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Explaining species diversity in a fractal world

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Background/Question/Methods

Multiple theoretical models seek to identify why some locations have more species than others. Our aim was to field test a new model of species organisation, the spatial scaling model (SSM). The SSM relies on the fractal dimension (FD) to explicitly capture spatial heterogeneity in its predictions, including that species richness is a function of FD, patch size and quality. The SSM has previously been applied to systems such as rangeland herbivores and dung beetles, using existing data sets.

FDs describe patterns of complexity, utilizing values between the well-known dimensions of 1, 2 and 3. Numerous methods can calculate FD; box counting is the best known, where squares of increasing size are overlain on a complex pattern. FDs have been calculated previously to describe spatial characteristics (e.g. river sinuosity) but not in such a way as to describe causative patterns in flora and fauna.

We tested the SSM using caddisflies that lay eggs exclusively on rocks that emerge above the water's surface (emergent rocks). Emergent rocks are a necessary resource for females to lay, with evidence that the number of eggs laid into individual riffles can limit population densities of larvae in streams. This makes it an ideal, if non-traditional, test system for model that was developed with the utilisation of food resources in mind. We surveyed 18 riffles over three rivers in south-eastern Australia, mapping every emergent rock, measuring physical characteristics of the rocks and riffles, and identifying and enumerating all caddisfly egg masses on those rocks.

Results/Conclusions

We found that emergent rocks in streams are fractal at both the riffle (ms) and reach scale (kms). At the reach scale, FDs calculated using an entropy method varied between 0.85 and 0.99, with variations correlated with physical characteristics such as rock shape in the channel. In comparison, FDs calculated using the box-count method were larger, ranging from 1.33 and 1.58. The ranking of individual reaches varied between the two methods. Thus, the method of calculating FD had large impacts on the result. Given that calculating FDs involved numerous expert judgements, the lack of consistency among the methods potentially presents a major barrier to the objective application of the SSM. That is, depending on how the FDs are calculated, the goodness of fit of the model as a predictor of species richness changes. As a result, we conclude that applying species assembly models such as the SSM requires additional development.