THE LITTLE-KNOWN WORLD OF FLIES!

Geetha Iyer

What makes flies different from a dragonfly or a butterfly? How do the lovely iridescent bluebottle and greenbottle flies help solve murders? What do insect bites, galls and chocolate have in common? Do flies have taste-buds? How do we introduce flies in science classrooms? This article explores the fascinating world of true flies, their incredible variety, and the diversity of services they provide us with, ending with an activity that teachers can use to unravel one aspect of the life of flies to students.

Introduction

"To know the fly is to share a bit in the sublimity of Knowledge." - Prof Vincent G Dethier

Flies generally conjure a vision of dirt, disease and disgust.

Our introduction to this image of flies is in school. A student is introduced to the humble housefly in a conclusive manner, leaving one with the impression that all flies are repulsive creatures. Limited scientific information about houseflies is accompanied by a vivid description of the mouth parts being used to drink from muck, thereby leaving an indelible image of a fly only as a vermin. A student's next encounter with the fly is during a lesson on health, as the carrier of diseases, thereby nailing the coffin on the possibility of flies being anything but loathsome creatures.

No doubt there are many flies that bite and spread disease. *But do all flies deserve such an image?* It's time someone spoke up for flies, whose colour, variety and elegance should not be judged only by the housefly, or the behaviour restricted to a frolic in decomposing heaps, although this frolic is not

Brown Muscid Fly

without benefit, and I shall soon tell you how and why.

Although there are many interesting aspects of flies that one can dwell on in this article I will confine myself to introducing you to a small group one can chance upon even in urban environments; and to the diversity and services some flies in this order perform. I shall conclude with how the mouth parts of a housefly can be observed in a manner that is more interesting than looking at a slide with artificial colours under a microscope.

Are flies filthy?

Flies are among the cleanest of insects, and are very particular about their own hygiene. In fact, humans could take a lesson or two on personal hygiene from them. Observe a fly closely next time, and you will notice how frequently it cleans itself.

If a fly does visit decomposing materials for its nutrient requirements, it does so to satisfy its nutritional needs. After all we humans too like food growing on decomposing matter, don't we? If you were to take a survey of your daily intake of food, you'd be surprised by *how many* of our favourite foods come from decomposing matter! Take mushrooms, for example, that grow so very well on cow dung; or Kombucha, a health drink, made by allowing certain yeast and bacterial species (kombucha culture appearing like a slimy pancake) to grow in a sugary solution of black or green tea! What a variety of fermenting food items we consume!

Perhaps, some of the blame for the diseases that flies transmit lies in humans too! If we gave more thought to our hygiene and sanitation, flies wouldn't frequent our environment so freely, would they?

What is a fly?

In a world populated by the Butterfly, Dragonfly, Scorpion fly, Mayfly, Stonefly, Firefly, Owlfly, and so on, what is this insect that is simply called a fly?

The insects listed above are not flies from an entomologists' point of view. True flies are insects that belong to the order Diptera, a name that describes their defining feature – these flies have only one pair of wings (in Latin, *di*: means two, and *ptera*: means wings). In contrast, insects belonging to all other insect orders have two pairs of wings! What makes this even more interesting is that true flies have evolved from four-winged ancestors in the Permian 250MYA (million years ago). In their modern-day descendants, however, this second pair - the hindwings - has become reduced to club-shaped structures, called Halteres. Each haltere can be likened to a gyroscope; they are essential in maintaining balance during flight.

Chrysops sp. **Biting fly.**

Two wings seem to have made them no less agile than other insects, eminently deserving the name "fly"! Consider these facts, not learnt in a class on flies. Flies are incredibly nimble in flight. The best aerialists among insects, they can hover, fly backwards, turn in place and fly upside down to land on the ceiling! They have sensors - speed indicators - located in a part of their antenna called arista, to gauge their flight speed. A housefly's wing speed is about 190 beats in a single second! The fastest muscular contraction a human being can manage clocks at ten times per second. No mystery then, why it is so difficult to swat a fly!

How many flies are there in the world?

No one knows an exact number. As mentioned before, true flies belong to the order Diptera, which is the third largest group among insects. Mosquitoes belong to this order too! More than 1,60,000 species of flies have already been described by specialists; with very many more yet to be classified, and several more to be discovered. As you can tell, this means a very large number, indeed!

Fly Services and Diversity

Every family of animals (including humans) on this planet, have their share of villains and heroes; and, fly families are no exception! There are many

interesting things one can learn by exploring the world of flies. I shall describe a handful of these here.

