Yellow Rain Experts Battle Over Corn Mold

An obscure toxin began killing chickens in Arizona 2 years ago; the experts fail to agree on what it is, but recent findings point to a compound similar to Yellow Rain toxins produced by a common corn mold

Arizona's farm establishment, shaken a few years ago by a scare over aflatoxin in milk, does not want to advertise another mold problem that turned up recently in corn in a far southeastern section called Cochise County. But the case, which began 2 years ago when chickens started dying mysteriously, deserves notice for its science, its politics, and its health implications.

It involves a new toxin that may belong to the trichothecene family, the same group found in Yellow Rain. Some scientists believe that the toxin has been produced by a systemic mold, *Fusarium moniliforme*, found in the kernels of all U.S. corn. If confirmed, its appearance in Arizona does a couple of things. It upsets the established view that this common mold does not produce broadly destructive toxins. This raises questions about the current system for protecting the quality of corn. And it raises questions about the categorical way in which U.S. officials have ruled out natural causes as an explanation for the appearance of Yellow Rain toxins in Southeast Asia. One such argument rests on the assertion that *Fusarium* molds do not produce trichothecenes in warm climates. Cochise County gets quite hot in the summer.

If *Fusarium moniliforme* is the culprit in the Arizona case, the implications for U.S. agriculture are extremely broad because the mold is so ubiquitous. So far, however, it is unclear whether the toxin is produced by a new strain of *moniliforme*, or whether it is formed by a common strain under special conditions. The toxin itself has also yet to be clearly identified.

In any case, the chicken deaths have sparked a blizzard of law suits involving corn growers, a feed company, and chicken farmers. "I suppose I should be happy to be earning money on the case," says Mark Collins, an attorney at the Tucson firm representing the Arizona Feeds Company, which is being sued for breach of contract and is counterclaiming that it was sold moldy corn. Collins says that, more than any other case he recalls, this one deserves to be settled out of court. In his office is a large gray file of depositions and briefs on the effects of the *moniliforme* toxin. He waves at it and says, "If this goes to trial, everyone will be hurt." Furthermore, he points out that the legal system is not designed to settle scientific disputes.

The trial was scheduled originally to begin in February, but Collins went to the Cochise County courthouse in Bisbee early this year and asked that it be postponed. He wrote in a brief in March that preparing a defense had become an onerous research project.

"It took an enormous amount of time and effort," Collins pleaded, especially since "this specific problem had never before been reported or investigated. Indeed, the source of the problem is so unique that, as the court will learn, there are still members of the scientific community that refuse to believe Arizona Feeds' findings. [The] investigation was and is on the cutting edge of scientific discovery and as a result the process of identifying the problem was at times painstakingly slow." The judge agreed and put off the trial indefinitely.

In private, Collins seems annoyed with the experts. From the outset, they brushed aside his company's allegations about a new toxin. His only reason for speaking with a reporter, he claims, is to make a plea for better research. "If they conclude that Arizona Feeds did something wrong—fine. At least we will understand what happened." But at the moment, Collins thinks some of the mycotoxin specialists are avoiding the task.

The case has provoked some intense but little-noted legal wrangling in Tucson and Phoenix. The local papers have not made much of it, but ever since the problem appeared in early 1981, the state's largest agricultural firms have been trading lawsuits like addled boxers trading blows. It began when chickens at the state's biggest poultry firm, the Arizona Egg Company, started eating erratically, laying fewer eggs, bleeding internally, and dying. Because the local experts were stumped, they brought in an international nutrition consultant, Thomas Bowen of Nutrition Specialties in Cucamonga, California.

After checking all other possibilities, Bowen decided that a mold toxin was responsible and suggested that the hens be taken off the supposedly high-quality diet of corn and put on milo. The problems cleared up. The feed supplier, Arizona Feeds, was notified. Chiefly on Bowen's advice, it stopped buying corn from Cochise County. The surviving chickens, permanently stunted, were slaughtered and sold for human consumption. Then the legal briefs began to fly.

