BENEFICIAL UTILIZATION OF HOUSE FLY, *MUSCA DOMESTICA* [DIPTERA: MUSCIDAE]

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ABSTRACT

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The house fly, Musca domestica, is a significant pest of Man and his livestock mainly because of its disease vectoring capacities and the fact that it constitutes a serious nuisance. Several cultural chemical and biological measures have been used to reduce house fly populations. Despite the fact of the known hazards this insect can pose, there are certain benefits man can gain through the utilization of this insect. Utilization of house fly can serve as an alternate protein source for livestock, a possible forensic indicator and can be implemented in the wastes management that has organic origins. However, to achieve the full utility of these flies, several challenges have to be surmounted.

Keywords: beneficial, house fly, protein source, waste management.

INTRODUCTION

The house fly, *Musca domestica* L., is one of the most notorious pests in terms of damage caused to Man and his livestock. The origin of the house fly is believed to have been from the savannah area of Central Asia, but today, it has a cosmopolitan distribution (Hussein & John, 2014; Ommi et al., 2015). In fact, this fly has significant medical and veterinary importance because of its ability to transmit hundreds of disease-causing organisms, such as bacteria, fungi, viruses, protozoans and metazoans (Nassiri et al., 2015; Tsagaan et al., 2015). The transmission of pathogens by *M. domestica* occurs usually when the fly makes contact with man, his food, livestock and their feed (Malik et al., 2007). Specific examples of pathogens transmitted by this fly are *Entamoeba coli*, *Entamoeba histolytica*, *Sarcocystis spp.*, *Toxoplasma gondii*, *Isospora spp.*, *Giardia spp.*, *Endolimax nana*, *Trichomonas spp.*, *Hammondia* and *Cryptosporidium parvum* (Graczyk

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et al., 2001). The characteristic of the pathogens carried by house flies depends on the geographical region from which the insect was collected (Khamesipour et al., 2018). For instance, house flies captured from the hospital environment or animal farms have been shown to carry bacteria and fungi that are resistant to antimicrobials (Hemmatinezhad et al., 2015; Nassiri et al., 2015). The fly is regarded as a successful insect because of its ability to multiply rapidly aided by its high fecundity. The menace caused by this fly can be minimized through proper control measures. Cultural, biological, and chemical methods are used to control the influx of house flies (Iqbal et al., 2014). However, the cheapest of these methods in terms of cost and environmental safety is cultural while the most commonly used one is the use of chemicals which is said not to be eco-friendly. The development of resistance in house flies to chemical insecticides and their associated toxicity has prompted researches into the development of safer alternatives for house fly control (Abbas et al., 2013). This has made the use of safer alternatives such as biological control or insect growth regulators (IGR) to gain attention as a veritable tool in house fly management programmes (Tunaz & Uygun, 2004). Although house flies are serious pests, they have some positive uses and benefits. Such benefits include the use of house flies in solving crimes as in the case of forensic entomology, production of feeds for livestock and its utilization in waste management. This review seeks to explore diverse ways of which the activities of house fly can be of benefit to man and his activities.

BENEFICIAL ASPECTS OF HOUSE FLIES

A possible forensic indicator

Forensic science can be defined as the application of scientific techniques and principles to provide evidence to legal or related investigations and determinations (Tilstone et al., 2006). Forensic entomology is focused on the use of the behaviour and life cycle of arthropods attracted to the corpse to provide such evidence. Different insect species are associated with various stages of the decomposition process of corpses. This process can be divided into five stages namely fresh, bloated, active decay, post decay and dry (Catts & Goff, 1992). Two major groups of insects namely Diptera and Coleoptera are associated with decomposition processes of corpses (Carvalho & Linhares, 2001). The first to arrive a site of a corpse is a dead body are dipteran families of Calliphoridae (blow flies) and then Sarcophagidae (flesh flies) but Muscidae (house flies) delay colonization until the body reaches the bloated stage of decomposition (Joseph et al., 2011). Coleopterans usually come during the later stages of decomposition (Kökdener, 2012). A critical factor in death scene investigations is the correct estimation of post mortem interval (PMI) whenever death is not witnessed (Anderson and Hobischak, 2004). Post mortem interval is the time between death and corpse discovery (Sukontason et al., 2007). Several scientific methods are used in the determination of PMI, however, approaches based on entomological data are perceived to be the most valuable and accurate when medical parameters are no longer relevant (Hall, 2001). Insect evidence is used in determining the PMI based on the estimated period of insect activity (Tomberlin et al., 2011). Insect activity period (IAP) is described as the time from insect colonization until the discovery of the corpse following death. Knowledge of insect succession on corpse and calculation of the growth rates of the insects feeding on the corpse are the two approaches used in the estimation of PMI based on entomological evidence (Anderson, 2015).

