The importance of species identity for community-wide species interaction strengths

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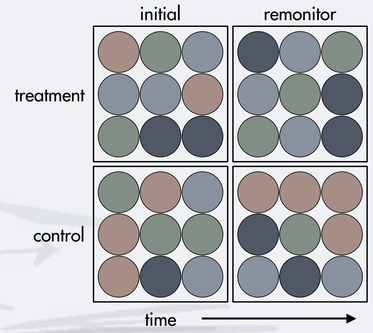
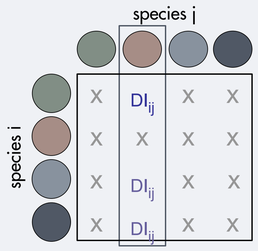
abstract

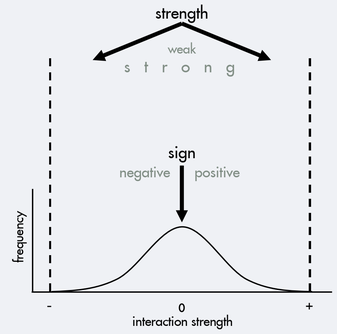
The strength of interactions among species in communities underpins higher order properties of ecosystems such as stability and fluctuations in species abundances. Theory suggests that weak interactions promote stability and favor species coexistence and greater diversity. In addition, positive, facilitative interactions are predicted to dominate in some environments and negative, competitive interactions in other habitats. I test these predictions in a suite of manipulatory experiments that measure community-wide species interactions in a rocky intertidal system. These experiments confirm that communities are characterized by weakly interacting species, but show that mean interaction strengths range from generally facilitative to inhibitive. Contrary to theoretical expectations, there is no relationship between community diversity and the sign or strength of species interactions. Interaction strength is instead set by the community members and their traits. In other words, complexity alone does not stabilize communities, rather particular types of species are more important determinants of community structure.

techniques





$DI_{ij} = (\ln(N/D)) / Y$



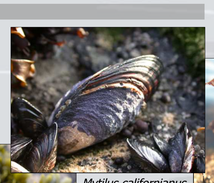
The interaction coefficient between two species is calculated using the log ratio of the response of the target species in the manipulated unit relative to the untreated control. This measure gives the per-capita impact of species j on the population of species i, DI_{ij}, when N is the abundance of the target organism in the unmanipulated control plots, D is the abundance of the target organism in the manipulated plots, and Y is the abundance of the focal species in the untreated control plot. This metric is centered around zero. As such, positive effects will generate positive interaction coefficients, and negative effects will correspond to negative coefficients.

local study

Species removal experiments were used to quantify pair-wise interaction coefficients in the removal matrix of one high intertidal community. Replicate .025 m^2 plots were arranged at one site in British Columbia in a completely randomized blocked design. Single species were removed from each of nine treatment levels in addition to the unmanipulated control. These taxonomically diverse species represent approximately 40% percent of macro-organisms in the study community and together span a range of sizes, abundances, morphologies, life histories, trophic levels, and likely include positive, negative, weak, and strong interactors.

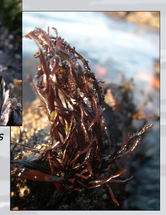
example species

Chthamalus dalli



Mytilus californianus

Fucus gardneri



Mastocarpus papillatus

Community-wide interaction sign and strength was calculated as described above using changes in biomass. The effect of focal species was tested using a linear mixed model, which included an autoregressive order one correlation between times:

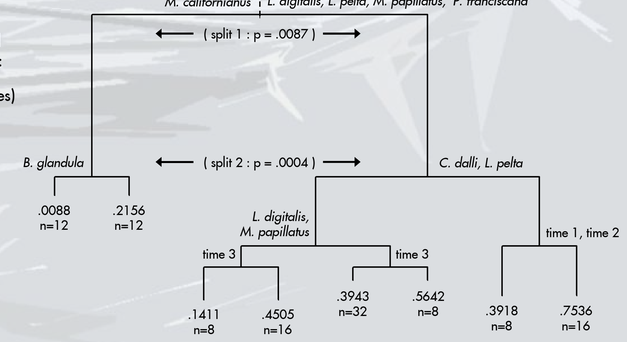
y = species + time + species * time; random block (species)

interaction sign

	df	F	p
intercept	1	.515499	.4759
species	8	.674130	.7092
time	2	3.38718	.0411
species * time	16	.481364	.9458

interaction strength

	df	F	p
intercept	1	30.2153	<.0001
species	8	2.44956	.0428
time	2	3.78998	.0288
species * time	16	1.06541	.4090

