Bugs in the Yellow Rain Theory

A Harvard biologist says yellow rain looks remarkably like bee excrement; government scientists now say many samples are fakes

The yellow dots which the government has been analyzing for 2 years as samples of "yellow rain" may be nothing more than bee droppings, according to Harvard biochemist Matthew Meselson and four other scientists.* They compared photomicrographs of a yellow rain sample from Southeast Asia with bee feces from a Harvard parking lot and found them to be almost identical, even to the detail of containing bee hairs. The main difference in yellow rain is that it contains a high level of T-2 mycotoxin, a trichothecene poison produced by fungus.

Meselson and biologist Thomas Seeley of Yale dropped the bee bomb on 31 May at the annual meeting of the American Association for the Advancement of Science. "Whatever the source of mycotoxins in various samples, it is possible that yellow rain is bee excrement," was their summary, a gibe at the outpouring of press releases from the U.S. State Department. Their paper has diminished the government's credibility but has not explained what is going on in Southeast Asia.

Meselson does not doubt that the hill people of Kampuchea and Laos are being driven from their homes and killed, nor that a noxious gas or powder is being used against them. But he believes the spray could be any of several things: a herbicide, like those used by the United States in Vietnam; a "riot control agent" such as CS, stocks of which were abandoned by U.S. troops; or an unprecedented new mycotoxin weapon used in violation of the 1925 Geneva Protocol and the 1972 treaty between the United States and the Soviet Union banning such weapons. Because of the terrible implications, Meselson argues, the third possibility should not be accepted without hard proof—the kind that firmly rules out other explanations for the presence of mycotoxins.

One theory which has not been ruled out, according to Meselson, is that mycotoxins occur naturally in the area and are consumed in moldy food. "Imagine that the end of the dry season comes along," Meselson says, "and people are running out of their normal food, glutinous rice. They begin eating less preferred food, occasionally very moldy stuff which they wouldn't eat normally.

Constance Holden

Matthew Meselson

Proposes a benign origin for yellow rain

They get toxin in their blood. They get sick. An airplane comes over and perhaps it drops something. Afterwards they look around and see yellow spots on the leaves. When asked about it later, a certain number will say that the yellow spots came from the airplane." In reality, the spots may have come from bees and the toxins from food, but all are combined in the sufferers' minds as a single malady linked with war.

Meselson began to suspect that there was something amiss in the yellow rain samples last year when he read an appendix to a report filed by H. Bruno Schiefer, a Canadian mycotoxicologist. Schiefer had collected samples of yellow material on a visit to Thailand in February 1982 and given them to a colleague, Gordon Neish, for analysis. Schiefer concluded that T-2 and related mycotoxins of the kind seen in yellow rain do not occur naturally at detectable levels in Southeast Asia, and he was generally supportive of the arguments advanced by the U.S. State Department. But Neish's appendix mentioned an oddity: the yellow spot on one of the leaves brought back from Thailand turned out to be "predominantly pollen." No toxin was found in the spot.

In addition, investigators working on a United Nations report on yellow rain also found pollen in two samples. And a study by Australia's Department of Defense concluded in August 1982 that samples of yellow splotches on leaves collected in Thailand at the same time Schiefer was there "are not toxic and in fact are composed of yellow pollen grains. . . . Since the samples are obvious fakes, they convey no information at all as the veracity or otherwise of the reports of chemical attacks." The author suggested that the spots might have been put on the leaves as part of a "disinformation campaign" or formed when sticky material dripped from a tree and collected wind-borne pollen.

Inspired by these reports, Meselson arranged to have Joan Nowicke, a pollen expert at the Smithsonian Institution, examine powder collected as a yellow rain sample by an ABC News team in Southeast Asia in 1981. Nowicke also looked at a sample of pebbles from Laos collected by an unidentified Canadian in 1982. Both contained pollen. Pollen was found in two other samples analyzed by the U.S. Army Chemical Systems Laboratory, with Nowicke's help. Meselson discussed all this with his friend Peter Ashton, director of Harvard's Arnold Arboretum, who spent 16 years specializing in Southeast Asian botany. Ashton suggested that bees might be involved.

