Other questions for class discussion:

- In what ways is this article unlike any research paper you've ever written?
- How does Conniff handle the factual material? How is it woven into the article?
- What kinds of facts does he use? Are they memorable? Why?
- What is Conniff's main point, or thesis? Where is it stated most clearly?
- Does the humor in the article make it less authoritative? Does the author's use of personal experiences and observations strengthen or weaken the research?
- Is this article *objective?* In what ways? In what ways is it *subjective?* Can a good research paper be both without sacrificing its authority?
- Compare "Why God Created Flies" with the student essay "Lemming Death" in Appendix A. How are they similar? How are they different?

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Why God Created Flies

by Richard Conniff

THOUGH I HAVE been killing them for years now, I have never tested the folklore that, with a little cream and sugar, flies taste very much like black raspberries. So it's possible I'm speaking too hastily when I say there is nothing to like about houseflies. Unlike the poet who welcomed a "busy, curious, thirsty fly" to his drinking cup, I don't cherish them for reminding me that life is short. Nor do I much admire them for their function in clearing away carrion and waste. It is, after all, possible to believe in the grand scheme of recycling without liking undertakers.

A fly is standing on the rim of my beer glass as I write these words. Its vast, mosaic eyes look simultaneously lifeless and mocking. It grooms itself methodically, its forelegs entwining like the arms of a Sybarite luxuriating in bath oil. Its hind legs twitch across the upper surface of its wings. It pauses, well fed and at rest, to contemplate the sweetness of life.

Reprinted by permission of writer Richard Conniff, from *Audubon Magazine,* July, 1989.

We are lucky enough to live in an era when scientists quantify such things, and so as I type and wait my turn to drink, I know that the fly is neither busy nor curious. The female spends 40.6 percent of her time doing nothing but contemplating the sweetness of life. I know that she not only eats unspeakable things, but spends an additional 29.7 percent of her time spitting them back up and blowing bubbles with her vomit. The male is slightly less assiduous at this deplorable pastime but also defecates on average every four and a half minutes. Houseflies seldom trouble us as a health threat anymore, at least in this country, but they are capable of killing. And when we are dead (or sooner, in some cases), they dine on our corrupted flesh.

It is mainly this relentless intimacy with mankind that makes the housefly so contemptible. Leeches or dung beetles may appall us, but by and large they satisfy their depraved appetites out of our sight. Houseflies, on the other hand, routinely flit from diaper pail to dinner table, from carrion to picnic basket. They are constantly among us, tramping across our food with God-knows-what trapped in the sticky hairs of their half-dozen legs.

Twice in this century, Americans have waged war against houseflies, once in a futile nationwide "swat the fly" campaign and again, disastrously, with DDT foggings after World War II. The intensity of these efforts, bordering at times on the fanatic, may bewilder modern Americans. "Flies or Babies? Choose!" cried a headline in the *Ladies' Home Journal* in 1920. But our bewilderment is not due entirely to greater tolerance or environmental enlightenment. If we have the leisure to examine the fly more rationally now, it is primarily because we don't suffer its onslaughts as our predecessors did. Urban living has separated us from livestock, and indoor plumbing has helped us control our own wastes and thus control houseflies. If that changed tomorrow, we would come face to face with the enlightened, modern truth: With the possible exception of *Homo sapiens,* it is hard to imagine an animal as disgusting or improbable as the housefly. No bestiary concocted from the nightmares of the medieval mind could have come up with such a fantastic animal. If we want to study nature in its most exotic permutations, the best place to begin is here, at home, on the rim of my beer glass.

IN THIS COUNTRY, more than a dozen fly species visit or live in the house. It is possible to distinguish among some of them only by such microscopic criteria as the pattern of veins in

the wings, so all of them end up being cursed as houseflies. Among the more prominent are the blue- and greenbottle flies, with their iridescent abdomens, and the biting stable flies, which have served this country as patriots, or at least provocateurs. On July 4, 1776, their biting encouraged decisiveness among delegates considering the Declaration of Independence. "Treason," Thomas Jefferson wrote, "was preferable to discomfort."

