Scale dependent responses of beetle genetic and phenotypic diversity to temporal variability

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Summary

Population diversity, an important level of biodiversity, can be measured as variation in the genetic and phenotypic makeup of populations along geographical and ecological gradients. The degree of such variation is strongly affected by both spatial and temporal variability. We conducted a field study on beetle populations inhabiting the fragmented landscape of the Southern Judean Lowland in Israel. To control for the effect of spatial heterogeneity, we sampled different populations of a generalist and highly abundant darkling beetle species along a steep climatic gradient where fragmentation intensity was approximately the same. We found that beetle genetic and phenotypic diversity were positively correlated with temporal weather variability at the monthly and seasonal scales. Nevertheless, genetic differentiation among these populations was moderate suggesting that gene flow is not restricted along this geographical gradient. Classical literature referring to the interplay between population diversity and temporal variability has examined temporal weather variation at the yearly scale. However, this time scale may be problematic when investigating univoltine species, which often respond to shorter scales such as season or month as presented in our study. We thus suggest that to better understand how an organism perceives the environment it is necessary to examine its response to varying temporal scales.

Research Goals

1. To test if genetic diversity and phenotypic variation of beetle populations are correlated with temporal weather variability.
2. To test if variation in the genetic and phenotypic makeup of populations along ecological gradients is scale dependent.

Conclusions

1. Genetic and phenotypic variation within populations were positively correlated with the degree of rainfall variation observed at the monthly and seasonal scales.
2. There was a moderate genetic differentiation among *Z. punctata* populations, i.e., gene flow is not restricted along N-S gradient.
3. As expected by the Bergman's rule, *Z. punctata* individuals were smaller in the southern vs. northern populations.

Results

	Population	n	Pi	*h*	hd
N	Luzit	13	0.0055	8	0.858
	Bet-Govrin	34	0.0089	17	0.912
	Dvir	22	0.0187	22	1
S	Goral	19	0.0610	18	0.994
	Total	88	0.0229	57	0.973

(a) Genetic diversity observed in the COI mtDNA gene within *Z. punctata* populations along N-S geographic gradient. (n) Sample size, (Pi) Nucleotide diversity with Jukes and Cantor correction, (*h*) Haplotype number, (hd) Haplotype diversity.

Source	df	SS	MS	Est. Var.	%
Among pops.	3	69.691	23.230	0.815	12%
Within pops.	84	505.365	6.016	6.016	88%
Total	87	575.057		6.832	100%
Stat	**Value**	**Probability**			
PhiPt	0.119	0.001			

(c) AMOVA for *Z. punctata* populations along North-South geographic gradient

Pop 1 Goral	Pop2 Dvir	Pop 3 BG	Pop 4 Luzit	
0.000	0.036	0.003	0.051	Pop 1 Goral
0.084	0.000	0.005	0.001	Pop2 Dvir
0.136	0.131	0.000	0.117	Pop 3 BG
0.114	0.256	0.050	0.000	Pop 4 Luzit

(d) Pairwise comparison of Molecular Variance. PhiPT values below diagonal. Probability values based on 999 permutation above diagonal.

Differentiation level:
very high
high
moderate
low

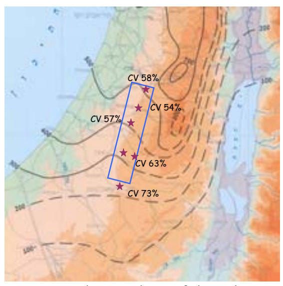
		Luzit	Bet-Govrin	Dvir	Goral
N	Luzit				
	Bet-Govrin	0.067			
	Dvir	0.260	0.143		
S	Goral	0.145	0.098	0.094	

(b) F_{ST} values of *Z. punctata* populations along N-S geographic gradient

MRPP analysis for phenotypic variation

	Obs.δ	Exp.δ	Var.	Skewness	*T*	*P*	*A*
Sorensen distances	0.67	0.91	<0.0001	-1.263	-20.831	<0.0001	0.263
Euclidean	0.663	0.957	0.00018	-1.376	-21.444	<0.0001	0.307
Multiple comparisons (Sorensen)							
Goral vs Dvir	0.903	0.923	<0.0001	-1.72	-1.82	0.0589	0.021
Goral vs Bet-Nir	0.663	0.963	<0.0001	-2.163	-23.97	<0.0001	0.311
Goral vs Luzit	0.758	0.972	<0.0001	-1.852	-16.83	<0.0001	0.220
Dvir vs Bet-Nir	0.579	0.806	<0.0001	-2.250	-16.22	<0.0001	0.281
Dvir vs Luzit	0.678	0.845	<0.0001	-2.136	-11.12	<0.0001	0.197
Bet-Nir vs Luzit	0.419	0.420	<0.0001	-2.065	-0.246	<0.2840	0.003

(e) Summary statistics for MRPP. Results comparing Euclidean and Sorensen distances across all groups, as well as multiple pairwise comparison of Sorensen distances.



precipitation (mm\year) map of the Judean lowland region. The research area is marked with a rectangle. Stars represent meteorological stations. Coefficient of variation (CV) measured at monthly scale.

Methods

We analyzed a 40 years period high resolution climatic data, from 7 meteorological stations along a N-S geographical gradient within the Southern Judean lowlands in Israel. We calculated the coefficient of variation for accumulated rainfall and number of rainy events at yearly, seasonal and monthly scales.
Z. punctata beetles were sampled using uniform-distributed pitfall traps within 5 different sites along the N-S geographical gradient, with control for habitat fragmentation. Following DNA extraction, we developed specific primers and amplified 700 bp of the COI mitochondrial gene. Sequences were aligned using ClustalW algorithm. We analyzed genetic diversity, population structure and genetic differentiation between populations using DNAsp software (Rozas *et al.* 2003) and GeneAlex (Peakall & Smause 2006).
For phenotypic analysis we measured the following parameters: Elytra length, Tibia length, Upper Tarsus length, E\T ratio, E\UT ratio and T\UT ratio. Statistical analysis was done using SYSTAT(2005) and PCORD (2004).