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DETERIORATION OF QUARTERMASTER FABRICS IN THE TROPICS

By WILLIAM LAWRENCE WHITE

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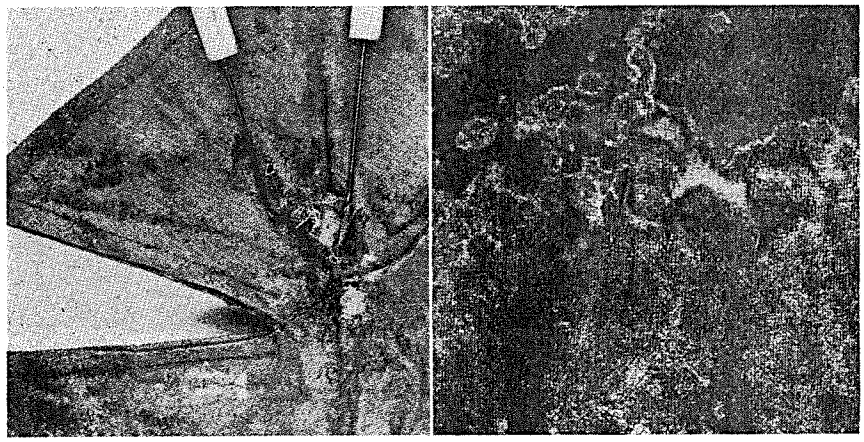
Deterioration of Quartermaster Fabrics

When fabrics are exposed in nature, they are affected by a combination of interacting adverse factors which bring about their deterioration at a rate depending upon the nature of the fabric itself and upon the particular environmental conditions. Special attention has been focused upon fungi as the causal agents, but other factors must not be forgotten. Sunlight, though slower in action, is equally, if not more, important in the over-all picture. Bacterial action may be as vigorous as fungus action under certain wet conditions, such as actual contact with the ground, or in pools of water formed by sagging of tents and tarpaulins. In and near cities, industrial gases are causes of deterioration. The British Ordnance Laboratories in India, after analysis of cotton fabrics exposed experimentally, have zoned that country according to the predominating causes of deterioration. A treatment required to prevent mold growth on tentage in the monsoon areas may be worse than useless in the semi-desert regions by catalyzing deleterious photochemical reactions in the intense and continuous sunlight.



(Left) Cotton field jacket attacked by **Chaetomium globosum** *in a warehouse on Biak Island. (Right) Flannel lining of jacket destroyed by an Actinomycete.*

Considering the tropical and subtropical areas of the entire world, one may generalize further. Mold growth on fabrics is most troublesome in the tropical rain-forest climates within 15 degrees of the equator. The presence of fungus is quite marked at such military installations as those of the Lae-Finschafen area of New Guinea, Biak Island, Tacloban on the Island of Leyte, Lagos and Port Harcourt in Nigeria, and in the area of the Firestone Rubber Plantation of Liberia. In contrast to these regions of dampness, cloudiness, pouring rains, and soaked soil is the great desert area extending all the way from Western India to the Atlantic Ocean, where mildew problems are extremely localized or unknown. Often the annual rainfall is less than one inch, and the ground is constantly dry. In Egypt, the only mold problem known to the cotton industry occurs in the Nile Delta, where, during the period of floods resulting from rain in Ethiopia, Uganda, and Kenya, the humidity becomes sufficiently high to allow some spoilage of baled and raw cotton. In such tropical desert regions of cloudless skies and constant, intense sunlight, the problem of ultra-violet deterioration is the all-important one. Fabrics not exposed to the sun or to the abrasive action of blowing sand, or other wear, should last indefinitely. Excavated Egyptian fabrics, in fair condition after 4,000 years, furnish ample evidence.

Most deterioration of fabrics in storage is due to fungus action. High humidity supports enough growth to cause mustiness and slow deterioration; actual wetting (frequent under military conditions) underlies the very rapid rotting action. There is less mold of military items in the closed-type, permanent warehouses of Honolulu, Saipan, and Trinidad than in the open-sided sheds of New Guinea and Biak, or under the tents and tarpaulins on Guam. Closed houses with floors set three or four feet off the ground, found in Trinidad, seem to be especially good. In all regions such items as socks and shirts move through storage too fast to be troubled by mold growths.