The true housefly, *Musca domestica,* does not bite. (You may think this is something to like about it, until you find out what it does instead.) *M. domestica,* a drab fellow of salt-and-pepper complexion, is the world's most widely distributed insect species and probably the most familiar, a status achieved through its pronounced fondness for breeding in pig, horse, or human excrement. In choosing at some point in the immemorial past to concentrate on the wastes around human habitations, *M. domestica* made a major career move. Bernard Greenberg of the University of Illinois at Chicago has traced human representations of the housefly back to a Mesopotamian cylinder seal from 3000 B.C. But houseflies were probably with us even before we had houses, and they spread with human culture.

Like us, the housefly is prolific, opportunistic, and inclined toward exploration. It can adapt to a diet of either vegetables or meat, preferably somewhat ripe. It will lay its eggs not just in excrement but in rotting lime peels, birds nests, carrion, even flesh wounds that have become infected and malodorous. Other flies aren't so flexible. For instance, *M. autumnalis,* a close relative, prefers cattle dung and winds up sleeping in pastures more than in houses or yards.

Although the adaptability and evolutionary generalization of the housefly may be admirable, they raise one of the first great questions about flies: Why is there this dismaying appetite for abomination?

Houseflies not only defecate constantly but do so in liquid form, which means they are in constant danger of dehydration. The male can slake his thirst and get most of the energy he needs from nectar. But fresh manure is a good source of water, and it contains the dissolved protein the female needs to make eggs. She also lays her eggs in excrement or amid decay so that when the maggots hatch, they'll have a smorgasbord of nutritious microorganisms on which to graze.

Houseflies bashing around the kitchen or the garbage shed thus have their sensors attuned to things that smell sweet, like flowers or bananas, and to foul-smelling stuff like ammonia and

hydrogen sulfide, the products of fermentation and putrefaction. (Ecstasy for the fly is the stinkhorn fungus, a source of sugar that smells like rotting meat.)

The fly's jerky, erratic flight amounts to a way of covering large territories in search of these scents, not just for food but for romance and breeding sites. Like dung beetles and other flying insects, the fly will zigzag upwind when it gets a whiff of something good (or, more often, bad) and follow the scent plume to its source.

HENCE THE SECOND question about the housefly: How does it manage to fly so well? And the corollaries: Why is it so adept at evading us when we swat it? How come it always seems to land on its feet, usually upside-down on the ceiling, having induced us to plant a fist on the spot where it used to be, in the middle of the strawberry trifle, which is now spattered across the tablecloth, walls, loved ones, and honored guests?

The housefly's manner of flight is a source of vexation more than wonder. When we launch an ambush as the oblivious fly preens and pukes, its pressure sensors alert it to the speed and direction of the descending hand. Its wraparound eyes are also acutely sensitive to peripheral movement, and they register changes in light about ten times faster than we do. (A movie fools the gullible human eye into seeing continuous motion by showing it a sequence of twenty-four still pictures a second. To fool a fly would take more than 200 frames a second.) The alarm flashes directly from the brain to the middle set of legs via the largest, and therefore fastest, nerve fiber in the body. This causes so-called starter muscles to contract, simultaneously revving up the wing muscles and pressing down the middle legs, which catapult the fly into the air.