At a small meeting last April in Cambridge, Massachusetts, about 40 scientists met to talk privately about the new findings and consider what role bees might play in the yellow rain story. William E. Sarver, director of the Chemical Systems lab, told the group that "most" of the government's environmental samples of yellow rain contain pollen. (The State Department insists that three do not: two gas masks from Afghanistan

*Peter S. Ashton, Director of the Arnold Arboretum, Harvard University; Joan W. Nowicke, palynologist, Smithsonian Institution; Julian Perry Robinson, Senior Fellow, University of Sussex; and Thomas D. Seeley, assistant professor of biology, Yale University. All collaborated on the pollen research, but not all endorse the moldy food theory of mycotoxin poisoning.

contaminated with T-2 and a water sample taken from a puddle in Kampuchea.) Sarver showed a photomicrograph of a sample with pollen grains. As an amateur beekeeper he was keenly interested in the new data but thought that pollen was being used deliberately as a carrier for the toxin.

The original theory was that pollen grains were the "perfect" size for maximum retention in the lungs (10 to 20 microns). After the cytoplasm had been removed from the center, it was thought, the grains could be impregnated with toxin to create a natural vehicle for a natural killer—an ideal gimmick for waging biological warfare in stealth. Sarver pointed out that bee pollen is not hard to collect before bees take it into the hive. It is gathered by the ton in this country for sale at health food stores. This thinking was encouraged when Bruce Jarvis, a mycologist at the University of Maryland working on an Army contract, learned that toxin-producing fungi grow well on bee pollen. Indeed, Jarvis found that the fungus is better primed for toxin production when started on pollen than on other laboratory media. He now prefers pollen from health food stores as a culture medium.

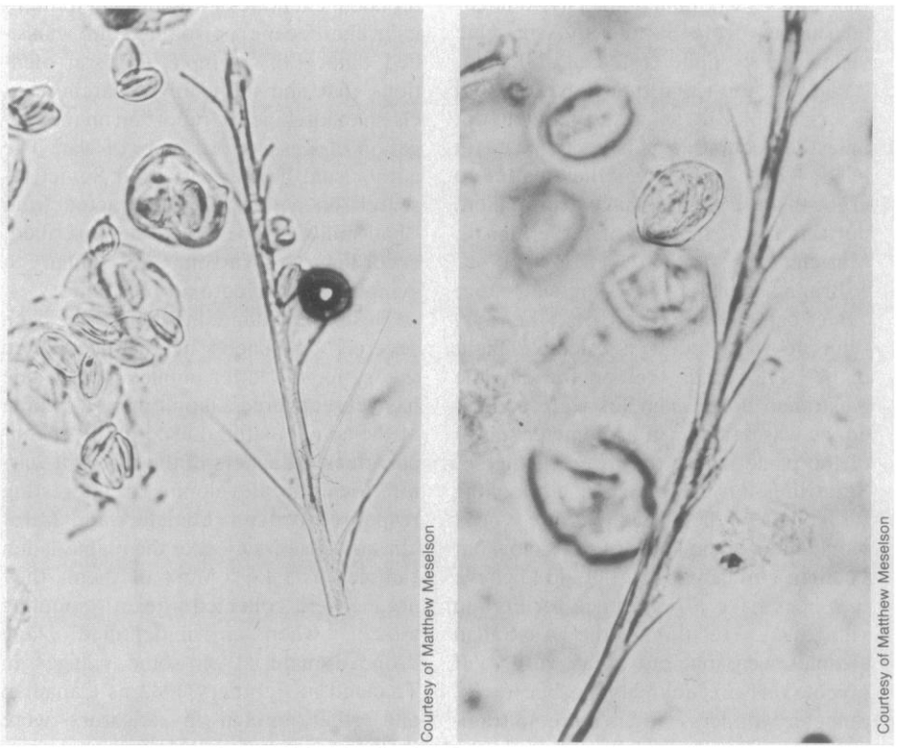
According to one government official, Sarver was one of the keenest proponents of the pollen-as-carrier thesis. But it is fading from vogue. It began to fade when it was noticed that pollen grains in other samples were larger than the perfect size (40 microns) and that bees seem to hollow the grains when they digest them. It makes more sense to think the grains were emptied naturally, Meselson argues, than to think the Soviets went to the trouble of collecting the pollen, washing it with acid, and filling it with toxins. Sarver could not be reached for comment.