A. Flies as Pollinators: It is a well-established fact that plants and insects have mutually influenced the evolution of their diversity. Flies are believed to be foremost amongst the pollinators of early flowering plants; yet their role in such an important service remains relatively unknown. Of the 150 dipteran families, fly species of nearly 70 families (Evenhuis et al. 2008) are known to visit flowers to feed. It has been documented that flies are the primary pollinators for several hundreds of wild or cultivated plants (close to 550, according to Larsen et al. 2001). Pollination by flies is, generally, referred to as myophily.

What makes flies such good pollinators? They are not only abundant, but are also present in widely diverse habitats. They are the most important pollinators in alpine or arctic regions, where pollination by bees is reduced. In the under-storey regions of forests, flies are believed to be important in pollinating a wide variety of shrubs with small, inconspicuous or dioecious flowers. Their abundant presence is complimented by anatomical features, such as variations in mouth parts, tongue length, size and degree of pilosity (hairiness); all of which contribute to making flies some of the most effective pollinators, ever. Plants would probably nod their (flower) heads in agreement!

Flies visit flowers for their own reasons: nectar and pollen are sources of food. The proteins in pollen are necessary for some flies to reproduce. Some flies visit flowers to lay their eggs, ensuring that their developing larvae have easy access to food – the flower heads, seeds or developing fruits. And, so, for some flies, flowers are mating (dating?) sites. How convenient!

My favourite among these pollinators, without doubt, would be the beautiful and colourful flies of the Family Syrphidae, commonly called hover flies or flower flies. At first glance, a hoverfly would hardly strike one as a fly, looking more like a bee, than a fly. Each of them, however, has such a long proboscis, that it can go into the deepest of corollas to sip nectar. This makes them excellent pollinators, serving a wide range of plants, and second only to bees in this role. A large number of foods we consume are pollinated by hover flies. Look for these flies amongst the flowers of mango, apple, pear, cherry, and strawberry; or among coriander, onion, carrot, pepper, and capsicum, to name a few.

The life of an insect is full of tricks and treats that contribute to its survival. One such feature is the differing food source for larvae and adults. Adult insects don't compete with their young ones for food. Thus, while the adult hover fly is a vegetarian helping with pollination; it's larvae or maggots are insectivorous, feeding on a wide range of prey - mostly aphids and other sap sucking insects, and thereby acting as pest control agents - another fact about flies that rarely receives any attention. Thus, syrphid flies are important as pollinators and pest controllers.

Hover fly *Mesembrius quadrivittatus.*

Plants put out a variety of odours to attract insects. The putrid smell of decaying flesh from some flowers attracts carrion and dung flies, belonging to the Family Calliphoridae. They visit these flowers, expecting to find decaying flesh and, pollinate them, even as they leave disappointed. Commonly called blow flies, the bluebottle and greenbottle flies are quite colourful and attractive. Interestingly, they play an important role in forensics (see below).

Blow fly-Blue bottle fly, *Calliphora sp.*

Blowfly – Greenbottle, ***Lucilla sp.***

Golden blowfly.

Robustly, built flies of the family Tabanidae, commonly called horse flies, or, simply, tabanid flies, are mostly bloodthirsty flies; but some of them are lesser fiends. They are considered pests, since many species bite animals and humans. But, some, with their spectacularly long tongues pollinate flowers that have long tube-shaped corollas (image Tabanid fly –*Philoliche sp.*). In the females of certain Philoliche species, the very long tongue is adapted to perform the dual functions of blood sucking and nectar sipping! Rhino-myophily is the term that describes pollination by long-tongued flies.

Tabanid fly - *Philoliche spp.* *Photo by Sanjay Sondhi*

Tabanid fly - *Philoliche sp.* *Photo by Sanjay Sondhi*

That universally loved food - chocolate, owes its existence to flies! Midges are flies. Those belonging to the families Ceratopogonidae and Cecidomyiidae, are known more for their biting and gall-forming habits than for anything applaudable. But, not all of them are biters or gallers! The cocoa plant relies on small midge species of these two families to pollinate its tiny white blossoms, produced on the lower parts of its main trunk. The mushroomish odour of the flower attracts midges, just as chocolates attract us. Other than a particular species of hover flies in some restricted regions, cocoa plants need midges to produce fruit. No midge, no cocoa, no chocolates! Do I hear shouts of three cheers for midges? Do remember to thank flies, the next time you feast on chocolates or cocoa.

