● NO SPRAY ZONE

Aerial Spraying of Bacillus Thuringiensis Kurstaki (Btk)

The aerial and ground spraying of insecticides based on Bacillus thuringiensis kurstaki (Btk) to eradicate various kinds of moth caterpillars is an increasingly widespread practice throughout the world. The potential long-term hazards to people that are exposed to this bacteria and its protein by-products are an important concern.

Studies of people exposed to Btk have been flawed because they are too short or look only for specific symptoms. This article examines some of the evidence that suggests potential hazards of Btk-based insecticides to people.

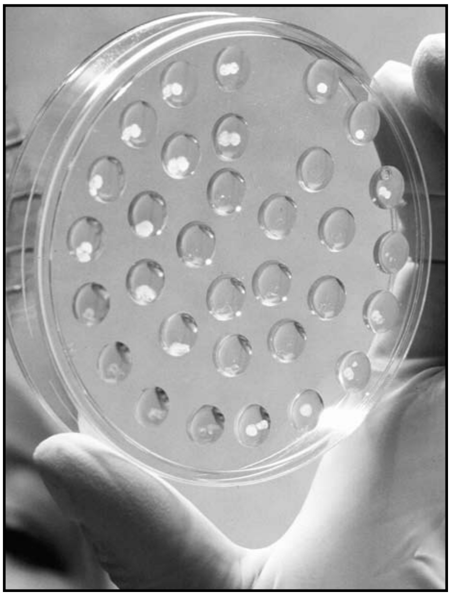
By Claude Ginsburg

The bacteria *Bacillus thurengiensis* (Bt) is found naturally at low levels in soil. It has been used as an insecticide for about 50 years, and has had widespread use for at least the last twenty years.[1]

Bt is part of a cluster of bacteria species that includes *Bacillus cereus*, a well known food poisoning bacterium, and *Bacillus anthracis*, the bacteria that causes anthrax.[2] Mapping of a Bt chromosome confirmed that Bt is "very closely related" to *Bacillus cereus*.[3] Bt and *Bacillus cereus* are identical in a variety of laboratory tests, except that most Bt contains insecticidal proteins.[1]

The variety of Bt considered in this article is called *Bacillus thuringiensis* var. *kurstaki* (Btk) and is used to kill caterpillars of moths and butterflies.

Btk works as an insecticide in the gut of caterpillars after they eat treated leaves. It releases a protein, called an endotoxin, that kills the caterpillar.[1] Commercial Btk products contain bacterial spores of Btk and crystals of the endotoxin,[1] as well as several "inert" ingredients.[4]



Growing Bt in a laboratory.

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Many public agencies have consistently considered Btk to be an insecticide that does not pose hazards for humans. For example, the World Health organization states that "Bt products may be safely used for the control of insect pests of agricultural and horticultural crops as well as forests."[1] Based partly on this kind of safety declaration, Bt products have been used in aerial spray programs in Canada, the U.S., and New Zealand.[5] This article critically evaluates the conclusion of no health hazards that usually accompanies Btk aerial spray programs.

Studies of people exposed to Btk during aerial spray programs have found that Btk causes few adverse effects. However, many of these studies have been too short,[6] or look only at a few possible symptoms.[7,8]

