housefly, *Musca domestica*, lives in close association with people all over the world (Fig 3). The insects feed on human foodstuffs and wastes where they can pick up and transport various disease agents.

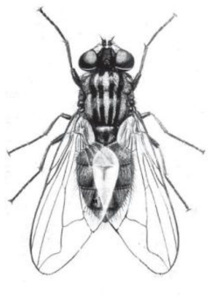

Figure 3: The housefly (*Musca domestica*) (J. Keiding, 1986)

Biology

Life cycle

There are four distinct stages in the life of a fly: egg, larva or maggot, pupa and adult (Fig 4). Depending on the temperature, it takes from 6 to 42 days for the egg to develop into the adult fly. The length of life is usually 2–3 weeks but in cooler conditions it may be as long as three months. Eggs are usually laid in masses on organic material such as manure and garbage. Hatching occurs within a few hours. The young larvae burrow into the breeding material; they must obtain oxygen from the atmosphere and can, therefore, survive only where sufficient fresh air is available. When the breeding medium is very wet they can live on its surface only, whereas in drier materials they may penetrate to a depth of several centimetres. The larvae of most species are slender, white, legless maggots that develop rapidly, passing through three instars. The time required for development varies from a minimum of three days to several weeks, depending on the species as well as the temperature and type and quantity of food available. After the feeding stage is completed the larvae migrate to a drier place and burrow into the soil or hide under objects offering protection. They form a capsule-like case, the puparium, within which the transformation from larva to adult takes place. This usually takes 2–10 days, at the end of which the fly pushes open the top of the case and works its way out and up to the surface. Soon after emergence the fly spreads its wings and the body dries and hardens. The adult fly is grey, 6–9mm long and has four dark stripes running lengthwise on the back. A few days elapse before the adult is capable of reproduction. Under natural conditions an adult female rarely lays eggs more than five times, and seldom lays more than 120–130 eggs on each occasion.

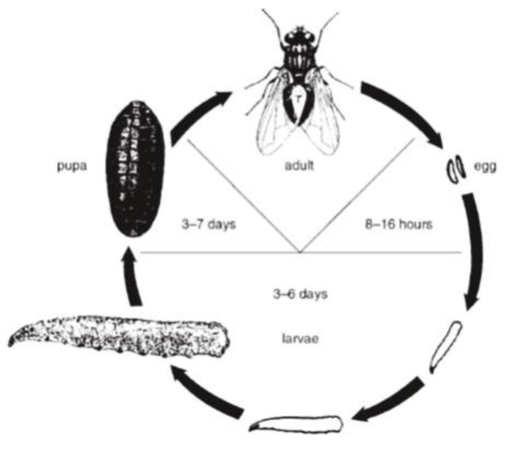

Figure 4: The life cycle of the fly (source: J. Keiding, 1986)

Feeding

All organic matter with fast decomposition can be used as substrate for the laying and the development of maggots (J. Hardouin *et al*, 2011). Both male and female flies feed on all kinds of human food, garbage and excreta, including sweat, and on animal dung under natural conditions flies seek a wide variety of food substances. Because of the structure of their mouthparts, food must be either in the liquid state or readily soluble in the salivary gland secretions or in the crop. Liquid food is sucked up and solid food is wetted with saliva, to be dissolved before ingestion. Water is an essential part of a fly's diet and flies do not ordinarily live more than 48 hours without access to it. Other common sources of food are milk, sugar, syrup, blood, meat broth and many other materials found in human settlements. The flies evidently need to feed at least two or three times a day (J. Keiding, 1986)

Ecology of adult flies

An understanding of the ecology of flies helps to explain their role as carriers of disease and allows the planning of control measures. Adult flies are mainly active during the day, when they feed and mate. At night they normally rest, although they adapt to some extent to artificial light.

Resting places

During the daytime, when not actively feeding, flies may be found resting on floors, walls, ceilings and other interior surfaces as well as outdoors on the ground, fences, walls, steps, simple pit latrines, garbage cans, clothes lines, grasses and weeds.

At night, flies are normally inactive. Their favourite resting places at this time are ceilings and other overhead structures. When temperatures remain high during the night, houseflies frequently rest out of doors on fences, clothes lines, electric wires, cords, weeds, grasses, hedges, bushes and trees. These resting places are generally near favoured daytime feeding and breeding areas and sheltered from the wind. They are usually above ground level, but rarely more than five metres high.

Fluctuations in fly numbers

Fly numbers in a given locality vary with the availability of breeding places, sunshine hours, temperature and humidity. Fly densities are highest at mean temperatures of 20–25 °C; they decrease at temperatures above and below this range and become undetectable at temperatures above 45 °C and below 10°C. At very low temperatures, the species can stay alive in a dormant state in the adult or
pupal stage.

Behaviour and distribution

During the day, flies are mainly gathered on or around feeding and breeding places, where mating and resting also take place. Their distribution is greatly influenced by their reactions to light, temperature, humidity, and surface colour and texture. The preferred temperature for resting is between 35 °C and 40°C. Oviposition, mating, feeding and flying all stop at temperatures below 15°C. Flies are most active at low air humidities. At high temperatures (above 20 °C), most houseflies spend the time outdoors or in covered areas near the open air.

When not eating, flies rest on horizontal surfaces and on hanging wires and vertically suspended articles and ceilings indoors, especially at night. A detailed study of local resting places is essential for successful control.

Nutritionals values of maggots

Table 5: Nutritionals values

Elements	Values
Humidité(%)	86.0 ± 0.47
protéine (%)	48 ± 0.52
Cendre (%)	10.03 ± 0.44
Fibre (%)	5.89 ± 0.05
Energie (kcal/kg)	3755 ± 190

Source : B.O. Odesanya *et al.*, 2011

Table 6 : Minérals elements

Elements	Values
Ca (%)	0.344
Mg (%)	0.067
Na(%)	0.864
K (%)	0.672
Mn (%)	0.004
Zn (%)	0.007
Cu (%)	0.003
P (%)	0.970

Source : (B.O. Odesanya *et al.*, 2011)

Use of the maggots in aquaculture

The maggot meal was used in the feed of the larvae of *Heterobranchus longifilis* (Y.B. Ossey *et al*, 2014). Fish meal was replaced by maggot meal to feed the fingerlings of *Clarias gariepinus* (A.O. Aniebo *et al*, 2009). Moreover the fish meal was also replaced by the maggot meal in the feed of tilapia (J.O. Ogounji *et al*, 2006).

Perspectives

The major problem of the aquaculture is the feed. A good feed in aquaculture requires a good content of fish meal. However, the population growth in the last decade resulted in a high pressure on the natural fish resources and the shap decrease in the availability of fish products (FAO, 2012). Moreover, the captures of fishing cannot be used in aquacultures feed against human consumption, which limits the development of the aquaculture. It is urgent to anticipate the research of the animal resources not returning in competition with consumption human and being able to replace the fish meal. Invertebrates like: Earthworms, Termites and Maggots are sufficiently rich in nutritional elements just like the fish meal to be introduced into aquacultures feed.

Conclusion

Aquaculture feed of good quality without fish meal will allow the development and the profitability of the aquiculture. The use of alternative fish feed aside from the conventional fish meal the profitability and development of aquaculture.

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