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Short communication

The impact of taxonomic change on conservation: Does it kill, can it save, or is it just irrelevant?

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1. Introduction

The important question of taxonomy and its impact on conservation efforts was brought to general attention by Robert May in 1990 with a News and Views article in Nature entitled “Taxonomy as destiny.” May commented on how an iguana-like reptile, the Brother’s Island tuatara (Sphenodon guntheri) off the coast of New Zealand, was not recognized as a distinct species from Sphenodon punctatus and had therefore been ignored by protective legislation. When genetic data became available, the island’s endemic population was deemed sufficiently distinct to justify special protection of its gene pool (May, 1990). The cover of the Nature issue was entitled “Bad taxonomy can kill” to highlight May’s point. Assigning the terms good and bad to taxonomic research (or the resulting taxonomies) introduced a value-laden framework to the issue. Nevertheless, numerous papers took up the idea that “bad” taxonomy can hinder conservation (Funk et al., 2002; Gittleman and Pimm, 1991; Khuroo et al., 2007; Mace, 2004; McNeely, 2002; Russell et al., 2005). However, none appear to have addressed the definition of good and bad taxonomy. Since there are no accepted criteria for judging what is “good” taxonomy, a pragmatic approach is to consider the most recently published taxonomy, which typically will include better sampling and more genetic data, as better than the previous (old, “bad”) taxonomic treatment that is being replaced on the basis of the new data.

All conservation—indeed, almost all biology—is based on taxonomy, part of which involves the proper identification of organisms. Such identification usually involves a scientific name assigned to the entity of interest, commonly a species name. No universal criteria exist for assigning taxon ranks, such as species or subspecies, or for establishing boundaries among taxa, such as between species or genera. As a result, taxonomic stability is an elusive goal, a fact well understood by systematists (Dubois, 2007; Heywood and Davis, 1963). Besides the subjectivity of ranking and circumscription, there are at least three additional causes of taxonomic instability. These are the continually improved knowledge of phylogenetic relationships, which can lead to the transfer of species names between genera, at least under a Linnean system of nomenclature (De Queiroz and Gauthier, 1990). A second cause is an increased understanding of gene flow, which could lead to lumping or splitting of taxa, even if previous circumscriptions were done objectively. A third source is the recognition of nomenclatural errors made earlier, for example, concerning priority or homonymy. These sources of taxonomic instability reflect scientific progress. Instability, therefore, is an expected outcome of active taxonomic research. Given this continuous change in taxonomic naming and classifying of organisms, it is important to know whether new (“good”) taxonomies tend to positively impact conservation efforts, as implied by May’s commentary or whether taxonomic change has no consistent impact on conservation efforts.
There have been several reviews that have analyzed the number of species moving on and off of local red lists as a result of changes in taxonomy. These changes were due mainly to the adoption of narrower or wider species concepts or to the correction of nomenclatural errors (Garnett et al., 2003; Lozano et al., 2007). However, changes in status on endangered species lists often do not equate to changes in conservation efforts. In this study, we therefore focus instead on cases where taxonomic change had a direct effect on conservation funding or efforts towards monitoring and research. This may have biased us towards finding positive or negative effects, rather than no impact (see Section 4). The specific question we wanted to answer was: Are the effects of “improved” (new) taxonomies on conservation efforts consistent and hence predictable? Although our review is limited by its qualitative nature, consisting of a number of case studies, it includes a broad range of clades, from several countries, classified under a variety of conservation laws and systems. To our knowledge, this is the first attempt to objectively focus on the practical effects of taxonomic instability on conservation efforts.

