Organismal complexity is an indicator of species existence value

Peer-reviewed letter

In a recent paper, Wilson *et al.* (*Front Ecol Environ* 2007; **5[8]**: 409–14) demonstrated that scientific output is strongly connected to society's interests. They reached this conclusion by comparing representation of selected species in the scientific literature and on the internet (Google). We agree that this is an interesting method for evaluating society's interests, and we argue that scientific output data can also be used as a proxy for the value we place on species.

The current biodiversity crisis compels us to decide how to allocate the limited resources available for conservation efforts (Wilson *et al.* 2007). These efforts might be directed toward geographic areas of special interest for conservation (Pressey *et al.* 1994; Brooks *et al.* 2006), to endangered species (Rodrigues *et al.* 2006), or endangered ecosystems (Noss 1996). However, as we learn more about biodiversity and classify an ever-increasing number of species, conservation decisions become more complex.

The value of species can be derived from two major perspectives: biocentric and anthropocentric (WebPanel 1). In a biocentric perspective, species have an intrinsic value (Rosa 2004). In an anthropocentric perspective, each species' value is defined either by their use value (Constanza *et al.* 1997) or by their existence value (MA 2003). Existence value is the value that people place on a species or environmental good, even if they do not derive any benefit or use from it.

Existence value is usually assessed through surveys in which people are asked about how much they value a species (Carson *et al.* 2001). Although this approach may be effective in small-scale assessments, it has several drawbacks in large-scale surveys. It is expensive and time consuming, and the subjective nature of existence value makes the results difficult to validate (Carson *et al.* 2001; MA 2003).

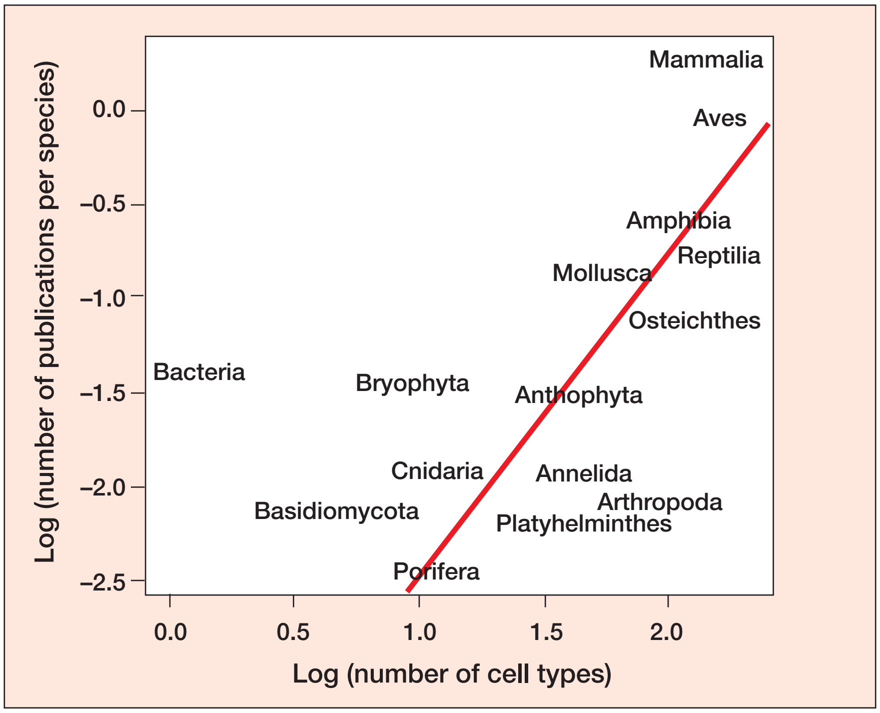

Figure 1. *Type II (reduced major axis) regression between number of papers per species and the minimum number of cell types. Regression equation (95% CI): intercept = –4.32 (–5.33, –3.3), slope = 1.78 (1.2, 2.37). Variables were log transformed. Bacteria were excluded from the analysis because they were an outlier (probably due to their use as a model system in biology).*

Wilson *et al.* found that the scientific output for a particular taxon reflects the interest of society in that taxon. An implication of this result is that scientific output might be used as a proxy for the existence value of species. Wilson *et al.* express concern for the effect of this bias on our biodiversity knowledge. Here, we hypothesize that this bias is related to the high existence values of complex organisms.