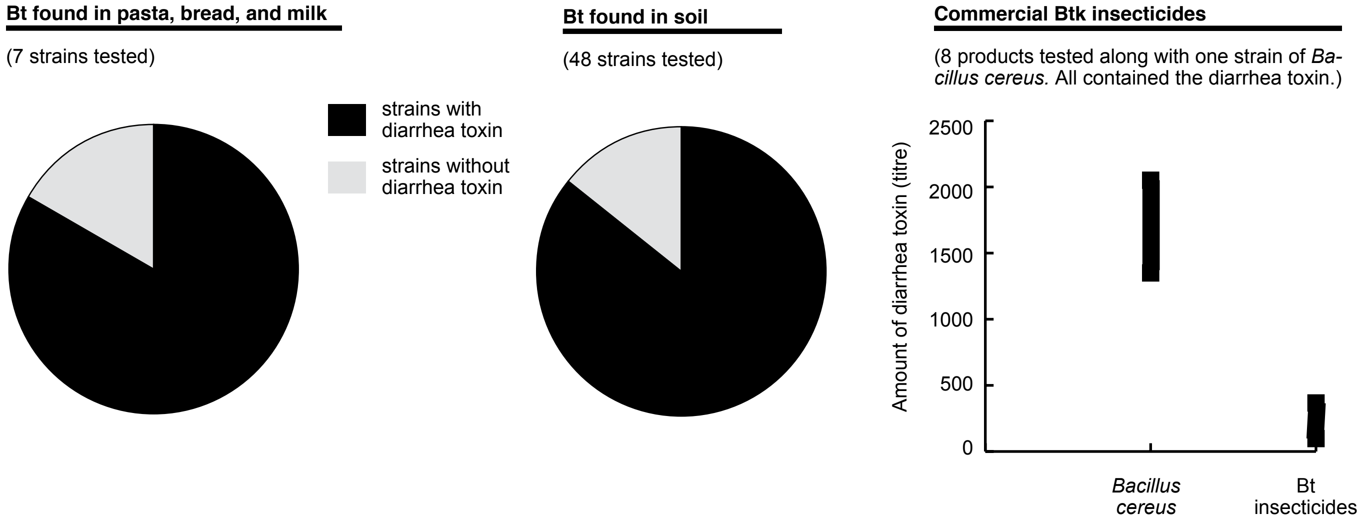
Exposure from Aerial Spraying

People can be exposed to Btk either by breathing in the bacteria while it is being sprayed, by ingesting it after touching sprayed objects,[9] or by eating treated food.[4]

To date, information about the sizes of particles and droplets produced when Btk is applied as an aerial spray indicates that a wide range of sizes are produced. Large particles settle quickly, while small ones remain suspended in the air for hours or days.[10] Small particles are tiny enough to reach small airways in the lungs.[11] Small particles are also more likely to drift off-target. The liquid in individual droplets will often evaporate, even in humid conditions, creating more small droplets or particles.[12]

Monitoring of a Btk-based aerial spray program in Vancouver, British Columbia, found that Btk was present in the air during spraying and for nine days after spraying. Buildings in the spray zone initially have lower concentrations of Btk than the outside air, but by five hours after spraying, the concentrations inside are higher than the concentrations outside. The authors of the study conclude that "the initial benefits of remaining indoors during spraying may not persist." In addition, a significant amount of drift was detected up to 1000 meters (0.6 miles) outside the spray zone, so that a larger than anticipated number of people was

Figure 2
Diarrhea Toxins in Bt



Damgaard, P.H. et al. 1996. Enterotoxin-producing strains of *Bacillus thuringiensis* isolated from food. *Lett. Appl. Microbiology* 23:146-150.
Perani, M., A. Bishop, and A. Vaid. 1998. Prevalence of b-exotoxin, diarrhoeal toxin and specific d-endotoxin in natural isolates of *Bacillus thuringiensis. FEMS Microbiology Letters* 160:55-60.
Damgaard, P.H. 1995. Diarrhoeal enterotoxin production by strains of *Bacillus thuringiensis* isolated from commercial *Bacillus thuringiensis*-based pesticides. *FEMS Immunol. Med. Microbiology* 12: 245-250.

Bt's close relative *Bacillus cereus* causes food poisoning because it produces a diarrhea-causing toxin. This toxin is also found in Bt in food, soil, and commercial Bt insecticides. The amounts of the toxin in Bt insecticides are less than they are in *Bacillus cereus.*

exposed.[11]

Neither No Spray Zone nor NCAP has located any measurements of exposure to Btk's insecticidal proteins or to other components of Btk products.

Can Btk Survive in People?