2. Methods

2.1. Survey for information

We searched for species or populations on lists of threatened or endangered species whose protection had changed due to changes in taxonomic rank or circumscription. Change in protection was defined and categorized as described below. At the global level, the International Union for Conservation of Nature and Natural Resources Red List of Threatened Species (IUCN Red List; www.iucnredlist.org) and the species listed in the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) were consulted. To determine changes in conservation status at regional or local levels and/or country legislation for protected species, we searched the following databases: US Fish & Wildlife Service (USFWS), the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the Species at Risk Act Registry (SARA) of Canada, the Joint Nature Conservation Committee (JNCC) of the United Kingdom, Bayerisches Landesamt für Umwelt (Bavaria State Environmental Agency, Germany), The British Columbia Conservation Data Centre (CDC) and the Missouri Species and Communities of Conservation Concern Checklist. We also looked for information in the World Wildlife Fund, the Nature Server and the Xerces Society for Invertebrate Conservation, given that these organizations are currently dealing with endangered species conservation efforts.

We found numerous examples where a change in taxonomy led to increased efforts in conservation, in groups as diverse as plants, birds, frogs, dolphins, and giraffes. One example is the Chiricahua leopard frog (Rana chiricahuensis), whose current range is restricted to eastern Arizona in the United States (Table 1). This species was originally assigned to Rana piperis, but was subsequently split into over two dozen species (Hillis, 1988), one being the Chiricahua leopard frog (Platz and Mecham, 1979). Because of the rapid extirpation of this frog from its historical range (Clarkson and Rorabaugh, 1989), the Chiricahua leopard frog was listed as threatened in 2002 under the Endangered Species Act of 1973 (ESA), whereas R. piperis enjoys no special conservation status (Humphrey and Fox, 2002; Rorabaugh, 2002). In response to the listing, the Malpai Borderlands Group was formed (Glick, 2005), which is a group of private landowners and over 12 public institutions that has thus far protected over 30,350 ha of private land in the form of conservation easements.

A plant example where taxonomic change (i.e., new taxonomy, not necessarily a taxonomy arrived at by majority consensus) has led to increased protection is in the mountain ash (Sorbus) of central Europe. Recently, over 20 new species were described in this formerly poorly documented genus (Meyer et al., 2006; but see Zink et al., 2000). All 20 are now found on the Bavarian Red List of Vascular Plants, with subsequent support for their conservation coming from the Bayerische Landesamt für Umweltschutz, the Naturpark Fränkische Schweiz, the foundation Schöpfung Bewahren Konkret, and other nature protection organizations, including several volunteer and benefactor agencies (Scheurer and Ahlmer, 2003).

Similarly, conservation of the Ozark spring beauty (Claytonia ozarkensis) was beneficially affected by a taxonomic name change. This herb occurs sympatrically with congeners in Arkansas, Missouri and Oklahoma. Specimens had been misidentified as Claytonia virginica or Claytonia caroliniana until a complete taxonomic revision of the genus resulted in the description of the new, previously overlooked species C. ozarkensis in 2006. This discovery triggered immediate protection efforts (Missouri Natural Heritage Program, 2009) due to the rarity of C. ozarkensis, which consists of only a dozen populations (G. Yatskievych, Missouri Botanical Garden, St. Louis, personal communication, 2008).

