The effect of patchiness and heterogenic landscape on species diversity in the southern Judean lowland region, Israel

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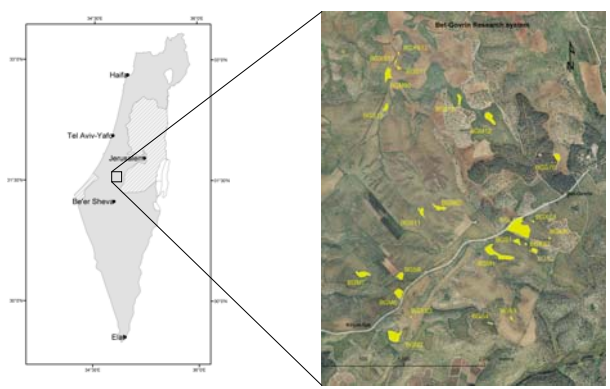
Introduction

Ecological communities that inhabit heterogeneous landscapes are affected by local-scale as well as by landscape-scale processes. Understanding species diversity patterns in heterogeneous landscapes requires comprehensive research on how these processes interact to determine community composition and structure. The semi-arid landscape of the Southern Judean Lowland (SJL), which currently undergoes intensive fragmentation, is highly heterogeneous, therefore requires the exploration of ecological processes at different spatial scales. It also requires a biodiversity management plan. In this research we use two common ground dwelling beetle families (*Tenebrionidae,* detrivors, and *Carabidae,* predators) to explore how different factors at both local and landscape scales determine community structure and diversity.

Research Goals

- To investigate the interaction between patch (local scale) and landscape-scale variables that determine beetle species-diversity patterns in both scales.
- To study the role of human-induced fragmentation and landscape heterogeneity in observed patterns of beetle community.



Map 1. The study site: natural scrub islands surrounded by agricultural fields. The southern Judean lowland, Israel.

Methods

We conducted beetle censuses by using uniformly-distributed pitfall traps, in 25 different-sized patches (500 m2- 40000 m2). We used Fisher's α and non-parametric extrapolators to estimate species diversity. Patch characteristics (vegetation species diversity and cover, soil cover and stoniness degree) were measured in the field by random transects. In order to examine patch spatial arrangements, we used a spectral-based classification of high-resolution aerial photos. Thereafter, we created cellular maps in which every pixel represented a habitat type. We used an aggregation index (AI) to define patch spatial heterogeneity from the cellular maps. Spatial variables (e.g., patch size, shape, physiognomy) were measured using GIS applications, with field GPS validations. In addition, we used GIS to define landscape characteristics at the landscape scale.

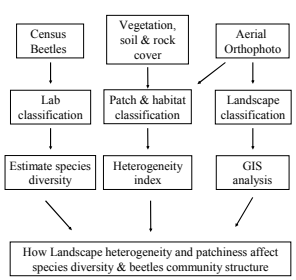


Fig.1. flowchart of methods we used in the research.

Picture 1-3. The study site: natural scrub islands surrounded by agricultural fields

Results

A total number of 11125 beetles of 56 species were trapped. Both area-abundance relationships and species area curves for the two beetles assemblages revealed no significant pattern. We found a significant difference between small patches and large patches in beetle diversity of both family groups (ANOVA test: *Tenebrionidae*: R^2 =0.47, p <0.001. *Carabidae*: R^2 =0.28, p =0.01).

Path-analysis results

- Landscape variables had the strongest effect on species-diversity patterns of the *Carabidae* family in all patches.
- *Tenebrionidae* species responded differently to patch and landscape variables: in small patches both patch and landscape variables affected species diversity. However, in large patches, mainly patch variables affected species diversity.
- Among patch variables, spatial heterogeneity and plant species diversity had the strongest effect on beetle species diversity.
- Among landscape variables, edge effect, contrast, and disturbance had the most significant effects on beetle species diversity.

