MST2204 Marine Research and Employability Skills

Diversity Indices

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Aims

- To consider how we compare ecological communities
- To understand biological diversity
- To recognise the difference between measures of biodiversity
- To appreciate when to use diversity indices

So far…

Focused on statistical tests that allow us to look at:

- Differences in averages between two samples and three or more samples
- Differences in frequency or an association between variables
- Relationships between two variables
- But in biology we often ask questions related to species/communities and how they are distributed

Biological diversity

- Biodiversity is heterogeneously distributed in ecological systems
  - Genetic
  - Organismal
  - Ecological
- Ecological systems exist within defined spatial boundaries, so diversity can be measured over a range of spatial scales

Diversity and community structure

- Ecological communities highly complex and diverse
- Important to examine communities for:
  - Monitoring
  - Ecological studies
  - Conservation
  - Exploitation
- Ask questions such as:
  - How similar are the different communities?
  - Is one community more diverse and of greater conservation value than another?
  - Do dominant species vary between sites?
  - Has there been a shift in community structure?

Measuring diversity

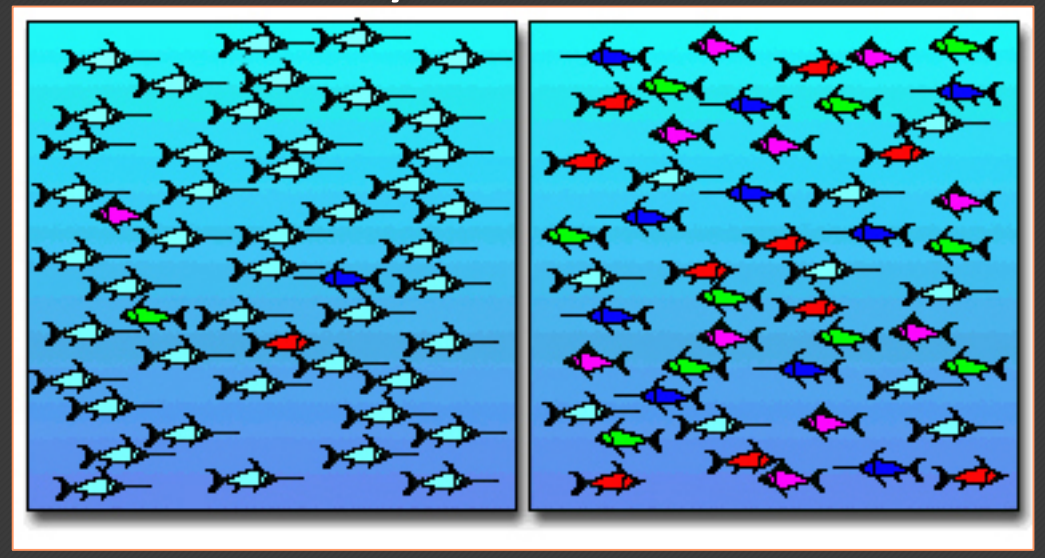
- Although biodiversity can be quantified in a number of ways, species diversity is considered to be a measure of diversity when describing communities
- Species diversity (species heterogeneity) is an expression of community structure

Species diversity

Consists of two components:

- Species richness - total number of species in a quantified area
- Species abundance (evenness) - the relative abundance of individuals within a community

In this sample there are five species, but one is much more common in its occurrence than the others



In this sample there are five equally common species

From Raffaelli & Gray, 2010

Species richness

Not constant through space

Negatively related to:

- Latitude
- Altitude

Complex relationship with:

- Time since disturbance
- Nutrients
- Predation rate
- Productivity

Positively related to:

- Area
- Environmental variability

Species richness

- Simplest measure of how diverse a habitat is, is to count the number of species in a given area of a community

Problems with species richness:

- Dependent (to a degree) on sample size
- Very rare all species are equally abundant so may overplay role of rare species
- Need an additional measure of diversity…

Species abundance (evenness)

- Distribution of individuals of a species is species evenness or equitability
- Measure of relative abundance of all different species in a community
- Maximal when all species are present in the same proportions of the community

Problems with species abundance

- No idea how many species there are or which have disappeared
- Often combine these measures into a mathematical index to provide more information about community composition

Diversity indices

What are diversity indices?

- Mathematical measures of species diversity
- Provide information on community composition
- Yield information about rarity and commonness in a community
- Useful in management and conservation for assessment purposes
- Wide range of indices available to use

Diversity indices

- Why so many types?
- Consider richness and evenness to differing degrees

Species	A	B	C	D
Site 1	10	11	13	3
Site 2	2	1	0	
Site 3	10	10	10	10
Site 4	2	3	14	3

Types of diversity indices

Three main categories:

- Species richness indices
- Species abundance indices
- Proportional abundance indices



Species Richness Indices

Species richness indices

- Useful when you can identify all species in a sample
- Require information on:
  - Number of species
  - Total number of individuals within a sample
- Can be used with a specific sample area
- Use with care as strongly influenced by sample size