Aside from all this we may say that, by and large, fabric deterioration is caused by a very complicated set of factors, operating simultaneously or alternately under conditions so complex that they have never been duplicated in a laboratory. Quartermaster-sponsored research has demonstrated that preexposure of cotton fibers to ultra-violet light increases their resistance to attack by fungi; that the action of the ultra-violet light is positively correlated with light intensity and temperature; and that iron, manganese, and other salts will accelerate the harmful effects of sunlight. The fungi themselves have complex relationships with one another and are very sensitive to their growing conditions. A fabric that is attacked by only one fungus under one set of conditions may be attacked by an entirely different organism if a slight alteration in moisture, or an alteration in available mineral elements, etc., occurs.

As a basis for efficient control, it is essential that all of these underlying and fundamental processes be understood by responsible Army personnel. This calls for research on a cooperative basis by specialists in various fields. Recognizing this, and realizing that there were already in existence numerous governmental and commercial laboratories engaged in prac-

in the Tropics

By WILLIAM LAWRENCE WHITE*

tical research and procurement testing, the Quartermaster Corps established the Tropical Deterioration Research Laboratory in 1944 for the purpose of investigating the fundamental problems of deterioration and finding a better basis for preventing such losses. It is anticipated that the information so gained will be as valuable in peace as in war. As a foundation for further work it is necessary to know what organisms are active. Already several thousand cultures of fungi have been isolated from deteriorated fabrics and related materials in numerous tropical stations.

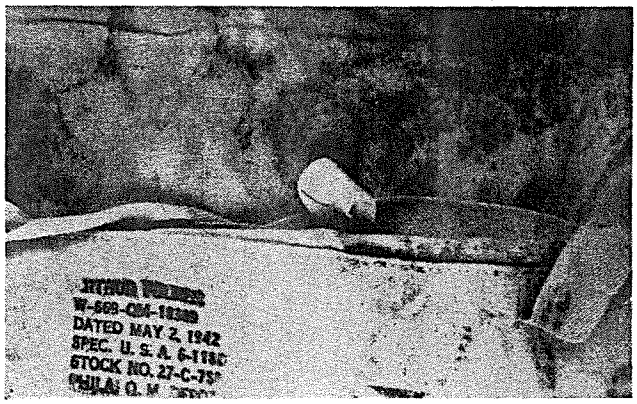
From the beginning it was realized that many of the fungi isolated from deteriorated cotton fabrics are probably not active as decomposers of cellulose. Although the non-cellulose-destroyers can be partially eliminated by some isolation procedures, it was considered unwise to disregard them altogether. Those organisms unable, in themselves, to break down and utilize the basic cellulosic constituents, may be acting on the various finishing materials, thus paving the way for later entrance of the actual cellulose rotters. In other cases, non-cellulolytic forms which are tolerant to fungicides may break down and render these treatments inactive, thus opening the gate to harmful cellulolytic forms.

As a part of this general program the writer joined the recent Army Air Forces Tropical Science Mission. The Mission consisted of a group of seventeen scientists and technologists, plus the plane crew. It departed from San Francisco on January 7th, 1946, in a C-54 plane especially equipped as a flying laboratory; traveled west around the tropical belt of the world; and arrived in West Palm Beach, Florida, on April 26th. Three objectives were proposed for the writer: (1) to supplement past laboratory work with a field study of the organisms to determine which ones are operative, their relative abundance, their specificity for materials, and the exact set of conditions under which each is operative or inhibited; (2) to consult with those who engaged in pertinent work in the tropics during the war—both military personnel and scientists in various research and educational institutions—to gain immediate knowledge and obtain their cooperation in the future; and (3) to gain a first-hand knowledge of tropical conditions.

Some of the statements in the foregoing paragraphs are based upon the findings of this Mission. A full report is forthcoming from Wright Field. The object of this article is to provide a fair idea of the scope and nature of the biological, or more specifically, the mycological side of the broad fundamental research program that is in progress.

After two years of concentrated effort, with cooperation from many sources—including elements of the Australian and British armies working along similar lines—we are now fairly well acquainted with the fungi occurring on fabrics and related materials in the tropics. We have determined by laboratory methods, and to a lesser extent by field observations, which of these are capable of destroying cotton and other fabrics and which are not. We know which are strongly active and which are weakly so. We know which are frequent and which are rare; which are tolerant to given fungicides and which are easily destroyed. This knowledge is constantly used—in the experimental development of chemically modified derivatives of cellulose and other basic materials to produce resistance to biological decay; in the choice of fungicides for particular purposes; and in many other practical ways. Extension of the behavior of fungi in the laboratory to behavior in the field is, however, not always easy. We are impressed with the fact that our knowledge, here, is still meager. A single example will illustrate.