Another example of new taxonomy leading to increased conservation efforts is that of the California gnatcatcher, Polioptila californica. The California gnatcatcher was originally recognized as a species in 1881, but was lumped back with the black-tailed gnatcatcher (Polioptila melanura) half a century later because of similarities in plumage coloring (Grinnell, 1926). It was re-split from the black-tailed gnatcatcher in 1989, on the basis of distinctive song and morphology (Atwood, 1988; later confirmed by molecular studies; Zink et al., 2000). After recognition of its species status, the California gnatcatcher received greater habitat protection (from encroaching development) and better monitoring programs (Zink et al., 2000), in a variety of national and state parks (Atwood and Bontrager, 2001). As in the case of the Chiricahua leopard frog, the species from which the California gnatcatcher was split receives no special attention. Taxonomic research revealed the narrow geographic range of these species, bringing to light the need to protect them and this need was acted upon with increased conservation efforts.
<table>
<thead>
<tr>
<th>Name</th>
<th>2006 IUCN ver. 3.1</th>
<th>Local red lists</th>
<th>Geographic region</th>
<th>Case details</th>
<th>Impact of taxonomy on conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxonomy protects Rowan/mountain ash Sorbus spp.</td>
<td>Not listed</td>
<td>All listed</td>
<td>Central Europe</td>
<td>Revision of Sorbus (Meyer et al., 2005), led to many new species receiving attention from local protection agencies</td>
<td>Increased conservation</td>
</tr>
<tr>
<td>Sump-Grass Carex humilis</td>
<td>Not listed</td>
<td>Highly endangered</td>
<td>Southern Bavaria</td>
<td>Subspecies which gained full species status in 1989 (Zink et al., 2000)</td>
<td>Increased conservation</td>
</tr>
<tr>
<td>California gnatcatcher Polioptila californica (Brown, 1888)</td>
<td>Least concern</td>
<td>Least concern</td>
<td>California</td>
<td>Genetically distinct from P. atricapilla, which has no special conservation status in the USA</td>
<td>Increased conservation</td>
</tr>
<tr>
<td>Chevalina leopard frog Rana chevalina (Platz and Mecham, 1970)</td>
<td>Not listed</td>
<td>Critically imperiled</td>
<td>Arkansas west to Oklahoma</td>
<td>Split from R. pipiens based on molecular evidence (Carstens et al., 2005; Nielsen et al., 2001)</td>
<td>Increased conservation</td>
</tr>
<tr>
<td>Bechyné mountain-tailed frog Acanthophorus montanus (Nielsen et al., 2001)</td>
<td>Data deficient</td>
<td>Data deficient</td>
<td>Amazon</td>
<td>Genetic data strongly indicate the existence of a separate gene pool/species in Bolivia (Bongers-Huisstede et al., 2002)</td>
<td>Increased conservation</td>
</tr>
<tr>
<td>Taxonomy is irrelevant Lapland marsh-orchid Dactylorhiza lapponica (d’Orbigny, 1834)</td>
<td>Not listed</td>
<td>Delisted</td>
<td>British Isles</td>
<td>Synonymized under D. roeseliana, a more frequent species (Bateman, 2001).</td>
<td>No change</td>
</tr>
<tr>
<td>Galápagos Sea Lion Zalophus wollebaeki</td>
<td>Endangered</td>
<td>Endangered</td>
<td>Pacific Northwest</td>
<td>There are actually five sp. (Friesen et al., 2005); Petition filed in May 2008 to remove the sp. from the endangered species list.</td>
<td>No change</td>
</tr>
<tr>
<td>West African Giraffe Giraffa camelopardalis peralta (Linnaeus, 1758)</td>
<td>Least concern</td>
<td>Critically endangered</td>
<td>SE Arizona</td>
<td>Genetic evidence points to another sp. or ssp. not represented in zoos and losing habitat in West Africa</td>
<td>No change</td>
</tr>
<tr>
<td>Polar Bear Ursus maritimus (Phips, 1774)</td>
<td>Vulnerable</td>
<td>Federally threatened</td>
<td>Circumpolar</td>
<td>Genetic evidence: this sp. is this species is poorly distinct from brown bears (Talbot and Shields, 1998b)</td>
<td>No change</td>
</tr>
<tr>
<td>Red Wolf Canis rufus (Audubon and Bachman, 1851)</td>
<td>Critically endangered</td>
<td>Endangered</td>
<td>Southeast USA</td>
<td>Genetic data shows that this is a form of the Gray Wolf, C. lupus (Wilson and Rondin, 2005)</td>
<td>No change</td>
</tr>
<tr>
<td>Marlbeled Mouflon Ovis ammon maritimus (Canicella, 1789)</td>
<td>Endangered</td>
<td>Endangered</td>
<td>Eastern Europe</td>
<td>Species status validated with molecular data (Wolf et al., 2007).</td>
<td>No change</td>
</tr>
<tr>
<td>Ramsey canyon leopard frog Rana subarvata (Platz, 1993)</td>
<td>Critically endangered</td>
<td>Critically endangered</td>
<td>SE Arizona</td>
<td>Genetic evidence points to another sp. or ssp. not represented in zoos and losing habitat in West Africa</td>
<td>No change</td>
</tr>
<tr>
<td>Green Sea turtle Chelonia mydas (Bowdich, 1854)</td>
<td>Endangered</td>
<td>Endangered</td>
<td>East-Pacific, but range unclear</td>
<td>No genetic distinction between C. agassizii and C. mydas (Karl and Bowen, 1999)</td>
<td>No change</td>
</tr>
</tbody>
</table>

All the above cases have one common thread: they represent species that have been subdivided, with the more narrowly circumscribed entities then afforded increased protection.