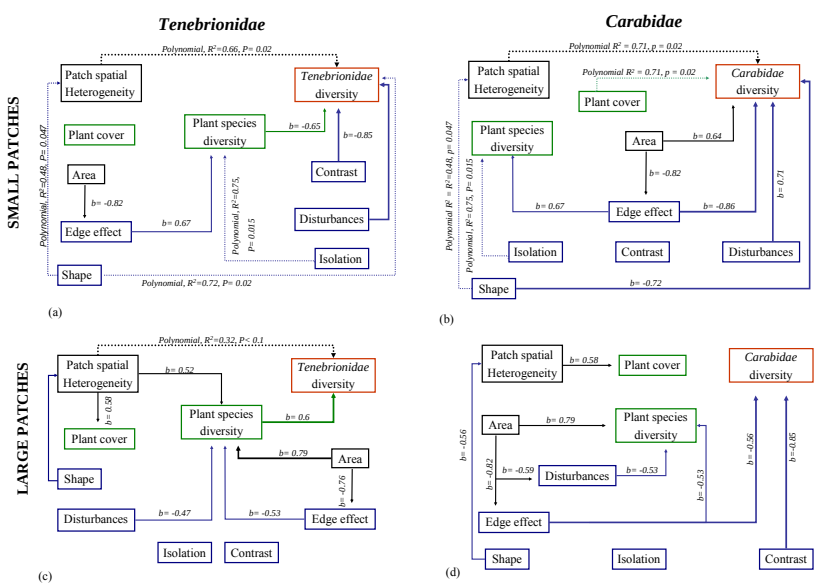


Fig. 2. Path analysis diagram for *Tenebrionidae* (a, c) and Carabidae (b, d) in small patches (a, b) and large patches (c, d).

The effect of patch variables

- We found a significant relationship between patch spatial heterogeneity and *Tenebrionidae* species diversity in both large and small patches (fig 3a,b). A correlative relation between *Carabidae* species diversity and patch spatial heterogeneity was found only in small patches (R^2 =0.71, p =0.02, n =9).
- There was a significant relationship between *Tenebrionidae* species diversity and plant species diversity in small (R^2 =0.45, p =0.067) and large (R^2 =0.38, p =0.013) patches.

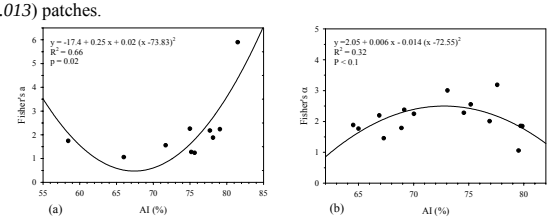


Fig.3a,b. The effect of spatial heterogeneity on *Tenebrionidae* species diversity in small (a) and large (b) patches

The effect of landscape variables

- We found a significant relationship between patch shape and beetle species diversity in both families only in small patches (fig 4a,b). Similar relationships were found between species diversity and disturbances (Carabidae; R^2 =0.56, p =0.01, *Tenebrionidae;* R^2 =0.63, p =0.01).

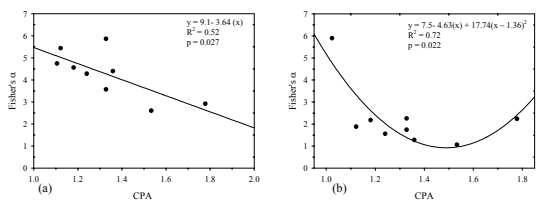


Fig.4a,b. The effect of patch shape on *Carabidae* (a) and *Tenebrionidae* (b) species diversity in small patches

- Edge effect was correlative only to *Carabidae* species diversity, across all patch categories (fig 5a,b).
- Patch contrast to the surrounding habitat was correlated to the *Carabidae* species diversity in large patches (R^2 =0.44, p =0.006) and to *Tenebrionidae* species diversity in small patches (R^2 =0.9, p =0.0001).

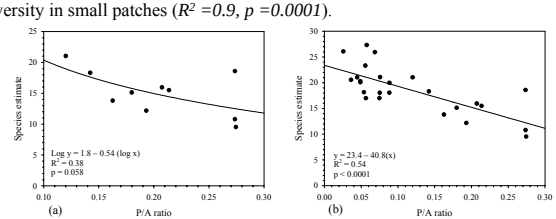


Fig.5a,b. The effect of edge effect on *Carabidae* species diversity in small (a) and large (b) patches

Conclusions

- **Biodiversity patterns in the heterogeneous, fragmented landscape of the Southern Judean Lowland show scale-dependent response of beetle communities to patch and landscape variables.**
- **Species diversity patterns are designed by interactive effects of local patch and landscape variables.**
- **Patch spatial heterogeneity has a major effect on species diversity at the local scale, while the contrast to the surrounding habitat and disturbance regime have the most powerful influence at the landscape scale.**