

not changed might have its name changed solely owing to a shift in rank. This is especially unfortunate because rank assignment is subjective and of dubious value (e.g. [2]). Rank-based nomenclature might also provide a disincentive for naming clades one at a time, as they are discovered, for fear of introducing cumbersome new categories (Parvorder, Cohort, Infraclass, etc.) and/or causing a cascade of rank-related name changes [3]. Also importantly, spelling changes associated with changes in rank (e.g. -idae for zoological family or -inae for subfamily) will diminish the utility of taxonomic names in accessing online resources, as search engines see a world of difference between 'Iguanidae' and 'Iguaninae'.

The PhyloCode has provoked strong reactions (e.g. [4]) and counter reactions (e.g. [5]). One unfounded fear is that the PhyloCode will lead to the replacement of all existing taxonomic names. On the contrary, if the PhyloCode is followed, names that currently refer to clades will stay the same. The difference is that they will be given 'phylogenetic definitions' designed to tie them unambiguously and permanently to hypothesized clades.

Species names are another major concern. However, the PhyloCode applies only to naming clades, not species, although the aim is to include provisions for naming species once the associated issues have been thought through. A variety of options have been considered for the form of species names [6], but, in the final analysis, the PhyloCode is likely to have little effect on the way we speak and write about species, except that species names would become more stable [7].

Other criticisms are unsupported assertions. For example, Barkley *et al.* [8] contend that conversion to the PhyloCode could cost 'millions to billions of dollars'. But, in the absence of any analysis, this seems like a scare tactic. Some believe that the PhyloCode will cause nomenclatural chaos, thereby eroding the credibility of the taxonomic community. The issue of the coexistence of the PhyloCode with the traditional Codes requires a thorough analysis, but the PhyloCode already goes a long way toward anticipating and ameliorating possible problems. For example, because the membership associated with particular names sometimes differs between rank-based and phylogenetic systems, the PhyloCode recommends use of a convention to mark which names are governed by which system.

There is also the issue of how societies and journal

editors might react to the formal existence of the PhyloCode [9]. Will they accept names put forward under different Codes, or under only one? It is hard to say, but one assumes that intellectual freedom will be respected and that there will be venues for naming under both systems. Implementation of the PhyloCode might even open new and quicker outlets, which would be wonderful given the exponential rate of clade discovery.

It is time to stop fretting over what might happen and instead to study calmly how to manage the situation to benefit us all. After all, those who favor switching to rank-free classification are no less concerned about the biodiversity crisis and understand the urgency to discover and describe the variety of life. Supporters of the PhyloCode have raised legitimate concerns and might have found some better ways to proceed. This possibility deserves our serious attention.

These are exciting times for biological nomenclature, the likes of which could not have been anticipated. Who would have guessed that we would be fundamentally rethinking the rules for naming? The meeting in Paris is certain to be both enlightening and entertaining, and whether one favors or opposes the PhyloCode, it is also certain to be of historic significance for biology.

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doi:10.1016/j.tree.2004.04.004

The long history of the biotic homogenization concept

David M. Wilkinson

Biological and Earth Sciences, Liverpool John Moores University, Byrom Street, Liverpool, UK, L3 3AF

A recent paper in *TREE* [1] about the consequences of biotic homogenization claimed that 'it was first noted by Elton' in his 1958 book *The Ecology of Invasions* [2].

However, the realization that human activity has been causing the distribution of some organisms to expand greatly around the planet and, in consequence, lead to the extinction of other species, has a much longer history.

Corresponding author: David M. Wilkinson (D.M.Wilkinson@livjm.ac.uk).

As described in detail elsewhere [3], Charles Lyell, writing in the first half of the 19th century, listed biotic homogenization (along with habitat destruction and hunting) as one of the main mechanisms by which human activities were leading to widespread extinctions. In particular, he pointed out that many animals that had been domesticated by humans were now found in large numbers on continents such as America and Australia, where they had previously been absent. He wrote that ‘The fact that so many millions of wild and tame individuals of our domestic species, almost all of them the largest quadrupeds and birds, having been propagated throughout the new continent within the short period that has elapsed since the discovery of America... affords abundant evidence of the extraordinary changes which accompany the diffusion and progressive advancement of the human race over the globe’ [4]. Interestingly, Lyell uses this as an argument in favour of the recent origin of humans, his idea being that, if we had a long geological history, this homogenization would be already complete.

As previously described [3], one of the most surprising aspects of Lyell’s discussion to a modern reader is that he

does not consider the resulting extinctions to be a cause for concern. Indeed, he considers human-caused extinctions to be a natural process, pointing out that any expanding species must lead to the reduction or extinction of other species. He considered that this applied as much to humans as to ‘the lion, when it first spread itself over the tropical regions of Africa’ [4], although he conceded that not all of his contemporaries held such a relaxed view of these changes. However, he cited poets, rather than ‘scientists’, as the people who lamented these changes.

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doi:10.1016/j.tree.2004.03.025

Letter Response

Clarifying biotic homogenization

Julian D. Olden and N. LeRoy Poff

Department of Biology, Graduate Degree Program in Ecology, Colorado State University, Fort Collins, CO 80523, USA

David Wilkinson correctly points out [1] that Charles Lyell’s recognition of species invasions and extinctions pre-dates the writings of Charles Elton by a century. Although we acknowledge the historical interest of this fact, we consider the assertion that the process of biotic homogenization is synonymous with widespread invasions and extinctions to be incorrect. Therefore, Lyell was not commenting about biotic homogenization as it is contemporaneously used. Here, we take the opportunity to clarify the subtlety of the concept of biotic homogenization.

Biotic homogenization basically refers to an increase in species similarity in space over time, and it can arise through several ecological mechanisms. Ecological processes leading to homogenization represent specific, and often quite different, interactions among non-native species, native species, and the environment ([2], Figure 2 in [3], Figure 1 in [4]), and they need not include either species invasion or extinction [4]. Rather, the degree of homogenization crucially depends on the taxonomic identities (and functional roles) of the species in the community, as well as on the rate and spatial pattern at which species are gained and lost across the landscape. Indeed, as recently illustrated [4,5], biotic homogenization can arise when only species invasions occur without any commensurate species extinction. The converse can also lead to homogenization. Furthermore, and significantly,

species invasions and extinctions (whether individually or interactively) can promote the opposite of biotic homogenization by causing regions to become more dissimilar in their species composition (referred to as ‘biotic differentiation’ [4]).

In conclusion, our research and that of others (e.g. [6–8]) shows that, although species invasions and extinctions do often fuel biotic homogenization (and differentiation), the details of temporal and spatial patterns at which these events are occurring provide the subtle context in which the homogenization process operates. The insufficiency of invasion and extinction alone to describe biotic homogenization leads us to argue that this process should be considered a unique ecological phenomenon [9], one first recognized by Charles Elton in his insightful treatise [10].

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Corresponding author: Julian D. Olden (olden@lamar.colostate.edu).