3.2. Taxonomy is irrelevant

We found at least five situations where conservation efforts ignore taxonomic changes. First, there is the case of charismatic organisms. An example of a charismatic animal is the red wolf (Canis rufus), a highly endangered mammal with remaining populations in small regions of the US and Canada (Nowak, 2002, 2003). The species status of the red wolf has been a matter of debate, with some workers viewing it as a distinct species, others as a hybrid between the grey wolf (Canis lupus) and the coyote (Canis latrans; Wayne and Jenks, 1991). Further molecular analyses suggest that the red wolf is a subspecies of C. lupus (Murray and Waits, 2007). As far as we could ascertain, these changes have not changed conservation efforts or monitoring and reintroduction programs (USFWS, 2007b).

A similar case is the polar bear (Ursus maritimus). Several phylogenies of Ursidae, based on mitochondrial and nuclear DNA, increasingly suggests that polar bears and brown bears (Ursus arctos) are not mutually monophyletic (Talbot and Shields, 1996a, 1996b; Waits et al., 1999). This may mean that the polar bear is not a biological species, a fact that could hinder conservation efforts. Nevertheless, after a 3-year long review, the USFWS made its final ruling in 2008 that the polar bear is a threatened species (Schliebe and Johnson, 2008). This has led to continued monitoring and conservation activities among assorted institutions (USFWS, 2008). However, the real threat for the polar bear now is climate change (Williams, 2009).

Another example of a charismatic animal that has received continued protection despite changed taxonomy is the green turtle (Chelonia mydas). This sea turtle had been considered an endangered species since 1982 due to decreasing population sizes (IUCN). In 1999, a molecular study indicated no significant distinction between the green turtle and the black turtle (Chelonia agassizii; Karl and Bowen, 1999), and as a result Chelonia mydas and C. agassizii are now treated as a single species (NMFS and USFWS, 2007). However, a monitoring program for the green turtle was started in Mozambique in 2004 by the WWF Homeland Foundation-USA and represents an investment of $210,000 USD (www.wwf.org.mz). Despite the fact that the taxonomy of black and green turtles remains doubtful, monitoring and protection have been maintained continuously.

The second situation where conservation decisions ignore taxonomic changes concerns certain areas and ecosystems of the world that are protected and, therefore, everything living within those areas receives conservation status, regardless of taxonomic name changes. One such ecosystem is the Galápagos archipelago, and the example animal is the Galápagos sea lion (Zalophus wollebaeki). Until recently, this sea lion was considered a subspecies of the Californian sea lion (Zalophus californianus), which has a different demography and conservation status. In 2006, an analysis of mitochondrial and nuclear DNA markers showed that the Galapagos sea lion is a separate species (Woll et al., 2007). However, monitoring and conservation actions have not been affected by the taxonomic change (Alava and Salazar, 2006; CDF, 2006).

A third case of conservation efforts consciously ignoring taxonomy (at least low-level taxonomies) involves endangered groups that receive blanket protection, for example, Orchidaceae. The lapland marsh-orchid (Dactylorhiza lapponica), which occurs in sloping fens throughout Europe, has received conservation attention in the British Isles due to habitat loss and degradation. It was included in Schedule 8 of the Wildlife and Countryside Act, 1981 (JNCC, 2008), giving it additional protection. However, morphological and molecular studies have shown that individuals from the British Isles belong to Dactylorhiza traunsteiner, a common European species (Bateman, 2001). Consequently, D. lapponica has lost its threatened status (Cheffings and Farrell, 2005). Regardless of this taxonomic lumping, its collection remains highly restricted as it is included in Appendix II of CITES, which lists species that are not currently threatened with extinction but that may become so unless trade is controlled.