After the Cambridge meeting, Ashton got in touch with a former student, Seeley, the Yale biologist, who had spent 2 years in the jungles of Southeast Asia studying bees' defensive behavior. Seeley quickly identified the pollen-laden spots as bee droppings, probably from the large wild honey bee, *Apis dorsata*. A microscopic comparison of droppings from related American honey bees with a few yellow rain samples seemed to confirm this, except for two discrepancies. Some Southeast Asian samples contain very high levels of toxin, and the ABC News team sample has about three times as many varieties of pollen in it as the bee droppings from Harvard. As of this writing, Meselson and colleagues have not explained these differences. Neither have they collected any samples of bee droppings from Southeast Asia, nor have they looked at them to see whether they contain mycotoxins.

The rest of Meselson's thesis, not all of which is endorsed by Seeley and colleagues, has to do with the toxins themselves and a seasonal pattern in their appearance. Meselson noticed that the toxin attacks cited by the State Department fell in a narrow seasonal slot: in February, March, and April—the end of the dry season in Southeast Asia. Meselson suggested that the poisonings were following a natural pattern, keyed to a shift from good to bad diet as supplies ran out.

The moldy food theory would be stronger if trichothecenes, particularly T-2, were found in things eaten by the highlanders. Research in the United States and the Soviet Union indicates that fungi increase their T-2 toxin output as the temperature is lowered and are most productive at cold temperatures (around 8°C). Meselson has scoured the literature for evidence and has come across several reports that molds producing T-2 can and do grow in the tropics. An Indian study in 1980 reported 24.5 parts per million (ppm) of T-2 in moldy sorghum. More recently, Schiefer's yellow-spotted leaves were found to contain a sometime producer of T-2, *Fusarium semitectum*. Meselson also cites a 1978 Indian report that a fungus common to Southeast Asia and most of the world (*Fusarium moniliforme*) produced T-2 in a very warm environment around 35°C. (Some American experts are skeptical because they say no one has been able to duplicate this.) All of this information, Meselson believes, gives a reasonable basis for thinking that T-2 could come from natural sources and make its way into food, pollen, and peoples' blood. There is no evidence that it has done so, however.

The bee theory is "childish" and "absurd," in the view of Chester Mirocha, the mycotoxin expert at the University of Minnesota who has been the primary sample tester for the government. He cannot understand why yellow rain falls only on insurgent villages in the highlands if it comes from bees. "It is very difficult for me to imagine 10,000 bees defecating in synchrony over a specific village at one time, and then somehow getting trichothecenes into the pollen. It seems to me scientifically unsound and rather ridiculous." Theories about pollen are a diversion from the real question, he says, which is: "Are trichothecenes naturally occurring in Southeast Asia on leaf surfaces and rocks, and if so, at what concentrations?" His contention, based on a career of analyzing fungi and toxins, is that "the trichothecenes do not occur naturally on leaf



Which one was manufactured by the Soviets?

ABC News sample of yellow rain, March 1981 (left) and bee feces from Harvard, May 1983 (right)

surfaces" and that the high concentrations of T-2 and related toxins found in yellow rain "indicate to me that they had to be put there by the intervention of man. There is no other conclusion I can reach."

In 15 years of testing agricultural samples, Mirocha says, he has detected T-2 only infrequently, and usually at levels no higher than 50 parts per billion, or 1000 times lower than in the environmental samples from Southeast Asia. One yellow rain sample tested at 150 ppm. "You just don't find that in nature, and it's ridiculous to suggest that you do, unless of course you have the data in hand." It is entirely another matter to argue that the samples have been spiked, but this is not the gist of the criticism, Mirocha says.

Bruno Schiefer is skeptical, too: "Bees can make yellow spots," he says, "but do they follow a selective flight path?" He recalls that on the day the Australian pollen samples were collected, he was less than 100 kilometers north of the place where they were gathered, "crawling through the jungle" looking for yellow stuff. "I can assure you I would have taken spots of any color, but I couldn't find any. Now should I believe that bees have a preference for certain villages?" (He thinks the Australian samples were put out as a "ruse.") If mycotoxins are abundant in bee feces, Schiefer wonders, why is there no traditional concern about yellow spots in the forest?

