Kwaghe International
Journal of Sciences and Technology

ISSN : 0000-0000
Index: Harvard, Boston, Sydney University, Dimensions, Lens, ResearchGet Scilit, Semantic, Google Scholar, Base etc

https://doi.org/10.58578/KIJST.v1i1.3685

A Review: Biochemical Role of House Fly in the Transmission of Medically Important Parasites

Emmanuel Askebnde Joel[1], Emmanuel Alooma[2], Ubur Terzulum Wilson[3], Isaac John Umaru[4], Kingsley Iyoko Iseko[5], Dafup Katdel Istifanus[6]
[1,2,3,4]Federal University Wukari, Taraba State. Nigeria
[5]Limi Hospital Limited Abuja Nigeria
[6]David Umahi Federal University Teaching Hospital, Ebonyi State Nigeria
umaruisaac@gmail.com

Article Info:

Submitted:	Revised:	Accepted:	Published:
Jul 1, 2024	Jul 20, 2024	Jul 27, 2024	Jul 31, 2024

Abstract

House flies (Musca domestica) can be found everywhere in the world except Antarctica, especially in regions with dense populations, hot weather, and inadequate hygiene. They are insects of small to medium size, featuring a unique gray body and big compound eyes that are colored red. House flies experience full metamorphosis, which includes four separate life phases: egg, larva (maggot), pupa, and adult. House flies are seen as important pests for public health because they can carry various pathogens, such as bacteria, viruses, protozoa, and parasites. Because of their close connection to human actions, capability to travel far distances, and inclination to breed in decaying organic material, they are highly effective carriers for transmitting different illnesses. House flies have been linked to the spread of more than 100 different disease-causing microorganisms, leading to illnesses like gastroenteritis, dysentery, and cholera. Apart from bacterial pathogens, house flies have also been discovered to play a role in spreading different viruses and medically significant parasites. This review describes the physical characteristics and behavior of the house fly, highlighting its unique attributes like compound eyes, antennae, thorax, abdomen, and wings. The stages of development of a house fly, from egg to larva, pupa, and adult. It also offers distinct ways in which house flies can spread medically significant parasites, emphasizing the public health impact of this occurrence, especially in regions with inadequate sanitation and restricted healthcare access. It is essential to comprehend the role of house flies in transmitting these parasites in order to create successful control methods and enhance public health results.

Keywords: Houseflies, Parasites, Disease transmission, Public health, Food Poisoning

Introduction

One of the world's most common and well-known insects is the house fly (Musca domestica). As members of the order Diptera, or true flies, they are members of the family Muscidae (Greenberg, 1971). With the exception of Antarctica, house flies are present on every continent. They are most common in regions with dense populations, warm temperatures, and inadequate sanitation (Graczyk et al., 2001).

The typical length of house flies is between 6 and 8 millimeters, making them tiny to medium-sized insects (Greenberg, 1971). Their body color is a characteristic gray, and they feature huge, red compound eyes and four dark longitudinal stripes on their thorax (Greenberg, 1971). House flies are typically 6 to 8 millimeters long, making them small to medium-sized insects (Greenberg, 1971). Their body color is gray, and they have large, red compound eyes and four dark longitudinal stripes on their thorax (Greenberg, 1971). House flies are typically 6 to 8 millimeters long, making them small to medium-sized insects (Greenberg, 1971). Their body color is gray, and they have large, red compound eyes and four dark longitudinal stripes on their thorax (Greenberg, 1971).

House flies undergo complete metamorphosis, with four distinct life stages: egg, larva (maggot), pupa, and adult (Greenberg, 1971). The eggs are usually placed in groups of 100 to 150 on substrates high in decaying organic matter, such as animal excrement, rotting foliage, and food waste (Greenberg, 1971). The eggs hatch into larvae, or maggots, which feed on organic debris and travel through three larval instars before pupating. The pupal stage lasts around 3 to 6 days before the adult flies emerge (Greenberg, 1971). Adult house flies have a relatively limited lifespan, usually 2 to 4 weeks, but they can live for up to a month under ideal conditions (Greenberg, 1971).

House flies are recognized for their quick breeding speed and capacity to adjust to numerous environments. Greenberg (1971) stated that in ideal conditions, females have the ability to lay a maximum of 500 eggs in their lifetime, with the entire life cycle potentially finishing in just 10 days. House flies are commonly found in human settlements because they prefer to reproduce in places with lots of organic waste, according to Graczyk et al. (2001).

Importance of House Flies in Public Health

House flies are regarded significant public health pests because of their ability to spread a variety of infections such as bacteria, viruses, protozoa, and parasites (Graczyk et al. 2001). Their intimate relationship with human activities, capacity to travel large distances, and affinity for breeding in decaying organic materials make them an effective disease vector (Graczyk et al., 2001).

House flies are known to transmit over 100 harmful pathogens, including Salmonella spp., Shigella spp., Escherichia coli, Vibrio cholerae, and Campylobacter spp. (Greenberg, 1971; Graczyk et al., 2001). These bacteria can cause a variety of ailments, including gastroenteritis, dysentery, and cholera, and can be spread through the mechanical transfer of pathogens from contaminated surfaces or materials to food, drinks (Greenberg, 1971; Graczyk *et al.,* 2001).

In addition to bacterial diseases, house flies have been linked to the spread of viruses such as hepatitis A, poliovirus, and enteroviruses (Graczyk et al., 2001). Flies can take up these viruses and deposit them on food or other surfaces, potentially spreading viral illnesses (Graczyk et al., 2001).

Furthermore, house flies have been found to be involved in the transmission of a number of medically significant parasites, which are the subject of this chapter. The ability of houseflies to mechanically transfer or serve as intermediate hosts for these parasites can have serious public health effects, especially in locations with inadequate sanitation and limited access to healthcare (Graczyk et al., 2001).

House flies are important in public health because of their widespread presence, close relationship with human activities, and capacity to serve as vectors for the transmission of a variety of illnesses. Understanding the specific processes via which house flies transmit medically significant parasites is critical for creating effective control tactics and improving public health outcomes.

General Description

Morphology

Its management is strongly reliant on correct identification; hence its morphology is detailed. The house fly's head is famous for its reddish-colored compound eyes, which give superb eyesight. The house fly's antennae are positioned in the slender neck that connects the head to the thorax. A fully-grown fly measures 1/4 inch in length and has four black stripes on its thorax (Grywacz et al., 2012). These antennae are small, three-segmented, and finish with a slender bristle-like arista, which distinguishes the house fly. The thorax is the main portion of the house fly's body, where the wings attach. The thorax is typically grey in hue, with four darker dorsal longitudinal stripes create a remarkable visual element. The thorax also houses the legs, which are blackish-brown in color. The thorax contains the house fly flying muscles, which are responsible for the insect's amazing ability to fly (Iqbal et al., 2014). The abdomen is the back portion of the house fly's body, and it contains the insect's reproductive organs.

The house fly's ovipositor, a modified segment used by females to lay eggs, is also located in the abdomen (Ashok et al., 2023). The house fly has one pair of veined wings that give it remarkable flight abilities. Its antennae are short, three-segmented, and end in a slender bristle-like arista (Schaumberg et al., 2016). Its compound eyes, which have excellent vision, are capable of processing visual information around seven times faster than humans, which is necessary for the house fly to survive in a fast-paced environment (Khamesipour et al., 2018).

The adult house fly has a length of 6 to 7 mm, making it a very small insect. In comparison to males, females have a somewhat wider gap between their eyes and are significantly larger. The thorax and abdomen of a house fly have darker patterns than the body, which is typically grey or yellowish in hue. The transparent wings feature a vein network that helps with support and makes flying easier. Halteres are the tiny, club-shaped structures at the base of the wings of the house fly (Siriwattanarungsee et al., 2005).

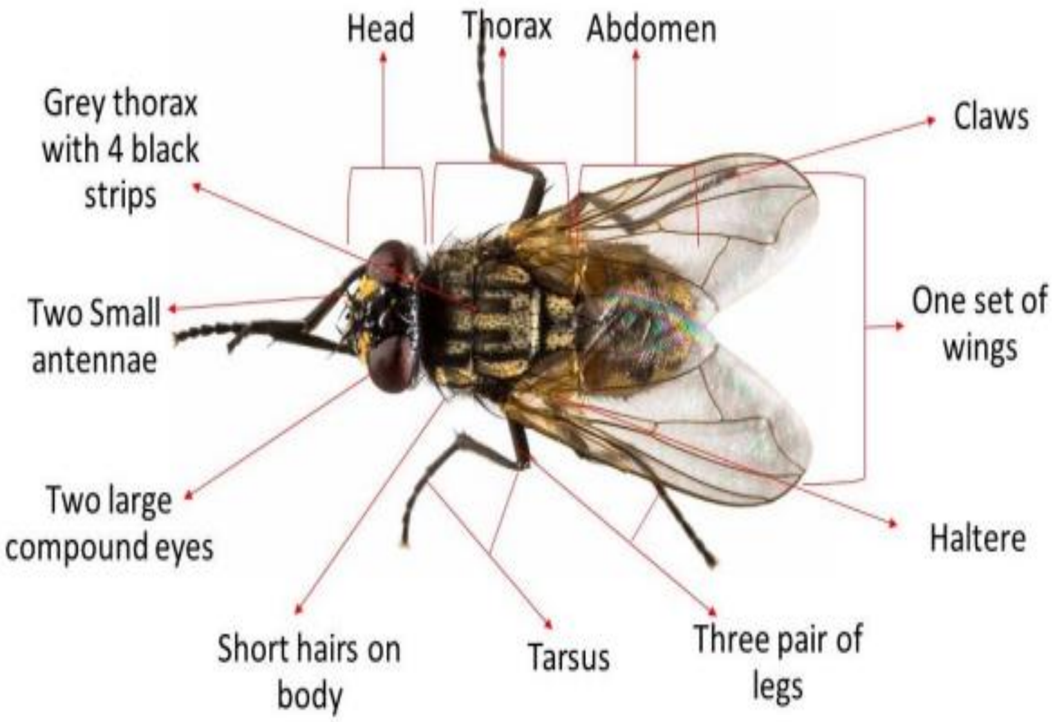

Figure 1: Morphology of Housefly (Musca domestica L.)