A midge

B. Flies in Forensics: From the living to the dead, from flowers to corpses - as flies search for nutrition, their actions bestow indirect assistance to other living organisms. Flies help humans in criminal investigations, and are a favourite with forensic entomologists.

Blowflies are not just pollinators; their love for decomposing animal matter draws them to the dead. In fact, they are the first to arrive at a death

scene! So acute is its sense of smell, that a blow fly can apparently smell a dead body 16 km away! Members of this family are known by various names – bluebottles, greenbottles. They are easily recognised - looking like a larger version of the common housefly. Why are they drawn to dead bodies, one may ask? Blow flies look at dead bodies as a food source for their young ones. They lay their eggs in the orifices of corpses, and maggots hatch out in 24 hours. Flesh flies, of the Family Sarcophagidae, give birth to live young ones on the flesh of the corpses! How does this behaviour help us? The life history of a blow fly is well-documented, providing a mine of information during post-mortems of the corpses that attract them.

Flesh Fly

Other species of flies, such as the black soldier fly, the coffin fly, the black scavenger fly, members of Hydrotea sp. of Family Muscidae, and humpbacked flies, are equally useful in providing important information during autopsies. Their services range from determining whether the corpse has been moved from the original scene of crime, information about toxicology, and, in many cases, even in fixing the time of death.

"The Washing Away of Wrongs" written in 1247 AD by Sung Tz'u, a crime investigator in China, is the first record of flies in criminal investigation. This book is the first to lay the foundations of forensic entomology. A murder happens in a Chinese village, and the dead man's body is discovered, cut up badly. Unable to make any headway with his investigation, the investigator asks all the villagers to bring their sickles, and lay it on the ground in front of him. Soon flies swarm to one sickle. The owner had not washed his sickle well, and the flies were attracted to the odour of blood. The owner confesses to the crime, and, so, began the use of flies to solve crimes.

If you are a fan of the TV serial "Bones", then, surely, you must already be aware of the nuances of forensic entomology, from the work of the character Jack Hodgins, a forensic entomologist-cum-botanist.

There are many other such interesting instances of crimes, solved with the help of flies.

C. Flies as Pest Control Agents: Agricultural researchers and pragmatic farmers will vouch for the services provided by flies in keeping a check on phytophagous insects. There are many flies that help in these roles, but described below are a few favourites of mine.

I call them Jewel flies, and not long-legged flies, as they are more commonly called. Their more common name points to their long legs, a striking feature of the flies of the family Dolichopodidae. Jewel flies are slender and dainty little flies, sporting beautiful colours. Mostly blue, green, and gold with a metallic shine, there are a few of these ecologically important flies that sport a dull grey colour too. Looking very much like a fly on stilts; you cannot miss them. They have a slender body, prominent eyes, and their trademark long legs. Males show off their long legs to attract females; quite the opposite of the human species it would seem! Lavish manoeuvres and signals mark the courtship behaviour of males. Many of these flies mate in flight, which is an exhausting practice; so, sometimes males create an illusion by sporting a pattern to con the females into thinking that they are mating in flight.

Found in most habitats, Jewel flies are predatory, feeding on a wide variety of invertebrates - aphids, thrips, spider mites, and collembolans. In fact, a particular species of Dolichopus preys on mosquito larvae! Some species are scavengers too. These flies are fidgety; so one has to be really still and silent to watch them.

A long-legged fly

Long-legged flies

Soldiers and Robbers performing similar functions could happen only in the world of insects! Soldier flies belong to the family Stratiomyidae whereas the robber flies, to Family Asilidae. In the world of flies, the robbers attack and catch pests more often than the soldiers; the latter's services are varied and include some predation.

Robber flies are the most predatory group in the world of flies, and feed exclusively on insects. Their name is truly representative of their behaviour. They are aggressive hunters, ambush their prey, and are strongly built with powerful muscles that help them capture insects in flight! They are robbers in appearance too, sporting a tuft of stiff bristles - like a moustache - between their eyes, that are mounted prominently on their head. In fact, the term 'mystax' used to describe these bristles is derived from the Greek word meaning 'moustache' or 'upper lip'. These cosmopolitan flies enjoy a worldwide distribution, but are common in tropical and subtropical areas, and abundant in dry and sunny arid or semi-arid zones.

