HERPETOLOGICA

VOL. 65 JUNE 2009 NO. 2

Herpetologica, 65(2), 2009, 115–128

TAXONOMIC FREEDOM AND THE ROLE OF OFFICIAL LISTS OF SPECIES NAMES

GREGORY B. PAULY[1,2], DAVID M. HILLIS, AND DAVID C. CANNATELLA

Section of Integrative Biology and Texas Natural Science Center, 1 University Station C0930, University of Texas, Austin, TX 78712, USA

ABSTRACT: The sixth edition of the Scientific and Standard English Names of Amphibians and Reptiles of North America (Crother, 2008, SSAR Herpetological Circular 37:1–84) is the "Official Names List" for the three major North American herpetological societies. Although this publication is intended to aid users of scientific and common names, we argue that current practices for authoring, reviewing, and using this list, in some cases, generate taxonomic chaos. By this we mean that users are uncertain of which name to use and/or the rationale for using a particular name, and efficient communication is hindered by this confusion. Most importantly, through inadequate and inconsistent review of this list, the societies have endorsed unnecessary and arbitrary name changes and are uncritically promoting individual taxonomic viewpoints when a clear choice on the most appropriate name has not been reached by the community. This problem is exemplified by North American anurans for which 57 of the 100 species have scientific names (i.e., genus-species combinations) different from the previous version of the list. Forty-eight of these new combinations result from changes to the genus name, and there is controversy over the proposed genus names for at least 43 of these. Despite this controversy and that a stated goal of the list is to report on such controversies, the alternative names are not discussed. As a result, for these taxa, the list fails to provide adequate information for users to make informed decisions on name usage. Here, we examine the role of such lists in taxonomy. Although we specifically focus on the arbitrary changes to the names of North American *Bufo* and *Rana*, the continuation of current practices for generating the list will promote instability and taxonomic confusion on a broader scale. We conclude with recommendations for improving the utility of such lists and for avoiding unnecessary taxonomic chaos.

Key words: *Bufo*; *Rana*; Species names; Taxonomic stability

THE LAST decade's flood of new phylogenies has rewritten our understanding of phylogenetic relationships and taxonomy of amphibians and reptiles. Publication of the sixth edition of the Scientific and Standard English Names of Amphibians and Reptiles of North America (Crother, 2008; hereafter referred to as "the list") brings this issue to the forefront. The sixth edition is sponsored by the three major North American herpetological societies: the American Society of Ichthyologists and Herpetologists (ASIH), the Herpetologist's League (HL), and the Society for the Study of Amphibians and Reptiles (SSAR). Although the authors, editors, and sponsoring herpetological societies have changed since the first edition (Collins et al., 1978), the list's primary motivation is the same: to standardize and stabilize common names and thereby promote efficient communication. (We will use "common name" rather than "standard English name" as our points are relevant to all lists of common names and not just those that stabilize standard English names; see Crother [2007] for a discussion of these terms.) Although standardizing common names was the reason the list was conceived (see Conant

[1] PRESENT ADDRESS: Department of Evolution and Ecology, and Center for Population Biology, University of California, Davis, California 95616, USA.

[2] CORRESPONDENCE: e-mail, gbpauly@ucdavis.edu

et al., 1956), the list also has an increasingly important role relevant to scientific names. With the rapid growth of phylogenetic studies and the concomitant increase in changes to scientific names, the list has become ever more important as a single, convenient reference to current scientific names.

We argue, however, that some current practices for authoring, reviewing, and using this list result in a disservice to the field of taxonomy and to users of scientific names. In particular, there appears to be inadequate and inconsistent review of proposed changes to scientific names. Without extensive review, the list may incorporate unnecessary taxonomic changes at the authors' whim (each taxonomic section—frogs, lizards, etc.—is authored by one to four individuals). Because the list is endorsed by the three major North American herpetological societies, a reader might assume that any changes are broadly supported by the society members, but, as we detail below, this is not always the case. Moreover, no evidence suggests that the changes incorporated in the list even reflect the consensus of the committee that compiled the list. As a result, the list may promote taxonomic instability and thwart the goals of efficient communication and information retrieval that motivated its establishment.

Although the situation described above (i.e., society endorsement of unnecessary and subjective name changes lacking a strong consensus among taxonomic specialists) may seem unlikely, we argue that this exact scenario has occurred for the North American anuran list (Frost et al., 2008) and is resulting in unprecedented name instability for North American frogs. More than half of the 100 species listed in Frost et al. (2008) have new names. Of the 57 new combinations of anuran names made between the 2000 and 2008 lists, 43 were recommended by Frost et al. (2006*a*) in their monograph on amphibian phylogeny. As suggested by several authors (Hillis, 2007; Smith and Chiszar, 2006; Vences, 2007), and as we show below, genus-name changes proposed by Frost et al. (2006*a*) for the North American anuran species are arbitrary and unnecessary to reflect evolutionary history. Nevertheless, these proposed changes are incorporated into the anuran section of the list, of which Frost is also the lead author (Frost et al., 2008).