Biology and Life Cycle of Housefly

The house fly undergoes complete metamorphosis, or the development of all four stages of insect life—egg, larva, pupa, and adult—and develops its wings internally during the pupal stage, placing it in the superorder Endopterygota. Enough food and the right temperature are essential for its survival (de Jonge et al., 2020; Iqbal et al., 2014). A female house fly will lay between 75 and 150 eggs in each batch. The purpose of placing eggs in cracks is to keep them from drying out. Contaminated food, garbage, and animal dung serve as the main breeding sites for house flies (Schuste et al., 2013). Depending on the temperature, the average adult house fly has a lifespan of 15 to 30 days. Although mating occurs when the female is three days old, males are only ready for mating on the day they emerge. Oviposition takes place a few days following copulation (Roffeis et al., 2015). The white, pear-shaped eggs have a length range of 0.8 mm. After a day after oviposition, eggs develop into larvae, or maggots, which travel through three stages (called instars) in a week. Because they consume dead and decaying organic stuff, such as trash or excrement, maggots are saprophagous in shape, have no legs, and are 10–18 mm long and yellowish in color (Olagunju, 2022). They live for three to six days. After finishing their third instar, maggots (larvae) move to a cooler, drier region where they develop into pupae. Pupae are about 5–6 mm long and have a reddish-brown color. The pupa matures into an adult house fly in 3–7 days (van Zanten et al., 2015). Warm conditions allow house flies to finish their life cycle in two to three weeks. Owing to its rapid growth and large egg production, it quickly establishes a considerable colony. It can produce 10–12 generations year in a temperate habitat. However, they may produce four to six generations in cold areas where breeding is limited to the summer (Ahmed et al., 2015). Furthermore, house flies have an incredible capacity for reproduction. In the right circumstances, a single pair of flies can give birth to thousands of offspring in a matter of weeks. The swift increase in population presents noteworthy obstacles for pest management endeavors, necessitating integrated management approaches that focus on various phases of the fly's life cycle (Abdelgaleil et al., 2009). House fly populations are sensitive to environmental conditions that affect their development and survival, including temperature and humidity. While extreme cold can cause diapause, a state of stopped development that allows them to endure harsh conditions, warm temperatures speed up their life cycle (Ileke et al., 2020).

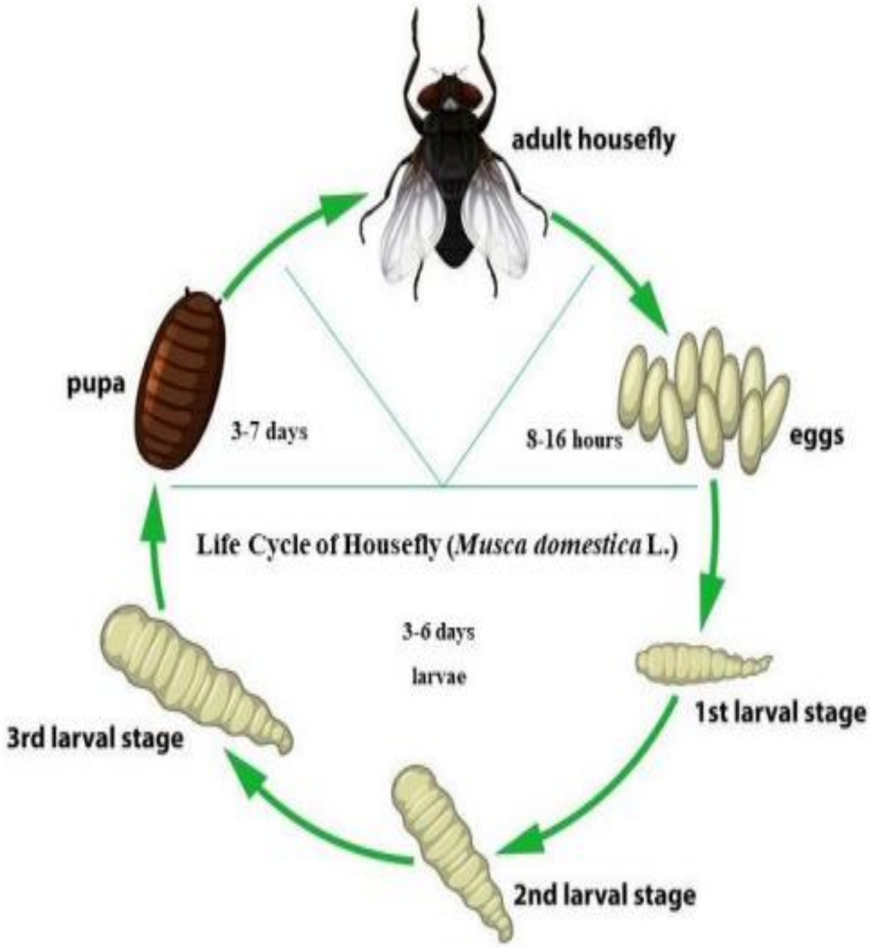

Figure 2: Life Cycle of Housefly (Musca domestica L.)

Genetics

The house fly has five pairs of autosomes in addition to an X and Y chromosome. Sex is determined by the Mdmd gene, which can be found on any chromosome and can exist in many copies. Y is most likely the ancestral chromosome of the Mdmd chromosome. The 2014 sequencing of the house fly genome revealed a high abundance of immune system effector and recognition components (Son et al., 2019; Scott et al., 2014), which is in line with the fly's close association with infections (Sharma et al., 2017). Preliminary studies revealed that male house flies did not undergo crossing-over, which is similar to the majority of Diptera. Subsequent research revealed that crossover frequencies in males differ based on the genes studied and the populations analyzed.

From 0-0.53%, 0.03-0.11%, 9.3-31%, and 7-28% are the range of estimated values (Hamm et al., 2015; Hamm and Scott, 2008). Males having Mdmd on an autosome typically have higher rates of male recombination (Feldmeyer et al., 2010).

Pest Status

There have been reports of common house flies since the dawn of human civilization. Fish markets, garbage disposal sites, slaughterhouses, and chicken farms are all known to harbor house flies, both as larvae and adults (Nazni et al., 2005). It is common to find them on human bodies in the oviposition form (Greenberg B, 1973). The house fly is a disease vector that affects people, animals, and poultry. It spreads to human environments and activities through these means (Moriya et al., 1999). It is a contributing factor to the spread of a number of illnesses in people, including typhoid, dysentery, diphtheria, leprosy, TB, and intestinal parasites; illnesses affecting poultry and cattle include anthrax and fowl cholera. Additionally, they serve as intermediate hosts and vectors for horse nematodes and some cestodes of poultry (Merchant et al., 1987).

They are the greatest carriers of animal sickness that spreads infections because they frequently migrate between animal and human sources of food and squalor. There have been reports of over a hundred distinct diseases on and in house flies. There are typically three methods in which diseases might spread. Initially, infections might adhere to certain bodily areas, particularly the legs and proboscis. Second, because the viruses liquify the food in their regurgitated saliva and then sucke it, they deposit themselves along the vomit drop onto the food. Finally, after making their way through the digestive system, germs end up in their feces (Grubel et al., 1997).

Various Controlling Methods

Generally, there is implementation of three types of control methods for suppression of house flies and other insects pests (aphid, (Sarwar *et al.,* 2014) wasp) population. The methods include cultural, biological and chemical control. Utilization of all three methods has been described by various researchers.

Cultural Control

Installing doors with mechanical opening and closing mechanisms, adjusting exhaust (blower) above doors, and covering windows and doors with gauze are some cultural practices for deterring house flies. However, odour-baited traps and electrocuting light traps are utilized indoors. Large sticky traps work better for this purpose, but their application is restricted because of a problem where dust particles quickly gather on the sticky substance (Keiding J, 1986). Odour-baited traps are not ideal because of their foul stench. Additionally, the baited traps with light and odor also contribute to the death of beneficial insects.

Generally, the usage of these traps captures a very small percentage of the housefly population because of inappropriate environmental elements such as light and odor sources (Bowden J, 1982).

The greatest cultural strategy is to properly dispose of any organic debris, including trash, as these things serve as housefly egg rearing grounds. It is a known fact that improper handling of the disposal of garbage from homes, businesses, and hospitals contributes to the existence of roughly 50% of house flies in urban areas. Garbage should be disposed of on a regular basis and waste material containers should have appropriate lids. Regular cleanups, preferably twice a week, are necessary to remove spilled feed, manure, and straw. Garbage disposal locations should have waste products covered with a layer of about 15 centimeters soil or any other suitable inorganic material every week (Kettle, 1990).

Biological Control

The use of natural enemies such as nematodes, parasitic wasps (some pteromalid species), fire ants, predatory beetles (histerial and staphylinid species), mites, flies (Hydrotaea aenescens wiedeman), and birds can reduce the population of houseflies. Using parasitic wasps is safe for both people and animals. They can locate and destroy immature houseflies, but they are unable to eradicate entire populations of houseflies. Therefore, it is recommended to utilize wasps in conjunction with other ways to control house flies (Skovgard and Jespersen, 1999). The MdSGHV virus, bacteria, fungi, nematodes, parasitic, parasitoid, and predatory insects, among other organisms, are examples of further biological control techniques.

Use of MdSGHV Virus

The virus that causes salivary gland hypertrophy in house flies is known by its acronym, MdSGH. 1990 saw its initial discovery in Florida, USA (Coler et al., 1993). The MdSGHV virus belongs to the recently identified Hytrosaviridae family. Pathogens in this family cause diseases in mature house flies and other flies, among other flies (Lietze et al., 2011a). The double-stranded, encased DNA of the MdSGHV virus. Both sexes can contract this virus, but male infection rates are higher than female rates (Lietze et al., 2007). The inhibition of yolk protein transcription and hexamerin production occurs in females infected with the MdSGHV virus, which prevents the development of young flies (Lietze et al., 2009).

Infected flies have a shorter life span and a worse success rate in mating when compared to healthy flies (Lietze et al., 2010). Less is known about the epizootiology and ecology of this virus, most likely as a result of its recent discovery (Coler et al., 1993). Additional research may improve the use of this virus as a biopesticide.

Use of Bacteria

By giving Bacillus thuringensis to chickens and cattle and introducing these bacteria to their breeding grounds in manure, it is possible to suppress the growth of house fly maggots (Miller et al., 1971).

Rupes claims that adding these bacteria directly to house fly rearing surfaces has also been documented to inhibit house flies (Rupes et al., 1987).

Early studies used bacterial strains of Bacillus thuringensis, which produces exotoxin, as a biological control agent (Carlberg, 1986). However, house flies rapidly developed resistance to exotoxin in those that had already demonstrated resistance to chemical insecticides (Wilson and Burns, 1968).

Johanson claims that several bacterial strains exhibit resistance to house flies and indicate that all bacterial strains that are active against house flies have the endotoxin Cry 1B, which is essential to their control (Johnson et al., 1998; Lysyk et al., 2010). Mwamburi et al. (2009) reported the discovery of novel Bacillus thuringensis strains for the purpose of controlling houseflies in many nations across the globe, including Egypt, South Africa, and Korea. According to reports from South Africa, the low endotoxin receptors or the acidic pH of the flies' digestive systems explain why locally obtained strains of Bacillus thuringensis subspecies israelensis (Bti) have little effect on housefly population control (Mwamburi et al., 2011a).

Use of Fungi

According to reports, adult house flies died after four to six days of coming into contact with the conidia of fungi such as Entomophthora muscae and E. schizophorae. Temperature and relative humidity have a correlation with the conidial discharge's duration and intensity for optimal operation (Kalsbeek et al., 2001). Around 50% of house flies in temperate regions become infected throughout the fall due to natural epizootics (Six and Mullens, 1996).

Beauveria bassiana and Metarhizium anisopliae have the drawback of killing house flies over a longer period of time—4-6 days—compared to 34 newer strains of fungi that kill house flies in less than 24 hours (Mwamburi et al., 2011b). Additionally, improved outcomes are possible. Furthermore, genetic alteration of the pathogen fungus can yield improved outcomes (Fan et al., 2010).