The Grain Co-op of Arizona, the corn growers' outfit, sued Arizona Feeds for $200,000 for breach of contract. The feed company countersued for $750,000 on grounds that the corn had been sold fraudulently. Then the Arizona Egg Company sued the feed company for $223,000 over and above the $250,000 it had already received in damages for bad cornmeal. The feed company petitioned successfully to bring in another granary in Cochise County which allegedly supplied bad corn. Another big poultry firm was roped in as well, to buttress the feed company's charges. More recently, the Grain Co-op has drawn up bankruptcy papers. The Arizona Egg Company has closed down the Tucson chicken ranch where the problems were most severe, and the feed company has been acquired by a new owner.

The legal brawl is clearly more than just a fight over monetary damages. The future of corn farming in Cochise County may be at stake, and that means that some major economic and political investments are at risk. Corn was introduced into the county in the mid-1970's in a state-supported plan to provide a new summer crop for Arizona and a local source of chicken feed. It is the only area of the state where corn is grown in the summer. The plan was backed by agribusiness, politicians, and agricultural scientists in Arizona, and tax incentives were used to attract investment into the area.

There are also international implications, for there have been allegations that some infected corn may have been exported. A spokesman for the Cochise County growers, Olen Zirkle, Jr., manager of the Grain Co-op, declined to talk

about this or any aspect of the case. His attorney also refused to comment. But several scientists who have followed it closely say that at least some of the corn went to Mexico, where it was sold for tortilla meal. In addition, some moldy corn may have been blended and sold as normal feed corn. This is a sensitive subject. Mexico, Spain, and the European Common Market have complained in the past about mold in U.S. corn.

The expert testimony, if anything, is more confused than the legal record on the case. Several private laboratories hired by the feed mill looked into it and produced controversial findings. Perhaps the most critical information has come from the USDA regional laboratory in Peoria, Illinois, where a chemist and his summer assistant went to work on a sample of feed collected by Bowen. (Few people are aware of this research, for it has not been reported.) They examined toxins in two batches of chicken feed (from Indiana and Arizona) and found them to produce trichothecene-like effects (skin rashes on rabbits, death in mice). Both feeds were loaded with *Fusarium moniliforme*.

In contrast, some renowned mycotoxin experts joined the fray on the farmers' side, minimizing the problem. Among them are Chester Mirocha of the University of Minnesota, the State Department's chief tester of Yellow Rain samples and its star scientific witness, and Clyde Christensen, Mirocha's long-time collaborator on grain storage research, now retired and living in Arizona. As one USDA scientist puts it, the distinguished "Minnesota mafia" has established the dogma that *moniliforme* does not produce trichothecenes, and this makes it difficult for them to accept an opposing point of view.

Mirocha says, "None of the [Arizona] samples that I am aware of have any trichothecenes in them. We looked for trichothecenes; we couldn't find any." He sees "no significance" in the fact that feed from Arizona contained extremely high counts of *moniliforme* spores. This is "coincidental." He disregards spore counts because "*Fusarium moniliforme* can be isolated from almost any corn at any time in almost any condition. Even in a healthy-looking plant, you will find it. It lies quiescent in the tissues." It will grow vigorously in the laboratory if encouraged, but Mirocha says, "Nobody has demonstrated a correlation between spore counts and toxicity of cereal grains."

Mirocha was asked if it were possible that *moniliforme*, normally innocent, is sometimes encouraged by natural conditions to grow vigorously and produce toxins that are not so innocent. It is possible, he says, but not likely. Asked about a report that vomitoxin, a trichothecene compound, may be in the feed, Mirocha says, "*Moniliforme* does not produce vomitoxin, and it does not produce trichothecenes. There are reports in the literature that it does, but these are wrong." In these cases, he believes, the researchers misidentified the mold, a common failure among chemists. This is precisely what Mirocha said in a letter to Zirkle in 1981 and in a deposition supporting the Grain Co-op in February—concluding that the chickens' problems cannot be blamed on Cochise County corn.

Pat Hamilton, a poultry scientist at the University of North Carolina and a witness for the feed company, tells the other side of the story. "Chet Mirocha, bless him," says Hamilton, "it's been a long time since he scraped manure off his shoes. If you listen to the chickens, they'll tell you there is something there." He agrees that "it may not be a trichothecene," but "it has produced reddened skin on rabbits, which is the classic way you test for trichothecenes." As for Mirocha's chemical analysis, Hamilton says, "he's looked for two trichothecenes. There are at least 50 of them. The failure to find 2 out of 50 is not very convincing." The problem is that the chicken feed may contain a toxin with slightly different characteristics than existing test models are designed to recognize.

