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Editorial

Mathematical modelling remains central to the development of our understanding of the physical world around us. Increasingly, it is also being used as a key experimental tool for the analysis of a wide range of biological phenomena. It is of no surprise then, that it has played a significant role in the development of our understanding of the growth and function of the fungal mycelium and its interaction with the environment (Davidson 2007). This issue of *Fungal Ecology* is devoted to recent developments in theoretical and mathematical approaches to important and varied aspects of fungal ecology. These papers collectively demonstrate that informative models must start with a clear definition of the questions to be addressed i.e. the construction of a theoretical framework on which to develop ideas. The subsequent steps – selection of appropriate modelling approach, model construction and, model analysis and prediction – are complex and delicate processes. However, the benefits that such an approach brings are significant, as highlighted in each of the contributions. It must be noted that it is *not* the goal of the mathematical modeller to form an extremely large and complex system of equations in an attempt to mirror reality, as all that achieves is the replacement of one form of impenetrable complexity with another. Instead, the aim is to reduce (or abstract) a complex (biological) system to a simpler mathematical system where the rigorous, logical structure of the latter can be used to identify, isolate and investigate key properties. Most importantly, by doing this, key predictions regarding emergent behaviour can be made. Hence, mathematical modelling is not about what to include, but instead, what can be omitted, where the art is in achieving a meaningful balance between the two.

The first contribution in this issue concerns ''Strategies of soilborne plant pathogenic fungi in relation to disease suppression'' and is by Aad Termorshuizen and Mike Jeger. Here, the authors provide a meaningful example of the difficulties surrounding the construction of a consistent, analytical framework. However, once completed, this ''theoretical taxonomy'' provides a clear definition of the questions to be addressed and prescribes key elements that the model must include if answers to these questions are to be obtained. The second article ''Can optimality models and an ''optimality research program'' help us understand some plant-fungal relationships?'', by Ryan *et al.*, begins by succinctly defining the benefits of a sound modelling approach. As in the first paper, this article focuses on plant–fungus interactions, but retains a generic element allowing for an easy translation of the modelling strategies discussed there, to other ecological systems. The importance of an iterative feedback between, on the one hand, model construction, parameterization and prediction and on the other, experimental design and data, is emphasized. The remaining papers represent a snapshot of the state-of-the-art of various modelling and theoretical techniques. Rotheray *et al.* use image analysis combined with network theory to show that ''Grazing alters network architecture during interspecific mycelial interactions.'' Here, the ''ecological scale'' is orders of magnitude below that considered in the first two papers. Fungal interactions occur on the millimeter–centimeter scale, with robustness of the mycelial network forming one of the key foci of the paper. The graph theoretic approach is ideally suited to this scale of analysis as it accurately captures the important property of network connectivity. In some cases, it is advantageous to attempt to construct models that operate at a range of scales by the transfer of information across scale boundaries. Indeed, this problem of multi-scale *modelling* of biological systems is currently the subject of intense interest. Nik Cunniffe and Chris Gilligan develop a model for ''Scaling from mycelial growth to infection dynamics: a reaction diffusion approach''. Here, the authors combine a mechanistic description of growth of the mycelium with a predictive model for the likelihood of plant pathogenesis. Finally, Graeme Boswell and Steven Hopkins take us back down the ecological scale to a consideration of the developing mycelium in heterogeneous environments by ''Linking hyphal growth to colony dynamics: spatially explicit models of mycelia''. Here again, transfer of information across scales is vital to an accurate and explicit description of the developing fungal network. This undoubtedly represents one of the most detailed mechanistic models for explicit mycelial development available at present.

REFERENCE

Davidson FA, 2007. Mathematical modelling of mycelia: a question of scale. *Fungal Biology Reviews* **21**: 30–41.

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