Use of Nematodes

Nematodes like Steinernematids and Heterohabditids can regulate the population of house flies (Taylor et al., 1998). An early report (Belton et al., 1987) stated that nematodes were a better fit for controlling house fly numbers in British Columbian chicken farms. However, one negative was that they did not demonstrate improved performance with manure from pigs and poultry (Renn, 1995; Renn, 1998). Conversely, combining cow dung with soil or bedding has favorable outcomes since nematodes like this type of habitat [48]. Nematodes are also more readily available on a commercial scale, which makes them superior for controlling the number of house flies while they are still larvae.

Use of Essential Oils obtained from plant sources

According to reports, essential oils' octopaminergic activity and acetyl cholinesterase inhibition give them fumigant pesticide qualities (Isman, 2000). Reportedly, the application of botanical oils has altered the attraction, repulsiveness, and toxicity of house flies when they come into touch with them at various phases of development (Koul et al., 2008). For adult house flies, essential oils with certain concentrations of 1, 8-cineole, menthol, limonene, and pulegone exhibit effective toxicity. According to reports, treatments that just include one active ingredient perform worse than combinations of oils that are helpful against house flies, such as bay laurel, blue gum, pennyroyal mint, peppermint, and rosemary (Urzua et al., 2010).

The biological management of the house fly population may benefit from new formulations and improved application of synergists, or botanical essential oils.

Use if insects as predator, parasite or parasitoid of Housefly

Large-scale consumption of house fly eggs and larvae is carried out by macrochelid mites and Histerid beetles (Hogsette et al., 2002). According to reports, Hydrotae (Ophyra) larvae have been shown to be facultative predators that can control the number of house flies (Achiano and Giliomee, 2005). For decades, a more effective biological control agent for the population of house flies has been a pteromalid parasitoid that feeds on them when they are pupae (Geden and Hogsette, 2006).

Use of Chemical Control

It is highly important and effective to apply insecticides to reduce the number of house flies.

It has been noted that housefly baits such as Quick Bayat-R and Golden Marlin-R are typically made of sugar and contain a substance that draws adult house flies to them. As a result, when adult house flies approach these baits, they are killed by feeding on the baits (insecticides). Numerous pesticide sprays with a prehyoid basis have the ability to reduce house fly populations in locations where people live. Additionally, it was noted that house flies shown resistance to pesticides such as carbamate, pyrethoid, DDT, and organophosphates (Perry AS, 1958; Buttler et al., 2007). Furthermore, it was noted that there was resistance to growth regulators such as cyclozine and diflubenzuron (Shen and Plapp, 2000).

When used early on, insecticides are a very effective way to control the population of house flies. However, because house flies have enzymes that break down pesticides or because they have adapted their behavior to avoid pesticides, they can easily become resistant to persistent insecticides (Sheppard et al., 1990). Furthermore, similar to juvenile hormone mimics, cross resistance has also been noted (Sheppard et al., 1990; Scott et al., 2000).

The toxicity level of pesticides for creatures other than house flies, rising insecticide costs, and resistance and tolerance of house flies to pesticide use are some of the reasons that reduce the effectiveness of using insecticides. Moreover, it seems difficult to find novel pesticides, and developing them comes at a great expense (Scot et al., 1989).

House fly impact on human and animal systems

Financial Losses

The current economic impact of the house fly epidemic is difficult to calculate. After taking inflation into account, a 2001 estimate of the annual cost of insecticides for fly control in the chicken industry is currently about $30 million (Geden et al., 2001). The estimates for the swine and dairy industries, after deducting inflation, are $35 million and $135 million, respectively. Consequently, it is feasible to determine that the combined cost of these three commodities for the use of insecticides to control house flies is around $200 million. In 1976, the projected cost of damage and control incurred due to house fly was $450 million. Even after accounting for inflation, these figures are clearly low.

One reason for this is the high cost of settlements from prior lawsuits against manufacturers. As populations migrate, tensions between formerly separate agricultural activities and residential areas are growing. The recent $50,000,000 million settlement for disturbance allegations related to hog farms against Smithfield Foods included difficulties with house flies (Brown, 2018).

Human Health

Since flies maintain constant contact with decaying substrates, they are carriers of a rich and diversified bacterial population. House flies are known to carry an increasing variety of medical illnesses that can either spread directly to humans or indirectly through contaminated food (Boulesteix et al., 2005; Rahuma et al., 2005). Concentrated livestock activities are the source of many infected flies and produce large populations of house flies. These house flies have access to animal manure-borne diseases that may be zoonotic and AMR. Fly species associated with livestock have been found to carry AMR strains and illnesses that impact both humans and cattle. According to Nayduch and Burrus (2017), protists, viruses, and helminth eggs are among the other illnesses linked to wild house flies.

Flies provide a threat to people who live near sources of human pathogenic bacteria, such as landfills, wastewater treatment plants, and cattle and poultry farms (Schaumberg et al., 2016). One can illustrate how house flies contribute to the transmission of illnesses by showing the link between the frequency of diarrheal illness and fly infestation. Early DDT studies from Texas shown that controlling flies with this insecticide reduced the number of diarrheal disorders in children under five (Hung et al., 2015).

House fly as a disease vector

Musca domestica is thought to be home to a diverse array of microorganisms, such as bacteria, viruses, and fungus (Nayduch and Burrus, 2017). According to Förster et al. (2009), the house fly is an active carrier of various pathogens, such as Salmonella spp., Campylobacter jejuni, Staphylococcus aureus, Pseudomonas aeruginosa, Enterococcus, and other bacteria. It is also known to transmit contagions like Shigella spp. and Campylobacter spp. Given its intimate relationship with bacteria and its function in the spread of infections, the house fly is a model organism of choice for studies examining the diversity and significance of the microbiota of vector species.

House flies can transmit a variety of diseases, including ascariasis, tuberculosis, anthrax, dysentery, the flu, and epidemic cholera. These are a few of the most common diseases that house flies can spread (Davies et al., 2016). The prevalence of diarrheal sickness was lower in areas where pesticides were used to control flies (Raza et al., 2019).

Animal Health

Prior to and during the harvest of various livestock commodities, house flies and other filth insects play a major role in ensuring food safety (Holt et al., 2007). The number of dangerous germs associated with flies is huge and continues to grow, especially those associated with cattle. According to Khamesipour et al. (2018), house flies act as mechanical carriers for a wide range of pathogens that sicken animals. Livestock illnesses can have a variety of impacts, contingent on the type and severity of the illness.

Food-related illnesses can have a big effect on the livestock industry as a whole because some disease outbreaks can lead to severe supply reductions, trade suspensions with trading partners, and a reluctance to eat meat products from areas where cattle illnesses are found (Nayduch and Burrus, 2017).

Family of Virus	Common Name	Human or Animals infected	Distribution	Site of Isolation	Source
Paramyxoviridae	Newcastle disease virus	Both	Worldwide	Internal Organ	Barin *et al.*, 2010
Filoviridae	Ebola virus	Humans	Worldwide	Internal Organ	Haddow *et al.*, 2017
Orthomyxoviridae	Avian Influenza virus H5N1	Animals	West and Central Africa	Internal Organ	Tyasasmaya *et al.*, 2016
Arteriviridae	Porcine Virus	Animals	Worldwide	Internal Organ	Otake *et al.*, 2003
Picornavirus	Senecavirus A	Both	Worldwide	Internal Organ	Graczyk *et al.*, 1999
Hytrosaviridae	MdSGHV	Animals	Worldwide	Internal Organ	Lietze *et al.*, 2012

Table 1: Viruses isolated from the Musca domestica.

Pathogen	Extent of Dispersion	Source
Yersinia pseudotuberculosis	Contaminate environment	Zurek et al., 2001
Pseudomonas aeruginosa	Viable in excreta	Joyner *et al.*, 2013
Salmonella typhimurium	Viable in excreta	Nayduch, 2018
Salmonella schottmullerris	Viable in excreta	Hawley *et al.*, 1951
Salmonella enteritidis	Transmit to hens	Holt *et al.*, 2007
Shigella dysenteriae	Viable in excreta	Hawley *et al.*, 1951
Staphylococcus aureus	Viable in excreta	Nayduch *et al.*, 2013
***Escherichia coli* O157:H7**	Viable in excreta	Sasaki *et al.*, 2000; Fleming *et al.*, 2014
Enterococcus faecalis	Contaminate environment	Doud and Zurek, 2012
Corynebacterium pseudotuberculosis	Viable in excreta	Braverman *et al.*, 1999
Campylobacter jejuni	Viable in excreta	Gill *et al.*, 2017
Aeromonas hydrophila	Viable in excreta	McGaughey and Nayduch, 2009
Aeromonas caviae	Contaminate environment	Nayduch *et al.*, 2002

Table 2: Pathogenic bacteria transmitted by Musca domestica

Cholera

The waterborne gastrointestinal disease cholera, which is typified by severe, wet diarrhea, is caused by the bacteria Vibrio cholerae. Life-threatening symptoms such as watery diarrhea and projectile vomiting could occur. Those who do not receive prompt medical attention may experience significant fluid and salt loss, which can result in fatal dehydration in a matter of hours (Sasaki et al., 2000). A common place for flies to eat, crawl, and lay eggs is near their meal. As mechanical carriers of the bacterium V. cholerae, house flies may aid in the spread of cholera (De Jesus et al., 2004).

According to Farhana et al. (2016), cholera can transmit from person to person by the fecal-oral channel or, in the other way, through contaminated food, contaminated nonliving objects, and contaminated liquids from a long-established ecological ditch. Cholera can be effectively and readily treated by replenishing the body fluids and salts lost due to diarrhea. Oral rehydration solution (ORS), a premade solution of sugar and salts, is mixed with one liter of water to treat cases. Intravenous fluid replacement is typically required in severe cases. When it comes to lessening the intensity and length of an illness, rehydration is more important than antibiotics. People with severe diarrhea and retching should get medical help as soon as feasible in cholera-affected nations (Fotedar, 2001).

Shigellosis

Shigella bacteria spread by the use of house flies and other mechanical vectors. The peak season of the bug and the peak periods of diarrheal episodes usually coincide. House flies are known to have a liking for human waste, and bacteriologic cultures of maintained flies have shown that contact with infected human waste can result in the transmission of Shigella bacteria (Muzembo et al., 2023). Because of the relative ease with which they spread, the enduring nature of scientific diseases, the strong opposition to medicine, and the absence of a licensed injectable, Shigella contaminations pose a public health threat in emerging and transitional economies. The fly M. domestica is thought to be mostly spread via continuous contact, whereas Shigella is thought to be spread primarily by mechanical vectors, less frequently through contaminated food and drink and through oral contact with feces (Sack et al., 2004).