To test this hypothesis, we investigated the relationship between the number of scientific publications about a taxon and its structural complexity. We limited our search to 20 journals in ecology and conservation biology (WebTable 1). Studies in these journals are less often linked with direct, utilitarian values than in other fields, such as medical or agricultural research, because they are, in many cases, associated with the personal preferences of researchers or funders. The 20 journals were selected according to three criteria: ISI impact factor (ie the frequency of citation to articles of that journal by other articles; http://scientific.thomson.com/products/jcr), a minimum of 5 years of publication, and a minimum of 50 articles published per year.

We chose fifteen taxa from different taxonomic levels in a sequence of increasing complexity (WebTable 2). Number of papers for each taxon published up to 2003 were obtained from the BIOSIS database (WebTable 2). The BIOSIS database has a global scope and a taxonomic hierarchical organization, which ensures that an article about a species of mouse is displayed in a search using either "Mammalia" or "Animalia" as keywords. This hierarchical structure has the advantage of producing a complete and exact output of the number of publications assigned to a taxon.

Our results suggest that structural complexity is positively related to scientific output about that taxon (Pearson's $r = 0.85$, n = 14, $P = 0.0001$; Figure 1). We therefore propose that existence values are related to organismal complexity. Two possible explanations for this relationship, although speculative, are that people feel more affinity for more complex organisms, or that complexity renders an organism more interesting. Note that, for each taxonomic group, we divided the number of papers by the number of species in the group, so we are estimating the existence value of a species in the group and not of the group as whole. This means that very diverse groups are somewhat penalized in our analysis. However, in a practical application of existence values to conservation planning, it is likely that this effect would be partially compensated for, because more diverse groups would also contribute more species to that planning, and those species would have a cumulative effect.

The large number of published articles confers robustness to scientific output as proxy for existence value. Scientific output reflects large-scale concerns about taxa and can only be affected by changes at this scale. However, scientific output can also be affected by direct, utilitarian values, because research on organisms that are potentially useful to humans tends to be better funded. We tried to control for this effect by focusing on ecological publications only, but we still found bacteria to be an outlier taxon (Figure 1). Organismal complexity is not affected by these problems, being a fairly unbiased indicator of existence value.

In conclusion, we argue that, in a world with finite resources for conservation, existence values, reflecting societal interests, can be one of the factors used in defining conservation priorities. It remains to be seen whether the use of existence values in conservation planning, for instance in prioritizing sites for conservation, would substantially change the results of that planning.

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The authors reply

How and why do humans value species? This is not just a question of esoteric interest, but is also important for applied reasons. For example, the management of invasive species is affected by the choices people make in selecting organisms, and the decision to prioritize certain species for conservation can also be affected by personal likes and dislikes.

In a recent article (*Front Ecol Environ* 2007; **5[8]**: 409–14), we showed that the amount of scientific research conducted on a species is related to the interest the public has in that species. In response to our article, Proença *et al.* conclude that scientific output could be used to identify which factors affect existence value (ie the satisfaction that humans derive from simply knowing that a species exists). They propose that organismal complexity (as quantified by the number of cell types in an organism) is related to existence value, and base this argument, in part, on the fact that scientific output per species is higher for more complex organisms. This concept is certainly appealing and is supported by their analysis. The question, however, is whether complexity per se drives people's interest.

Despite the fact that most life is microscopic, humans tend to concentrate on macroscopic organisms. This is natural, as we can directly perceive and interact with these organisms, using our unaided senses. However, the apparent interest of humans in more complex species may be due, in part, to an anthropocentric view of complexity. A different measure, say the number of life stages, would result in a very different relationship between scientific output and complexity. Instead, we propose that existence values are more affected by how closely a species resembles our own.

To test this hypothesis, we regressed the number of scientific articles per species (as presented by Proença *et al.* above) against the age since divergence between each group and the human lineage. Age since divergence was used as a measure of similarity to the human species, although measures of morphological similarity could also be used. We found a similar relationship to that demonstrated by Proença *et al.* (Figure 1).

