## FactorFiction?



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What do canaries, mice, fish, spiders, ants and bees have in common? They all have been used in an attempt to monitor environmental pollution. Canaries were used in coal mines as crude air-quality sensors because they are more sensitive than humans to carbon monoxide. A bird that succumbed not only warned of the danger but could be revived by quickly taking it to clean air, and it could be used again without any loss of sensitivity.<sup>1</sup>

Mice are routinely used as indicators of the toxicity of food and chemicals. Hardly a month goes by when we don't hear the latest scare about what causes cancer in mice. Many plating shops proudly display a fish tank showing critters thriving in recycled rinsewater from the facility. Bluegill fish have been used to monitor stream temperatures and water quality near waste treatment plants.<sup>2</sup> Lake trout are used in the Great Lakes to monitor both threats to human welfare and the integrity of the aquatic ecosystem.<sup>1</sup>

## Spiderwebs Spin Tales

Spiderwebs are influenced by every environmental factor, from weather to diet. Drugs recently absorbed by a spinner may noticeably affect its next web. If it was coffee, the web will have a loose, ragged array of crooked, unfinished spokes. A marijuana web lacks outer threads, while one spun under chloral hydrate is barely begun before the spider passes out.<sup>3</sup> Scientists at NASA have evaluated house spiders to gauge toxicity of chemicals.<sup>4,5</sup>

Figure 1 shows webs spun by a house spider after exposure to a variety of chemicals. The resemblance

## Biomonitors



Webs spun by an Araneus Diadematus (house spider) after exposure to various chemicals. Adapted from Noever et al., ref. 4.

between spider webs and crystal lattices led to the discovery that NASA folks could apply statistical crystallographic techniques to photos of webs spun under toxic and normal conditions to obtain quantitative measures of toxicity.<sup>5</sup> This work, published in the mid-1990s, showed promise, but I am not aware of any current effort in this area.

Recently, ants were evaluated as indicators of exposure to environmental stressors in desert grasslands.<sup>6</sup> The study demonstrated that exposure to both chronic disturbance—such as continuous or seasonal grazing—and to acute disturbance—such as root plowing, bulldozing and herbicide application—had little effect on the ant communities. The authors concluded that most desert ant species were remarkably resistant to disturbance and environmental stress. Perhaps they should have tried city ants.

Even Fido, the family pet dog, is useful as a monitor because the dog shares the same environment as the owner. It drinks water from the same sources, breathes the same air and often consumes the same food as the owner. As Backer<sup>7</sup> states, "The use of pet dogs as sentinels provides some freedom from confounding factors, such as alcohol consumption, active smoking and other lifestyle and occupational factors that plague human epidemiological studies. In addition, dogs don't 'worry' about the environment." Is your dog really that perfect? The one we had years ago certainly wasn't. Regardless, this isn't meant to be an all-inclusive list of species and plants that have been used as biomonitors. For more detail, see reference 8.

What's the Buzz About Bees?

Now let's talk about bees, which appear to offer potential because they have low tolerance to many chemicals. A biomonitor can increase its value if it can detect pollution in more than one of the three exposure media: gas, liquid and atmospheric. Honey bees provide a spatially integrated sample of all three modes in which pollutants may be transported.<sup>2,9</sup> Beekeepers of Puget Sound, WA, showed that honey bees are effective biological monitors of environmental contaminants over large geographic areas. Researchers collected pollen and bees for chemical analysis and, from these data, Kriging maps (maps that show the distribution of pollutants such as arsenic, fluoride and cadmium) were generated. These efforts revealed that a sample of pollutants could be obtained from an

area of more than 7 km<sup>2</sup> with honey bees.<sup>9</sup> Bees have been used at Aberdeen Proving Ground (APG) in Aberdeen, MD, on a five-acre landfill that was a dumping ground for chemical warfare agents, as well as unexploded ordnance, munitions and wastes from research and production facilities. Analysis of bees foraging at APG in 1996 and 1997 showed more cadmium in some areas of the base than others.<sup>10</sup>

Researchers at the University of Montana have unique indoor and outdoor facilities for assessing the cumulative effects of environmental stressors on honey bee colonies. Their project, called Bee Alert, utilizes computers, electronic hives and chemical analysis to help assess risks posed by environmental contaminants and to signal their presence early enough so that protective action can be taken before further harm occurs.<sup>10</sup>

Honeybees visit plants to pick up nectar, pollen and resins. They also collect water to use in making pollen preparations and to cool the hive during summer. They are, therefore, excellent samplers of the environment, covering everything within about a half-mile radius of the hive. In addition, they carry an electrostatic charge on their body hair, causing them to act like dusters. Anytime they land on something, little flecks jump and adhere to them. Dr. Jerry Bromenshenk, in charge of the project, calls them "electrostatic dust mops."10

The Montana researchers utilize electronic hives equipped with bidirectional counters that track every bee flying in or out of the colonies. Electronic sensors continuously monitor conditions such as temperature, relative humidity, air flow, etc., inside each hive, as well as changes in the weight of the entire unit. These hives are fitted with chemical sensors for examining volatile chemicals in hive atmospheres and clock-driven traps that collect pollen every 15 minutes. Gas chromatography analysis allows detection of substances that are present in the environment at levels as low as 100 parts-perquadrillion. Banks of portable computers inside metal tool boxes log colony performance and hive data. Electronic weather stations continuously monitor meteorological conditions. Artificial neural network

software, a form of pattern-recognizing artificial intelligence, helps correlate bee activities with food availability and weather conditions.

In a detailed article on the Bee Alert project, Roughi<sup>10</sup> mentions that in case of war, one could simply send some honeybees to sample and analyze the site. Other examples:

- 1. If Iraq is worried about weapons inspectors being spies, why not send bees instead?<sup>10</sup>
- 2. The University of Montana researchers are working with the Department of Energy labs to test the theory that if bees can be trained, they can be a means for locating land mines.<sup>11</sup>

Finally, it's even been suggested that bees might be trained to go after aroma profiles of particular people so we could locate them.<sup>10</sup> This all sounds like something Tom Clancy could use in one of his books, but it isn't all that far-fetched. If you would like to watch the observation hive in the lab at the University of Montana, check their website at www.umt.edu/ biology/bees.

## References

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