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Vaughn Bryant, Honey Sleuth

What's that honey? Odds are, it's not what it's labeled.

And scofflaws are erasing the pollen fingerprints.

By M.E.A. McNeil

"I am just starting to feel comfortable," said Vaughn Bryant, 40 years into his career as a palynologist, a pollen scientist. What he means is that he has acquired the skill to identify hundreds of common pollens through a microscope and key out thousands more -- something that can be done only by a long-trained human eye. He is a specialist in melissopalynology, the study of pollen found in honey, which he does "because it is a challenge, and it has broadened my knowledge of pollen."

Vaughn Bryant, a palynolgist at Texas A&M University.
Photo courtesy of Vaughn Bryant

As he spoke at his lab at Texas A&M University, he was processing samples of honey from all over: from a Florida packager concerned that her tupelo honey was valid, from members of the North Carolina State Beekeepers Association checking to see if store-bought sourwood honey was authentic, from importers, sellers and curious beekeepers spanning the country wanting to know if they have premium honeys favored for taste, mead making, cuisine, or lack of crystallization – white acacia, ironwood, fireweed.

"I'm flooded with samples," he said. "I tested an East Texas tallow honey that was not tallow at all; it was a blend from the Dakotas. A sample of California clover honey turned out to be from canola and rapeseed. I have had buckwheat honey with no buckwheat in the sample, star thistle with no star thistle. People have no idea what they are buying, both importers and local buyers. Right now it is a crap shoot. You may or may not get what it says on the label, and that's wrong.” A Virginia merchant labels his tested honey with Bryant’s name, the only person in the United States doing this analysis routinely.

Although isotopes of sugars can be indicators, pollen identification is hands down the best way to determine the source of a honey. It can trace what bees forage to identify prized varietals. It can also place a sample geographically -- crucial to the American honey market, which was flooded with underpriced Chinese honey that undercut the stability of domestic beekeepers. Those imports are often diluted and cannot be guaranteed to be of the stated floral source. “There is purposeful deception, but many unknowingly have it wrong, saying ‘This has got to be mesquite because I saw bees all over the mesquite flowers.’” How often? “60% of the samples I test are not what they are said to be,” said Bryant, who has verified that estimate with several thousand samples.

Apple pollen., Malus domestica. Photo: Russ Crutcher, Microlab NW

Bryant holds degrees in geography, anthropology and botany. Son of an Associated Press correspondent, he’d lived in 14 countries and become trilingual by the time he was seven, so geography was a natural start. His fascination with fauna and cultures of the lands followed, with their stories to be unlocked with clues found in pollen. It is this combination of disciplines that allows him to link pollen to plants and plants to their geographical range, revealing the provenance of a honey.

He has been a professor at Texas A& M since 1971, where his first commitments are to teaching students and directing the palynology research laboratory there. Much of his lab work involves forensic pollen studies in criminal investigations, but he also uses pollen to detect paleoenvironments, ancient human diets or the cargos from sunken shipwrecks. About a quarter of his time is devoted to pollen and honey research. “My University salary comes from being a professor, doing archaeological work and teaching, not from testing honey samples,” he said. “The honey testing is important because it funds graduate students and buys the supplies needed for the pollen research lab.”

Bryant’s work with honey began in 1975, when the Office of Inspector General of the USDA approached him to test the origins of domestic honey purchased by the federal government as part of its farm loan program. “I had no idea what I was getting into,” Bryant said. “I thought it would be easy. At $70 per sample, I probably earned about ten cents an hour, but I sure learned a lot about pollen and honey.” He did discover that about 6% of the samples were foreign honey, mostly from Mexico, that was fraudulently sold to the government.

Since then, he has amassed a multi-million dollar collection of over 20,000 pollen samples from around the world, housed in cabinets with slide-out trays in his lab. Much of the collection, he says, was donated by oil companies, BP-Amoco and Exxon-Mobil, which use pollen to define the ages of rock strata during oil exploration.

The U.S. imports about a third of the honey it consumes. In 2001, the government imposed high tariffs on Chinese honey, which was priced lower than its cost and undercut the domestic market by about half of what American beekeepers could ask. Since then, honey exports from other Asian countries have risen dramatically, again at low prices. Bryant has found samples from Viet Nam, Cambodia, Indonesia and Laos that contain "a little honey from those countries and a majority of the blend coming from Chinese sources…At the rate the Chinese are dumping this honey, it could devastate the U.S. honey industry," he said.

