Birds Can Smell, and One Scientist is Leading the Charge to Prove It

For more than a century nearly everyone believed birds sense of smell was poorly developed or nonexistent. They were wrong.

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Gabrielle Nevitt's supply list for her first Antarctic research cruise in 1991 contained some decidedly odd items. The huge kites and vats of fishy smelling liquid wouldn't be a problem, the macho National Science Foundation contractor told her. Then she asked for hundreds of boxes of super-absorbent tampons. "He just kind of stammered," recalls Nevitt a petite brunette who was then a 31-year-old zoology post-doc at Cornell University. "Then he said, 'Uh, I don't think I can get those for you, ma'am.' " So Nevitt lugged them onboard herself and set to work. She was hoping to lure albatrosses and petrels from the open sea with the scent of dinner, like a street-food vendor might entice passersby with a hot pretzel. She dipped the tampons in pungent compounds found in marine fish and small crustaceans called krill, and painstakingly attached the briny bait to parachute-like kites that she let fly off the rear deck. Then she waited.

It was an outlandish experiment, and not just because of the tampons. For more than a century nearly everyone believed that the sense of smell was poorly developed or nonexistent in most birds. So no one had ever fully investigated to what extent tube-nosed procellariiformes--petrels, albatrosses, and shearwaters--use their olfactory anatomy to pinpoint prey in the vast, featureless ocean. The long-lived birds spend nearly their entire existence at sea, soaring for hundreds to thousands of miles in search of ever-shifting schools of krill, fish, and squid. On the day Nevitt ran her experiment, dozens of them swooped in so close that she feared they would tangle in the line and drown. So she grounded the kites and improvised, releasing vegetable oil into the water, some of it laced with the fishy compounds. Albatrosses and petrels flocked to the stinky slicks. She was ecstatic. But she still had no idea how they used olfactory cues to home in on their ephemeral quarry. "I was really passionate about figuring this out, so I wasn't giving up," says Nevitt. "I knew I'd be back again soon on another cruise."

Nevitt is 53 now and a professor at the University of California-Davis. She is a woman obsessed with smell. As head of a sensory ecology lab, she's spent the past two decades picking apart how seabirds' ability to detect scents is key to their survival. Nevitt had the good fortune to arrive in the field on the heels of a handful of pioneering bird olfaction studies. Yet changing long-held beliefs takes time, and the scientific community is no exception. Dozens of Nevitt's grant proposals have been rejected because of the birds-can't-smell fallacy. A program officer once called to say her application was the worst he'd ever seen. "Your idea that birds can smell is ridiculous,"he said. "This will never be funded, so stop wasting your time." She ignored him, and her perseverance and inventive methods have inspired others who share her fascination.

"Gaby's been very influential," says Julie Hagelin, a wildlife biologist with the Alaska Department of Fish and Game who has conducted several studies on the role of odor in bird behavior. "Her work propelled me forward and helped me develop several ideas." Nevitt, Hagelin, and other avian olfaction trailblazers have pushed past criticism, failure, and even bodily injury in their quest to disprove one of biology's most pervasive myths. "In science," says Nevitt, "we rediscover the obvious sometimes."

Nevitt could blame John James Audubon, of all people, for the incredulity she's endured. In the 1820s the famous naturalist set out to prove that turkey vultures use their superior eyesight, rather than their nostrils, to find carrion. He stuffed a deerskin with grass and added clay eyes, sewed up the imposter, and placed it in a meadow with its legs in the air. He watched as a vulture swooped down on it. The duped bird ripped out the eyes and tore apart stitches, flying after failing to find any meat. Audubon later placed a dead hog, its carcass reeking of decay in the July heat, in a ravine and covered it with brush. This time vultures circled but didn't descend. The results were "fully conclusive," he wrote. Vultures did not scavenge by smell.

Audubon's ego would've taken a hit had he lived to see Kenneth Stager put his findings to the test. In 1960 Stager, an ornithologist at the Los Angeles County Natural History Museum, showed that turkey vultures prefer fresher carcasses--typically no more than four days old--to putrid ones like Audubon hid. Stager also identified the specific scent that drew vultures to carrion, with the help of natural gas engineers who told him they followed the birds to ruptured pipelines. Decomposing carcasses, it turns out, give off ethyl mercaptan, the same sulfurous compound added to natural gas so humans can sniff out a leak (and which gives asparagus eaters' urine that distinctive rotten-egg odor). Stager had shattered Audubon's theory. Hardly anyone noticed.

If Stager was an early proponent of bird olfaction, his contemporary Bernice Wenzel quickly became a pioneer. A physiology professor at UCLA, Wenzel shared a penchant for wander-lust with the pigeons she studied. She jumped at an invitation in 1965 to travel to Japan to present a paper at the International Symposium on Olfaction and Taste conference on how pigeons could detect smells. Every time she exposed the birds to scented air, their heart rates went up. By attaching electrodes directly to the birds' olfactory bulbs, she saw that the signal spiked whenever they got a whiff of the scented air. "I thought, 'For heaven's sakes, that's kind of interesting. I think I'll go to Tokyo and give a paper on that,' " says Wenzel. "After that, inevitably, as crazy scientists are apt to do, avian olfaction became my main interest, and everything else was sort of shoved aside." Now 92, Wenzel's wavering voice and halo of white hair belie her gusto: She scours scientific journals for the latest olfaction papers and drives herself to the scientific conferences she attends.