Lumpy Skin Disease

Lumpy skin is an epidemic viral transboundary disease with considerable economic significance that affects domestic water buffalo and cattle. The sickness can quickly spread hundreds of kilometers distant and manifest itself. Blood-sucking arthropods such as mosquitoes, stable flies, and hard ticks are the most likely carriers of LSDV (Sprygin *et al.,* 2019). The house fly may also contribute to LSDV transmission, according to recent data. The domestic house fly appears to be able to spread bacterial and viral diseases to animals. Non-biting flies can spread the illness when their proboscises get infected by feeding on rabbits with myxomatosis that have well-developed skin lesions (Barin *et al.,* 2010). 8.4. ORF Virus The Contagious ecthyma (sore mouth), which mostly affects animals worldwide but can potentially affect humans who come into contact with infected animals, is brought on by the ORF virus (Poxviridae). When ORFV infection develops, house flies have been observed gathering on body areas that have reportedly been afflicted by skin lesions (Galante *et al.,* 2019). The results demonstrate for the first time that the house fly can mechanically transport and transfer ORFV (DNA). Through fecal routes, the dipteran can also excrete the ORFV genome and deposit it in the crops (Raele *et al.,* 2021).

Ascariasis

Human ascariasis disorders are brought on by the Acrididae family parasitic worm Ascaris lumbricoides. It is the most prevalent parasitic worm in humans. Ascaris infects hosts by a fecaloral route. Ascaris larvae grow in the parenteral tissues of the host once infected eggs are ingested and hatched (Dold and Holland, 2011). It is widely accepted that house flies contribute to the spread of helminth eggs, including A. lumbricoides. Ascariasis is the most typical kind of roundworm infection (Emmanuel *et al.,* 2016).

Corona Virus

The fecal-oral route, respiratory secretions, direct contact with surfaces infected with the virus, and unclean hand contact with the eyes, nose, and mouth are all routes through which coronaviruses can transmit. Most coronaviruses are only mildly harmful, but they can infrequently result in more severe human disorders, including severe acute respiratory syndrome and Middle East respiratory syndrome. House flies, which are important mechanical carriers of disease, may spread this virus (Dehghani and Kassiri, 2020) when they come into contact with infected persons or even the excrement of infected people (Kassiri *et al.,* 2012).

Therefore, it becomes crucial to understand how insects like house flies contribute to COVID transmission (Nasirian, 2017).

Sanitation management and manure handling

A variety of decaying organic materials that are rich in microbial communities serve as substrates for the development of house fly larvae. The related bacteria and pathogens are continually in touch with the fly larvae, which are thus able to transport pathogens from the substrates of the larvae through pupation to adult exclusion (Marques-dos-Santos *et al.,* 2023). Furthermore, for breeding, oviposition, and eating, adult house flies congregate around areas of larval development. They can readily pick up related infections from these areas (Bjors, 2023). Muscid flies, particularly house flies, may establish and flourish in animal dung, manure-soiled animal bedding, home waste, and other decomposing organic substrates (Miranda *et al.,* 2023). These organic wastes include a wide variety of living microorganisms. The importance of these microbial communities in the growth of young muscid flies, especially house flies, has been the subject of several research studies (Hendrata and Riyanto, 2023). Poultry enterprises must keep manure dry to prevent the growth of house flies. Especially if it is wet, dairy farms should eliminate accumulated manure. Restaurants and homeowners alike should maintain the area clean and remove trash at least twice each week (Abbas *et al.,* 2013).

Medically Important parasite transmitted by Houseflies

Houseflies (Musca domestica) are notorious vectors for various pathogens due to their frequent contact with waste and human habitats. This document explores the medically significant parasites transmitted by houseflies, emphasizing their role in the transmission of bacterial, viral, protozoan, and helminthic pathogens, as well as the mechanisms and factors affecting transmission dynamics and control measures.

Bacterial Pathogens.

Houseflies are vectors for various bacterial pathogens, including Salmonella and Shigella. Salmonella spp. are responsible for salmonellosis, characterized by gastroenteritis, fever, and abdominal cramps. Shigella spp. cause shigellosis, leading to severe diarrhea, fever, and stomach pain. Houseflies acquire these bacteria from contaminated sources such as feces and then transmit them to human food and surfaces through their feeding and defecation activities. Studies have demonstrated the presence of these pathogens on the bodies and in the digestive tracts of houseflies, highlighting their role in foodborne illnesses (Tan *et al.,* 2018; Sulaiman *et al.,* 2018).

Viral Pathogens (Diarrheal Disease)

Houseflies also contribute to the spread of viral pathogens causing diarrheal diseases. Viruses such as rotavirus, norovirus, and enteric adenoviruses are commonly associated with these conditions. These viruses are highly contagious and can be transmitted through the fecal-oral route. Houseflies facilitate viral transmission by contaminating food, water, and surfaces with viral particles carried on their bodies or excreted in their feces. The association between houseflies and viral pathogens underscores the importance of controlling fly populations to prevent outbreaks (Olesen *et al.,* 2018).

Parasitic Protozoan (Amoebiasis, Giardiasis)

Houseflies play a significant role in the transmission of parasitic protozoa such as Entamoeba histolytica and Giardia lamblia, causing amoebiasis and giardiasis, respectively. Amoebiasis is characterized by diarrhea, abdominal pain, and dysentery, while giardiasis causes chronic diarrhea, malabsorption, and weight loss. Houseflies act as mechanical vectors, transporting cysts of these protozoa from fecal matter to food and water sources. The resilient cysts can survive harsh environmental conditions, increasing the likelihood of transmission (Zumla *et al.,* 2018; Kosek *et al.,* 2018).

Helminthic Parasite (Tapeworm and Roundworm)

Helminthic parasites such as tapeworms (Taenia spp.) and roundworms (Ascaris lumbricoides) are transmitted by houseflies, causing significant health issues. Tapeworm infections lead to nutritional deficiencies and gastrointestinal disturbances, while roundworm infections result in malnutrition, intestinal blockage, and impaired growth. Houseflies carry the eggs of these parasites from contaminated fecal matter to human food and water sources. The ingestion of these eggs leads to infection and subsequent health complications (Bethony *et al.,* 2018; Jourdan *et al.,* 2018).

Epidemiological Significance of House Flies in Parasitic Transmission

The epidemiological significance of house flies in the transmission of medically important parasites is well-documented in the scientific literature. Several studies have highlighted the role of house flies as vectors for a wide range of parasitic infections, contributing to the global burden of these diseases.

House flies have been implicated in the transmission of various protozoan parasites, such as Entamoeba histolytica, the causative agent of amoebiasis (ameobic dysentery) (Graczyk *et al.,* 2005; Barreto *et al.,* 1978). The mechanical transfer of E. histolytica cysts by house flies from contaminated sources to food or water has been widely reported, leading to the potential spread of this parasitic infection (Graczyk *et al.,* 2005; Barreto *et al.,* 1978).

Similarly, house flies have been observed to transmit the cysts of Giardia lamblia, a common cause of diarrheal illness known as giardiasis (Graczyk *et al.,* 2005; Fayer *et al.,* 2012). The ability of house flies to pick up and deposit Giardia cysts on various surfaces can contribute to the transmission of this parasitic infection, particularly in areas with poor sanitation and limited access to clean water (Graczyk *et al.,* 2005; Fayer *et al.,* 2012).

Cryptosporidium spp., the causative agents of cryptosporidiosis, have also been associated with house fly-mediated transmission (Graczyk *et al.,* 2005; Fayer *et al.,* 2012). The oocysts of Cryptosporidium can be mechanically transferred by house flies, leading to the contamination of food, water, and other surfaces, and subsequently causing outbreaks of this diarrheal disease (Graczyk *et al.,* 2005; Fayer *et al.,* 2012).

In addition to protozoan parasites, house flies have been implicated in the transmission of certain helminth (worm) infections, such as ascariasis caused by Ascaris lumbricoides, and enterobiasis caused by Enterobius vermicularis (Greenberg, 1973; Meunier *et al.,* 2016). The ingestion and subsequent excretion of the eggs or larvae of these parasites by house flies can contribute to the spread of these infections, particularly in areas with poor sanitation and high population density (Greenberg, 1973; Meunier *et al.,* 2016).

Furthermore, house flies have been identified as intermediate hosts for certain parasitic tapeworms, such as Hymenolepis nana, the dwarf tapeworm (Greenberg, 1973). In this scenario, the larval stages of the tapeworm develop within the body of the house fly, which can then be transmitted to humans upon the ingestion of the infected flies (Greenberg, 1973).

The epidemiological significance of house flies in parasitic transmission is particularly pronounced in developing countries, where poor sanitation, limited access to healthcare, and high population density create an environment conducive to the proliferation and spread of these parasitic infections (Graczyk *et al.,* 2001; Meunier *et al.,* 2016). Effective control of house fly populations and the implementation of proper hygiene and sanitation practices are crucial in mitigating the impact of house fly-borne parasitic diseases on public health.

Mechanism of Parasite Transmission by Houseflies

House flies typically transmit diseases through mechanical means. The bulk of infectious microorganisms are mechanically spread by house flies. As soon as the vector makes direct contact with the vertebrate host, mechanical transmission takes place (Khamesipour *et al.,* 2018). The mechanism prevents the bacteria that cause the sickness from growing within the vector. Their hairy body shape and sticky jointed appendages pad are thought to contribute to their capacity to transmit diseases (Ebenezer *et al.,* 2020). Even when there are various breeding sites and the climate is favorable, they only travel a short distance in a few days. Mechanical transmission does not lead to pathogen multiplication in the host, unlike biological transmission (Zuhora *et al.,* 2023). On the other hand, it has been demonstrated that the fly possesses enough bacteria on its body surface to cause a disease. The fact that more disease-causing organisms are typically discovered within the stomach than on the body's exterior suggests that excreta and vomitus may be the main means of pathogen transmission. House flies have a close relationship with microbes throughout their life cycle (larvae, pupae, and adults) (Miranda *et al.,* 2023).

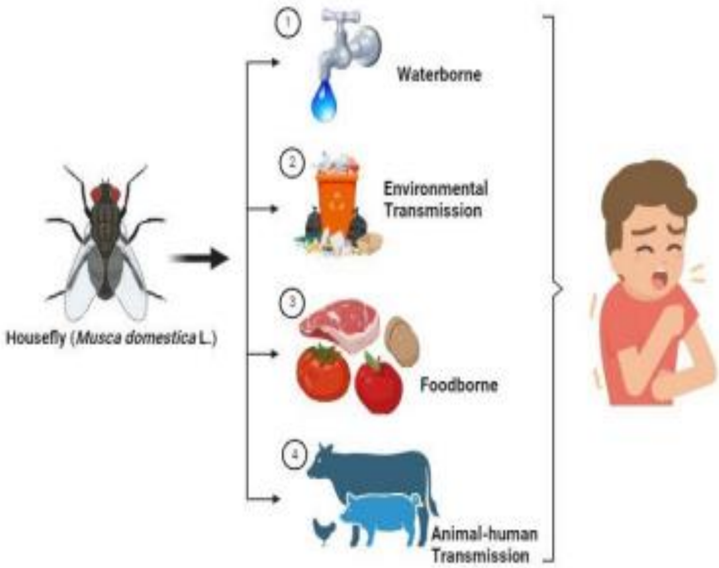

Figure 3: Diseases Transmission by Housefly (Musca domestica L.)