The list is one of the most far-reaching contributions of the herpetological societies to fellow professionals and the general public. It is an important resource to legislators, law enforcement personnel, amateur herpetologists and naturalists, and a diverse group of professional biologists, including wildlife managers and conservation biologists, journal editors, authors of natural history lists and publications, and managers of biological databases (e.g., GenBank, HerpNet, Encyclopedia of Life, etc.). Given this huge user group, all members of the societies have an interest in ensuring that the list represents the best available science and taxonomic practice. In our opinion, this standard was not met, at least in the case of the anuran list, because it promotes individual viewpoints that do not follow long-established taxonomic principles.

This essay is intended to stimulate discussion of both best practices in taxonomy and how names lists can best benefit the scientific and nonscientific user community. We first examine the purpose of classification and the role of stability. We argue that stability of the genus-species combination (i.e., the "species name" or "scientific name of the species" according to the Code; ICZN, 1999) should be maintained, except in cases of nonmonophyly of genera. In such cases, the number of changes in genus-species combination should be minimized. We also discuss the relationship between phylogeny and taxonomy. We then examine the purposes of standard lists and discuss the importance of broad peer review for evaluating proposed changes in lists of scientific and common names. We demonstrate ways to name taxa and provide additional phylogenetic information without changing genus-species combinations; taxonomic problems are addressed only as they relate to the scientific names—the genus-species combinations, rather than suprageneric names or controversies related to subspecies status. Last, we explore how these issues of instability and official lists are exemplified with changes in the species names for North American anurans, and we make general recommendations to promote stability.

Stability and the Purpose of Biological Classification

Modern biological classifications are generally recognized as having two principal goals (Ashlock, 1979; Benton, 2000; Mayr, 1982; Ross, 1974; Simpson, 1961). The first is to function as a reference system (Ross, 1974). As such, classifications facilitate communication; this is the practical or utilitarian purpose of classification (Mayr, 1982). The second goal is to reflect evolutionary history (Ashlock, 1979; de Queiroz, 1988, 1997). This is the general or scientific goal of classification (Mayr, 1982). The phrase "reflect evolutionary history" requires clarification; some have argued that both paraphyletic and monophyletic taxa reflect evolutionary history (e.g., Ashlock, 1979). However, we accept the modern consensus that the phrase means that taxon names, at least those above the species level, refer only to monophyletic groups (clades).

Obviously, there can be conflict in achieving these two goals. As noted by Cantino et al. (1999:796), "the communication function of nomenclature is best served if names remain stable through time." This is especially true given that the nonexpert user community is virtually unlimited (Kennedy et al., 2006). Changes in species names require that all users (academic and professional biologists, amateur biologists, laypersons, etc.) learn new names to communicate about the taxon of interest. Furthermore, name changes separate a species from its previous literature. Therefore, users must also maintain a record of the previous name to access published information. Clearly, reducing stability and familiarity of classifications simultaneously diminishes their utility.

Absolute stability, however, is not desirable because it would hinder the scientific goal of reflecting evolutionary relationships. As new phylogenetic information becomes available, changes to names may be necessary to reflect an increased understanding of evolutionary relationships. This conflict in simultaneously meeting the two principal goals of classification has been long recognized by taxonomists (e.g., Mayr et al., 1953; Simpson, 1961). For example, Simpson (1961:112) argued, "there must be some compromise between the usefulness of up-to-date classifications and the usefulness of stable classifications."

The scientific name of the species is the primary token by which biologists refer to a particular species. Given this, our view is that changes to the genus name should be avoided, except in cases of nonmonophyly (or where demanded by the Principle of Priority, which will not be discussed further). Even then, the number of changes to scientific names should be minimized. We recognize that informatics systems are increasingly better at mapping equivalencies between different taxonomic reference systems (Kennedy et al., 2006), but even the best informatics system will not eliminate the need to communicate using generally understood names. To ignore the goal of stability is to deny the role of biological classifications as general reference systems for all end users.

The Connection Between Phylogeny and Classification

It is generally accepted that classification should reflect phylogeny, but classifications differ from phylogenies in at least two ways. First, a classification is usually an incomplete representation of phylogeny, because only a subset of branches of the Tree of Life are named. Second, one phylogeny can yield many different but equally informative classifications.