Hamilton says the chickens' ailments are clearly associated with high levels of *moniliforme* in corn and that the pattern has appeared in at least 11 places (Alabama, Arizona, California, Georgia, New Mexico, New York, North and South Carolina, Tennessee, Virginia, and Mexico). In his area, it is known as the "new crop corn syndrome" and in Georgia as the "fall syndrome." It appears when newly harvested local corn is run through the feed mills and given to chickens and pigs. Later in the season, when local supplies have run out and midwestern corn stocks are being used, it disappears. The symptoms, Hamilton claims, are "variations on the theme" that turned up in Arizona: erratic behavior, poor absorption of nutrients, and immune system failures.

"When I first heard about the high counts of *Fusarium moniliforme* I thought it was impossible," Hamilton recalls. He knew the dogma that *moniliforme* is usually innocuous and considered the high mold counts mistaken. But he went back and checked the data recorded by technicians in his lab. "There were the same high numbers, and my own lab had been ignoring them because I had told them to." The colony counts for *moniliforme* in bad feed were three to four orders of magnitude higher than normal, up to 2 or 3 million per gram, "enormous levels," Hamilton says.

Wanda Freeman, manager of residue monitoring at the private agricultural testing lab Woodson-Tenent in Memphis, Tennessee, takes credit for alerting Hamilton to these high levels of infection. Her lab came into the Arizona case early in 1981 when Bowen, the nutritionist, sent in some feed samples. Woodson-Tenent could not isolate a toxin but did notice the high mold counts. Freeman alerted others and sent some of the meal to Peoria for further study. She also wrote a booklet on the importance of *moniliforme*, warning clients that the mold may produce trichothecenes. "The USDA should open up this investigation," she says. Skeptics in Arizona think that Woodson-Tenent lacks expertise in mold identification and may be trying to drum up new business.

Eliot Marshall

Cochise County, Arizona

The area where mold appeared in the 1981 crop. Not much corn is being grown this year.

Even if one rejects the mold counts, as Mirocha does, Hamilton says there is evidence that *moniliforme* produces strong toxins. Research on Southern Corn Leaf Blight in the early 1970's identified a toxin, dubbed "moniliformin," produced by a special strain of *moniliforme* and capable of stunting plants and killing chicks. One of its odd qualities is that animals show no pathology at low doses but simply die when they cross the lethal threshold. Separate research in Tennessee and South Africa has confirmed that *moniliforme* produces another toxin capable of liquefying a part of the brain in horses and donkeys, with obviously devastating effects. The disease is called leukoencephalomalacia. Harland Burmeister, a microbiologist at USDA's Peoria lab, announced in March that he has isolated several other toxins produced by *moniliforme*, one of which created a "feed refusal" effect that mimics a trichothecene called vomitoxin.

Then there is the curious case of the Morasas letter. W. F. O. Morasas is a well-known South African mycotoxicologist interested in *Fusaria* and particularly in *moniliforme* toxins. In addition to studying moniliformin and the horse toxin, he has shown that *moniliforme* in cornmeal is associated with a high incidence of esophageal cancer among blacks in the South African "homeland" republic of Transkei. He also is collaborating with the foremost cataloger of *Fusaria* in the United States, Paul Nelson of Pennsylvania State University. They intend to publish a new and definitive taxonomic ranking of *Fusaria*. (Like Mirocha, Nelson is one of the government's Yellow Rain consultants.)

Nelson got a shipment of Cochise County corn in 1981 and from it he isolated an unusual strain of *moniliforme*. He sent this to Morasas in South Africa. Morasas obtained a toxin from it which was lethal to duck chicks. Morasas wrote a letter reporting this to Nelson. Nelson forwarded the letter to his brother Merritt, who had obtained the original batch of Arizona corn from which the mold was isolated. Merritt is a plant pathologist in Tucson in charge of the state university's aflatoxin program and other university projects. He had become involved because his dean, the former president of Arizona Feeds, wanted to learn more about what was in the corn.

Hamilton heard about the letter and asked for a copy. His request was denied. Hamilton is not one to be put off easily, so he called Morasas in South Africa, who confirmed the effect on duck chicks. Morasas, who was in New Hampshire recently for a meeting on trichothecenes at a Gordon Conference, declined to return phone inquiries. The structure of the toxin Morasas found has not been identified.