The fly's wings beat 165 to 200 times a second. Although this isn't all that fast for an insect, it's more than double the wingbeat of the speediest hummingbird and about twenty times faster than any repetitious movement the human nervous system can manage. The trick brought off by houseflies and many other insects is to remove the wingbeat from direct nervous system control, once it's switched on. Two systems of muscles, for upstroke and downstroke, are attached to the hull of the fly's midsection, and they trigger each other to work in alternation. When one set contracts, it deforms the hull, stretching the other set of muscles and making it contract automatically a fraction of a second later. To keep this seesaw rhythm going, openings in the midsection stoke the muscles with oxygen that comes di-

rectly from the outside (flies have no lungs). Meanwhile the fly's blood (which lacks hemoglobin and is therefore colorless) carries fuel to the cells fourteen times faster than when a fly is at rest. Flies can turn a sugar meal into useable energy so fast that an exhausted fly will resume flight almost instantly after eating. In humans . . . but you don't want to know how ploddingly inadequate humans are by comparison.

An airborne fly's antennae, pointed down between its eyes, help regulate flight, vibrating in response to airflow. The fly also uses a set of stubby wings in back, called halteres, as a gyroscopic device. Flies are skillful at veering and dodging—it sometimes seems that they are doing barrel rolls and Immelmann turns to amuse themselves while we flail and curse. But one thing they cannot do is fly upside-down to land on a ceiling. This phenomenon puzzled generations of upward-glaring, strawberry-trifle-drenched human beings, until high-speed photography supplied the explanation. The fly approaches the ceiling rightside up, at a steep angle. Just before impact, it reaches up with its front limbs, in the manner of Superman exiting a telephone booth for takeoff. As these forelegs get a grip with claws and with the sticky, glandular hairs of the footpads, the fly swings its other leg up into position. Then it shuts down its flight motor, out of swatting range and at ease.

While landing on the ceiling must be great fun, humans tend to be more interested in what flies do when they land on food. To find out, I trapped the fly on the rim of my beer glass. (Actually, I waited till it found a less coveted perch, then slowly lowered a mayonnaise jar over it.) I'd been reading a book called *To Know a Fly,* in which author Vincent Dethier describes a simple way of seeing how the fly's proboscis works. First I refrigerated the fly to slow it down and anesthetize it. Then I attempted to attach a thin stick to its wing surface with the help of hot candlewax. It got away. I brought it back and tried again. My four-year-old son winced and turned aside when I applied the wax. "I'm glad I'm not a fly," he said, "or you might do that to me." I regarded him balefully but refrained from mentioning the ant colony he had annihilated on our front walk.

Having finally secured the fly, I lowered its feet into a saucer of water. Flies have taste buds in their feet, and when they walk on something good (bad), the proboscis, which is normally folded up neatly inside the head, automatically flicks down. No response. I added sugar to the water, an irresistible combination. Nothing. More sugar. Still nothing. My son wandered off, bored. I apologized to the fly, killed it, and decided to look up the man who had put me in the awkward position of sympathizing with a fly, incidentally classing me in my son's eyes as a potential war criminal.

DETHIER, A BIOLOGIST at the University of Massachusetts at Amherst, turned out to be a gentle, deferential fellow in his mid-seventies, with weathered, finely wrinkled skin and gold-rimmed oval eyeglasses on a beak nose. He suggested mildly that the fly might not have responded because it was outraged at the treatment it received. It may also have eaten recently, or it may have been groggy from hibernation. (Some flies sit out the winter in diapause, in which hormones induce inactivity in response to shortened day length. But cold, not day length, is what slows down hibernating species like the housefly, and the sudden return of warmth can start them up again. This is why a fly may miraculously take wing on a warm December afternoon in the space between my closed office window and the closed storm window outside, a phenomenon I had formerly regarded as new evidence for spontaneous generation.)

Dethier has spent a lifetime studying the fly's sense of taste, "finding out where their tongues and noses are, as it were." He explained the workings of the proboscis to me.

Fly taste buds, it seems, are vastly more sensitive than ours. Dethier figured this out by taking saucers of water containing steadily decreasing concentrations of sugar. He found the smallest concentration a human tongue could taste. Then he found the smallest concentration that caused a hungry fly to flick out its proboscis. The fly, with 1,500 taste hairs arrayed on its feet and in and around its mouth, was ten million times more sensitive.