So, which branches of a phylogeny should be named? In most cases we start not from a blank slate, but from existing classifications. New hypotheses of evolutionary relationships may require taxonomic changes to maintain monophyletic taxa. How should classifications be revised, when change is required by nonmonophyly? A common-sense approach was well-articulated by Simpson (1961:112): "A published classification in current use should be changed when it is definitely inconsistent with known facts and accepted principles, but only in so far as necessary to bring it into consistency." In the language of modern phylogenetics, "known facts and accepted principles" suggests well-established and strongly supported clades that are inferred under multiple analyses and from various data sources, a view echoed by the Turtle Taxonomy Working Group (2007) and

the American Ornithologists' Union (1998) in their discussions of protocols for revising classifications. Changing names based on poorly supported branches, or for issues unrelated to monophyly, is ill advised and counter to the goals of biological classification (Cantino et al., 1999; Gaffney, 1979; Godfray and Knapp, 2004; Mayr, 1982; Simpson, 1961).

But Simpson's rule of thumb is just that—a rule of thumb. It is up to the biological community to evaluate whether proposed changes promote the goals of classification. If they do, such proposals should be adopted. However, if proposed changes generate unnecessary instability, then they should be disregarded. Importantly, all users of names have the opportunity to make these decisions. Although many users of scientific names follow the most recent proposal or most recent taxonomic revision, there is no obligation to do so, and doing so, may contribute even further to taxonomic instability.

As secondary literature, names lists, especially those sponsored by scientific societies, should state the current scientific name, or, in cases where there may be alternatives, state these names and a brief summary of the rationale for each with relevant citations. We explicitly reject promotion of an individual viewpoint by authors of lists, and especially of their own taxonomic proposals. Likewise, we do not wish to replace that imposed system with our own. Rather, the herpetological community at large should be invested in the process of evaluating alternative classifications. Because numerous classifications of differing taxonomic stability may result from one phylogeny, the choice of which taxonomy best serves the purposes of biological classification is too important to be left only to taxonomists.

The Role of Standard Lists

Standard names lists should serve multiple functions that help to achieve both principal goals of classification:

1. Standard lists stabilize common names so that a diversity of end-users will use the same names for the same organisms even though no codes govern the use of common names. Thus, standard lists facilitate communication, a basic goal of classification.
2. Lists of scientific names also help to ensure that classifications reflect evolutionary history. Phylogenetic studies may suggest that the existing taxonomy is inconsistent with phylogenetic relationships. Thus, updated classifications provide an important format for disseminating the results of specialized phylogenetic research to a broad audience (see Hillis, 2007, for further discussion).

There is also a more general role for lists endorsed by professional societies or agencies. These lists are viewed as authoritative, presumably because users assume that the names reflect the general consensus of the societies' membership or at least the consensus of the taxonomic specialists within that society. As a result, these lists are an important resource to authors of more regional lists and publications (e.g., conservation and management agency lists, field guides, etc.) and may guide name usage in these works. Given this role, authors, editors, reviewers, and sponsoring organizations of such lists must recognize that they are a relatively small group whose decisions on content impact a huge audience. These decisions also determine whether a list will promote or hinder the goals of classification. Thus, it is critical that these individuals work to ensure that classifications reflect the best information available and simultaneously respect the interests and needs of the diverse user community. Importantly, lists should not restrict taxonomic freedom, including future debate on the most appropriate taxonomy. Below, we explore these issues by examining (1) taxonomic freedom, and (2) peer review/evaluation of names lists.

The Use of Lists to Legislate Taxonomy

The fifth and sixth editions of the list (Crother, 2000, 2008) were the first designated as the "Official Names List." More specifically, the title page of the fifth edition states that the list is "officially recognized and adopted by the SSAR, ASIH, and HL" while the phrase "Official names list of the ASIH, HL, and SSAR" is on the front cover of the

sixth edition. Use of the word "official" designates that the list is a publication of the sponsoring societies and distinguishes it from lists generated by other organizations and agencies. However, some readers may misinterpret the word "official" as implying that the scientific names are regulated by the societies; that is, the list may be misinterpreted as a list of official names (e.g., Stuart, 2008).

We argue that no scientific society should suggest or imply that they are regulating scientific names because such regulation is counter to the spirit of the International Code of Zoological Nomenclature (ICZN, 1999). Indeed, the first principle of the Code (1999:XIX) states, "The Code refrains from infringing upon taxonomic judgment, which must not be made subject to regulation or restraint."