Houseflies transmit parasites through various mechanisms:

- Contact Transmission: Pathogens adhere to the fly's body, legs, and mouthparts when they land on contaminated surfaces. These pathogens are then transferred to food, water, or other surfaces when the fly makes subsequent contacts.
- Regurgitation and Defecation: Flies feed by regurgitating digestive enzymes onto food to liquefy it, and they often defecate while feeding. This process contaminates the food with pathogens present in their digestive system.
- Mechanical Vector: Houseflies do not host the parasites internally for their development but rather mechanically carry the pathogens from one place to another (Scott *et al.,* 2018).

Factors Affecting Transmission Dynamics

Several factors influence the transmission dynamics of parasites by houseflies:

- Environmental Conditions: Temperature, humidity, and sanitation levels significantly impact the survival and breeding of houseflies. Warmer temperatures and high humidity levels create ideal conditions for fly proliferation.
- Human Behavior: Poor sanitation, improper waste disposal, and inadequate food handling practices increase the risk of housefly-borne infections.
- Fly Population Density: Higher fly populations correlate with increased transmission risk due to more frequent contact with contaminated sources and subsequent food and surface contamination.
- Pathogen Survival: The ability of pathogens to survive on fly bodies and in the environment affects their transmission potential (Davies *et al.,* 2018).

Molecular Genetics and Pest Management

Molecular genetics has transformed the domain of pest management by providing cutting-edge methods for managing pest populations in agriculture, forestry, and public health.

Sterile Insect Technique (SIT): In SIT, several sterile insects are raised and then released into the wild. These insects don't generate any healthy offspring when they mate with their wild counterparts, which reduces the number of pests (Bourtzis and Vreysen, 2021). The development of approaches to sterilize insects without compromising their general fitness using molecular techniques contributes to the efficiency of SIT (Lance and McInnis, 2021).

RNA Interference (RNAi): The effective technology known as RNAi makes use of the natural process of gene silencing. Researchers can suppress the expression of certain pest genes, reducing pest survival and reproduction, by introducing double-stranded RNA molecules that match these genes (Kebede and Fite, 2022).

CRISPR-Cas9: The DNA of an organism may be precisely modified using the CRISPR-Cas9 system. Through the introduction of genetic alterations that impair the pests' capacity for reproduction or disease transmission, this technique has been utilized to manipulate the population dynamics of pests (Ashok *et al.,* 2023). For instance, scientists have looked at using CRISPR to change mosquito genes to lessen their capacity to spread dengue or malaria (Kyrou *et al.,* 2018).

Incompatible Insect Technique (IIT): IIT entails introducing genetically altered insects that are incompatible with the wild population into a population. The entire pest population is decreased when these modified insects scan mate with their wild counterparts because no viable progeny are born. This strategy has been investigated for eradicating a variety of insect pests, including fruit flies, house flies and mosquitoes (Pagendam *et al.,* 2020).

Wolbachia-Based Approaches: A bacteria called Wolbachia can be spread across insect populations. It has the ability to control an insect's reproductive system, reducing fertility or producing solely male progeny. This method has been researched as a means of preventing mosquitoes from carrying illnesses like dengue and Zika (Gong *et al.,* 2023).

Gene Drive Technology: Gene drive involves using genetic engineering to ensure that a specific gene is passed down to a high percentage of offspring, promoting the spread of desirable traits through populations. This technology holds potential for controlling pest populations by modifying or suppressing certain genes critical for the pests' survival or reproduction. However, ethical and ecological concerns have prompted thorough risk assessments (Schairer *et al.,* 2021; Dearden *et al.,* 2018).

Autocidal Approaches: Autocidal strategies include introducing genetic alterations that cause the pest population to die off. For instance, scientists have created mosquitoes called "RIDL" (Release of Insects Carrying a Dominant Lethal). These mosquitoes have a fatal gene that they pass on to their progeny, which eventually causes the colony to perish (Figurskey *et al.,* 2022; Mullin, 2020) Genetic Markers for Sexing: Creating genetic markers that make it simple to identify an insect's sex can be an effective strategy for pest control. Strategies like SIT are made more effective and economical by dividing the sexes before release (Koskinioti *et al.,* 2021).

Evolutionary Applications: Management tactics can be influenced by an understanding of the genetic diversity and evolutionary trends of pest populations. Genetic information may be used to monitor the migration of pests, evaluate the likelihood of resistance, and plan out the best time and place for treatments (Sudo *et al.,* 2018; Leftwich *et al.,* 2016).

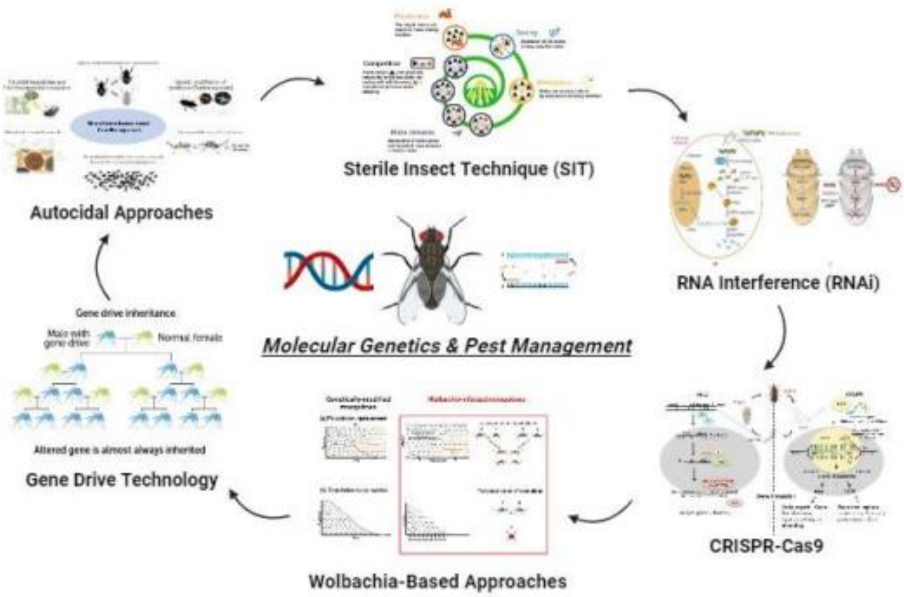

Figure 4: Different molecular methods for pest management.

Housefly Control measures

Different management techniques Three various types of management measures are typically used to reduce the number of house flies and other nuisance insects (Sarwar *et al.,* 2014). Chemical, biological and cultural control are three approaches for the management of house fly population.

Cultural Control: Culture management includes altering the environment to deprive pests of access to necessary resources. The best cultural tactic is to properly dispose of any rubbish or organic waste that might act as a breeding environment for house fly eggs. It is a fact that households, hospitals, and marketplaces with inadequate waste management are responsible for around half of all house flies in municipal areas. Regular trash collection is necessary, and waste containers should have tight lids. At the absolute least, waste should be cleaned up once a week (Khamesipour *et al.,* 2018). Sanitation should be the first step in any fly-control campaign. The materials on which house flies will lay their eggs should be separated from the adults capable of laying eggs, destroyed as a breeding site, or eliminated (Ileke *et al.,* 2020). Given that house flies may complete their full reproductive cycle in only one-week, improved dung disposal techniques, such as the proposed once-a-week disposal, can be crucial in disrupting the house fly's life cycle. The method has shown to be an economical means of reducing house fly populations. The quantity of exposed waste disposal facilities should be decreased, or sealed or protected locations should be chosen. Relocating disposal facilities away from populated regions can reduce sources of pollutants affordably (Das *et al.,* 2018).

Chemical Control: Insecticides are essential in controlling this harmful insect. The use of a variety of insecticides is thought to be a quick way to reduce the number of insects, including house flies (Norris *et al.,* 2023). Pesticides are quite efficient at controlling house fly populations when used early on; however, house flies can quickly acquire resistance to them due to either their enzymes that can break them down or their behavioral modifications that allow them to escape insecticides (Butler *et al.,* 2007). In lawns, gardens, and homes, several pesticides are mistakenly used in higher quantities, gravely jeopardizing the quality of the environment, living things, and food. Inhaling pesticides can result in neurotoxicity, oxidative stress, liver toxicity, kidney damage, hepatotoxicity, teratogenicity, carcinogenicity, and other adverse effects in mammals. Pesticide usage is less successful due to several variables, including insecticide resistance, rising insecticide prices, and insecticide toxicity for creatures other than house flies (Nteziyaremye *et al.,* 2023).

Biocontrol: Chemical insecticides are the traditional methods for controlling house flies. But in addition to being harmful to human and animal health, these chemicals can pollute land and water in a few ways. Additionally, over time, insects have a tendency to become resistant to these pesticides, which results in a recurrence of pests (Kumar *et al.,* 2011). Terpenoids and essential oils might therefore be a good alternative. Terpenoids play a significant role in plant essential oils. The pesticidal properties of plant oils are allegedly attributed to terpenoids, which mostly consist of monoterpenes and sesquiterpenes. With potential effects as a contact toxicant, fumigant, repellent, and antifeedant, monoterpenes have been shown to have insecticidal efficacy against a variety of agricultural and domestic pests (Abdelgaleil *et al.,* 2009). The neem tree, Azadirachta indica, has several chemical components that may be employed as pesticides and may be able to diminish pest populations (Koller *et al.,* 2023).

Biological Control: Natural pest enemies utilized in biological pest control include predators, parasitoids, illnesses, and herbivores. When parasitic wasps are utilized, neither people nor animals are affected. Although they can find and destroy immature house flies, they cannot eliminate house fly populations. As a result, it is advised to utilize wasps in addition to other methods of reducing house flies (Paliy *et al.,* 2018). House fly numbers will be controlled by their natural enemies, including endosymbiotic fungus and nematodes, fire ants, beetles, mites, opportunistic wasps, birds, and flies. It has been discovered that Hydrate larvae are predators for managing the population of house flies (Am *et al.,* 2022). The Hytrosaviridae family, which was very recently identified, includes the MdSGHV virus. It is known that the family may infect adult house flies and other flies (Senthoorraja *et al.,* 2022). Compared to healthy flies, infected flies have shorter lives and have a lower success rate in mating. By giving Bacillus thuringiensis to chickens and cattle, then transferring the bacteria to their breeding grounds in compost, it is possible to control house fly maggot populations (Azevedo *et al.,* 2019).