There is evidence that Btk survives in exposed people. In a study of an aerial spray program in Victoria, British Columbia, Btk was isolated from nasal swabs from people who lived in and outside of the spray zone.[13] Btk has also been isolated from the feces of workers who applied Btk in greenhouses.[14] These researchers also found evidence that some Btk spores germinated in the intestines of the greenhouse workers. (Btk spores germinate under conditions similar to those found in human intestines.[14]) A study of farmworkers who harvested Btk-treated vegetables found Btk in nasal swabs, and also evidence that Btk spores had germinated in the upper respiratory tract.[15] No Btk-related illnesses were reported in these studies; however, two studies measured immune responses in exposed people that suggested the development of Btk allergies.[15,16]

Btk and Intestinal Illness

Bacillus cereus, a bacteria closely related to Bt, causes two types of food poisoning; one characterized by pain and diarrhea, the other by nausea and vomiting.[17] Each type of poisoning is caused by a particular toxin produced by *Bacillus cereus*.[17] The diarrhea toxin has been found in commercial Btk insecticides.[18,19] (See Figure 1.) It may be difficult to find a natural Btk strain that produces insect toxins while not producing the food poisoning toxins.[20]

There is one documented case of Bt causing an outbreak of intestinal illness.[21] The actual number may be significantly larger. *Bacillus cereus* is identified as the cause of between one and five percent of food poisoning incidents in several European countries and the U.S.[21] However, Bt and *Bacillus cereus* are rarely distinguished when these incidents are studied,[18] and much of the *Bacillus* found on food may actually be Bt rather than *Bacillus cereus.* When researchers from the Danish Institute for Food and Veterinary Research precisely identified 40 *Bacillus cereus* strains found on ready-to-eat foods, they decided that 31 of them were actually Bt. The amount of *Bacillus* in these foods exceeded Danish guidelines in about 500 samples.[22] The diarrhea toxin is produced after the Bt spore germinates, and this appears to be possible in human intestines, as described above.[14]

Recent research describes a method for using genetic engineering to produce Bt that doesn't make the diarrhea toxin.[23] This raises new concerns about potential hazards to human and environmental health.

Other Bt Infections

Although rare, there are documented cases of significant Bt infections in humans.[24,25] In both of these cases the infection occurred in a healthy person, although one had suffered a serious war injury.[25] *Bacillus cereus* is known to have caused infections in people with immune systems compromised by leukemia and steroid medication.[26] Bt infections have caused death in laboratory animals with both compromised and normal immune systems.[25,27] In addition, Bt has killed mice infected with influenza.[28]

Bioaerosols

Bioaerosols, found in virtually all indoor and outdoor environments, are a complex mixture of viruses, fungi, bacteria, pollens, animal dander, and spores.[29] The endotoxins, made by bacteria including Bt,[4] may play a key role in sensitization and disease caused by bioaerosols.[5,29] Endotoxins from other bacteria have been liked to asthma[30] and other airway diseases.[29] Common symptoms reported after aerial spraying of Bt pesticides include the same symptoms caused by bioaerosols.[5] Therefore, it is plausible that Bt bioaerosols might trigger chronic airway diseases.

Are Btk Infections Associated with Later Disease?

There is a large body of evidence suggesting that bacterial infections play a role in the later development of autoimmune diseases. For example, bacterial infections have been identified as possible triggers for the development of lupus,[31,32] multiple sclerosis,[33] psoriasis,[34] scleroderma,[35] other skin diseases,[36] arthritis,[37] and amyotrophic lateral sclerosis.[38] There has been no link established between Btk and these autoimmune diseases, but this possiblility has not been explored.

Btk Is Still an Unknown

Not enough is known about the many substances produced by Btk to accurately predict their effects. For example, a recent study described a new protein produced by some Bt strains. This protein kills some human cancer cells while being less toxic to normal cells.[39] Another study identified proteins in Bt insecticides that cause disintegration of human cells in laboratory tests.[19]

To complicate matters more, there is evidence that *Bacillus cereus* and Bt can exchange genetic material. This means that the genetic material that produces a disease-causing protein could be transferred from one bacteria to another one. This transfer of genetic material occurs in the gut of earthworms.[2]

The ecology of Bt in the soil is also poorly understood.[2]