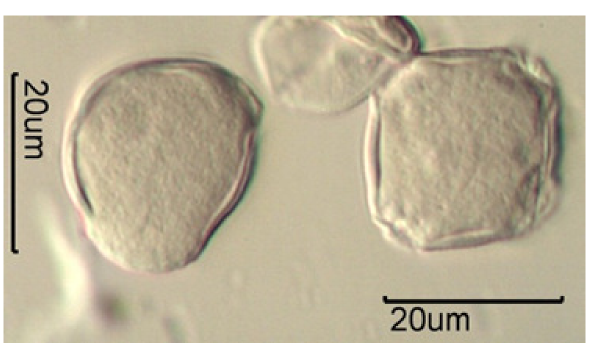
The goal of the melissopalynologist, connecting pollen with nectar source, is not a simple proposition. For starters, worldwide there are about 330,000 flowering plant species, each with its unique pollen. And the ability to distinguish one microscopic speck of that pollen just gets you in the door to a labyrinthine puzzle.

If you are current on bee biology and behavior, skip on, otherwise it is useful to briefly review the relationship of honey bees to pollen. It is the bee's major source of proteins, fatty substances, minerals, and vitamins -- vital to the growth of larvae and young adult bees. Pollen is the key to reproductive survival for the bees as well as the flowering plants: In the 40s it was discovered that colonies could survive but not reproduce on sugar syrup alone; when pollen was added to the syrup, egg laying began within 12 hours.

While pollen looks like food to a bee, for a flower it is the source of its male gametes or sperm cells. Grains hitch a ride on a pollinator – animal, water or wind – to a compatible pistil, where pollination occurs. That is to say, a pollen tube is produced that transfers the sperm to the ovule, the female gametophyte. While a forager is gathering nectar or removing pollen from an anther, grains adhere to the forked hairs that cover her. She combs the pollen from her body, mixes it with nectar, and transfers it to pollen baskets, the corbiculae, on her posterior legs.

How does pollen get into honey? On the flower, a honey bee can dislodge grains that fall into the nectar that she then stores in her honey sac. In the hive, pollen that she carries on her body can be groomed off or tracked by other bees to open cells of unripe honey. Airborne pollens produced by anemophilous, wind-pollenated plants, can be blown into a hive, and bees collect pollen from wind-pollenated plants as well; although those pollens are a small fraction of the pollen spectra found in honey, they can also serve as geographic markers.

One complication for the melissopalynologist, and it is not a small one, is that the types and percentages of recovered pollen in honey are not a 1:1 correlation with their related nectar. Far from it; many pollen types are over or under-represented in the relative counts in honey samples. For example, some plants, such as sourwood and fireweed, are weak pollen producers or, for morphological reasons next explained, are not found proportionately in honey. So to know the true nectar content of a honey is to unravel an intricacy of pollen mass, pollen morphology, pollen production, and method of

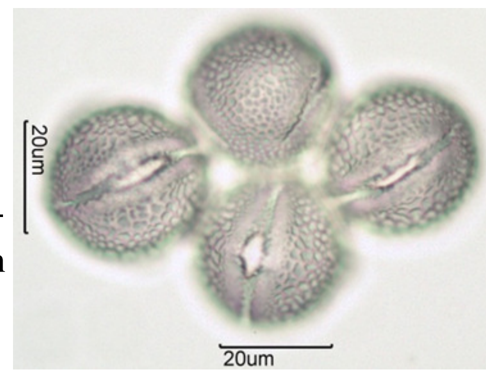


Blackberry pollen, Rubus fruticosus.
Photo: Russ Crutcher, Microlab NW

dispersal – enough to leave you holding your head before it is mentioned that it also involves flight time of the bee.

In the 1940s two USDA scientists, Frank Todd and George Vansell, collected the nectar from more than 2,600 flowers representing 73 different plant taxa in California – from the honey stomachs of bees that had just fed on a specific plant as well as from flower nectaries. They established pollen concentrations for each nectar source, demonstrating that pollen content varies widely by floral species. Their research became the foundation for the later development of pollen coefficient (PC) values, correctives for these variations. Researchers have continued to refine PC values to come up with more reliable determinations of nectar sources.