One of the two species now in use in all laboratories in procurement testing and in chemical experimental work is *Metarrhizium glutinosum*. It was first isolated by workers of the U. S. Department of Agriculture from baled cotton. This is one of the most vigorous laboratory cellulose-destroyers known; its nutrition is simple and it is easy to work with. These factors, combined with others, make it a natural experimental subject. One is tempted to reason, therefore, that this



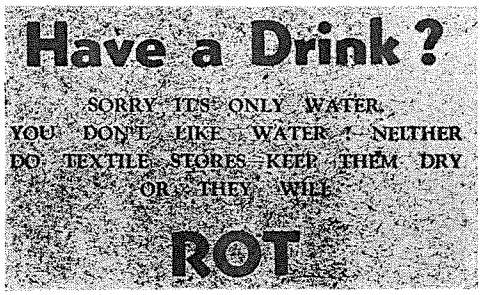
***Mattress cover, from a QM warehouse in Manila, showing action of* Memnoniella echinata.**

species must account for much of the decomposition of cotton fabrics as well as of other cellulosic materials in nature. Such is not the case. To the best of the writer's knowledge this form has never been observed growing and fruiting on cotton goods in nature, aside, perhaps, from the original bale of cotton. In our own laboratory it has turned up once or twice in several thousand cultures. Workers in New Zealand, Australia, India, and Nigeria report similar results. All these laboratories were using the original USDA strain in their experimental and testing work.

*Tropical Deterioration Research Laboratory, Philadelphia Quartermaster Depot.

The species has not been isolated frequently enough to preclude the possibility that such occasional isolates are simply chance contaminants of the original strain from the air of the laboratory. On the other hand, *Memnoniella echinata,* with its relatively complex nutritive requirements, difficult and unsatisfactory for routine laboratory experimentation, is found to be perhaps the most common and destructive of any single species in the tropics. The first of these two species was unknown to science at the beginning of the war, and the latter was thought to be so rare that, as late as 1943, one reputable mycologist in England wrote that he doubted its existence. We have now learned much about these molds which attack fabrics, but we must know still more before we can synthesize the fragments into an intelligent whole. This will require additional laboratory work, supplemented constantly by field experimentation and observation.

There are nearly a hundred thousand kinds of fungi recorded, some widely distributed and others



Poster in British warehouse, India.

localized. The previously mentioned *Memnoniella echinata* has its center of distribution in the warm, damp tropics, and appears only sporadically in temperate regions. On the whole, however, the fabric destroyers are the most widely distributed of the fungi. Relatively few of this large number of species are of major importance, and the lines are being drawn constantly tighter. Fabrics and related materials are attacked more vigorously in tropical than in temperate regions because the moisture and temperature conditions are more favorable to growth of the organisms, and because military fabrics cannot, as a rule, be given the same care they are given at home.

Many of the fungi found on cotton fabrics are of importance in the medical field in causing asthma, skin diseases, etc. For example, *Aspergillus fumigatus* —one of the strongest of a half-dozen forms of known cellulose-destroyers among eighty-nine members of that genus—has an extensive literature in the pathology of animals, especially birds and man. *A. unguis,* frequently isolated from tropical fabrics, but noncellulolytic, grows on the nails of humans. One could continue indefinitely, and new information is constantly being brought to light. A species of *Stachybotrys* well known to all research workers in the field of prevention of fabric-decay was recently demonstrated to be the cause of a disease of horse and man in the Ukraine. Others are of importance—useful or harmful as the case may be—in antibiotics, in fermentation processes, or as the cause of plant diseases. Hence the study of mycological deterioration is not an isolated one, but must draw from, and contribute to, the several other fields of fungus control.

An Australian scientist who made a study of the deterioration of the "non-tropicalized" materials dumped unprotected on the beaches in the early landings in New Guinea, and who accompanied the Mission through the same region this year, said there was little left that was reminiscent of the utter decay which occurred in that period. Much has been done in both the laboratory and the field to make materials last under adverse conditions. While better materials are being developed, much can be accomplished by field personnel through the application of some of the information displayed on posters in and about the British warehouses in India. The importance of this problem to military operations must be fully realized, and present plans for attack fully supported. It is a problem of special responsibility to the Quartermaster Corps, but of great significance to the whole field of military supply and operations. The advances during the war are notable, but are only indicative of the character and scope of the problem of deterioration.