Conclusions

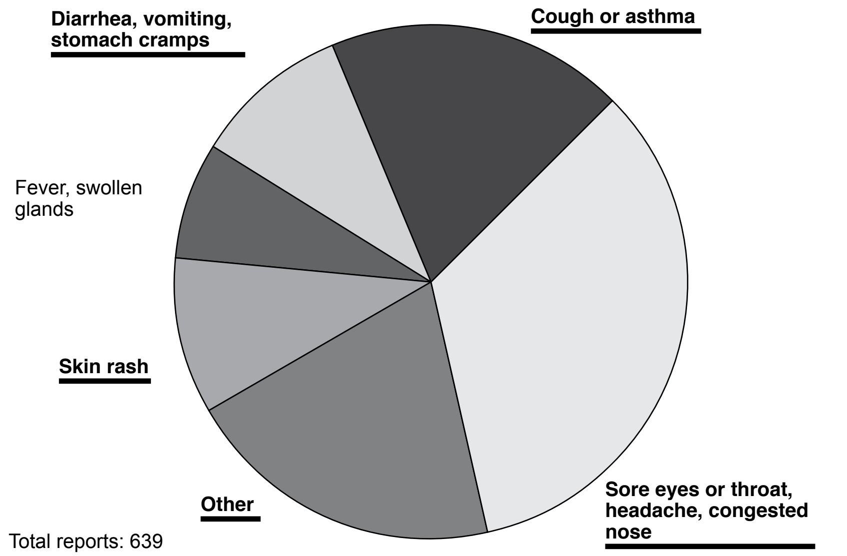
Considerable questions remain about the health effects of Btk. In keeping with the precautionary principle, No Spray Zone believes that there is not sufficient evidence of safety to humans and the environment to continue to expose large populations to aerial applications of Btk.

Possible risks to public health are exacerbated in large-scale insect eradication and control programs because these programs are designed and administered primarily by entomologists. Entomologists often consult with health professionals, but they are generally not knowledgeable about current microbiological and health research. Btk has been presented for years as a safer alternative to chemical pesticides. This may explain why so many entomologists are still of the opinion that Btk is a magic bullet with no potential for adverse health or environmental effects.

There is some information about allergic reactions and sensitization caused by exposure to Btk, especially repeated exposure, and No Spray Zone believes that a fuller exploration of these problems is needed. The data concerning a link between asthma and Bt exposure is mixed and inconclusive, although larger studies, such as the one done for the New Zealand Ministry of Health, show a marked number in asthma complications.[9] (See Figure 2.) Long-term information about Bt as an asthma trigger is needed.

More research is needed to accurately identify droplet sizes at the ground during and after spraying, both inside and outside of spray areas. There may longterm risks from breathing the bioaerosols produced by spraying. Large numbers of exposed people must be followed for a number of years to identify health problems caused by spraying. It will be difficult to link the development of later disease with the initial exposure, but we believe it is necessary to ensure safety.

Figure 2
Symptoms Reported after Aerial Applications of Btk



Hales, S. et al. 2004. Assessment of the potential health impacts of the 'Painted Apple Moth' aerial spraying programme, Auckland for the New Zealand Ministry of Health. Feb. 2004. http://www.moh.govt.nz/moh.nsf/0/ F9BDFEA13787E57DCC256DA2001951F9/$File/PAMreport_final.pdf.

Residents of sprayed areas reported a variety of symptoms, including asthma, following a Bt spray program in New Zealand.

An Alternative to Btk

A target-specific alternative to Btk-based pesticides for eradicating gypsy moths is a technnique called mating disruption. It relies on the male sex attractant or pheromone given off by the female gypsy moth. It is attractive only to male gypsy moths.

The pheromone, called disparlure, is encapsulated in pinhead-sized beads that release the pheromone slowly over several months. The beads are spread in the spring by aircraft or ground equipment in an infested area. The resulting cloud of pheromone confuses the males and prevents successful mating. An extensive study of gypsy moth spraying in the eastern U.S. showed that disparlure beads are as or more effective than Btk for eradicating low-density gypsy moth infestations.

"No risk to human health is expected from use of these pheromones," according to the U.S. Environmental Protection Agency. It's worth noting that commercial disparlure products, like most pesticides, contain unidentified ingredients. In addition, a common disparlure product requires users to add an adhesive to help the beads stick to leaves higher up in trees.

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