



Interactions between taxonomic diversity and agricultural habitat diversity: the importance of spatial scale

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Nancy Jennings, School of Biological Sciences, University of Bristol. nancy@dotmoth.co.uk

Introduction

Increasing habitat diversity in farmland is predicted to have beneficial effects on biodiversity. However, little empirical evidence for any broad relationship between habitat diversity and biodiversity exists, and it is unclear at which spatial scale any changes in habitat diversity might benefit biodiversity. Using data on taxon abundance already collected for a study of mammals and their prey as biotic indicators, I therefore aimed to test the following hypotheses:

1. Is there a relationship between the diversity of invertebrate and mammalian taxa present in farmland, and the diversity of the habitat quantified at four spatial scales (500 m to 25 km radii) around sample points?
2. If a relationship exists, how does it change as the scale of measurement of habitat diversity changes, and do changes depend on the taxon?

Methods

As part of another research project, we sampled for 5 taxonomic groups (carabid beetles, moths, Diptera, bats and shrews) at 43 farmland sites in England and Wales. For details of methods, go to http://www2.defra.gov.uk/research/project_data/Default.asp and search for "bioindicators" (Pocock & Jennings 2006, Jennings & Pocock submitted, Pocock & Jennings submitted).

We quantified taxonomic diversity from abundance data, pooling abundance in the members of each pair of sites but keeping results for sampling points near the boundary and in the field separate, in two distinct ways. Firstly, species richness was quantified as the number of species. For all analyses of species richness, $\log(\text{number of individuals})$ was included as a covariate (Magurran 1988). Secondly, normalised dominance was expressed as $\text{logit}(\text{proportion of the total composed of the most abundant species})$; (Magurran 1988). Species richness increases, and dominance decreases, with increasing taxonomic diversity. Sites with ≤ 2 individuals and/or ≤ 2 taxa were not included, and data for shrews were not analysed, since only two species were recorded regularly.

For each site, indices of habitat diversity (Simpson's Indices; Magurran 1988) were calculated from Defra's 2003 agricultural census database (by Steve Langton, Agricultural Change and Environment Observatory). Categories were based on 17 land use types. The grid reference of the centre of each pair of sites was used to derive habitat diversity data for farm holdings within circles with 1km, 5km and 25km radii. Habitat diversity at a smaller spatial scale (500m radius) could not be derived from the census data because not enough sites had farm holdings within 500m of them. Instead habitat diversity within 500m of our sites was derived from Ordnance Survey maps as the number of fields in the circle.

Analysis of covariance (ANCOVA) was used to investigate relationships between the diversity of the study taxa, the habitat diversity indices, and variables relating to season (for all taxa) and weather conditions (for bats and their prey). For Carabidae, the only covariate was Simpson's Index (and $\log(\text{number of individuals})$ where appropriate). For bats, Diptera and moths, environmental variables were included as covariates (moon phase, air temperature, wind speed, and cloud cover). Seasonality was a factor in the analyses, expressed as date period, and based on the date of sampling. There were four or five date periods per year, per sampling method.

Results

I found very few significant relationships between agricultural habitat diversity and the diversity of the study taxa, at any spatial scale, whether taxonomic diversity was expressed as species richness (Table 1) or dominance (Table 2), whether it was measured in the field or near the boundary in cereal or in grass, and despite controlling for season and environmental conditions. Only two

significant relationships were in the expected direction.

Taxa, sample	Cereal crops				Grass crops			
	500m	1km	5km	25km	500m	1km	5km	25km
Bats, field	0.180	0.375	0.802	0.048 -	0.739	0.263	0.993	0.059
Bats, boundary	0.108	0.290	0.405	0.674	0.141	0.711	0.587	0.067
Carabidae, field	0.630	0.017 -	0.995	0.594	0.362	0.629	0.777	0.500
Carabidae, boundary	0.784	0.057	0.477	0.860	0.273	0.065	1.000	0.296
Diptera, field	0.511	0.670	0.661	0.719	0.114	0.932	0.767	0.921
Diptera, boundary	0.734	0.287	0.341	0.543	0.519	0.902	0.450	0.418
Moths, field	0.424	0.784	0.920	0.347	0.572	0.084	0.656	0.139
Moths, boundary	0.780	0.928	0.863	0.790	0.305	0.189	0.565	0.941

Table 1. *P* values from ANCOVAs on the species richness of each taxon (in fields and near boundaries), for the covariate Simpson's Index of habitat diversity quantified at three spatial scales (1km, 5km and 25km radii from study sites), and for the number of fields (in 500m radii from sites), in cereal crops (organically and conventionally farmed) and grass crops (hay and silage). *P* values for other variables, included in the ANCOVA and described in the text, are not shown. Log(number of individuals) was also included as a covariate. Bold text indicates significant *P* values. The directions of the relationships between species richness and the habitat diversity index are indicated (they are negative, i.e. contrary to expectation).

Taxa, sample	Cereal crops				Grass crops			
	500m	1km	5km	25km	500m	1km	5km	25km
Bats, field	0.288	0.041 +	0.854	0.022 +	0.366	0.849	0.525	0.168
Bats, boundary	0.218	0.375	0.289	0.628	0.919	0.380	0.939	0.745
Carabidae, field	0.238	0.182	0.399	0.142	0.232	0.717	0.447	0.713
Carabidae, boundary	0.805	0.076	0.554	0.706	0.087	0.099	0.209	0.126
Diptera, field	0.960	0.425	0.594	0.759	0.897	0.404	0.229	0.994
Diptera, boundary	0.413	0.560	0.105	0.002 -	0.999	0.424	0.115	0.685
Moths, field	0.994	0.428	0.404	0.168	0.837	0.047 -	0.791	0.165
Moths, boundary	0.332	0.687	0.412	0.423	0.186	0.098	0.412	0.805

Table 2. *P* values from ANCOVAs on the normalised dominance of each taxon (in fields and near boundaries), for the covariate Simpson's Index of habitat diversity quantified at three spatial scales (1km, 5km and 25km radii from study sites), and for the number of fields (in 500m radii from sites), in cereal crops (organically and conventionally farmed) and grass crops (hay and silage). *P* values for other variables, included in the ANCOVA and described in the text, are not shown. Bold text indicates significant *P* values. The directions of relationships between dominance and the habitat diversity index are indicated (two of the four are positive, i.e. contrary to expectation).

Discussion

My results were surprising, because declines in the abundance of several taxa have been attributed to decreasing agricultural habitat diversity. The lack of statistical power due to the correlative approach I used contributed to the lack of significant results. Also, our research was limited to the geographical area in which the study taxa are found (south west Britain), and here there may be little variation in habitat diversity.

Acknowledgements

Steve Langton (Agricultural Change and Environment Observatory) calculated the habitat diversity indices, and Michael Pocock suggested this research and calculated diversity indices for the taxa.

References

- Jennings, N. & Pocock, M.J.O. (submitted) Ecological and life-history correlates of sensitivity to agricultural intensification and habitat change.
- Magurran, A.E. (1988) *Ecological Diversity and its Measurement*. Croom Helm, London.
- Pocock, M.J.O. & Jennings, N. (submitted) Testing biotic indicator taxa: the sensitivity of insectivorous mammals and their prey to the intensification of lowland agriculture.
- Pocock, M.J.O. & Jennings, N. (2006) Use of hair tubes to survey for shrews: new methods for identification and quantification of abundance. *Mammal Review*, 36, 299-308.