When the fly hits pay dirt, its proboscis telescopes downward and the fleshy lobes at the tip puff out. These lips can press down tight to feed on a thin film of liquid, or they can cup themselves around a droplet. They are grooved crosswise with a series of parallel gutters, and when the fly starts pumping, the liquid is drawn up through these gutters. Narrow zigzag openings in the gutters filter the food, so that even when it dines on excrement, the fly can "choose" some morsels and reject others.

A drop of vomit may help dissolve the food, making it easier to lap up. Scientists have also suggested that the fly's prodigious vomiting may be a way of mixing enzymes with the food to aid digestion.

If necessary, the fly can peel its lips back out of the way and apply its mouth directly to the object of its desire. Although

a housefly does not have true teeth, its mouth is lined with a jagged, bladelike edge that is useful for scraping. In his book *Flies and Disease,* Bernard Greenberg writes that some blowflies (like the one on the rim of my beer glass, which turned out to be a *Phormia regina*) "can bring 150 teeth into action, a rather effective scarifier for the superficial inoculation of the skin, conjunctiva, or mucous membranes."

HENCE THE FINAL great question about flies: What awful things are they inoculating us with when they flit across our food or land on our sleeping lips to drink our saliva? Over the years, authorities have suspected flies of spreading more than sixty diseases, from diarrhea to plague and leprosy. As recently as 1951, the leading expert on flies repeated without demurring the idea that the fly was "the most dangerous insect" known, a remarkable assertion in a world that also includes mosquitoes. One entomologist tried to have the housefly renamed the "typhoid fly."

The hysteria against flies earlier in the century arose, with considerable help from scientists and the press, out of the combined ideas that germs cause disease and that flies carry germs. In the Spanish-American War, easily ten times as many soldiers died of disease, mostly typhoid fever, as died in battle. Flies were widely blamed, especially after a doctor observed particles of lime picked up in the latrines still clinging to the legs of flies crawling over army food. A British politician argued that flies were not "dipterous angels" but "winged sponges speeding hither and thither to carry out the foul behests of Contagion." American schools started organizing "junior sanitary police" to point the finger at fly breeding sites. Cities sponsored highly publicized "swat the fly" campaigns. In Washington, D.C., in 1912, a consortium of children killed 343,800 flies and won a $25 first prize. (This is a mess of flies, 137.5 swatted for every penny in prize money, testimony to the slowness of summers then and the remarkable agility of children—or perhaps to the overzealous imagination of contest sponsors. The figure does not include the millions of dead flies submitted by losing entrants.)

But it took the pesticide DDT, developed in World War II and touted afterwards as "the killer of killers," to raise the glorious prospect of "a flyless millennium." The fly had by then been enshrined in the common lore as a diabolical killer. In one of the "archy and mehitabel" poems by Don Marquis, a fly visits garbage cans and sewers to "gather up the germs of typhoid, influenza, and pneumonia on my feet and wings" and spread them to humanity, declaring that "it is my mission to help rid the world of these wicked persons/i am a vessel of righteousness."

Public health officials were deadly serious about conquering this arch fiend, and for them DDT was "a veritable godsend." They recommended that parents use wallpaper impregnated with DDT in nurseries and playrooms to protect children. Believing that flies spread infantile paralysis, cities suffering polio epidemics frequently used airplanes to fog vast areas with DDT. Use of the chemical actually provided some damning evidence against flies, though not in connection with polio. Hidalgo County in Texas, on the Mexican border, divided its towns into two groups and sprayed one with DDT to eliminate flies. The number of children suffering and dying from acute diarrheal infections caused by *Shigella* bacteria declined in the sprayed areas but remained the same in the unsprayed zones. When DDT spraying was stopped in the first group and switched to the second, the dysentery rates began to reverse. Then the flies developed resistance to DDT, a small hitch in the godsend. In state parks and vacation spots, where DDT had provided relief from the fly nuisance, people began to notice that songbirds were also disappearing.