Margalef's index, D_{mg}

- Indication of diversity of a sample in terms of species richness

Margalef's Index

- Concerned only with species richness
- Based on the number of species present in a given number of individuals (Clark & Warwick, 2001)

$$D_{mg} = \frac{(S-1)}{\ln N}$$

Where S = number of species

N = total number of individuals

As S increases so does D

The larger the number the more diverse the community

Species Abundance Indices

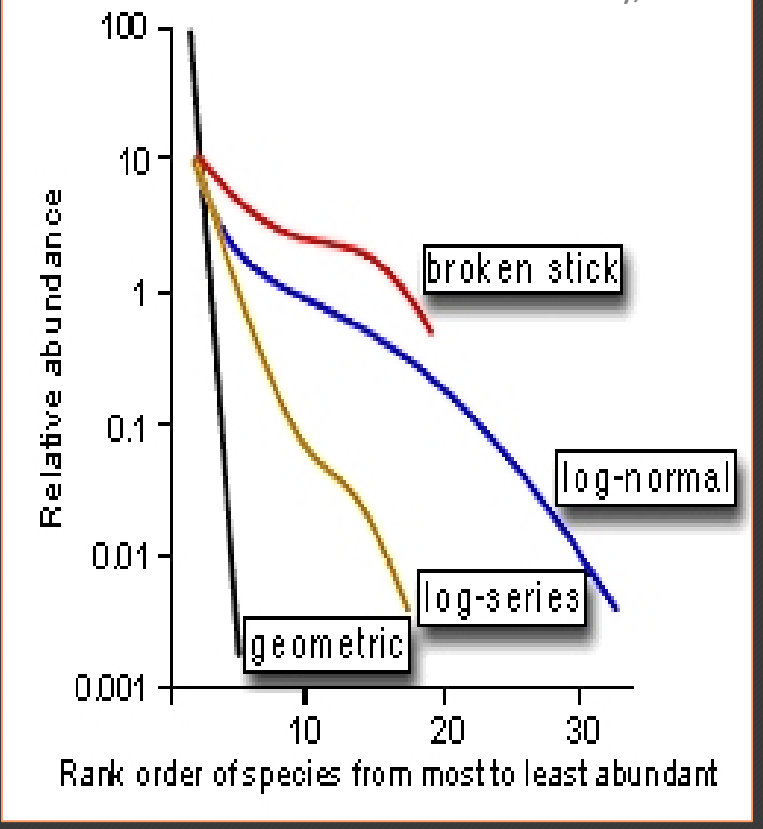
Species abundance indices

Graphical representation of abundance - four main models:

- Log normal - few species very rare, many uncommon and a few very abundant
- Geometric series - few dominant, most common
- Log series - majority species rare, but a few very abundant
- Broken stick - species relatively equally abundant (high evenness)

Identified by plotting rank/abundance graphs (Magurran, 1991)

From Raffaelli & Gray, 2010



Proportional Abundance Indices

Proportional abundance indices

Shannon-Wiener, H’

- Considers the proportion of each species within the sample
- Need to calculate a separate measure of evenness, J’

Simpson’s index, λ or Berger-Parker index, d

- Weighted towards the abundance of the commonest species
- Useful in giving a measure of evenness
- Can be reported with a species richness index

Shannon-Wiener Index

- Most widely used in ecology, comprises of three elements which must all be considered to interpret the findings:

  S = species richness (number of species in sample)

  H’ = Shannon Wiener diversity index = $- \Sigma (pi * \ln pi)$

  Where pi = proportion of total abundance each species accounts for

  H’ usually falls between 1.5 - 3.5

  J’ (or E) = Evenness or Equitability = $\frac{H'}{\ln S}$

  J’ falls between 0 - 1, closer to 1 the more even the distribution

So, H’ can increase due to an increase in number of species OR where the relative abundance of the different species is more even

Shannon-Wiener

- H’ conforms to a normal distribution (can also check S and J’) so you can apply statistical analyses to further test H_0
  - If comparing two sites - t-test
  - If comparing three or more sites - ANOVA
- Must always use S and J’ in conjunction with H’
- NB: H’ has been criticised extensively as two sites could have the same H’, S and J’ values but comprised of entirely different species (Margurran, 1991)

Dominance indices

- Indices are weighted towards abundance of commonest species

Simpson's Index, λ	Berger Parker Index, d
$\lambda = \sum pi^2$	$d = N_{max} / N$
Where pi = proportion of abundance accounts for most common species	N_{max} = abundance of a species N = total abundance
Probability two individuals picked at random will be same species Weighted towards most abundant species	Expresses proportional abundance of commonest species Can be expressed as 1/d so ↑ in 1/d shows ↓ in dominance (↑ in evenness)

- As λ and d become larger they reflect the fact that particular species dominate the community

Choosing the right approach

- To be useful diversity indices must be capable of detecting subtle differences between sites
  - Collect data in same manner from areas to be compared
  - Compare like with like
  - Always have a clear idea of why you are applying the indices (not always practical to calculate when measuring diversity)
  - Use combination of indices *e.g.* D_{mg} and d

Summary

Three main measures of diversity:

- Species richness - simple but sensitive to sample size
  - Margalef's index, D_{mg}
- Species abundance - good indication of relationships but difficult to calculate
  - Log normal; Geometric series; Log series; Broken stick
- Proportional abundance - some simple, some complex but a useful compromise
  - Shannon-Wiener, H'; Simpson's Index, λ; Berger Parker Index, d

Resources

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