Despite Muscidae not being frequently mentioned in forensic studies, many of them are frequently attracted to a corpse (Grzywacz et al., 2017). Nevertheless, some researchers have reported the high diversity of Muscidae among arthropods that are attracted to a decomposing corpse in the rural and forest parts of Central Europe (Matuszewski et al., 2008; 2010; Mądra et al., 2015). The muscid species greatly outnumbered Sarcophagidae that is widely regarded as one of the most important forensic classes of insects in these environments (Matuszewski et al., 2010; Szpila et al., 2015). Specific synanthropic species such as *Musca domestica* and *Muscina stabulans* are likely to be linked with corpses under household conditions and maybe the only colonizers of a body under such circumstances (Smith, 1986; Grzywacz et al., 2017). In such cases where house flies are found on a corpse site, can be used as a tool in solving drug-related crimes, abuse and neglect. The immature stages, when found on a crime scene, can be taken to the laboratory for analysis. This is so because of the habit of the immature stages of the insect. In fact, larvae feed on all types of substrates in the decaying body. Hence, the body composition of the immature stages will contain substances emanating from the dead body. In such cases, the larvae that feed on this body can be macerated and analysed using techniques such as thin-layer chromatography, gas chromatography and/or mass spectrometry (Joseph et al., 2011). These analyses when done can reveal the kind of substance found on or in the immature stages of the insect.

Waste management

The lifestyle and the breeding type of house flies make them perfect candidates for waste decomposition. In fact, house fly larvae feed on diverse organic matter. When they develop in animal manure, they extract the nutrients as they tunnel in the excrements. Their tunnelling activity helps improve the structure of the substrate. During the biodegradation of manure, the maggot action alone is not responsible for the changes that occur in the manure. However, this change occurs as a result of the interaction between the fly larvae and microflora (bacteria, yeast and fungi) that are resident in the manure. The major role the fly larvae plays in biodegradation is to mechanically aerate the manure through their movements which usually leads to an increase in the water loss and ammonia which favours the growth of aerobic microorganisms (Beard & Sands, 1973). Not all bacteria resident in the manure favours the growth of the maggot as some have been shown to have a negative effect on their growth (Zurek et al., 2000). Biodegradation of wastes could be enhanced by inoculating the larva substrate with conspecific larval gut bacteria or a commercial bacterial product (Yu et al., 2011; Zhang et al., 2012). This will improve the efficiency of bioconversion and rate at which the larva grows, thus increasing the speed of biodegradation. During the process of biodegradation by the fly larvae, there is an increase in temperature within substrate rises and the pH changes from neutral to alkaline, thus causing an increase in the release of ammonia making the activities of some enzymes within medium shifts tremendously and also a decrease in moisture (Zhu et al., 2012). All these activities when complete decrease the humidity and odour emissions in biodegraded manure (Wang et al., 2013). The end products of manure processed by fly larvae have a loose granular structure with earthy odour and this makes it fit for usage as an organic fertilizer for crops (Kovačik et al., 2010). Aerobic composting can be further used in the treatment of manure to greatly reduce its volume. Renčo et al. (2011) stated that manure residues may be used as a soil amendment to reduce the numbers of cysts, eggs and juveniles of several species of potato cyst nematodes. House fly larvae can break up and dry out large amounts of poultry manure, and this ability makes them a potential biological tool for waste management in poultry farms (El Boushy et al., 1985).

Animal feed supplements

The production of livestock can be resource consuming as livestock occupies about 30% of the world's ice-free surface and constitute 8% of the total global human water use majorly for the irrigation of the crops they feed on (Food and Agriculture Organization [FAO], 2009). Because keeping livestock can greatly deplete Earth scarce resources, finding other sustainable means to provide animal food is important. One of such ways looking into how insects could be used to supplement food sources for livestock (Van Huis et al., 2013). Insects are perfect candidates as livestock food because of their fast reproduction and short life span, besides being cold-blooded. Hence, they have a high feed conversion rate and proficiency, and they can be rear on virtually any substrate because they feed on a diverse range of food (Makkar et al., 2014). Some species of insect such as *M. domestica* thrive on waste products that are even generated by farm animals. House fly is equipped with the ability to convert waste (such as manure and decaying organic waste that they feed on) into high protein feedstuffs that can be used to feed farm animals. (Hussein et al., 2017). The use of poultry manure to grow house fly larvae has been shown to be of great benefit as it can act as an alternative protein source in poultry nutrition (Pretorius, 2011). The best conditions that support the optimum development of house fly larva are the warm temperatures above 25 ° C and the availability of moisture. The productivity of the substrate is highly efficient as small amounts may help the development of numerous larvae (Hardouin & Mahoux, 2003). For example, 1500 maggots can be produced using 450 g of fresh manure (Hussein et al., 2017). House larvae and pupae meal in the diet of animals such as fish, pigs and poultry birds have been proven to have no negative effect on these animals (Hussein et al., 2017).