"Not all flowers are made the same," said Bryant. And honey is rarely from a single botanical source; the term "unifloral" describes honey that is produced mainly from one plant species. Some 50 years ago, The International Bee Commission set a standard for a varietal honey: 45% of the total pollen needs to be from that plant. "There is no way in hell you could get 45% fireweed pollen in honey." With a simple relative pollen count, one tested Alaskan honey sample would have been classified as rapeseed-canola honey, since it had only 6.3% fireweed pollen; but when the PC value is considered, the primary nectar source becomes fireweed flowers at 95%, not rapeseed/canola flowers at 1.9%. The range is enormous: In fireweed honey there are 2-3000 grains of pollen in 10 grams of honey -- 0.1% of that found at the other end of the spectrum in pollen-dense forget-me-not honey, which averages 1.5 million grains per 10 grams of honey.



Red clover (Trifolium pretense).
Photo: Russ Crutcher, Microlab NW

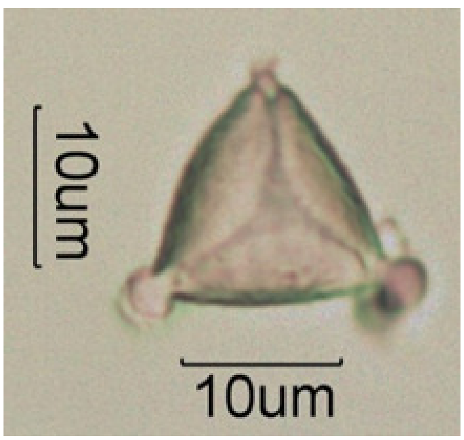
He cited other examples of pollens with a low ratio of pollen to nectar: New Zealand thyme honey is considered a premium commercial type, although thyme pollen rarely reaches a total of 45%. Flowers from some species, such as blueberry and heather, produce small amounts of pollen. Some species have flowers that are morphologically more difficult for pollen collection, such as alfalfa. Other pollen types that usually underrepresented in honey samples include basswood, avocado, orange blossom, thistles, mint and locust. In contrast, some pollens proliferate in the nectar: "You expect a pure clover, eucalyptus, or canola honey to have much more than the required 45%," Bryant said.

Scientists have long known that bees remove pollen from nectar in their honey stomachs. Scientists studying dysentery in honey bees in the 1920s found pollen grains in bee feces and determined that grains were ingested along with nectar. What we know now is that once in the honey stomach, nectar flows over the proventriculus, the organ that acts not only as control for the nourishment entering the bee's digestive tract but as a nectar filter. Nectar in the honey stomach is drawn back and forth through triangular lips of the proventriculus, removing much of the pollen, fungal spores and debris which might spoil the honey to be made from it. A valve prevents the filtered nectar from passing into the bee's digestive system but permits the particulates to pass.

Bees are more efficient at filtering out large pollen grains produced by some plants, such as honeysuckle and fireweed. Conversely, small pollen grains, such as those of eucalyptus, sweet clover, and chestnut, are usually over-represented in honey; their numbers are prolific, and fewer grains are filtered out by the bees. The filtering process is rapid and effective, taking only about 10 minutes to remove most of the pollen from the nectar. The phenomenon caused by foragers filtering nectar-laden pollen and defecating it as they fly is called yellow rain. Perhaps the recipients of those showers on their cars and patios would be less peevish if they thought of them as purifying honey.

So, foraging time is added to the influences on the amount of pollen in the resulting honey: depending on the length of flight, the bees can remove as much at 90%. Also, it is known that some bees are more efficient at removing pollen from their honey stomachs than their sisters.

With so many variables, the potential for error in determining the nectar sources of a honey can be great, so lab work needs to be precise. Over the years Bryant has refined his analytical protocol, realizing that the century-old methods of diluting honey samples with water lost a small but significant number of grains. "Lipids on the outside of pollen are buoyant, and pollen grains can contain air in vacuoles. 95% sink, but some float. You could lose a small portion, and you need to look at all the pollen," he said. There was also loss of pollen during centrifugation. A former student developed a filtration process that addressed the problem, which is used, but it is expensive and time-consuming. Bryant and Gretchen Jones, then his grad student and now a palynologist with the USDA, came up with a simpler solution (so to speak): "We solved it by dropping the specific gravity with ethanol." Both the filtration and alcohol processing methods increased pollen recovery from honey samples by an average of more than 200% over water dilution processing methods normally in use.



Eucalyptus pollen grain. Photo: Russ Crutcher, Microlab NW

Jones and Bryant also established a ratio of added tracer spores for each test -- using a fern-like plant, *Lycopodium*, which would not be found in honey – to create a reliable matrix for the pollen count.

