

## HISTORY

# Witchcraft or Mycotoxin? The Salem Witch Trials

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### ABSTRACT

**Background:** The Salem witchcraft trials of 1692 have been studied by many historians looking for the complex social, political, and psychological determinants behind the community-wide hysteria that led to a travesty of justice and the deaths of 20 innocent Puritans. Recently, ergot poisoning has been put forth by some as a previously unsuspected cause of the bizarre behaviors of the young adolescent girls who accused the townsfolk of witchcraft. In this essay the circumstances behind the ergot poisoning theory for this historical event are described. When the evidence is weighed carefully both pro and con, it seems unlikely that ergotism explains much of what went on in colonial Salem.

### INTRODUCTION

The New England Puritans formed an insular society and intensively enforced their theocratic way of life. The autumn of 1691 was not a good harvest year for them. The previous winter had been cold. Then a wet, warm planting season was followed by a hot, stormy summer. A failed harvest had forced Salem villagers to turn to rye grain to make their bread. Thomas Putnam, a well-regarded and prosperous Salem farmer whose swampy land supplied much of the colony's rye flour, donated grain regularly to the Reverend Samuel Parris's house-

hold. By October after the poor harvest, 11-year-old Abigail Williams, the Reverend's niece, was spending time with their 2 Caribbean servants, Tituba and John Indian, who told hair-raising, yet seductive, voodoo stories to Abigail and 3 or 4 other 9–17-year-old girls. The girls were soon talking magic; they started writhing in pain, insensate with convulsive twitching, occasionally accusing fellow townsfolk of being witches who tormented them.

In his play *The Crucible*, Arthur Miller delivers a masterful portrayal of the Salem witch hunt in the context of societal intolerance, cruel vengeance, and ethical para-

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doxes. In the 2nd Act, Elizabeth Proctor, wife of the existential hero of the play, John Proctor, delivers a stinging summary of the fearful turn of events:

*The Deputy Governor promise hangin' if they'll not confess, John. The town's gone wild, I think. She speak of Abigail, and I thought she were a saint, to hear her. Abigail brings the other girls into the court, and where she walks the crowd will part like sea for Israel. And folks are brought before them, and if they scream and howl and fall to the floor, the person's clapped in the jail for bewitchin' them.*<sup>1</sup>

The Puritans lived in an era of belief in the devil as a physical being who was incarnate, there to seduce them from the path of righteousness. Bewitching was a generally recognized phenomenon in the 1600s, both in Europe as well as in Puritan New England. The devil was an invisible but very real being, whose constant tests and temptations were to be rebuffed by strict adherence to a set of laws describing behavior and societal order. The diagnosis of bewitching was both clinical and analytical. Clinically, stages of bewitching could be described. The “preliminaries” involved intense spirituality, leading to the onset of fainting and disordered speech. Intensification of symptoms was associated with visual delusions and hallucinatory confrontation with spectral witches or “familiars” (the devil presenting himself in animal forms). Occasionally, the symptoms would wax and wane, interspersed with quiet days of boredom mixed with depression. Behaviors of a bewitched person frequently included sensations of pricking, pinching, or burning of the skin; fornication; animal imitation; odd contortions; simulated flying or diving; paralysis and rigidity; anorexia; the forced consumption of invisible fluids; and physical assaults or verbal insults.

By late December, 1691, 8 girls, including the niece and daughter of Samuel Parris, were afflicted with “unknown distempers” of disorderly speech, odd postures and gestures, and convulsive fits. One doctor suggested that the girls might be bewitched. The minister resorted to fasting and prayer. But a neighbor suggested that Tituba bake a “witch cake” made of rye grain and dog urine. Soon the village was awash with rumors of witchcraft; the girls accused Tituba and 2 other women in Salem, Sarah Good and Sarah Osgood, of witchcraft, that is, directing their spirits to visit and torture them by pinching and burning their skin. The 3 women were taken into custody on February 29, 1692. The Court of Oyer and Terminer was empowered and, after the consultation of Cotton Mather and other clergy, determined that the critical tests of witchery would be both “spectral evidence” (the victim would see a ghost of the accused

pinching or otherwise harming them) and “critical touch” (the spasms of the victims would end only if they were touched by the accused). Court-approved spectral evidence provided by the girls of visions of witchcraft-practicing townsfolk defined the “proof” of such preternatural mischief. The girls readily complied with the 2 tests, often creating such pandemonium in the courtroom that the proceedings had to be halted.