Robber flies can very easily be identified by their long slender bodies, with the tips of their abdomens visible beyond the folded wings. The mystax is unmistakable, and the head and thorax is hairy. Because of their long tapering abdomen, combined with brightly coloured – black, grey, red or yellow -patterns, they are often mistaken for wasps. Some of them with stout, hairy bodies, mimic bees; while others with slender, lithe bodies, imitate damselflies. As you can see, these robbers have mastered the art of disguise too! Their perch is another way of identifying these flies in a habitat. Robbers like to perch on the topmost end of a plant waiting to seize prey.

Robbers inject captured prey with saliva containing neurotoxic and proteolytic enzymes, killing them. Both adult and juvenile robber flies prey on a wide variety of insects, thus serving the important ecological function of keeping a check on the insect fauna in any area.

Mating Robber Flies

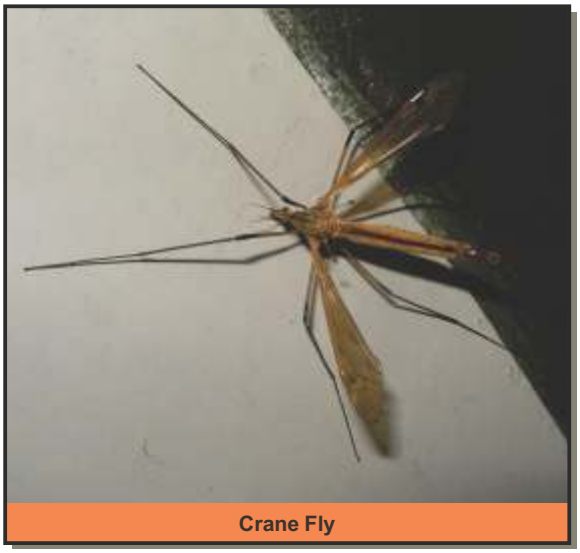
Green Soldier Fly

Soldier Fly

Soldier flies are diverse in their habits and food preferences, but are mainly recognised by their unique wing venation. Some soldiers are pollinators; some assist with forensics; others are helpful in composting waste; while a few of them are predatory. The brightly coloured ones resemble wasps and bees. Soldiers may be saprophagus, myophagous or predatory; and are generally found close to aquatic habitats in which their larvae develop. These flies are not a widely researched group, except Hermetia illucens, which is commonly called the black soldier fly. We shall look at this fly again, in the next section.

Small Soldier Fly

D. Flies in Composting: The black soldier fly, *Hermetia illucens*, is now being extensively used to compost wastes. However, this process is yet to find wider application in India, and is currently being practised only by a few researchers in Pune.



Crane Fly

The compost pit in my backyard has black soldier flies. The photo given here is of one of them helping decompose waste, along with other organisms.

Black Soldier Fly

E. Flies in Scientific Research: Fruit flies have been in our laboratories for decades now, and continue to play a well-known and extensively documented role in our efforts to understand gene action and inheritance mechanisms.

What is less well-known is the role of flies in some other kinds of experiments. In 2007, for example, some researchers at Harvard University built a robotic fly. Weighing 60mg, and with a wingspan of 3cm, this life-like fly was modelled to imitate the movements of a real fly. Made of ultra-thin carbon fibre, the robotic fly has a wing beat of 110 beats/second. This effort is the first step to

building flying insects that can be mounted with sensors, to function as spies. 'Fly on the wall' will soon become a reality, and not just be a fancy idiom, or so it seems. Army laboratories have definitely shown a great interest in these fly spies.

F. Flies and Soil Fertility: Imagine an oversized mosquito - that is what a Crane fly or Tipulid fly, belonging to the family Tipulidae, looks like. But, the similarity ends with their appearance. These gentle flies not only do not bite; adults do not feed at all! Adult flies live for about 10 to 15 days. Females emerge from their pupa with mature ova. They seek out mates, and soon after, lay their eggs on moist soil, or sometimes, on the surface of water. As they feed, their larvae help decompose organic matter, and increase microbial activity in the soil. They are, therefore, very useful in a soil ecosystem, keeping the soil fertile through their activities.

They are very easily recognized by their slender elongated bodies and legs. Their legs, especially, are quite long. Although they are found worldwide, their diversity is greatest in the tropics. Easily attracted to light, you can see them clinging to the walls with their long legs spread out. Or if you are out for a walk in the morning, they can be seen resting on leaves. Interestingly, crane flies can often be seen walking as easily as flying!