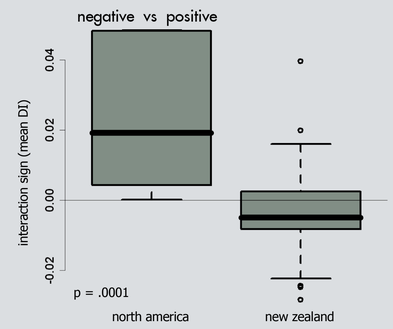


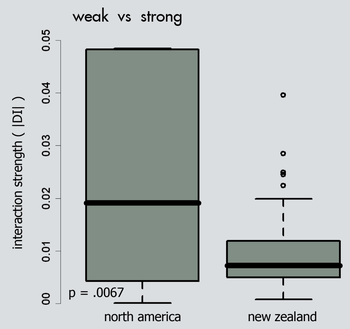
categorical tree

The categorical tree analysis shows how mean community-wide interaction strength depends on species and time by repeatedly splitting data into homogenous groups. The first two divisions are explained by focal (removed) species, accounting for the majority of variation in mean interaction strengths. p-values for these splits were determined using independent contrasts of the linear mixed model.

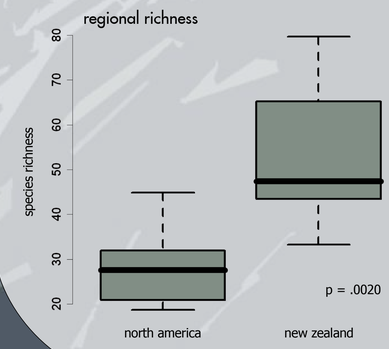
regional comparison

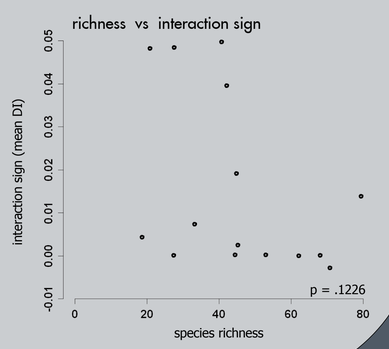
In total, data from 35 field experiments were analyzed to assess the strength and sign of the distribution of species interaction strengths across a range of rocky intertidal habitats and local scales in New Zealand and North America. Interaction strength (DI) was calculated using changes in species abundance. Analysis of variance was used to test for the effect of region.





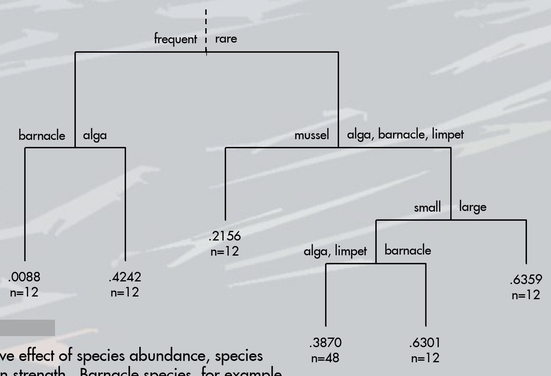
The results of the analyses indicate that community-wide interaction sign and strength varies by region (above) but this result is not driven by differences in regional species richness (below). Instead, particular species or types of species, and how they interact in their locales, structure the distribution of interactions in the communities.





generality

Species traits were used to predict mean community-wide interaction strength in a categorical tree. As part of the experiment described above, three species traits were tested as predictors: species abundance (two levels), species type (four levels), and body size (two levels). Analyses using linear mixed models detected no singular effect of any species trait on interaction strength. The categorical tree analysis (right) however indicated an interactive effect of species abundance, species type, and body size on interaction strength.



categorical tree

The categorical tree analysis (above) reveals an interactive effect of species abundance, species type, and body size on mean community-wide interaction strength. Barnacle species, for example, interact strongly with other community members when rare (split two; right side), but are weaker interactors at higher abundances (split two; left side). This indicates that nonlinear interactions between species, such as those dependent on the density of the focal species, may be important.

Primary conclusions

- Mean community-wide interaction strength is not generally positive or negative, rather distributed equally around zero
- Communities are characterized by weak interactions
- Community diversity alone does not explain the distribution of interaction types in communities
- The strength of mean community-wide species interactions changes when studying different focal species
- Variations in interaction strength may be explained better by considering higher order processes that account for species traits

appreciation

betsy abbott, rebecca best, pylin chuapetcharasopon, stefan dick, robyn dunmore, molly dutton, melissa foley, stacie lilley, katie lotterhos, dieta lund, mark novak, roly russell, david schiel, jon shurin, sarah thompson, andrew w. mellon foundation, bamfield marine sciences centre, huu-ay-aht first nations, NZ foundation for research science & technology, university of british columbia