IN THE END, the damning evidence was that we were contaminating our water, ourselves, and our affiliated population of flies with our own filth (not to mention DDT). Given access to human waste through inadequate plumbing or sewerage treatment, flies can indeed pick up an astonishing variety of pathogens. They can also reproduce at a godawful rate: In one study, 4,042 flies hatched from a scant shovelful, one-sixth of a cubic foot, of buried night soil. But whether all those winged sponges can transmit the contaminants they pick up turns out to be a tricky question, the Hidalgo County study being one of the few clearcut exceptions. Of polio, for instance, Bernard Greenberg writes, "There is ample evidence that human populations readily infect flies . . . But we are woefully ignorant whether and to what extent flies return the favor."

Flies probably are not, as one writer declared in the throes of hysteria, "monstrous" beings "armed with horrid mandibles . . . and dripping with poison." A fly's body is not, after all, a playground for microbes. Indeed, bacterial populations on its bristling, unlovely exterior tend to decline quickly under the triple threat of compulsive cleaning, desiccation, and ultraviolet

radiation. (Maggots actually produce a substance in their gut that kills off whole populations of bacteria, which is one reason doctors have sometimes used them to clean out infected wounds.) The fly's "microbial cargo," to use Greenberg's phrase, reflects human uncleanliness. In one study, flies from a city neighborhood with poor facilities carried up to 500 million bacteria, while flies from a prim little suburb not far away yielded a maximum count of only 100,000.

But wait. While I am perfectly happy to suggest that humans are viler than we like to think, and flies less so, I do not mean to rehabilitate the fly. Any animal that kisses offal one minute and dinner the next is at the very least a social abomination. What I am coming around to is St. Augustine's idea that God created flies to punish human arrogance, and not just the calamitous technological arrogance of DDT. Flies are, as one biologist has remarked, the resurrection and the reincarnation of our own dirt, and this is surely one reason we smite them down with such ferocity. They mock our notions of personal grooming with visions of lime particles, night soil, and dog leavings. They toy with our delusions of immortality, buzzing in the ear as a memento mori (a researcher in Greenberg's lab assures me that flies can strip a human corpse back to bone in about a week, if the weather is fine). Flies are our fate, and one way or another they will have us.

It is a pretty crummy joke on God's part, of course, but there's no point in getting pouty about it and slipping into unhealthy thoughts about nature. What I intend to do, by way evening the score, is hang a strip of flypaper and cultivate the local frogs and snakes, which have a voracious appetite for flies (flycatchers don't, by the way; they seem to prefer wasps and bees). Perhaps I will get the cat interested, as a sporting proposition. Meanwhile, I plan to get a fresh beer and sit back with my feet up and a tightly rolled newspaper nearby. Such are the consolations of the ecological frame of mind.

I love "Why God Created Flies" partly because it never occurred to me when I first read it that I was reading research. Elmore Leonard, a distinguished fiction writer, says that when his writing *sounds* like writing, he needs to rewrite it. His prose, which is lean, efficient, yet powerful, reflects that philosophy. It doesn't call attention to itself. Much research writing does. It lumbers along from fact to fact and quote to quote, saying "Look at how much I know!"

Demonstrating knowledge is not nearly as impressive as *using* it toward some end. Conniff does just that, masterfully weaving surprising information about the common housefly with his longing to determine where in God's plan the pest might fit in.

It's informative, it's funny, and yes, it's research. Richard Conniff is not a bug expert. (If he were, he'd probably be published in the *Journal of Entomology*.) He's just a guy who noticed a fly on his beer glass and wondered, What is it doing there? The best research often starts that way, with what at first seems to be a simple question. Like a lucky archaeologist, the researcher often finds more than he expects just below the surface of even the simplest questions. But first, he's got to want to dig.