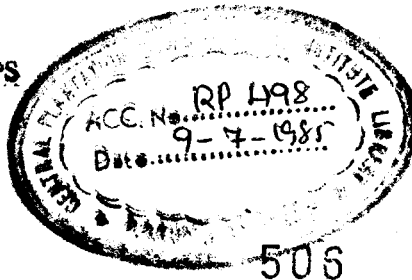


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PROBLEMS IN ESTIMATING PARASITIC FITNESS

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INTRODUCTION

Durable resistance is a characteristic of a pathosystem and not only of the host population as the expression implies. It is measured in terms of disease quantity, e.g. diseased leaf area, and this entity is influenced by the resistance of the cultivar as well as by the mean fitness of the parasite population. Therefore, parasitic fitness is an important component in studies of durable resistance. One group of problems in estimating parasitic fitness comes from the possible effects of density dependent growth of the parasite. The analysis of a mathematical model including density dependence in spore production and in survival of infections has shown that parasitic density has to be taken into account in studies on characteristics of pathosystems.

MODEL FOR A HOMOGENEOUS PARASITE POPULATION

The life cycle of a fungus is divided into four processes, spore production, dispersal, infection, and survival. The total number of spores produced from all sporulating infections on one plant during the infectious period is described by two parameters: the potential spore production per sporulating infection (B), and the density dependence coefficient of the spore production process (I). The model assumes that for a low density of infections there is an approximately linear relationship between the number of sporulating infections and the total number of spores produced, but when

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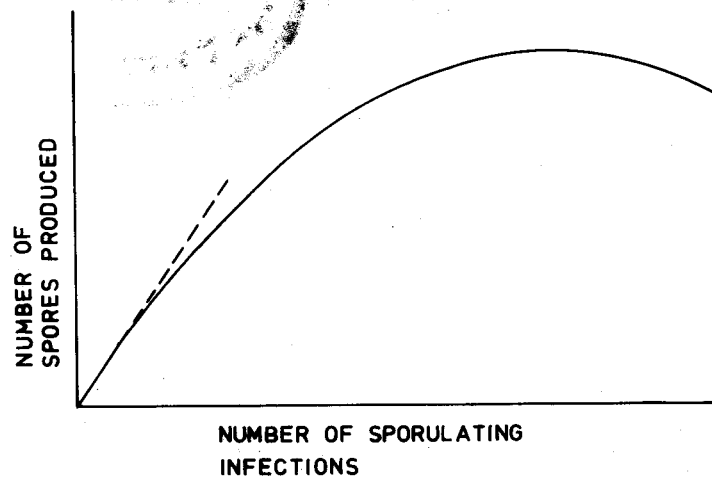


Fig. 1. The spore production processes (numbers in arbitrary units). The linear relation is $y = xB$ (broken line) and the density dependent relation is $y = x(B-Ix)$ (full line).

the density becomes higher the number of spores produced per infection decreases. This relationship is expressed mathematically by a parabola as shown in Fig. 1 (full line). It is seen from the density dependent relation that a large value of the density dependence coefficient (I) implies that the spore production per infection is much restricted.

The dispersal process is simplified by assuming deposition of spores on new plants, and removal of old plants at a fixed time. The number of spores deposited is assumed to be small compared to the leaf area so the infection process is density independent. Thus a fixed proportion of spores, given by the infection efficiency (P), germinate and establish infections.

The survival of infections during the latent period is density dependent because the infections are competing for the resources in the host. The relationship between the number of spores deposited and successfully infecting, and the number of sporulating infections produced is expressed by three parameters: the potential survival efficiency (D), the density dependence coefficient of the survival process (j), and the latent period (T). Since the number of infections decreases continuously during the latent period, the mathematical relationship, as shown in Fig. 2 (full line), is different from the one used for the spore production process, even if the biological assumptions are similar, e.g. the relationship is approximately linear when the number of spores infecting is small.

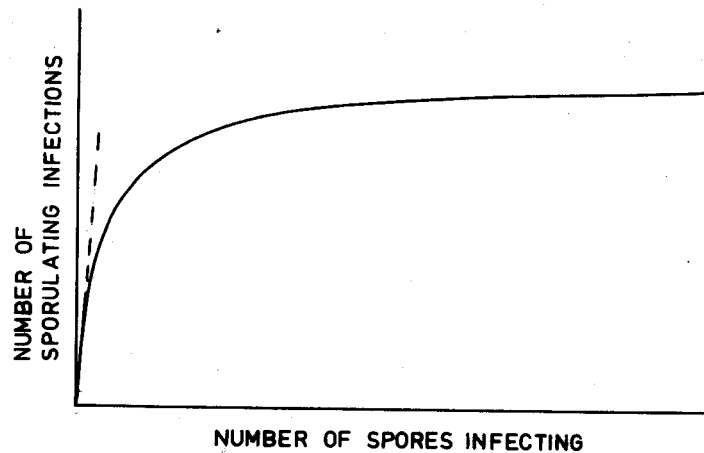


Fig. 2. The survival process (numbers in arbitrary units). The linear relation is $y = xD$ (broken line) and the density dependent relation is $y = xD / (1 - x(I-D)jT / \log D)$ (full line).

By combining the four processes successively, the expression for the potential reproduction value (fitness) is found as the product of the potential spore production per sporulating infection, the infection efficiency, and the potential survival efficiency (BPD).

PREDICTING FOR A HETEROGENEOUS PARASITE POPULATION

The extension of the model to describe the growth of a population consisting of different genotypes with synchronous development is done by specifying the parameters for each genotype and defining the interactions among genotypes. Most previous studies of heterogeneous populations have dealt with mixtures of only two genotypes. The usual way to present data from such experiments is to plot the logit of the proportion of genotype 1 against the generation number. When omitting density dependence ($I=0$ and $j=0$) this would theoretically result in a straight line with a slope measuring the logarithm of the relative fitness of genotype 1, i.e. $\log (B_1 P_1 D_1 / B_2 P_2 D_2)$ (cf. Leonard, 1969). Including density dependence, as done in the present model, a straight line is in general not expected. The reason is that even if each generation is initiated with the same amount of spores, the total number of sporulating infections changes from generation to generation as long as the composition of the spore population changes. Furthermore, the relative fitness changes from generation to generation and its average over several generations might differ considerably from the relative fitness defined as above.

In a few cases different inoculum densities have been included in the experiments (Katsuya & Green, 1967; Rastegar, 1976) and it was observed that different isolates of cereal rust dominated at light and heavy infection. A similar result is expected in the model if the density dependence is determined by the total number of sporulating infections and by the total number of spores infecting, respectively, i.e. even if there are no antagonistic effects.

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