In March of 1692 the girls accused Martha Corey and Rebecca Nurse of bewitching them and actively practicing witchcraft in collusion with the devil. Both of these women were previously well respected in Salem. The march to the gallows on Witches' Hill in Salem began later in the spring. The court heard its first case on June 2nd, and convicted and hung its first witch, Mary Sibley, at Gallows' Hill on June 10th. The travesty did not end until September 1692, with 20 “witches” convicted, sentenced, and executed, 19 by hanging and one, Giles Corey, by being crushed with stones. When asked, while his chest was being compressed with massive rocks, whether or not he would confess to being a wizard and bewitching the girls, Giles Corey refused the life-saving confession (those who confessed would be pardoned if they implicated other “witches”) by simply answering “*more weight*,” and then died. The colony had sown distrust, jealousy, superstition, and moldy grain; it reaped death and despair. The nightmare did not cease until the Court of Oyer and Terminer adjourned in September 1692, and the new Governor, Phipps, of the Massachusetts Bay Colony suspended all indictments for witchcraft and issued a general reprieve for the 150 innocents imprisoned in the spring of 1693.

What caused this tragedy in the Salem village? It probably was not mass hysteria, which would have to have been repetitive and lasting for months. It surely wasn't fraud, given the gravity of the charge and the youth of the girls. Mental illness has been cited, but that would have to be contextual and involve the entire community.<sup>2,3</sup>

Some historians<sup>2,4</sup> have postulated that the girls responsible for the travesty suffered from ergotism. The *Claviceps purpurea* grows on a wide variety of cereals: rye, corn, wheat, rice, sorghum, barley, oats, and millet. The word *ergot* comes from the French name for a rooster's spur, which the sclerotia of the *Claviceps* resembles as the mass of mycelia grow to a length of 2–3 centimeters.<sup>5</sup> The sclerotia of the fungus grow on the rye flower, replacing the grain with a hard, purplish bundle of mycelia that may contain as much as 1% ergot alkaloids.<sup>5</sup> Favorable growing conditions for ergot include a cold preceding winter and cloudy, wet spring, with fog and high



humidity. Newly farmed low-lying marshland containing ergot-infested wild grasses is more susceptible to ergot, with winter rye a better host than spring rye.<sup>4</sup>

Ergot alkaloids are potent 3,4-indole-substituted mycotoxins: ergoline (I), lysergic acid derivatives (II) such as isoergine (lysergic acid amide) similar to LSD, and clavine alkaloids (III).<sup>5</sup> More than 40 different alkaloids have been isolated from *Claviceps*; although some are derived from lysergic acid, most are proline-containing peptides, with an ergoline ring structure derived from tryptophan.<sup>6</sup> Besides the ergot alkaloids, the fungus also contains histamine, tyramine, acetaldehyde, acetylcholine, and isoamylamine, all of which may contribute directly to the patient's toxic profile. Tall fescue grass, which causes gangrenous "fescue foot" and "summer syndrome" of weight loss and systemic symptoms among livestock, has been linked to a nonclaviceps but ergot alkaloid-producing endophyte.<sup>7</sup> Ergot poisoning of grazing animals is a serious concern; it can cause retarded growth, abortion, stillbirth, lameness, gangrene, and death among cattle and other species.<sup>5</sup>

Ergot alkaloids can act peripherally as alpha-adrenergic agonists to cause vasospasm.<sup>8</sup> Ergotamine also directly stimulates the chemoreceptor trigger zone in the medulla oblongata, accounting for the frequently observed symptoms of nausea and vomiting.<sup>9</sup> Serotonergic actions also are seen with some of the alkaloids, causing uterine contraction and vascular response. Serotonergic and dopaminergic actions may be responsible for delusions and hallucinations and other neurological signs of poisoning. Ergotamine tartrate is used therapeutically to treat migraine headaches; ergonovine has obstetric uses to contract the uterus and stem bleeding after birth.<sup>10</sup>

Gangrenous ergot poisoning is characterized by vasoconstriction, weak peripheral pulses, sensations of coldness or numbness, and dry gangrenous injury to the extremities; painless autoamputation eventually occurs. The paresthesias, burning and pain of the extremities, including formication, are toxic signs of ergotism described in the Middle Ages as "St. Anthony's Fire" or "Holy Fire." These symptoms also resembled Raynaud's Syndrome, so much so that it has been suggested that at least 3 patients originally described in Raynaud's case series probably had ergotism, rather than an autoimmune condition.