There are several ways to examine honeys. "With light microscopy I can go down as far as necessary for most identification," said Bryant. "For example, I can often say a pollen grain is from some genus with the light microscope. But I can't refine it down to the species. If you need to know which species, it is necessary to move to the scanning electron microscope, and for that you need deep pockets. In one sample, I identified pollen as being basswood, and with the electron microscope we found that there were really four different species of basswood in the sample."

"As for identifying honey by the isotopic signatures, there is a paper on the isotopes in the Canary Islands. So if you have a sample from the Canary Islands it's good, but not much has been done for the rest of the world. The problem is that isotope analysis of honey can be done, but there is no worldwide databank to compare it to."

"I have been creating a pollen data base for domestic honey," said Bryant. Still going strong at 71, he hopes new melissopalynolgists will enter the discipline to refine it. "I don't know of anyone willing to expand the pollen coefficient database. The research would be very time-consuming although it is not difficult. Most of the work was done in the 40s 50s and 60s by women because I think they have the needed patience." The work would involve a new series of experiments to determine the precise PC values for many of the nectar sources used to produce premium types of honey. One benefit of such research could be that honey samples from specific species could provide the opportunity to determine pollen amounts and the expected ranges of pollen for those types.

As to the potential for automating pollen identification analysis, Bryant said, "Currently some computer programs can recognize and count limited numbers of pollen types, but they still have trouble differentiating some types and especially identifying broken pollen grains. Next month there will be meetings to address the potentials for refining a useable automated pollen counting system. Right now, for honey and for forensics pollen work, the human eye is better than the computer. Nevertheless, such a technique might soon become reality, and when it does, there would still be the need for palynologists to check for errors. If it works, it would have so many applications it would be like inventing fusion energy."

One problem that he hopes the federal government will address is accurate honey labeling. Bryant analyzed 60 honeys brought to him by Food Safety News, a web-based newspaper dedicated to issues of food safety. The samples came from farmers' markets, and big box, grocery, natural food and drug stores across the country. More than 75% of the samples had all the pollen filtered out.

Honeysuckle pollen (Lonicera sp.)
Photo: Russ Crutcher, Microlab NW

Does it matter? Any discussion of nutritive value aside, there is no way to identify not only the floral but the geographic source of the honey with its pollen fingerprints removed. The food safety divisions of the World Health Organization and the European Commission have ruled that without pollen there is no way to determine whether the honey came from legitimate and safe sources. "You can't sell honey to EU countries without pollen proof," said Bryant. Florida has passed new laws saying that honey for sale must contain pollen, and North Carolina has new regulations to verify sourwood honey sold in that state.

The problem is Congressional law, according to Bryant: "The USDA standards for honey sold in the US state that it is okay to sell honey without pollen…The problem is the foreign or illegally imported honey with no pollen. We have no way to track the honey, no idea where it comes from. We have strict laws and tariffs to protect US citizens against illegally-imported honey, but with no pollen there is no fingerprint of origin. The American Beekeeping Federation has lobbied Congress to pass laws. Beekeepers have been pleading with the federal government to enact stricter guidelines." Five U.S. honey producers have begun a campaign, now called True Source Honey, to raise consumer awareness of the problem with imports.

"We've never had 'truth in labeling' for selling honey, and we should," Bryant said. "The U.S. needs to make it illegal to import filtered honey because it is almost impossible to detect where it came from. Most other countries do have laws, so why don't we?"

Recent arrests of a Taiwanese executive and a Chinese honey producer for separate fraudulent honey labeling schemes have stopped a few of the millions of pounds of illegal honey entering the country. But Bryant says there are other examples: He has examined imported honey for US companies that were blended or filtered and don't match what the companies thought they bought.

He does get to have some fun with it. Asked to analyze the honey from the White House hive, he concluded that it is a unifloral clover honey with minor amounts of other nearby nectar, including dogwood, honeysuckle and magnolia – a bona fide taste of the Washington neighborhood served at State dinners.

Bryant continues to run his one-person CSI operation. He said, "I'm trying to help out here and there, but it's almost impossible to keep up." The kind of pollen analysis of honey that he does for a fraction of the cost can run as much as a thousand dollars per sample at some European labs. The hope is that others will take up his quest and learn to understand what he comprehends through the ocular piece of his microscope.

He has a mission: "People want truth in honey labeling. That is one reason I do this work."