Meanwhile, at the USDA lab in Peoria, chemist Ronald Vesonder extracted several toxins from the Arizona cornmeal obtained by Bowen. He showed that these could kill mice and irritate rabbit skins as trichothecenes do. However, when run through the lab's test for 13 of the 50 or so trichothecenes, they produced no recognizable results.

While Vesonder was attending the Gordon Conference this year, his student, Douglas Demarini, isolated a toxin from *moniliforme* in a batch of Indiana chicken feed. It appears to be a form of vomitoxin bound with another compound, thus appearing in an unexpected spot on the test plate. Vesonder said after returning from the Gordon Conference, "We [Vesonder, Mirocha, and Morasas] decided that *Fusarium moniliforme* produces no trichothecenes." Yet later, on the basis of Demarini's new findings, he agreed that something like vomitoxin was produced by *moniliforme* in the Indiana feed. It is a confusing situation. More tests are planned, but Demarini says he does not know whether he will have time to run comparable tests on the Arizona feed before he has to return to school at the end of the summer.

NASA

Southern corn leaf blight, 1971

Georgia researchers isolated a toxin produced by moniliforme *in blighted corn.*

The implication of all this inchoate research is that *moniliforme* does present a significant economic threat to U.S. agriculture, if not because of the intensity of its toxins, then because of its prevalence. As one researcher says, *moniliforme* is the equivalent in corn of *Escherichia coli* bacteria in the animal gut: "it's just there." In some places and under some conditions, it seems to produce disastrous effects. It might be worthwhile finding out why. At present the USDA does not even require that corn be tested for fungus toxins, although the Federal Grain Inspection Service will check for aflatoxin, on request. Sampling and surveying techniques are considered rudimentary.

Insofar as human health is concerned, most researchers seem to agree that the hazard is slight. However, they are reluctant to generalize because so little is known. There are indications, for example, that one of the *moniliforme* toxins is carcinogenic. Paralleling Morasas' work in South Africa, Chinese researchers have associated *moniliforme* in moldy corn bread with a high incidence of esophageal cancer in one province. A U.S. collaborator, Leonard Bjeldanes at the University of California at Berkeley, explains that the people in this province like the flavor of moldy bread the way some Westerners like Roquefort cheese. Bjeldanes regards this mold with respect. He has checked 50 fungi using the Ames test for mutagenicity and found *moniliforme* to be "the one that was consistently positive." It stood out from all the others. He says that *moniliforme* strains from all over the world have tested positive on the Ames assay. Bjeldanes isolated several toxins and labeled the most consistently mutagenic "Fusarin-C." It is not as potent as aflatoxin, he says, but perhaps as worrisome, because *moniliforme* is so common and "people do consume corn products."

The effect of moldy corn on chickens seems clearer. Bowen theorizes that the unidentified *moniliforme* toxin blocks the animals' ability to absorb vitamins A, D, and K. No matter how thoroughly their feed is saturated with vitamins, chickens eating this toxin will suffer from poor blood clotting, immune system failures, and other aspects of the "malabsorption syndrome." Bowen says there is reason to be concerned about human health. Half the crop in Cochise County was white corn, intended for human consumption, and Bowen "knows for a fact" that it was shipped to Mexico for tortilla meal. Generally, mycotoxins are not destroyed by cooking. Bowen says he would be "scared" if he had to subsist on a diet primarily of *moniliforme*-loaded corn.

"We have a problem," Hamilton says. "Exactly how it came about, we don't know." But he is willing to speculate. It began to appear in the mid-1970's as energy prices shot upward. "People

stopped fertilizing corn the way they used to," Hamilton notes. This lowered the protein content, he thinks, yet feed formulation handbooks, geared to the least-cost use of cereals, did not take account of the change. Animals are less susceptible to mycotoxins when well fed. So normal *moniliforme* problems may have been magnified as corn growers and chicken raisers tried to cut margins too closely. The poultry industry is more efficient, more mechanized, and more sensitive to change than others. It noticed the problem first, but Hamilton says hog farmers in his state are also having mycotoxin problems.