Mass production of larva and pupa

Several techniques can be used to mass-produce house fly larvae and pupae. However, the major technique being used follows the one that was described by Miller et al., in 1974. This technique involves the filling of manure tanks or crates that are intermittently sprinkled with water to ensure that the manure is moist, making it attractive to the fly. The temperature is then set between 25–30°C as lower temperatures lead to poor larval growth. The moisture range is also controlled by keeping it between 60–75%. Examples of substrates that may be used in breeding house fly larvae include animal offal, poultry manure, pig manure, cattle intestines and rumen contents, cattle blood and wheat bran, bovine blood and intestine contents, hatchery and wheat bran, fish intestines and a mixture of egg contents, and all sorts of food waste. (Odesanya et al., 2011; Ossey et al., 2012; Čičková, et al., 2012; Zhu et al., 2012, 2015; Niu et al., 2017; Fitches et al., 2018; Hashizume, 2019).

Method of Harvesting Larva and Pupa

House fly maggots can be harvested using a variety of methods. Flotation and screening methods are the most common methods used (Hussein et al., 2017).

Flotation method: This involves mixing the manure with water to make the larvae and the pupae float out. The larvae and pupae are then collected using a sieve.

Screening method: This approach uses the fact that larvae are photophobic. Manure containing larva or pupa is spread over a thin layer of 3 mm mesh net over a bath. This setup is placed where the sunlight is. So, as the larvae try to escape the sunlight, they pass through the screen and fall into the basin (Sogbesan & Ugwumba, 2006).

For the two methods described above, the larvae and pupae collected are washed, killed in hot water, dried and milled.

CHALLENGES TO THE BENEFICIAL UTILIZATION OF HOUSE FLY

Financial constraints: the establishment of a waste treatment plant, which would involve the use of fly larvae to degrade waste, usually requires considerable financial resources to execute the project. This type of plant requires a large area of land (e.g. 1100 m^2), 5 permanent workers to process approximately 3 tons of organic waste per day. (Diener et al. 2009). A typical example is a fly waste treatment planted in Costa Rica with an initial construction cost of about $85,000 and annual running costs (including salaries) of $35,700 (Diener et al. 2009).

Design and operation of house fly biodegradation/larvae production facilities: During concentrated stages of biodegradation, a large quantity of heat and highly volatile compounds (by-products) is generated. As such, provision has to be made in the designing of these facilities to give room for cooling as differences between the temperature of the larvae substrate and the environment may amount to 12.5˚C (Zvereva, 1984). For better management of such facilities, biodegradation and egg-production zones could be divided into subunits. The separate monitoring and management of each unit will help forestall problems such as parasitoid attack or any diseases that may pose a threat to the flies' welfare.

Quality control measures: insect development is an ever-changing process that is largely controlled by several biotic and abiotic factors. Since the backbone of waste biodegradation by fly larvae is largely dependent on the meticulous mass recovery of these insects, measures must be put in place to maintain the desired fly strain. These measures are important for the continuity of the biodegradation facility. Routine measures such as continuous health monitoring, egg productivity of adult fly colony, egg hatching index, basic parameters of larval development and physicochemical parameters of end products of the biodegradation process (Hussein et al., 2017). Problems associated with inbreeding should be prevented to avoid instances of decreased fitness in the strain of flies (Day et al., 2003). Decreased fitness may have an impact on their biodegradation capabilities in waste management and nutritional value when used as feed. Ample food and desired environmental conditions should be provided to adults (Pastor et al., 2011). Effective monitoring of the colonies to avoid infection of the flies, parasitoid and entomophagy attack should be done (Diener et al., 2011; Čičková et al., 2012).

Legislation affecting insect utilization: the primary objective of any government around the world is to control and eliminate insects that have established themselves as pests and vector of diseases. Such insects are generally treated as pollutants. This has led to a serious obstacle to the use of insects known to have a harmful effect on the welfare of man under strict legislation. If these regulations are relaxed mainly for the sole purpose of the beneficial use of these groups of insects in feed production and waste management, this will go a long way towards improving the ethical challenges associated with their use.

Technological development: currently, there is a dearth in the development of modern technologies that will make the rearing and utilization of flies in the production of feed and organic waste biodegradation to be highly efficient. In the case of fly biodegradation facilities, the main problem is the increase in temperature and the mass production of harmful by-products, which may pose serious health risks to workers. (Čičková et al., 2012). An effective method for removing such a by-product has not been developed at present. Therefore, if such technology can be invented, this kind of problem will be adequately addressed.

CONCLUSION

Some insects that are known pests in terms of the nuisance and diseases vectoring capacity could be made useful. Considering their habits and way of life, they could be transformed into useful ventures. The problem of house fly can easily be curbed when proper control measures are employed. The combination of different methods for the prevention and control of infestations of house flies, i.e. integrated house fly control program (IPM – Integrated Pest Management) is recommended. Once they are properly controlled, it becomes imperative to focus on the beneficial parts. House fly larvae / pupae production is a good alternative for integrated agricultural aquaculture production to provide high-quality protein to produce fish, chicken and pigs. Problems associated with organic waste management can be addressed using house fly larvae to convert them into useful substances that could be used to enrich the soil to increase its fertility.

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