During the next 25 years Wenzel launched olfaction studies at home and abroad. She repeated the electrode tests on a raven, a turkey vulture, mallards, canaries, bobwhite quail, and black-vented shearwaters. "Every bird we tested showed some kind of olfactory function," she says. Her fieldwork in New Zealand revealed that kiwis, the only bird with a nostril at the tip of its beak rather than at the base, sniff out their earthworm prey. The National Science Foundation nixed her request to visit an Antarctic station--scientists were required to share rooms, and they wouldn't let her bunk with a man--so she studied seabirds closer to home. Off the Southern California coast, she released odors of various substances, from fish oils to bacon fat, and found that two seabirds, northern fulmars and sooty shearwaters, were most attracted to the smells. "What was especially noticeable was that on a foggy morning the fulmars would appear out of the fog from downwind and fly around and round as if to say, 'There's got to be a fish here someplace,' " Wenzel recalls. "That convinced us it really was an important concept to pursue."

Wenzel retired in 1989, but before she did, her conviction inspired another young researcher to continue nailing down the slippery stuff of bird smell. Wenzel spoke at a conference in Norway that year, and Nevitt was in the audience. "Bernice was just so fierce and passionate and emphatic that birds could smell," says Nevitt, who at the time was writing her dissertation on salmon olfaction. "It really impressed me."

By 1992 Nevitt was back at sea, riding out a rough storm near the Antarctic Peninsula. Hurricane-force winds blew. Sheets of rain and sleet pummeled the ship. Waves topped 40 feet. Below deck, Nevitt had secured her chair to her desk with a bungee cord to keep from tipping over as she tapped away at her computer. Suddenly the vessel pitched and the tether snapped. Nevitt flew across the room, slammed into a metal tool cabinet, and was knocked out. She awoke to excruciating pain from a torn kidney. She gutted out the rest of the voyage, lying in her bunk, unable to move without assistance, listening to a Mary Chapin Carpenter tape to help her stay conscious.

Grueling as it was, the injury led to a fortuitous encounter. When the ship finally docked a week later, Nevitt stayed aboard while a different scientific crew loaded its equipment and prepared for a new trip. Tim Bates, an atmospheric chemist with NOAA, poked his head into her cabin. He was studying dimethyl sulfide, or DMS, a gas emitted by phytoplankton, microscopic plants that live at the ocean's surface. Bates was interested in the gas because it might help combat climate change; it contributes to the formation of clouds, which reflect heat. He began calibrating his equipment as they chatted. Nevitt, who has a keen sense of smell herself, immediately picked up an aroma like oysters on the half shell. She felt a tingle of excitement. She knew that the gas is released when krill--a major food source for seabirds--devour phytoplankton. "I'd read about DMS," she says. "But it never occurred to me it might have an odor."

It all clicked into place. The birds pick up the DMS trail and follow it to schools of krill. When Bates showed her a map of DMS plumes, Nevitt saw that they were more concentrated in areas with geographic formations near the ocean's surface. "I could see peaks and valleys of DMS over shelf breaks, seamounts, and other underwater features, and I realized the ocean's surface wasn't featureless to the birds," she says. "They have their own map, an odor landscape, in the air above the water." It was, says Nevitt, the kind of "aha" moment scientists live for.

She still had to prove it, though. Four months later Nevitt was back in Antarctic waters to test her theory. Her vessel, the RRS *James Clark Ross,* rescued the crew of another ship that had caught fire, and escorted the damaged vessel to port. That made for a slow trip, but Nevitt took advantage of the opportunity. She recruited the extra passengers to help with an experiment that would have been impossible at full speed. She launched aerosols of DMS and control substances into the air, and the volunteers tallied seabirds that turned back toward the boat. It worked-- they made a beeline for the DMS plumes. She'd proved that the gas drew tube-nosed seabirds to their dinner on the open sea.

It's not all that surprising that Audubon's erroneous claim has persisted for so long. Birds sport flashy plumage, sing melodic songs, perform dramatic mating rituals. Vision and hearing are obviously important. But smell? Birds don't have noses, or sniff everything the way dogs do. They lack the vomeronasal organ that most mammals, amphibians, and reptiles use to detect odor particles. And the smelling equipment they do possess can be hard to find: Many species have microscopic olfactory bulbs, a structure in the forebrain that receives odor signals from the nasal cavity.