Flies in Science Classrooms

The housefly, no doubt, will continue to be the one that students will encounter most often in their lessons. Why not make it interesting to teach a lesson on the mouth parts of a fly in a different way? Mouth parts are for feeding, and what better way to learn about them than to actually see a fly feeding.

How does one do this? To begin with, one would, of course, need a live fly. And, manipulating a small fly can be a tricky affair! But with a little bit of practice, you should be fine! It's only fair to mention that this investigation calls for a lot of patience and time, but is well worth the time spent in doing it, for I assure you that a lot more than how a fly detects or feeds is learnt through such activities. For example, this investigation will show that flies taste with their feet!

Leave some overripe banana or a mango around, and very soon you will see many houseflies paying them a visit. Use a small tea strainer or a moist cloth to trap a few of these flies, and store them inside a dry transparent jar. Do not keep too many of them inside one jar.

The next few steps are the tricky ones. Take three glass slides, and number them 1, 2 and 3. Put a few drops of water on 1 and, 2, and sugar solution on 3.

The step following this has to be done very quickly. Smear some Fevicol (not Feviquick, please note) on your fore finger, open the jar with the trapped flies, and touch the thorax of the nearest fly with your forefinger. The fly will get stuck to your finger. Hold it gently with your fingers in such a way that both its wings remain folded on its back. Don't worry - at the end of this experiment, you can release the fly by washing your forefinger in water. The fly will be wet for some time (you can gently dab it dry with a cloth), but will soon dry itself out, and fly.

The fly will be stressed because of its captivity. When you gently lower it close to the water-drop on slide 1, you can actually see its proboscis pop out of its head to drink water. When it has finished drinking water, take it off from slide one, and now lower it onto the water drop in slide two in such a way that its feet touch the water. Do you see the proboscis coming down?

Now, repeat the same with slide three, and you will see that as soon as its legs touch the sugar solution, out pops the fly's proboscis to feed on the sugar solution. You may now try different kinds of food, and investigate the fly's feeding preferences or how much it needs to feed on, etc. Seeing an insect feed creates an active learning atmosphere in the classroom, which can then be followed up with anatomical details under the microscope.

Conclusion

This is but a small introduction to a few families of flies that may be found more commonly in our human environments, and are big enough to be recognised. More than 1,60,000 species of flies, and still counting - makes me agree with Nash, when he says:

God in his wisdom
Made the fly
And then forgot
To tell us why

–Ogden Nash

References

1. One proboscis, two tasks: Adaptations to blood-feeding and nectar-extracting in long-proboscid horse flies (Tabanidae, Philoliche). Karolyia Florian et al. Arthropod Structure & Development, Vol. 43: Issue 5, Sept 2014: 403-413.
2. The use of insects in forensic investigations: An overview on the scope of forensic entomology. Joseph et al. Journal of Forensic Dental Sciences, Vol. 3(2); Jul-Dec 2011:89-91. URL: www.ncbi.nlm.nih.gov/pmc/articles/PMC3296382/
3. Lords of the flies: the insect detectives. Jon Henley. The Guardian: Forensic Science. Sep 23, 2010. URL: http://www.theguardian.com/science/2010/sep/23/flies-murder-natural-history-museum.
4. Courtship in long-legged flies (Diptera:Dolichopodidae): function and evolution of signals. Martin Zimmer, Olaf Diestelhorst, and Klaus Lunau. Behavioral Ecology, Vol. 14, No. 4: 526–530. URL: http://beheco.oxfordjournals.org/content/14/4/526.full.pdf
5. Robber Flies (Asilidae). Fritz Geller-Grimm, Torsten Dikow & Robert J. Lavigne. URL: http://www.geller-grimm.de/asilidae.htm.
6. Occurrence of Black Soldier Fly *Hermetia illucens* (Diptera: Stratiomyidae) in Biocompost. Gujarathi Gayatri R. and Pejaver Madhuri K. Research Journal of Recent Sciences, Vol. 2(4), April (2013): 65-66. URL: http://www.isca.in/rjrs/archive/v2/i4/9.ISCA-RJRS-2012-469.pdf.
7. Black soldier fly farming. URL: http://www.blacksoldierflyfarming.com/.

Geetha Iyer *is an Author and Independent consultant working in the twin fields of Education and Environment. She has written extensively on topics in Education, Environment and Natural History. Dr Iyer can be reached at brownfishowl@yahoo.co.uk*