This concept of taxonomic freedom is important. The Code (1999:119) defines a "taxonomic taxon" as

> "A taxon (e.g., family, genus, species) including whatever nominal taxa and individuals a zoologist at any time considers it to contain in his or her endeavour to define the boundaries of a zoological taxon (q.v.)."

This delineation of the "taxonomic taxon" is known as the Taxon Concept (Kennedy et al., 2006): the mapping of a taxon name to a publication stating the author's opinion of the taxon's content. According to the Code, an author is free to decide the content of a taxon, or taxon concept, even without regard to data or published literature. On one hand, an individual may propose a bewildering number of new names. Although such action would be highly irresponsible, the formal rules of nomenclature do not prevent it. On the other hand, taxonomic freedom also allows each individual to ignore published proposals. Presumably, because users want to be up-to-date with the latest research, an extremely common misconception is that the most recent taxonomy must be followed. However, nothing in the Code obliges or encourages authors, editors, or other users to do this.

So how do we reconcile taxonomic freedom with the goal of stability? We feel that "taxonomy by informed consensus" is a good descriptor of the process by which nomenclatural changes are accepted by the community of biologists, and we support this process. Given two competing taxonomic arrangements, a user ideally should select the one that promotes the goals of classification (to facilitate communication and indicate evolutionary history) and whenever possible maintains stability and familiarity. Preferably, the user should justify the choice of taxon concept in publication. As more users make their opinions known, a consensus will emerge.

Taxonomy by informed consensus might collapse for several reasons. First, nonsystematist users are unlikely to be familiar with, or equipped to assess, the pertinent taxonomic literature and may therefore make ill-informed choices. Second, uncritical acceptance of the most recent published classification, simply to be current, will destabilize taxonomy and hinder broader communication. Third, the enforcement of a particular name by editors when there is debate over the most appropriate choice prevents discussion and evaluation of taxonomic proposals.

This third point is especially important. Inclusion in the list may suggest to many users that only these names are acceptable for use. Although there are no formal requirements in most society journals that authors follow the names in the list, authors may feel obligated to comply simply because these names are in the society-sponsored list. One exception is Herpetological Review, in which authors of natural history and geographic distribution notes are explicitly required to follow the names in this list (this requirement dates back to Volume 10, 1979, the first volume following the publication of the SSAR's first common and scientific names list [Collins et al., 1978]). Similarly, editors of nonherpetological journals may require that authors also follow the list. Thus, if the list presents a one-sided viewpoint, then the authors of the list, and the endorsing societies, are effectively, if unintentionally, legislating taxonomy. This result is counter to the way in which taxonomy as a field should function. In our view, the list should strive to summarize the current state of nomenclature for each taxon, which should include discussing multiple names if alternatives exist.

Interestingly, early versions of the list recognized that such lists might restrict taxonomic freedom. The first attempt by a North American herpetological society to standardize common names was undertaken by the Committee on Herpetological Common Names of the ASIH; this effort followed the ASIH-sponsored checklist of scientific names by Schmidt (1953). The authors made "the list informal and as free as possible from the legalistic practices that have plagued binomial nomenclature" (Conant et al., 1956:172). The names in this list were given "no official status, and their use (was) in no way compulsory" (p. 172). The goal was simply to promote more efficient communication. The current list (Crother, 2008) is a direct outgrowth of this ASIH list. Although the current list is also not intended to be compulsory, some users may not recognize this.

Peer Review and Evaluation of the Names List

Balancing the dual goals of stability and conveying phylogenetic information is no easy task. This challenge requires input from a broad group of biologists, because the need for a general consensus makes this task too important to be left only to taxonomists. Even though taxonomists have the primary expert knowledge, scientific names should serve the entire community. We suggest that the protocols of the Committee on Standard English and Scientific Names (the joint committee that published Crother, 2000, 2008) for evaluating proposed name changes are inadequate because some individual viewpoints have been promoted to the exclusion of alternatives that maintain both stability and phylogenetic information.