Second, Hamilton thinks corn growers have cut back on the use of dryers because energy costs so much. It is a well-known fact, often ignored, that wet corn encourages mold. Corn purchase agreements generally specify a maximum moisture content. However, farmers apparently find it profitable to try to meet or beat the limit, because the corn weighs more when wet. Hamilton's crowning example of the ignorance that prevails on this subject is an article that appeared in the magazine *Successful Farming* a year ago. Entitled "Pumping the Value Back In," it recommends that farmers wet their corn to the limit, since granaries do this in any case. It provides detailed tables for going about the task, set off by a vivid photograph of a hose pouring water onto a truckload of corn.

Hamilton is one of many who believe it is time to focus on some of the less known mycotoxins, to try to understand how and why they are created and learn what may be done to discourage their formation. He says a USDA official told him that because of worries about international grain prices, the big campaign to clean up *Fusarium* problems would have to wait until next year. "Well," Hamilton says, he has waited, and "This is next year."—**ELIOT MARSHALL**

CEQ Staggering Under Latest Budget Cut

The Council on Environmental Quality (CEQ) has fallen on sorry times since the days when its halls were thronging with experts, its reports were abundant and much-heralded, and its chairmen had the ear of Presidents.

Now it is one council member short, its staff is down to 13, and it has been dealt a nasty budgetary blow. Congress recently voted to give the council $700,000 for fiscal year 1984—even less than the Administration's request of $913,000 and quite a tumble from the old high-water mark of $3.2 million.

The House Appropriations Committee is particularly unhappy about CEQ. In its report it says that "not a single scientist or technical expert is on the permanent staff," which "renders the Council unqualified to offer substantive contributions or policy advice." The report portrays CEQ's accomplishments under this Administration as "modest at best" and observes that the "Council's major function seems to be acting as a spokesperson for the Administration's environmental agenda."

People from the House committee have lately been rummaging through the files at CEQ in the course of an investigation that includes looking at what the council does with its consolidated working fund, the money it gets from other agencies to do studies. This has prompted recurrence of rumors that certain Democrats are looking for a reason to "zero out" the budget, a prospect viewed with alarm by environmentalists since, once the office is dismantled, it will be extremely difficult to bring it back together when the political climate improves.

The CEQ is regarded as having performed an extremely valuable function in the past, issuing reports, monitoring the National Environmental Policy Act (NEPA), performing policy analysis, acting as a direct line to the President on environmental issues, and putting out an annual report that contained extensive independent analyses of environmental progress and problems.

Now, as far as many observers can see, all that CEQ does is put out tardy annual reports that are little more than justifications of government policies.

To be fair to the council, it does not have much to work with. After Reagan came in the staff was slashed from 42 to 13. Council member W. Ernst Minor has just left for the Environmental Protection Agency, to be executive assistant to William D. Ruckelshaus. The only staff scientist has returned to California. Remaining with council chairman A. Alan Hill is Nancy A. Maloley, a former EPA employee who was brought over last year from the White House Office of Policy Development.

Hill admits to being "kind of upset" about the latest budget reduction, which means four or five more employees will have to go. Nonetheless, he feels CEQ has at least one major feat to its credit, namely fending off repeated attempts from within the Administration at emasculating NEPA. He also says that, contrary to the House report's criticisms, CEQ has been influential in arbitrating disputes (such as over the Dickey-Lincoln dam) and getting the environment considered in high-level decisions (the MX). "We're doing a lot more than is obvious," he says.

One of CEQ's activities has been housing the Interagency Task Force on Acid Precipitation, which came out with a report last month. Another will be a conference, arranged with EPA, on the country's long-term environmental research needs.

But Hill's main preoccupation has been the government's role in global resources policies and projections. He initiated the creation of the Global Issues Work Group which advises the Cabinet Council on Natural Resources and Environment. The effort was basically designed to pursue issues raised by the *Global 2000* report on the government's role in data gathering and global foresight. A scientist is at CEQ on detail from the Army Corps of Engineers to staff the effort. The eventual report will include results of a contract to the World Wildlife Fund which has been assigned to find out about data needs in the private sector. Hill is evidently proud of this effort: "We've moved from 'gut the goddamn *Global 2000*' to 'how do we fix the system,' " he says.

Nonetheless, alumni of the old CEQ and others find little to applaud. Washington consultant Dan Tunstall notes that CEQ is a much-admired model abroad—"there's not a country that I go to that doesn't want a CEQ." But, says one environmentalist, ours has been "downgraded, stepped on, kicked, and turned from a wonderful watchdog to a cringing little mutt."—**CONSTANCE HOLDEN**