Sharon Watson, the mycotoxicologist leading yellow rain research at the U.S. Army laboratory at Ft. Detrick, Maryland, rejects the natural toxin theory, chiefly because the levels and combinations of toxins "are highly unusual and have not occurred naturally previously." Using data released by the government after Meselson's bee talk, she claims that there is no seasonal pattern in the poisonings. Mirocha has now analyzed frozen blood from several additional attack victims. Two samples that were positive for mycotoxins were taken from people exposed to chemical attacks in November 1981 and January 1982, earlier than the narrow season cited by Meselson.

Watson says there are many "control" samples from surrounding areas, none of which are positive for T-2. However, the data are not precise. The Army has around 200 environmental samples of yellow rain, only six of which have been tested, and five of which were positive. Watson does not know how many yellow rain samples contain pollen. Sarver's lab is now responsible for investigating this and for testing all environmental samples. In addition, Watson's lab at Ft. Detrick has about 180 biomedical samples, less than half of which have been tested. Of about 69 individuals whose blood or urine was tested, 36 were positive for toxins.

Watson and State Department officials also refer to a body of nonlaboratory evidence that favors their argument: refugees' accounts, symptoms reported after chemical attacks which seem to mimic trichothecene poisoning, and classified data. For example, Watson mentions that she found in the archives a German intelligence report on an interrogation of Russian prisoners of war. The author said he learned about Soviet research on a new toxin extracted from "bad millet." The effects he described, according to Watson, are similar to symptoms of mycotoxin poisoning.

This circumstantial evidence has been severely challenged by the bee pollen theory for the latter implies that no one has yet recovered a munition or a sample of the actual material used in the chemical attacks. Backers of the biotoxin warfare thesis are developing an interesting response. Watson, Schiefer, and Mirocha now dismiss most of the pollen-laden samples as fakes. Most of them, they argue, were collected after a "spoofing attack" when an unidentified plane dropped material on some villages in Thailand in February 1982 as Canadian and other foreign investigators were looking for samples. "My personal opinion of this very atypical attack was that it was a deliberate attempt to confuse those investigating the yellow rain mystery," Watson wrote in an unpublished letter to the *New York Times* in May. However, at least two government samples containing pollen, two United Nations samples, and the ABC News sample were collected before the "spoofing" raid, in 1981.

The problem with throwing out adverse evidence is that it invites a response in kind. Just how certain can government researchers be that their own samples are not fakes?

Once a technical discussion reaches this level of debate, it needs help from outside. Indeed, it may be wrong to call this a debate, for some participants such as Watson see "no point" in entertaining discussions with Meselson. The best way out of this morass is to create an independent panel of specialists and give them the funding and the authority to review all the data and come up with the most comprehensive interpretation the facts will permit. The Administration has no plan to do this at this time.

—ELIOT MARSHALL

Lobbying Pays Off for Catholic U. and Columbia

Catholic and Columbia universities have passed another hurdle in their unusual campaign to wrest money from the Department of Energy (DOE) for new research facilities. On 7 June, in spite of objections from President Reagan's science adviser, George A. Keyworth, the House of Representatives voted to give the two universities $5 million each to start constructing the facilities. What upset Keyworth was that neither facility has been reviewed by DOE or the House Committee on Science and Technology, which oversees DOE's research activities (*Science*, 3 June, p. 1024).

James Sensenbrenner

Upset by lack of peer review.

Instead of going through the long and uncertain review process, Catholic and Columbia took their proposals straight to Congress and enlisted a consulting firm to help in the lobbying. Thus it was that on 12 May, the House agreed to amendments proposed on the floor that approved the facilities in principle. On 7 June, the proposals came up again during debate on DOE's appropriations bill, and Representative James Sensenbrenner (R–Wis.) tried to shoot them down.

Sensenbrenner proposed an amendment to delete funding for the facilities, and to bolster his case cited a letter from Keyworth complaining that "Although these may be worthy construction projects, the method by which they were inserted into the authorization and appropriation bills will result in a serious erosion of the orderly Executive Branch planning and