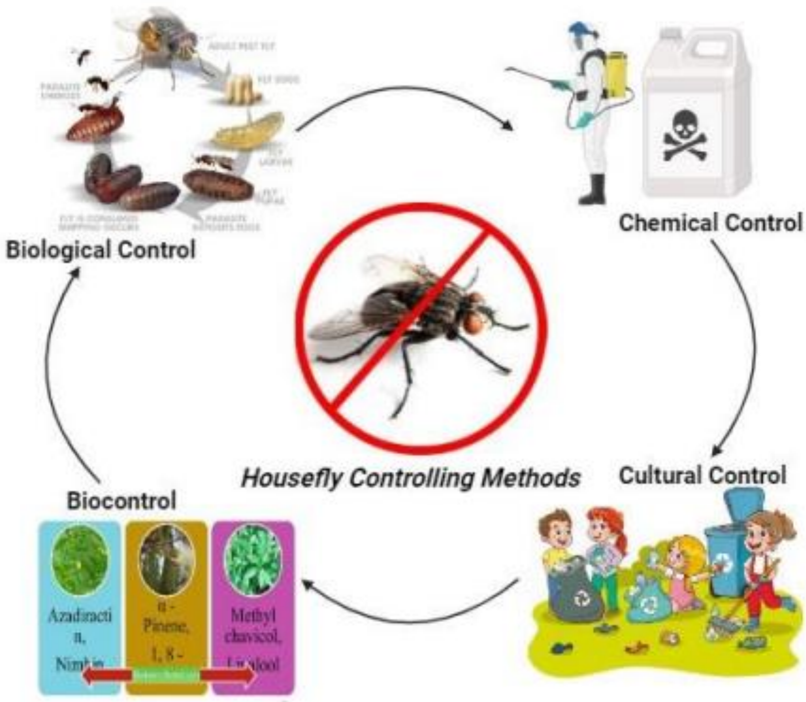

Figure 5 : Housefly (Musca domestica L.) different controlling methods.

Conclusion

The house fly (Musca domestica) is a significant public health pest due to its ability to transmit a wide range of pathogens, including bacteria, viruses, protozoa, and parasites. The flies' ubiquity, close association with human activities, and preference for breeding in decaying organic matter make them efficient vectors for the spread of various diseases. Understanding the specific mechanisms by which house flies can transmit medically important parasites is crucial for developing effective control strategies and improving public health outcomes.

References

Abbas, M. N., M. Sajeel & S. Kausar, 2013. House fly (*Musca domestica*), a challenging pest; biology, management and control strategies. Elixir Entomol, 64: 19333-19338

Abdelgaleil, S. A., M.I. Mohamed, M.E. Badawy & S.A. El-arami, 2009. Fumigant and contact toxicities of monoterpenes to *Sitophilus oryzae* (L.) and *Tribolium castaneum* (Herbst) and their inhibitory effects on acetylcholinesterase activity. J. Chem. Ecol., 35: 518-525.

Abdelgaleil, S. A., M.I. Mohamed, M.E. Badawy & S.A. El-arami, 2009. Fumigant and contact toxicities of monoterpenes to *Sitophilus oryzae* (L.) and *Tribolium castaneum* (Herbst) and their inhibitory effects on acetylcholinesterase activity. J. Chem. Ecol., 35: 518-525.

Achiano KA, Giliomee JH. Biology of the Housefly predator *Carcinops pumilio* (Erichson) (Coleoptera:

Ahmed, S., A.S. Khan, M.S. Nisar & M.M. Shakir, 2015. Effect of aqueous extracts of different plants on life cycle and population build up parameters of house fly, *Musca domestica* L. (Diptera: Muscidae). J. Agric. Sci. Technol., 4: 1-6.

Approaches in Housefly *Musca domestica* L. 1758 Management. New Fut. Dev. Biopest. Res., 281-303.

Ashok, K., C.N. Bhargava, K.P. Babu, W. Rohan, M. Manamohan, A. Rai & R. Asokan, 2023. First report on CRISPR/Cas9 mediated editing of the eye colour gene, Tryptophan 2, 3dioxygenase in eggplant shoot and fruit borer *Leucinodes orbonalis* Guenée (Lepidoptera: Crambidae). J. Asia-Pac. Entomol., 26(1): 102031.

Ashok, K., C.N. Bhargava, K.P. Babu, W. Rohan, M. Manamohan, A. Rai & R. Asokan, 2023. First report on CRISPR/Cas9 mediated editing of the eye colour gene, Tryptophan 2, 3dioxygenase in eggplant shoot and fruit borer *Leucinodes orbonalis* Guenée (Lepidoptera: Crambidae). J. Asia-Pac. Entomol., 26(1): 102031.

Azevedo, L.H., L.G. Leite, J.G. ChaconOrozco, M.F.P. Moreira, M.P. Ferreira, L.M. González-Cano & E. Palevsky, 2019. Free living nematodes as alternative prey for soil predatory mites: An interdisciplinary case study of conservation biological control. Biol. Control, 132: 128-134.

Barin, A., F. Arabkhazaeli, S. Rahbari & S.A. Madani, 2010. The housefly, *Musca domestica*, as a possible mechanical vector of Newcastle disease virus in the laboratory and field. Med. Vet. Entomol., 24(1): 88-90

Barreto, M. L., Milroy, C. A., Strina, A., Prado, M. S., & Leite, J. P. (1978). Transmission of Entamoeba histolytica infection within a family. Memórias do Instituto Oswaldo Cruz, 73(1-2), 27-31.

Barreto, M. L., Milroy, C. A., Strina, A., Prado, M. S., & Leite, J. P. (1978). Transmission of Entamoeba histolytica infection within a family. Memórias do Instituto Oswaldo Cruz, 73(1-2), 27-31.

Belton P, Rutherford TA, Trotter DB, Webster JM. *Heterorhabditis heliothidis*: A potential biological control agent of house flies in caged-layer poultry barns. Journal of Nematology 1987; 19:263-266.

Bethony, J., Brooker, S., Albonico, M., Geiger, S. M., Loukas, A., Diemert, D., & Hotez, P. J. (2018). Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm. The Lancet, 367(9521), 1521-1532.

Björs, M. 2023. Separation and acidification of digested animal manure.

Boulesteix, G., P. Le Dantec, B. Chevalier, M. Dieng, B. Niang & B. Diatta, 2005. Rôle de *Musca domestica* dans la transmission des bactéries multirésistantes dans un service de réanimation en Afrique subsaharienne. Ann. Francaises d'Anesthesie et de Reanimation, 24(4): 361-365.

Bourtzis, K., & M.J. Vreysen, 2021. Sterile insect technique (SIT) and its applications. Insects, 12(7): 638.

Bowden J. An analysis of factors affecting catches of insects in light-traps. Bulletin of Entomological Research 1982; 72:535-556

Brewer, N., M.S. McKenzie, N. Melkonjan, M. Zaky, R. Vik, J.G. Stoffolano & W.C. Webley, 2021. Persistence and Significance of *Chlamydia trachomatis* in the House fly, *Musca domestica* L. Vector-Borne Zoonotic Dis., 21(11): 854-863.

Brown, H.C. 2018. North Carolina jury fines Smithfield foods $50 million in unprecedented hog nuisance lawsuit.

Butler SM, Gerry AC, Mullens BA. Housefly (Diptera: Muscidae) activity near baits containing (Z)-9- tricosene and efficacy of commercial toxic fly baits on a southern California dairy. Journal of Economic Entomology 2007; 100:1489-1495.

Carlberg G. *Bacillus thuringiensis* and microbial control of flies. Journal of Applied Microbiology and Biotechnology 1986; 2:267-274.

Coler RR, Boucias DG, Frank JH, Maruniak JE, GarciaCanedo A, Pendland JC. Characterization and description of a virus causing salivary gland hyperplasia in the housefly, *Musca domestica.* Medical and Veterinary Entomology 1993; 7:275-282.

Das, J.K., Hadi, Y. B., Salam, R. A., Hoda, M., Lassi, Z. S., & Bhutta, Z. A. 2018. Fly control to prevent diarrhoea in children. Cochrane Database Syst. Rev., (12).

Davies, M. P., Sonego, P., & Fleck, F. (2018). Environmental factors influencing the spread of vector-borne diseases: A review. Global Health Action, 11(1), 143-152.

De Jesús, A.J., A.R. Olsen, J.R. Bryce & R.C.Whiting, 2004. Quantitative contamination and transfer of *Escherichia coli* from foods by house flies, *Musca domestica* L. (Diptera: Muscidae). Int. J. Food Microbiol., 93(2): 259262.

de Jonge, N., T.Y. Michaelsen, R. Ejbye-Ernst, A. Jensen, M.E. Nielsen, S. Bahrndorff & J.L. Nielsen, 2020. Housefly (*Musca domestica* L.) associated microbiota across different life stages. Sci. Rep., 10(1): 7842.

Dearden, P.K., N.J. Gemmell, O.R. Mercier, P.J. Lester, M.J. Scott, R.D. Newcomb & D.R. Penman, 2018. The potential for the use of gene drives for pest control in New Zealand: a perspective. J. R. Soc. N. Z., 48(4): 225-244.

Dehghani, R., & H. Kassiri, 2020. A brief review on the possible role of houseflies and cockroaches in the mechanical transmission of coronavirus disease 2019 (COVID-19). Arch. Clin. Infect. Dis., 15.

Dold, C., & C.V. Holland, 2011. Ascaris and ascariasis. Microbes Infect., 13(7): 632-637.

Emmanuel, O.N.Y.E.N.W.E., O.OW. OKORE, P.C. Ubiaru & A.B.E.L. Chika, 2016. Houseflyborne helminth parasites of Mouau and its public health implication for the university community. Animal Res. Int., 13(1), 2352-2358.

Fan Y, Pei X, Guo S, Zhang Y, Luo Z, Liao X, Pei Y. Increased virulence using engineered protease chitin binding domain hybrid expressed in the entomopathogenic fungus *Beauveria bassiana.* Microbial Pathogenesis 2010; 49:376-380.

Farhana, I., Z.Z Hossain, S.M. Tulsiani, P.K.M. Jensen & A. Begum, 2016. Survival of *Vibrio cholerae* O1 on fomites. World J. Microbiol. Biotechnol., 32, 1-8.

Fayer, R., Santin, M., & Macarisin, D. (2012). Detection of concurrent infection of dairy cattle with Blastocystis, Cryptosporidium, Giardia, and Enterocytozoon by molecular and microscopic methods. Parasitology Research, 111(3), 1349-1355.

Fayer, R., Santin, M., & Macarisin, D. (2012). Detection of concurrent infection of dairy cattle with Blastocystis, Cryptosporidium, Giardia, and Enterocytozoon by molecular and microscopic methods. Parasitology Research, 111(3), 1349-1355.

Feldmeyer, B., I. Pen & L.W. Beukeboom, 2010. A microsatellite marker linkage map of the house fly, *Musca domestica*: evidence for male recombination. Insect Mol. Biol., 19(4), 575-581.

Figurskey, A. C., B. Hollingsworth, M.S. Doyle & M.H. Reiskind, 2022. Effectiveness of autocidal gravid trapping and chemical control in altering abundance and age structure of Aedes albopictus. Pest Manage. Sci., 78(7), 29312939.

Förster, M., K. Sievert, S. Messler, S. Klimpel & K. Pfeffer, 2009. Comprehensive study on the occurrence and distribution of pathogenic microorganisms carried by synanthropic flies caught at different rural locations in Germany. J. Med. Entomol., 46(5), 1164-1166.

Fotedar, R. (2001). Vector potential of houseflies (*Musca domestica*) in the transmission of *Vibrio cholerae* in India. Acta trop., 78(1), 31-34.

Galante, D., M.A. Cafiero, D.A. Raele, N. Pugliese, I. Padalino, N. Cavaliere & C. Buonavoglia, 2019. Identification and characterization of Orf viruses isolated from sheep and goats in Southern Italy. Vet. Ital., 55(4), 347-353.