The vasoconstriction is capable of producing other ischemic complications, including myocardial infarction.<sup>11,12</sup> Treatment of these vasoconstrictive phenomena with peripheral vasodilators such as nitroprusside and anticoagulants such as heparin has been suggested.<sup>8</sup>

Convulsive ergotism is associated with vertigo, head-

aches, painful muscular contractions, mania, delirium, and visual and auditory hallucinations. Chronic ergotism has been associated with progression of seizures and dementia.

Ergot poisoning can be diagnosed by a simple bedside chemical test of urine. Ergot alkaloids all react with sulfuric acid containing p-dimethyl aminobenzaldehyde to yield a solution which, when mixed with ferric chloride, produces an intense blue reaction known as the Van Urk test.<sup>5-7</sup>

Epidemics of ergot poisoning have been recorded throughout history. Morgan<sup>13</sup> investigated an outbreak of ergot poisoning in Manchester, England, in 1927 which involved over 200 patients, most of whom had gangrenous signs, but also had headache, nervousness, and intense itching with the sensation of insects crawling along their backs. All ate rye bread, as much as half a loaf per day. Morgan measured ergotamines in the rye flour and showed that a contaminated loaf contained up to 9 grains of ergot. He was able to demonstrate a relationship between the rapidity of onset of ergot symptoms and the quantity of mycotoxin eaten. A more recent epidemic in Ethiopia in 1978 followed the contamination of barley with ergot-infested wild oats. There were more than 47 deaths and another 93 patients afflicted with symptoms such as weakness, nausea, vomiting, diarrhea, gangrene, and the loss of extremities (21.5% of cases). Another 50–60 infants died because their mothers, victims of both famine and ergot poisoning, did not produce enough milk to prevent their infants' starvation.<sup>5</sup>

The arguments for ergotism as the cause of the Salem affair include<sup>2,4</sup>:

- 1691 was a cold winter; the following spring and summer were humid. These are conditions ripe for ergot contamination of rye grain.<sup>4</sup>
- A crop failure forced the Puritans to eat freshly harvested, infested rye.<sup>4</sup>
- The afflicted were nonrandom and lived along rye supply routes in the town.<sup>2</sup>
- Three of the afflicted girls lived on the Putnam farm, where ergoty rye may have thrived.<sup>2</sup>
- The age and sex of those afflicted resemble other ergot poisoning epidemics.
- Animals were also affected; several cows died during the trials. Ergotism is a recognized veterinary problem among grazing animals.<sup>2</sup>
- Symptoms (seeing apparitions, feeling pinpricks and pinches, burning sensations, "urinary stoppage") of the afflicted resemble convulsive ergotism.<sup>2</sup>



- Witchcraft trials were in decline elsewhere, demanding a special explanation as to why they occurred here.

Skeptics of this toxicological explanation abound. The arguments against ergotism as the cause of Salem tragedy include<sup>3,14</sup>:

- There are no data to suggest Salem had a cold winter. Tree rings relied upon to reach this conclusion by ergot proponents were located in New Hampshire.<sup>3</sup>
- Likewise, there is no verification of a crop failure in the Massachusetts Bay Colony.<sup>3</sup>
- The afflicted and accused in Salem were nonrandom because of sociopolitical and economic divisions within the village, not because of who bought Putnam's rye.<sup>14</sup>
- The ages of the afflicted were older than other ergot epidemics.
- A few cows died; so what?
- Symptoms of the afflicted could be turned on and off, depending on the audience, unlike the toxidrome of convulsive ergotism.<sup>3</sup>
- Symptoms were disparate and singular; none of the afflicted had the full constellation of symptoms and signs typical of an ergot syndrome.<sup>3</sup>
- There were none of the constitutional, residual effects typical of ergotism, such as weakness, strictures, or dementia. The afflicted were hale and hearty.
- Other witchcraft trials besides Salem in New England brought 141 persons to trial between 1638–1699. Were they all suffering ergotism?<sup>13</sup>

Although we are left with many questions surrounding the bizarre events in Salem, it seems very unlikely that the convenient theory of ergot poisoning is an adequate explanation. At the time, the Reverend Parris was a controversial minister in the village and was the pivotal figure in a swirl of political, economic, and social divisions and jealousies in the town. Although he had the support of politically powerful proponents, others, like John Proctor, disapproved of his preaching and occasionally skipped Sunday meetings in defiance of his authority. His ministry divided the colony and resulted in sociopolitical jealousy and neighborly vindictiveness, which perhaps played itself out in the victimization of those accused of

witchcraft. Clearly, giving such credence to the words of young adolescent girls, who held a mesmerizing and irrational power over the community, was a bad idea. This led to the tragic events that eventually found their conclusions on "Gallow's Hill," as well as in the hearts and minds of the survivors.

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