Organisms with economic value are a fourth case where taxonomic change is irrelevant to conservation efforts. An example are marine stocks such as salmon, tuna, oysters, and anchovies; taxonomic work on these animals focuses on identifying genetically distinct stock lines for creating guidelines and quotas. In the case of salmon, there was a push to identify wild strains that could qualify for wildlife protection under the ESA act (Allendorf and Waples, 1996; National Research Council, 1996).

3.3. Taxonomy kills

Cases where taxonomic change (i.e., new “good” taxonomy) resulted in less protection for populations concerned species that were lumped with another, typically becoming a subspecies or variety. The larger group then has a greater range, resulting in decreased conservation efforts for the subspecies. This was the case for the Idaho spring snail (Pyrgulopsis idahoensis), with a range limited to the Snake River in Idaho, USA (Hershler, 1994). In 1992, P. idahoensis was listed under the ESA as endangered (Duke, 1992), followed by recovery plans by the USFWS to restore habitat along the Snake River as well as ensure self-sustaining breeding populations of P. idahoensis (USFWS, 1995). However, new genetic evidence emerged in 2004, after which P. idahoensis was grouped with Pyrgulopsis robusta (Hershler and Liu, 2004). As a result, the USFWS removed P. idahoensis from the endangered list (USFWS, 2007a), which has resulted in decreased monitoring efforts (USFWS, 2007c).

The dusky seaside sparrow (Ammodramus maritimus nigrescens), declared extinct in 1990, is another case where a species was lumped within another larger species. This passerine bird’s extinction was due to loss of habitat in the salt marshes of Florida, USA (Walters, 1992). The dusky seaside sparrow was ranked as a species, Ammospiza nigrescens, until 1973 when the American Ornithologists’ Union (AOU) Checklist Committee lumped it with the seaside sparrow (AOU, 1973; Rising, 2005). The seaside sparrow has a much larger range and is a species of least concern. In the 1980s, there were petitions for protection of the duskies and for according them species status. However, by 1990, the dusky seaside sparrow was extinct (Walters, 1992; Rising, 2005).

Another case where new taxonomic insights (and following name changes) can result in less protection concerns hybrids, which are not protected under conservation acts and laws. Lloyd’s hedgehog cactus (Echinocereus lloydii) was listed as endangered in 1983 due to threats from over-collection and highway projects in the state of Texas (Poole and Riskind, 1987). However, data from morphology, cytology and experimental hybridization revealed that E. lloydii was a hybrid between Echinocereus coccineus and Echinocereus dasyacanthus (Powell et al., 1991). Accordingly in 1999 Lloyd’s hedgehog cactus was removed form the Federal List of Endangered and Threatened Plants, thereby receiving less habitat protection (Kennedy, 1999).

4. Discussion

Our findings show that the phrase “bad taxonomy can kill,” coined by the editorial staff of Nature (1990) and used widely since
A limitation of our review is that it is only qualitative; yet to our knowledge, this is the first attempt to compile information on whether taxonomic change has a consistent (positive or negative) effect on conservation efforts. Our failure to pick up any consistent relationship between revised taxonomic views and conservation efforts suggests that the positive and negative effects of taxonomic change on conservation efforts may balance each other. A question for a future metaanalysis would be if different species concepts in the different taxonomic sub-disciplines have influenced conservation measures for those organisms. If specialists in a given group tended to accept narrower species, with their attendant smaller ranges, they might unintentionally help their taxon’s conservation. It is important to remember, however, that taxonomy has many functions besides helping biodiversity conservation. Taxonomy is the basis for communicating about organisms. Moreover, it is important for medicine and human health (Utevsky and Trontelj (2005) for a striking example). And, while taxonomic change may have no predictable effects on conservation, a better understanding of evolutionary relationships, resulting from taxonomic research, is always an important addition to our knowledge about the organisms that we want to protect.

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References


