

ECOLOGICAL RELATIONSHIPS OF FUNGI IN CULTURES.

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The efficiency of any organism in nature depends upon two factors, heredity and environment. This is true regardless of whether the organism be a fungous parasite or a man. Our control over heredity is limited and is the problem of the geneticist. We are constantly seeking to conserve and to improve nature by a more accurate and precise control of the environment of those organisms with which we work and have to deal.

The fungi present many problems of importance in both a constructive and a destructive sense. We are constantly adding to our knowledge concerning the environment of these lowly organisms. We know, for instance, the effect of various toxic agents upon the growth and reproduction of this form of life; we know in a great many cases the thermal death points; we have learned to know their likes and dislikes with regard to food materials. To ascertain the most favorable hydrogen-ion concentration is one of the chief pastimes of the mycologist. We must not forget, however, that one of the most important factors of environment is the presence of other forms of life both of the same and of different species. This phase of mycological ecology while frequently observed by many workers has not received the proportion of time and attention which its importance justifies. This failure may be ascribed partly to the difficulties inherent in the problem and partly because the significance has not been realized.

Modern ecology has given us many examples among higher plants and animals of the effect of one organism upon another in the succession. Even as far back as the time of Darwin and Wallace we were taught the delicate balance that pervaded nature and how when this balance was disturbed that consequences for good or ill might result to mankind. We are seeking always to maintain a balance favorable to our own ends. This, of course, is only a part of the general plan whereby man is constantly seeking to control all natural forces. At present, a possible method of controlling the corn borer is by means of certain parasites.

The balance which exists elsewhere in nature is also to be found among the fungi; not only among themselves but also in their relationships with their more highly organized associates. The study, then, of fungous environment, particularly in its relationships, should furnish us valuable information concerning the scientific control of obnoxious forms, and also information leading to the utilization of many fungi in the arts and industries.

In order to gain an accurate knowledge of the morphology and physiology of any species it is necessary to work with pure cultures. The bacteriologist and mycologist have so long followed this practice that they have forgotten that pure cultures are scarcely ever to be found in nature and what is gained by working with a known pure line culture is lost in the knowledge of the relationship which comes from contact with foreign organisms and even with those of its own kind.

Mixed cultures constitute the rule and not the exception in nature. Laboratory workers know with what difficulty they finally succeed in making an isolation of any disease organism. Even following careful technique our plates and tubes become contaminated with a frequency that is annoying.

A constant struggle exists in the mycological and pathological laboratories against the encroachment of undesirable forms into our cultures. Elaborate precautions have to be taken to insure success in this regard against "weeds" which seem to be omnipresent.

I have often found an apple diseased with both blotch and scab, the lesions being in close proximity. The surface of the same fruit may be marred with the fungi causing flyspeck and sooty blotch. In addition to these quite evident disorders it may be demonstrated that spores of *Penicillium*, *Alternaria*, and *Mucor* together with numerous bacteria are plentifully distributed over the surface. We have here, therefore, in this limited space not a homogeneous community but a heterogeneous population. The consequences of such heterogeneity has never been adequately studied either with respect to the host or to the complex and mixed population which inhabits it. What contests exist here for the available food supply? What are the effects of the several and diverse enzymes upon the various members of the group? The toxins and other waste products must necessarily cause reactions within the organisms themselves which will modify their natural habits and activities. Likewise, we have seen ears and even kernels of corn infested with two species of *Fusaria*, and *Diplodia*. It has been shown¹ that the organic population of a single node of a cornstalk is often numerous and quite diverse. The nearest market will usually furnish examples of oranges and lemons being rotted by two species of *Penicillium* contesting the limited space that they occupy. Manns² has demonstrated that two species of bacteria working in conjunction cause the blight of oats.

As has been suggested, these mixed populations inhabiting a host must react upon one another in such a way as to change their habits of growth and even affect their general metabolism. We have by numerous experiments of our own^{3,4} demonstrated this thesis and our obser-

¹ Porter, C. L. A study of the fungous flora of the nodal tissues of the corn plant. *Phytopath.* 17:563-568, 1927.

² Manns, T. F. The blade-blight of oats a bacterial disease. *Ohio Agr. Exp. Sta. Bul.* 210, 1909.

³ Porter, C. L. Concerning the characters of certain fungi as exhibited by their growth in the presence of other fungi. *Amer. Jour. Bot.* 11:168-188, 1923.

⁴ Porter, C. L. Phenomena exhibited by fungi when grown in close proximity. *Pro. Ind. Acad. Sci.* 34:259-260, 1924 (1925).

vations are supported by a rather voluminous if incidental literature.

The following variations from the normal have been observed in mixed cultures: change of color of the fungus, changes in color of the medium, distortion of the fungous hyphae, cessation of growth, increased sporulation, change in the character of the colony itself. Various explanations are possible to account for these changes and they have all been given from time to time by those who have observed and reflected on the phenomenon. It is possible that nutrients may have been withdrawn from the neutral area between two approaching colonies to such an extent that partial or complete starvation may cause cessation of growth. It is, of course, not necessary to assume that all nutrients have been drained away from this area; but the partial exhaustion of one nutrient may so affect the nutrient balance of the medium as to inhibit the growth of one or both of the organisms. If a nutrient so reduced is equally essential to both approaching fungi, both will be inhibited; if such a nutrient is, however, more essential to one than to the other the inhibition will not be the same for both colonies.

Brown⁵ speaks of staling products produced by an organism in a culture which will ultimately become self-inhibitory and which might affect another species even more than it does itself. Enzymes or toxins which diffuse outward through the medium undoubtedly play an important part in causing inhibition and particularly the malformations that accompany inhibition. Wherever antagonism is registered over an intervening area free from fungous growth it has been demonstrated that a piece of the medium removed from such an area and which is entirely sterile will cause the characteristic antagonistic symptoms when inlaid in the medium of another plate having the reacting fungus growing upon its surface.

The effect is not always inhibitory, however. The effect may stimulate growth. Pringsheim⁶ offers an interesting example of this particular point in an experiment where he grows *B. mesentericus vulgatus* in the same culture with *B. diptheriae*. He concludes that the former organism produces a thermolabile poison which stimulates the latter organism in small doses but which inhibits it in large doses.

An enormous amount of work remains to be done on this particular phase of mycological science before we will be in a position to fully analyze the phenomena and consequences of the growth of two or more organisms in close proximity and before we will be able to use the knowledge so gained in any practical control of fungous activities. The whole problem remains one of the most attractive forms of research in the field of mycology.

⁵ Brown, W. Experiments on the growth of fungi on culture media. *Annals Bot.* 37:105-129. 1923.

⁶ Pringsheim, E. G. Über die gegenseitige Schädigung und Förderung von Bakterien. *Centralbl. Bakt.* II 51:72-86. 1920.

