

## Fungal Spots in a Book Dated 1854: Causative species ID and Distribution; and Time, Source, and Method of Contamination

### ABSTRACT

One hundred eleven “irregular fungal fox spots” in one book, published in 1854, were examined under SEM. The rust red spots are irregular in shape and are caused by fungal activity. Over four hundred micrographs of these “irregular fungal fox spots” were analyzed to determine the morphology of the hyphae, conidiophores, and conidia in the fungal spots throughout the book. The purpose was to determine the number of different species and their distribution in the book and how the book paper was contaminated. The results showed basically two fungal species (T1 and T2 species) which were randomly distributed on all positions on a page and on all pages examined throughout the book, but one species was on top of the ink and the other under the ink. This suggests contamination of the pages during papermaking or book preparation by contact with contaminated materials but at two different times, one prior to printing and one at the time of printing or shortly after.

Each species had a unique hyphal characteristic: T1 had fuzzy surface mycofibrils, and T2 hyphae were smooth with bacterial lytic holes. This suggested that the two species came from two different environments. The T1 hyphae with mycofibrils were commonly on top of the ink text and the T2 hyphae with bacterial lytic holes were beneath the ink.

The research book (Bauer 1854) was published by Harper and Brothers Publishers in New York in 1854. In “Harper’s Story Books” written by Abbott, 1855, the complete process of printing books at that time is described. It describes how each sheet and both sides of each sheet were exposed after printing to hard boards—the printed sheets were dried, then placed between two very smooth hard boards and stacked for pressing. They could be the source of T1 contamination on top of the ink.

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The presence of bacterial damage of the T2 hyphae suggest that the fungi came from a wet environment. These fungi could have been attacked by bacteria during the papermaking process, in the Hollander beater, in the warm water of the vat of pulp, or in the wet felts used in pressing dry each sheet of paper.

Using standard culturing techniques, viability tests showed that the 145-year-old fungal structures in the spots were not viable. Even if cultures developed, it is impossible to know if they are contemporary contaminants or the causative species; thus SEM analysis of the conidiophore type and conidia ornamentation was undertaken for species identification. The two species are of the *Aspergillus glauca* group, probably two different *Eurotium* species, which are facultative xerophilic species that have the ability to grow under normal and dry environmental conditions. The migration of the discoloration in the spots on facing pages or through two to six sequential pages shows the discoloration developed after the book was completed.

Comparison with another book published in 1785 showed similar results but different fungal species.

The presence of minute mite-like animals and their egg-shells, silk threads, and fecal pellets suggests a complex ecosystem.

The significance of this project is that it has identified the causative fungal species of the fungal spots in this book and shows that the book was uniformly contaminated with two species, each at a different time, one during the papermaking process and the other after the printing of the pages. This type of analysis is of value in authenticity and forgeries studies.

A full test report of this research appears in the reference cited below

### REFERENCE

Florian, M-L. E., and L. Manning. 2000. SEM analysis of irregular fungal fox spots in an 1845 book: population

dynamics and species identification. *International Biodeterioration and Biodegradation* 46(3) :205-220.

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