We would caution, as we did in our original article, that it is very easy to generate plausible hypotheses using data on scientific output or public interest. Scientific output is measured here using journals that define themselves as publishing papers on ecology or conservation biology. Taxonomic biases in the delineation of fields of study need not reflect general value systems. Existence value (as with scientific output or web presence) can be affected by trivial or frivolous factors. For example, when, in 1997, visitors to the London Zoo were shown pictures of the red-faced black spider-monkey and the Diana monkey, they said they would prefer to conserve the red-faced black spider-monkey; but if

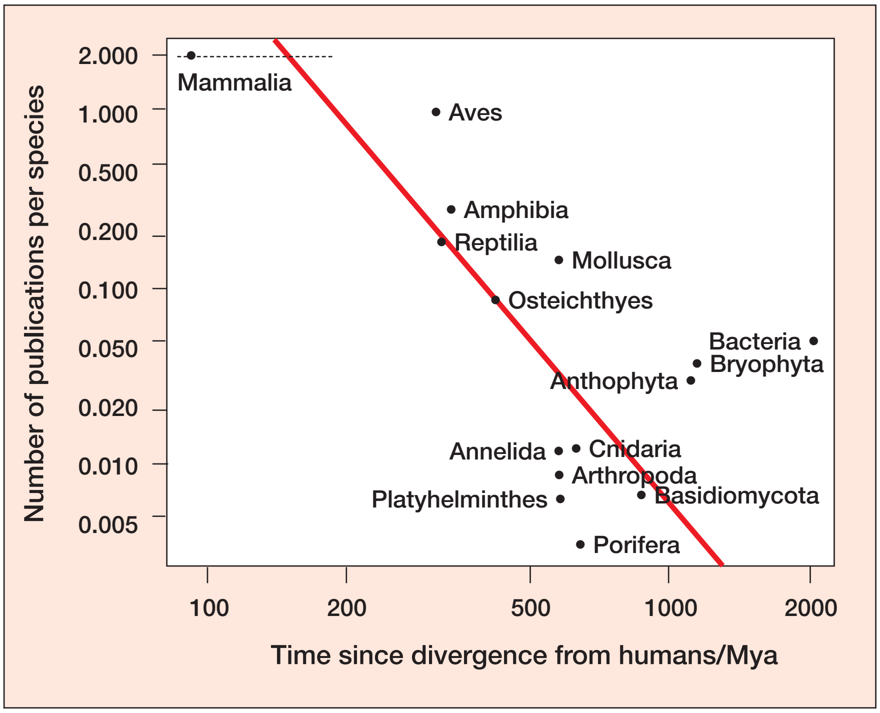

Figure 1. *Type II (reduced major axis) regression between number of papers per species and the time since each group became separated from our own lineage. Pearson r = 0.75, n = 14, P < 0.01; regression equation (95% CI): intercept = 6.97 (3.48, 10.46), slope = –3.07 (–4.36, –1.79). Variables were* $\log_{10}$ *transformed. Age since split was derived from recent dated phylogenies (Berney and Pawlowski 2006; Donoghue and Benton 2007). In the case of mammals, we used an average value between the split from chimpanzees (most recent, 8.25 Mya) and the split from monotremes (oldest from a living lineage, 176.8 Mya), values were derived from averaging minimum and maximum estimates in references, and the range in time of divergence for mammals is shown as a dotted line.*

they were told the common names, their preference was reversed. This effect is partly attributable to the fact that Diana, Princess of Wales, had recently died (Carvell *et al.* 1998). Scientific output, however, gives a much better indication of utilitarian value and shows less geographic and taxonomic bias than measures of how generally popular species are (eg internet presence). As such, scientific output is not the best surrogate for existence value (as defined here).

We conclude by suggesting that multiple factors are needed to explain the way humans assign value to species – complexity, size, accessibility, degree of anthropomorphism, edibility, and cultural influences. Each factor is only useful if used in the appropriate context, when it is closely related to what we are trying to measure. We doubt whether taxonomic patterns in research output, and the peculiar cultural biases that are partly responsible for those patterns, should be used to set conservation goals.

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