Geden CJ, Hogsette JA. Suppression of house flies (Diptera: Muscidae) in Florida poultry houses by sustained releases of *Muscidifurax raptor* and *Spalangia cameroni* (Hymenoptera: Pteromalidae). Environmental Entomology 2006; 35:75-82.

Geden, C. J., & J.A. Hogsette, 2001. Research and Extension Needs for Integrated Pest Management for Arthropods of Veterinary Importance. Proceedings of a Workshop in Lincoln, Nebraska, April 12-14, 1994 Last Updated–October 2001.

Gong, J.T., T.P. Li, M.K. Wang, & X.Y. Hong, 2023. Wolbachia-based strategies for control of agricultural pests. Curr. Opin. Insect Sci., 101039

Goulson, D., & Derwent, L. C. (2018). Effectiveness of housefly traps in reducing fly populations. Pest Management Science, 74(2), 210-215.

Graczyk, T. K., Fayer, R., Trout, J. M., Lewis, E. J., Farley, C. A., Sulaiman, I., & Lal, A. A. (2005). Giardia sp. cysts and infectious Cryptosporidium parvum oocysts in the feces of migratory Canada geese (Branta canadensis). Applied and Environmental Microbiology, 64(7), 2736-2738.

Graczyk, T. K., Fayer, R., Trout, J. M., Lewis, E. J., Farley, C. A., Sulaiman, I., & Lal, A. A. (2005). Giardia sp. cysts and infectious Cryptosporidium parvum oocysts in the feces of migratory Canada geese (Branta canadensis). Applied and Environmental Microbiology, 64(7), 2736-2738.

Graczyk, T. K., Knight, R., Gilman, R. H., & Cranfield, M. R. (2001). The role of non-biting flies in the epidemiology of human infectious diseases. Microbes and Infection, 3(3), 231-235.

Graczyk, T. K., Knight, R., Gilman, R. H., & Cranfield, M. R. (2001). The role of non-biting flies in the epidemiology of human infectious diseases. Microbes and Infection, 3(3), 231-235.

Greenberg B. Flies and disease, Volume second, Princeton, Princeton university press. New Jersy, 1973; 447

Greenberg, B. (1971). Flies and disease (Vol. 1). Princeton University Press.

Greenberg, B. (1971). Flies and disease (Vol. 1). Princeton University Press.

Greenberg, B. (1973). Flies and disease (Vol. 2). Princeton University Press.

Greenberg, B. (1973). Flies and disease (Vol. 2). Princeton University Press.

Grubel P, Hoffman JS, Chong FK, Burstein NA, Mepani C, Cave DR. Vector potential of houseflies (*Musca domestica*) for *Helicobacter pylori*. Journal of Clinical Microbiology 1997; 35(6):1300-1303.

Grzywacz, A., T. Pape & K. Szpila, 2012. Larval morphology of the lesser house fly, *Fannia canicularis*. Med. Vet. Entomol., 26(1), 70-82.

Hamm, R. L., & J.G. Scott, 2008. Changes in the frequency of YM versus IIIM in the housefly, *Musca domestica* L., under field and laboratory conditions. Genet. Res., 90(6), 493498.

Hendrata, R., & D. Riyanto, 2023. The effect of root growth regulator and environmental sanitation of salacca edulis seedling on Sleman. In AIP Conference Proceedings (Vol. 2583, No. 1). AIP Publishing.

Histeridae). Biocontrol 2005; 50:899-910.

Hogsette JA, Farkas R, Coler RR. Development of *Hydrotaea aenescens* (Diptera: Muscidae) in manure of unweaned dairy calves and lactating cows. Journal of Economic Entomology 2002; 95:527-530.

Holt, P.S., Geden, C. J., Moore, R. W., & Gast, R. K. 2007. Isolation of *Salmonella enterica* serovar Enteritidis from house flies (*Musca domestica*) found in rooms containing *Salmonella serovar* Enteritidis-challenged hens. Appl. Environ. Microbiol., 73(19), 6030-6035.

Hung, K.Y., T.J. Michailides, J.G. Millar, A. Wayadande & A.C. Gerry, 2015. House fly (*Musca domestica* L.) attraction to insect honeydew. PloS one, 10(5), e0124746

Ileke, K.D., M.F. Olaoye & I.O. Olabimi, 2020. Beneficial utilization of house fly, *Musca domestica* [DIPTERA: MUSCIDAE]. Leban. Sci. J., 21(2), 146.

Ileke, K.D., M.F. Olaoye & I.O. Olabimi, 2020. Beneficial utilization of house fly, *Musca domestica* [DIPTERA: MUSCIDAE]. Leban. Sci. J., 21(2), 146.

International Congress of Entomology 1958; 2:157-172.

Iqbal, W., M.F. Malik, M.K. Sarwar, I. Azam, N. Iram & A. Rashda, 2014. Role of housefly (*Musca domestica*, Diptera; Muscidae) as a disease vector; a review. J. Entomol. Zool. Stud., 2(2), 159-163.

Isman MB. Plant essential oils for pest and disease management. Crop Protection 2000; 19:603-608.

Johnson C, Bishop AH, Turner CL. Isolation and activity of strains of *Bacillus thuringiensis* toxic to larvae of the housefly (Diptera: Muscidae) and tropical blowflies (Diptera: Calliphoridae). Journal of Invertebrate Pathology 1998; 71:138-144.

Jourdan, P. M., Lamberton, P. H., Fenwick, A., & Addiss, D. G. (2018). Soil-transmitted helminth infections. The Lancet, 391(10117), 252-265.

Kassiri, H., K. Akbarzadeh & A. Ghaderi, 2012. Isolation of pathogenic bacteria on the house fly, *Musca domestica* L. (Diptera: Muscidae), body surface in Ahwaz hospitals, Southwestern Iran. Asian Pac. J. Trop. Biomed., 2(2), S1116S1119.

Kebede, M., & T. Fite, T. 2022. RNA interference (RNAi) applications to the management of fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae): Its current trends and future prospects. Front. Mol. Biosci., 9, 944774.

Keiding J. The housefly—biology and control. Training and information guide (advanced level). Geneva, World Health Organization, 1986 (unpublished document WHO/VBC/86.937; available on request from Division of Control of Tropical Diseases, World Health Organization, 1211 Geneva 27, Switzerland).

Kettle DS: Muscidae (Houseflies, Stableflies). In Medical and Veterinary Entomology 1990; 223–240

Khamesipour, F., K.B. Lankarani, B. Honarvar & T.E. Kwenti, 2018. A systematic review of human pathogens carried by the housefly (*Musca domestica* L.). BMC Public Health, 18, 1-15.

Khamesipour, F., K.B. Lankarani, B. Honarvar & T.E. Kwenti, 2018. A systematic review of human pathogens carried by the housefly (*Musca domestica* L.). BMC Public Health, 18, 1-15.

Koller, J., L. Sutter, J. Gonthier, J. Collatz & L. Norgrove, 2023. Entomopathogens and Parasitoids Allied in Biocontrol: A Systematic Review. Pathogens, 12(7), 957.

Kosek, M., Alcantara, C., & Lima, A. A. (2018). Epidemiology of Giardia and Cryptosporidium infections in developing countries. Parasitology, 143(1), 3-14.

Koskinioti, P., A.A. Augustinos, D.O. Carvalho, M. Misbah-ul-Haq, G. Pillwax, L.D. de la Fuente & K. Bourtzis, 2021. Genetic sexing strains for the population suppression of the mosquito vector Aedes aegypti. Phil. Trans. R. Soc. B., 376(1818), 20190808.

Koul O, Walia S, Dhaliwal GS. Essential oils as green pesticides: Potential and constraints. Biopesticides International 2008; 4:63-84.

Kumar, P., S. Mishra, A. Malik & S. Satya, 2011. Repellent, larvicidal and pupicidal properties of essential oils and their formulations against the house fly, *Musca domestica*. Med. Vet. Entomol., 25(3), 302-310

Kyrou, K., A.M. Hammond, R. Galizi, N. Kranjc, A. Burt, A.K. Beaghton & A. Crisanti, 2018. A CRISPR–Cas9 gene drive targeting doublesex causes complete population suppression in caged *Anopheles gambiae* mosquitoes. Nat. Biotechnol., 36(11), 10621066.

Lance, D.R., & D.O. McInnis, 2021. Biological basis of the sterile insect technique. Sterile Insect Technique, 113-142.

Leftwich, P.T., M. Bolton & T. Chapman, 2016. Evolutionary biology and genetic techniques for insect control. Evol. Appl., 9(1), 212-230.

Lietze VU, Abd-Alla AMM, Vreysen MJB, Geden CG, Boucias DG. Salivary gland hypertrophy viruses: a novel group of insect pathogenic viruses. Annual Review of Entomology 2011a; 56:63-80.

Lietze VU, Geden CJ, Blackburn P, Boucias DG. Effects of salivary gland hypertrophy virus on the reproductive behavior of the housefly, *Musca domestica*. Applied and Environmental Microbiology 2007; 73:6811-6818.

Lietze VU, Salem TZ, Prompiboon P, Boucias DG. Tissue tropism of the *Musca domestica* salivary gland hypertrophy virus. Virus Research 2010; 155:20-27.

Lietze VU, Salem TZ, Prompiboon P, Boucias DG. Transmission of MdSGHV among adult houseflies, *Musca domestica* (Diptera: Muscidae), occurs via salivary secretions and excreta. Journal of Invertebrate Pathology 2009; 101:49-55

Lysyk TJ, Kalischuk-Tymensen LD, Rochon K, Selinger LB. Activity of *Bacillus thuringiensis* isolates against immature horn fly and stable fly (Diptera: Muscidae). Journal of Economic Entomology 2010; 103:1019-1029.

Marques-dos-Santos, C., J. Serra, G. Attard, U. Marchaim, S. Calvet & B. Amon, 2023. Available Technical Options for Manure Management in Environmentally Friendly and Circular Livestock Production. In Technology for Environmentally Friendly Livestock Production (pp. 147-176). Cham: Springer International Publishing.

Merchant ME, Flanders RV, Williams RE. Seasonal abundance and parasitism of Housefly (Diptera: Muscidae) pupae in enclosed, shallow-pit poultry houses in Indiana. Environmental Entomology 1987; 16:716-721.

Meunier, A., Amar, M., Sow, D., Roucher, C., Legall, P., & Gantois, N. (2016). Role of the housefly (Musca domestica) in the transmission of human and animal parasites. Parasite, 23, 25.

Meunier, A., Amar, M., Sow, D., Roucher, C., Legall, P., & Gantois, N. (2016). Role of the housefly (Musca domestica) in the transmission of human and animal parasites. Parasite, 23, 25.

Miller RW, Pickens LG, Gordon CH. Effect of *Bacillus thuringiensis* in cattle manure on Housefly (Diptera: Muscidae) larvae. Journal of Economic Entomology 1971; 64:902-903.

Miranda, C.D., J.A. Cammack & J.K. Tomberlin, 2023. Large-scale production of house fly, *Musca domestica* (Diptera: Muscidae), larvae fed 3 manure types. J. Econ. Entomol., toad099.

