Title: Biodiversity: more than just how many species
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Volume: 1
Article: 2
Page(s): 1-6
Published Date: 01/07/2011
PermaLink: http://www.palaeontologyonline.com/articles/2011/biodiversity-more-than-just-how-many-species/

CITATION OF ARTICLE

Please cite the following published work as:

McGowen, AlistairJ. 2011. Biodiversity: more than just how many species. Palaeontology Online, Volume 1, Article 2, 1-6.

Biodiversity: more than just how many species

by Alistair J. McGowan*1

Introduction:

Biological diversity, or biodiversity, shot to prominence among non-specialists in 1992, after the Rio Earth Summit (Fig. 1). Media coverage of the summit did a tremendous amount to raise awareness of the need to gather baseline data on species, and of the spectre of extinction hanging over some of them. The international Convention on Biodiversity declared 2010 the International Year of Biodiversity, and 2011–20 the Decade of Biodiversity. The use of the term biodiversity in the media has increased greatly, and the word is now in general use. Many countries now have biodiversity action plans that start locally and move through various levels and habitat types to the national level (for example, see the United Kingdom's Biodiversity Action Plan).

What is Biodiversity?

At a number of talks at conferences and at academic meetings last year, I asked audiences how they would define biodiversity. The answer usually contained some reference to the number of species. I barred any ecologists in the audience from answering first, but they would invoke the other numerical parameter that ecologists routinely measure: abundance. Usually, ecologists measure the number of species in an area (often referred to as diversity, but richness is a more exact term) and the abundance (how many individuals of each species are present), and will use this pair of measurements to perform a series of calculations and draw sets of graphs.

Abundance is crucial for understanding biodiversity change. Tracking the abundance of a single species over time gives the change in population size. The International Union for Conservation of Nature (IUCN) publishes Red Lists of plants and animals considered to be

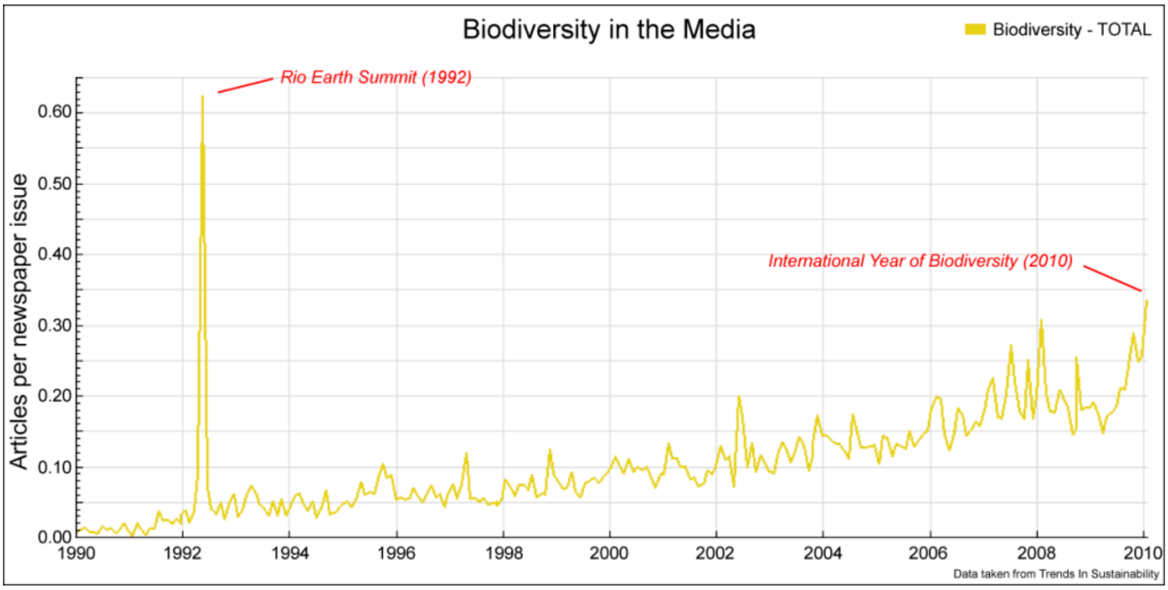

FIGURE 1 – BIODIVERSITY IN THE MEDIA

under threat of extinction. The original IUCN criteria were drawn up largely by ecologists and are based on measures such as population size, geographic range and how quickly individuals of a species grow from juveniles to adults able to reproduce. These criteria work best for species for which we have population data over decades, such as birds and mammals. Because the IUCN has a global remit, the criteria have been altered over time to help conserve species that are less well studied, and to reflect a growing shift in focus towards conserving whole landscapes or habitats rather than focusing on individual species. The IUCN has developed broader criteria to help in the assessment of less well-studied groups of organisms, and now includes information on the conservation actions that are already being taken. The organization also recognizes that there are social, economic and political dimensions to conservation biology, and the website discusses conservation in its wider context. The role of scientists in such work is to provide impartial evidence and encourage the other parts of society to take an evidence-based approach to actions.

But what does not get reported is the importance of population monitoring. I am particularly familiar with bird-surveying work in the British Isles. When I tell people that birds such as starlings, house sparrows and herring gulls are on the UK Red List, they are surprised and sceptical. They do not realize that a species may have UK Red Status because of population decline within the country, not just because it is globally threatened (IUCN red-listed). This seems to be down to a fundamental failure of communication by the scientists, or a failure of non-specialists to appreciate the nature of the UK's Red, Amber, Green system of rating conservation status.

When I have explained the UK criteria, the reaction from some people is that if the species is not threatened worldwide, why should they be conserved? The arguments for preserving threatened species are manifold and cover a number of dimensions, including political, legal, economic and moral arguments. These are covered on the IUCN website. However, the scientific case for preserving small populations is that the more widely distributed a species is in space, the less likely it is that the whole species could be wiped out by a chance event. Even a large population in a single place cannot withstand an event such as a tsunami or massive volcanic eruption.