No wonder, then, that in 2008, when Indiana University post-doc Danielle Whittaker first proposed studying how dark-eyed juncos smell, a professor she confided in, Jim Goodson, was aghast. "I thought it was a monumental waste of time," says Goodson, a neurobiologist who studies bird brains. "Vertebrates that really emphasize olfaction have very prominent olfactory bulbs on the front of their brains, sometimes hanging off on long stalks, as in many fish. But you can't even see a bump on a junco brain."

"It just goes to show," he says, "appearances can be deceiving."

In fact, every bird tested has passed the sniff test. All 108 species examined in a landmark 1968 study possessed an olfactory bulb; the tissue took up as little as 3 percent of songbird brains and as much as 37 percent of seabird brains. Recent molecular studies back up the findings. In 2008 researchers looked at nine species that represent seven major branches of the avian family tree. They found that bulb size correlates with the number of genes that encode olfactory receptors, which detect odors. In other words, a bigger structure equals more genes. Two nocturnal birds, kakapos and kiwis, topped the list with more than 600 smell-related genes, while canaries and blue tits had about a third as many. (Humans have about 400.)

Biologists generally assume that animals with larger olfactory bulbs and more receptor genes have a stronger sense of smell. The remarkable variation that birds display may be due to environmental adaptations. Nocturnal kiwis' acute sense of smell may help them find food at night. And then there are Nevitt's relatively large-bulbed tube-nosed seabirds. Their smelling anatomy includes an elongated tube on their upper beak, perfectly adapted to pick up odors in a cold, windy climate that chops up scent trails. One species, wandering albatrosses, are feathered bloodhounds that can follow their nose to food some 12 miles from their starting point, zigzagging upwind to keep track of the patchy odor plume.

Yet small scent machinery doesn't necessarily condemn a bird to a poor sense of smell. Blue tits will refuse to enter their nest boxes when they catch a whiff of the chemical cue of weasels. For Eurasian rollers, a different scent acts as an alarm. Frightened chicks vomit a foul-smelling orange liquid, likely becoming a less attractive snack to a potential predator; their parents pick up the odor when they return and react cautiously, delaying settling down in the nest where they might be an easier target if the marauder is still lurking nearby. Another songbird, the European starling, can detect and distinguish scents in aromatic herbs, such as the chrysanthemum-like odor of milfoil. Males weave these plants into their nests to attract females during the breeding season, like a man applying cologne.

Smell, of course, is just one of birds' six senses (in addition to the standard five, some species have a built-in magnetic compass). Nevitt has discovered that even among tube noses, the degree to which they rely on scent varies. Larger, more aggressive albatrosses and giant petrels follow DMS to food, but they also use visual cues, such as other birds feeding on krill. Burrow-nesting birds, such as smaller white-chinned and blue petrels, tend to be more attuned to the chemical trail. That's probably because, raised in the dark, smells dominate their early sensory experience. Burrow-nesting species use their nostrils for other purposes, too. Diving petrels distinguish their burrow from hundreds of similar-looking ones by scent, and Antarctic prions choose their mates by their unique odors.

For very visual and auditory birds, like crested auklets, olfaction is only part of the mix. But for juncos it may play a far larger role. Whittaker discovered that the odor of junco preen oil, secreted from a gland at the tail base, varies among individuals, and that the birds can distinguish among those divergent smells. Those whose smells are most strongly "male-like" or "female-like" have the most chicks survive to fledglings. In fact, smell turned out to be far more important in making males attractive than other factors, such as a whiter tail, where there was no correlation. "Odor is probably a more reliable indicator of reproductive success than visual cues," she says.

That may be true for New Zealand's kakapos, too. Hagelin performed some of the first research showing the chicken-sized, critically endangered parrots could smell (the sweet, strong odor that some say smells of lavender and honey that both sexes produce tipped her off that the sense might be important). Now, a Swiss scientist, newly minted Ph.D. Anna Gsell, has picked up where Hagelin left off. Gsell is identifying the compounds and hopes to create a synthetic version of the odor of the best breeders. Less successful males sprayed with the stuff might have a better chance of wooing otherwise disinterested females, thus increasing the gene pool. With 124 birds left, they need all the help they can get.

Last year a sales rep tried to peddle Nevitt a textbook containing the tired meme that birds can't smell. She kicked him out of her office. Nevitt and her cohorts haven't convinced everyone yet, but word is getting out.

Besides, Nevitt is too busy to take on every naysayer. In addition to continuing her long-running studies, she's juggling several new investigations. Mammals, humans included, typically prefer potential mates whose immune system is different from their own. They pick up on the smell produced by immune function genes, known as the major histocompatibility complex. Nevitt and Scott Edwards, an evolutionary biologist at Harvard, have launched a large, multiyear study to see if the same is true for Leach's storm-petrels. Nevitt is wading into climate research, too, looking at how seabird losses due to global warming might be affecting krill and phytoplankton production and overall ocean health. And recently, the CIA came calling. She's teamed up with the agency to investigate whether birds can smell volatiles associated with plastic explosives. "It's a weird world," she says. But it's clear that Nevitt wasn't wasting her time after all.

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