Moriya K, Fujibayashi T, Yoshihara T, Matsuda A, Sumi N, Umezaki *et al*. Verotoxin-producing *Escherichia coli* O157:H7 carried by the housefly in Japan. Medical and Veterinary Entomology 1999; 13:214-216.

Mullin, L. J. 2020. The effects of infusion water type and fermentation time on mosquito and non-target organism collected in the CDC's Autocidal Gravid Ovitrap. J. Florida Mosq. Control Assoc., 67(1), 23-27.

Mwamburi LA, Laing MD, Miller R. Interaction between *Beauveria bassiana* and *Bacillus thuringiensis* var. *israelensis* for the control of Housefly larvae and adults in poultry houses. Poultry Science 2009; 88:2307-2314.

Mwamburi LA, Laing MD, Miller R. Laboratory and field evaluation of formulated *Bacillus thuringiensis* var. *israelensis* as a feed additive and using topical applications for control of *Musca domestica* (Diptera: Muscidae) larvae in caged-poultry manure. Environmental Entomology 2011b; 40:52-58.

Mwamburi LA, Laing MD, Miller R. Laboratory screening of insecticidal activities of *Beauveria bassiana* and *Paecilomyces lilacinus* against larval and adult housefly (*Musca domestica*). African Entomology 2011a; 18:38-46.

Nasirian, H. (2017). Infestation of cockroaches (Insecta: Blattaria) in the human dwelling environments: a systematic review and metaanalysis. Acta Trop., 167, 86-98.

Nayduch, D., & R.G. Burrus, 2017. Flourishing in filth: house fly–microbe interactions across life history. Ann. Entomol. Soc. Am., 110(1), 618.

Nazni WA, Luke H, Wan Rozita WM, Abdullah AG, Sadiyah I, Azhari AH *et al*. Determination of the flight range and dispersal of the Housefly, *Musca domestica* using mark release and recapture technique. Tropical Biomedicine 2005; 22(1):53-61

Norris, R. H., O.S. Baker, E.R. Burgess IV, A. Tarone, A. Gerry, R.T.T. Fryxell & J.G. Scott, 2023. Selection for, and characterization of, fluralaner resistance in the house fly, *Musca domestica*. Pestic. Biochem. Physiol., 191, 105355.

Nteziyaremye, P., Cherutoi, J., Makatiani, J., & Muhizi, T. 2023. Insecticidal potential of essential oils from *Cupressus lusitanica* growing in ecological zones of Rwanda against adult housefly, *Musca domestica* L. Int. J. Trop. Insect Sci., 1-13.

Olagunju, E. A. 2022. House fly: Common zoonotic diseases transmitted and control. J. Zoonotic Dis., 6(1), 1-10.

Olesen, B., Neimann, J., Böttiger, B., Ethelberg, S., Schiellerup, P., Jensen, C., ... & Molbak, K. (2018). Etiology of diarrheal disease outbreaks in Denmark, 1995–2017. The Journal of Infectious Diseases, 207(1), 144-152.

Pagendam, D. E., B.J. Trewin, N. Snoad, S.A. Ritchie, A.A Hoffmann, K.M. Staunton & N. Beebe, 2020. Modelling the Wolbachia incompatible insect technique: strategies for effective mosquito population elimination. BMC Biol., 18, 1-13

Paliy, A. P., N.V. Sumakova & K.V. Ishchenko, 2018. Biological control of house fly. Ukr. J. Ecol., 8(2), 230-234.

Perry AS. Factors associated with DDT resistance in the Housefly *Musca domestica*. Proceedings of 10th

Raele, D. A., J.G. Stoffolano Jr, I. Vasco, G. Pennuzzi, M.C. Nardella La Porta & M.A. Cafiero, 2021. Study on the role of the common house fly, *Musca domestica*, in the spread of ORF Virus (Poxviridae) DNA under laboratory conditions. Microorganisms, 9(11), 2185.

Rahuma, N., K.S. Ghenghesh, R. Ben Aissa & A. Elamaari, 2005. Carriage by the housefly (Musca domestica) of multiple-antibioticresistant bacteria that are potentially pathogenic to humans, in hospital and other urban environments in Misurata, Libya. Ann. Trop. Med. Parasitol., 99(8), 795-802.

Raza, H. A., R.M. Amir, M.A. Idrees, M. Yasin, G. Yar, N. Farah & M. Younus, 2019. Residual impact of pesticides on environment and health of sugarcane farmers in Punjab with special reference to integrated pest management. J. Global Innov. Agric. Soc. Sci., 7(2), 79-84.

Renn N. Mortality of immature houseflies (*Musca domestica*) in artificial diet and chicken manure after exposure to encapsulated entomopathogenic nematodes (Rhabditida: Steinernematidae, Heterorhabditidae). Biocontrol Science and Technology 1995; 5:349-359.

Renn N. The efficacy of entomopathogenic nematodes for controlling housefly infestations of intensive pig units. Medical and Veterinary Entomology 1998; 12:46-51.

Roffeis, M., B. Muys, J. Almeida, E. Mathijs, W.M.J. Achten, B. Pastor & S. Rojo, 2015. Pig manure treatment with housefly (*Musca domestica*) rearing–an environmental life cycle assessment. J. Insects Food Feed, 1(3), 195-214.

Rupes V, Ryba J, Hanslova H, Weiser J. The efficiency of beta-exotoxin on *Bacillus thuringiensis* on susceptible and resistant Housefly. In: Proceedings of the International Conference of Medical and Veterinary Dipterology 1987; 262-265.

Sack, D.A., R.B. Sack & G.B. Nair, 2004. Siddique Ak. Cholera lancet, 363(9404), 233233.

Sarwar MK, Azam I, Iram N, Iqbal W, Rashda A, Anwer F *et al*. Cotton Aphid *Aphis gossypii* L. (Homoptera; Aphididae); A challenging pest; Biology and control strategies: A review. International Journal of Applied Biology and Pharmaceutical Technology 2014; 5(1):288-294.

Sarwar, M. K., I. Azam, N. Iram, W. Iqbal, A. Rashda, F. Anwer & R. Ali, 2014. Cotton Aphid *Aphis gossypii* L. (Homoptera; Aphididae); a Challenging Pest; Biology and Control Strategies: A Review. (unpublished)

Schairer, C. E., J. Najera, A.A. James, O.S. Akbari & C.S. Bloss, 2021. Oxitec and Mosquito Mate in the United States: lessons for the future of gene drive mosquito control. Pathog. Glob. Health, 115(6), 365-376.

Schaumburg, F., F.C. Onwugamba, R. Akulenko, G. Peters, A. Mellmann, R. Köck & K. Becker, 2016. A geospatial analysis of flies and the spread of antimicrobial resistant bacteria. Int. J. Med. Microbiol., 306(7), 566571.

Schaumburg, F., F.C. Onwugamba, R. Akulenko, G. Peters, A. Mellmann, R. Köck & K. Becker, 2016. A geospatial analysis of flies and the spread of antimicrobial resistant bacteria. Int. J. Med. Microbiol., 306(7), 566571.

Scot JG, Roush RT, Rutz DA. Insecticide resistance of house flies (Diptera: Muscidae) from New York USA dairies. Journal of Agricultural Entomology 1989; 6:53-64.

Scot JG, Roush RT, Rutz DA. Insecticide resistance of house flies (Diptera: Muscidae) from New York USA dairies. Journal of Agricultural Entomology 1989; 6:53-64.

Scott JG, Alefanti TG, Kaufman PE, Rutz DA. Insecticide resistance in house flies from caged layer poultry facilities. Pest Management Science 2000; 56:47-153.

Scott, H. G., & Borom, M. (2018). Vectors of infectious diseases: houseflies as mechanical vectors. American Journal of Public Health, 108(S3), S178-S183.

Senthoorraja, R., P. Senthamarai Selvan & S. Basavarajappa 2022. Eco-Smart Biorational

Sharma, A., S.D. Heinze, Y. Wu, T. Kohlbrenner, I. Morilla, C. Brunner & D. Bopp, 2017. Male sex in houseflies is determined by Mdmd, a paralog of the generic splice factor gene CWC22. Science, 356(6338), 642-645.

Siriwattanarungsee, S., K.L. Sukontason, B. Kuntalue, S. Piangjai, J.K. Olson & K. Sukontason, 2005. Morphology of the puparia of the house fly, *Musca domestica* (Diptera: Muscidae) and blowfly, *Chrysomya megacephala* (Diptera: Calliphoridae). Parasitol. Res., 96, 166-170.

Six DL, Mullens BA. Seasonal prevalence of *Entomophthora muscae* and introduction of *Entomophthora schizophorae* (Zygomycotina: Entomophthorales) in *Musca domestica* (Diptera: Muscidae) populations on California dairies. Biological Control 1996; 6:315-323.

Skovgard H, Jespersen JB. Activity and relative abundance of hymenopterous parasitoids that attack puparia of *Musca domestica* and *Stomoxys calcitrans* (Diptera: Muscidae) on confined pig and cattle farms in Denmark. Bulletin of Entomological Research 1999; 89:263-269.

Son, J. H., T. Kohlbrenner, S. Heinze, L.W. Beukeboom, D. Bopp & R.P. Meisel, 2019. Minimal effects of proto-Y chromosomes on house fly gene expression in spite of evidence that selection maintains stable polygenic sex determination. Genetics, 213(1), 313-327.

Sprygin, A., Y. Pestova, D.B. Wallace, E. Tuppurainen & A.V. Kononov, 2019. Transmission of lumpy skin disease virus: A short review. Virus Res., 269, 197637.

Sudo, M., D. Takahashi, D.A. Andow, Y. Suzuki & T. Yamanaka 2018. Optimal management strategy of insecticide resistance under various insect life histories: Heterogeneous timing of selection and interpatch dispersal. Evol. Appl., 11(2), 271283.

Sulaiman, S., Othman, W. H., & Omar, B. (2018). Houseflies as vectors of bacterial pathogens causing food poisoning. Tropical Biomedicine, 35(1), 14-19.

Tan, S. W., Yap, K. L., & Lee, H. L. (2018). Transmission of Salmonella and Shigella by houseflies (Musca domestica L.). Journal of Vector Ecology, 43(1), 93-97.

Urzua A, Santander R, Echeverria J, Cabezas C, Palacios SM, Rossi Y. Insecticide properties of the essential oils from *Haplopappus foliosus* and *Bahia ambrosioides* against the housefly, *Musca domestica*. Journal of the Chilean Chemistry Society 2010; 55:392-395.

van Zanten, H.H., H. Mollenhorst, D.G. Oonincx, P. Bikker, B.G. Meerburg, B. G., & De Boer, I. J. (2015). From environmental nuisance to environmental opportunity: housefly larvae convert waste to livestock feed. J. Cleaner Prod., 102, 362-369.

Wilson BH, Burns EC. Induction of resistance to *Bacillus thuringiensis* in a laboratory strain of house flies. Journal of Economic Entomology 1968; 6: 1747-1748

Zumla, A., Petersen, E., & Nyirenda, T. (2018). Amoebiasis and giardiasis: neglected intestinal protozoal diseases in Africa. The Lancet Global Health, 6(4), e374-e375.