This leads neatly on to the other routine uses of abundance data. A common means of combining and displaying the joint information about richness and abundance is the rank-abundance plot (Fig. 2). This ranks species from the most abundant to the least abundant. A simple example is given in the figure. Species with high abundance are considered 'common', and the least abundant are 'rare'. Common species are also often said to be dominant. As well as representing it in graphs, ecologists have many, many ways of combining the information on richness and abundance to numerically express the distribution of individuals among species. This system of measurements is collectively referred to as evenness/dominance metrics. A perfectly even community would have an equal number of individuals in every species in the community. A totally uneven community would contain one taxon with many, many individuals: all other taxa would be represented by a single individual. These different numerical descriptions of communities can be compared with idealized mathematical models of different types of communities to define how the community is structured. An excellent summary is given here.

Measures of richness and evenness capture some aspects of the overall picture we need to understand the threats to species, but there are further facets. One particularly overlooked aspect is occupancy. Imagine laying a grid over a landscape and then checking whether particular species have

Another metric is the taxonomic distinctiveness of a community. This measures how closely related the species in a community are. A simple analogy would be a 'community' formed by your family (highly related, low taxonomic distinctiveness) versus the community of people in your class or workplace (probably less closely related, higher taxonomic distinctiveness).

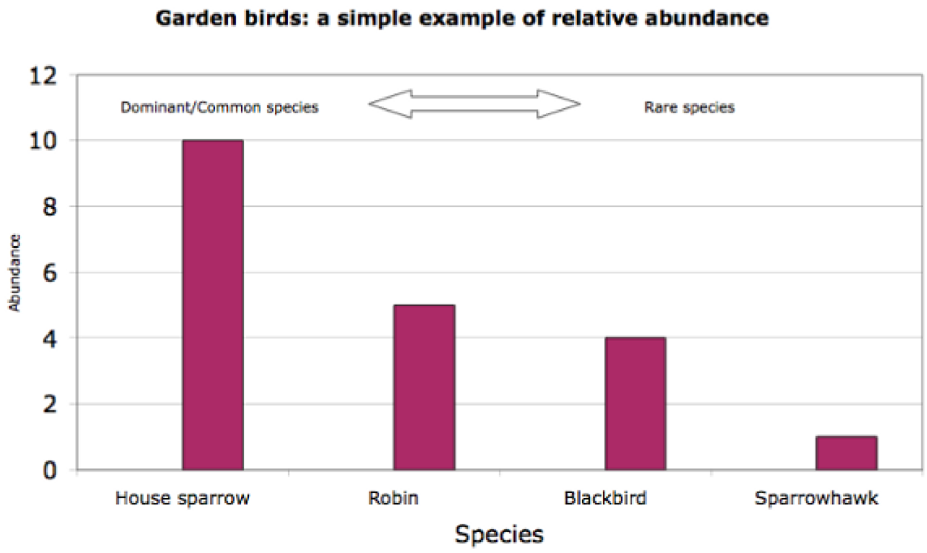

FIGURE 1 – EXAMPLE OF A RELATIVE RANK-ABUNDANCE PLOT

individuals in each grid square. Those species with high occupancy will have individuals in most of the grid cells. Those with low occupancy will occupy few squares. The resulting data table is called a presence/absence matrix. Measures of the spatial distribution of species are important in determining extinction risk; a species may have a large geographic range, as measured by the endpoints of its distribution, but if the populations at the endpoints are isolated from each other, they can be more vulnerable. Work conducted this year on the only poisonous snake in Great Britain, the adder, demonstrates an excellent example of this.

So far we have only considered counting individuals and taxa, but not considered the nature of the organisms themselves. During growth from juvenile to adult, an individual can occupy different levels of consumption in the food chain. The diversity of forms, or morphology, within a group of organisms can be measured in a variety of ways. This is routinely referred to as morphological diversity or disparity.

The currency of evolution is the number of offspring contributed to the next generation, but within an ecosystem, just as within an economy, there are many ways to exploit the environment and make a living, earning that currency. This is often described as functional diversity, and depicted as an idealized grid defined by characteristics such as whether a species is mobile, is a predator or scavenger, or burrows into the earth or flies in the air. The more boxes in the grid are filled, the more functionally diverse and complex the community is.

Biodiversity and the fossil record:

This may seem a strange essay to find on a website about palaeontology, but consider that all of these factors can be measured in the fossil record to a greater or less extent. The fossil record is the most significant documentation of extinctions available to us in our efforts to stem biodiversity loss. If it is to be useful to conservation biology, conservationists and palaeontologists need to describe it using the same terms. The fossil record offers us the opportunity to test our understanding of what indicators are the early warning signs of extinction. Ecologists have proposed several characteristics that increase the likelihood of extinction for a species, including small geographic range, large body size and slow growth to maturity. Palaeontologists have shown that these factors did indeed increase the extinction risk among now-fossilized species. It is important that we explain to non-specialists and policy-makers why we are collecting and analysing these data, whether from the fossil record or our front gardens, and what they can tell us that simply counting the number of species cannot.

Acknowledgements:

Alan Spencer was kind enough to invite me to contribute an article for the opening of Palaeontology [online]. The thoughts and ideas expressed in this article reflect conversations that I have had with colleagues over the past 15 years.

Suggestions for further reading:

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Magurran, A. E. 2004 *Measuring Biological Diversity*. Hoboken, New Jersey: Wiley-Blackwell. ISBN-10: 0632056339. **—** *A classic text that provides an accessible overview.*

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