A list of names is a snapshot in time whereas taxonomic debates about names occur over long periods. At any point, a clear consensus on the most appropriate names may not exist. Crother (2000, 2008) recognized the importance of providing information on competing proposals and specifically included "comments regarding confidence in our understanding." We agree that this is a very useful contribution. Unfortunately, such comments are inconsistently used across taxonomic sections. For example, de Queiroz and Reeder (2008) provide informative discussions of recent taxonomic changes to North American skinks (*Plestiodon*, formerly *Eumeces*) and whiptails (*Aspidocelis*, formerly *Cnemidophorus*). However, such discussions are minimal for controversial changes in the anuran section (Frost et al., 2008). Of the 57 new combinations of anuran species names made between the 2000 and 2008 lists, 43 were proposed in an earlier publication by the same lead author (Frost et al., 2006*a*). Several publications have argued against these proposals (e.g., Smith and Chiszar, 2006; Hillis, 2007), but these objections were largely ignored by Frost et al. (2008). Clearly, the list of anuran names does not reflect the current state of anuran taxonomy or the opinions of taxonomists who have published phylogenies or taxonomic revisions for the relevant groups. Thus, the list fails to elucidate the available alternatives and provides but a single viewpoint. In our opinion, authors of this list should not arbitrate taxonomic controversies, and the herpetological societies should not endorse lists that attempt to do so. In the case of the current list, and specifically Frost et al. (2008), we feel that the inconsistent approach to dealing with proposed taxonomic changes and the failure to catch these inconsistencies in the review process demonstrate that the protocol for authoring, editing, and reviewing this list needs to be revised.

The protocol for evaluating proposed nomenclatural changes has changed dramatically over the six editions of the list. At present (Crother, 2008), one to four authors establish the list for their subsection (e.g., frogs, lizards, etc.), including decisions about proposed changes to standard English and scientific names. The list is then reviewed by a small number of herpetologists. As discussed above, we believe that this review was inadequate. Given the importance of this list (and other similar lists of various taxa), we suggest that the review process be expanded to ensure that the list discusses current alternative names if these exist.

Our concern about lack of community input and prevalence of individual viewpoints extends to other lists as well. For example, ITIS is the Integrated Taxonomic Information System, a partnership of several U.S. federal agencies, including the Environmental Pro-

tection Agency, Department of the Interior, and the National Museum of Natural History. The ITIS website lists the data stewards for North American amphibian species as Roy McDiarmid and Darrel Frost, two of the three authors of the anuran section of the list. The goal of ITIS

> "is to create an easily accessible database with reliable information on species names and their hierarchical classification." (www.itis.gov/info.html)
> And further,
> "…ITIS is meant to serve as a standard to enable the comparison of biodiversity datasets, and therefore aims to incorporate classifications that have gained broad acceptance in the taxonomic literature and by professionals who work with the taxa concerned." (www.itis.gov/standard.html)

Just as with the Crother list, the ITIS list will likely influence other lists and publications. Such lists and the communities they serve will benefit from a broad review and greater focus on increasing taxonomic stability.

Stability and Phylogenetic Information: Examples from *Bufo* and *Rana*

Normally, changes to classifications result from new discoveries of taxon relationships. It is worth noting that the 43 changed species names for the North American *Bufo* and *Rana* represent no discoveries of new clades by Frost et al. (2006*a*). The phylogenies of North American *Bufo* and *Rana* had been previously resolved and sampled more thoroughly by Pauly et al. (2004; all 22 species of *Bufo*) and by Hillis and Wilcox (2005; 25 of 28 extant species of *Rana*; the 3 unsampled species were all formerly treated as subgroups of sampled taxa). For the North American species, Frost et al. (2006*a*) sampled only 9 species of *Bufo* and 12 species of *Rana*.

Frost et al. (2006*a*) provided a general motivation for dismantling paraphyletic groups and a specific rationale for proposed changes to *Bufo*:

> "A serious impediment in amphibian biology, and systematics generally, with respect to advancing historically consistent taxonomies, is the social conservatism resulting in the willingness of many taxonomists to embrace, if only tacitly, paraphyletic groupings, even when the evidence exists to correct them. The reason for this is obvious. Recognizing paraphyletic groups is a way of describing trees in a linear way for the purpose of telling *great* [emphasis theirs] stories and providing favored characters a starring role." (p. 12).
> "A complete remedy of the polyphyly/paraphyly of *Bufo* is beyond the scope of this study, although we take limited actions to start this inevitable process. We could place all of the names that are demonstrably derived from '*Bufo*' into the synonymy of *Bufo*, thereby providing a monophyletic taxonomy. However, because much of this paraphyly was understood in 1972 (various papers in Blair, 1972*a*), it is clear that social inertia is standing in the way of progress. We judge that progress will require the partition of '*Bufo*' into more informative natural units." (p. 214)

Frost et al. (2006*a*) considered the partitioning of the paraphyletic genus *Bufo* into smaller generic units to be "progress." Here, progress is confused with change. We feel this proposed change demands needless taxonomic chaos at the expense of stability. Certainly, we do not oppose naming newly discovered clades, but the solution offered by Frost et al. (2006*a*) and mirrored in Frost et al. (2008) is not the only one. There are two general classes of solutions for resolving the paraphyly of *Bufo*. One is to break *Bufo* up into smaller monophyletic taxa at the same rank. A second is to retain *Bufo* as a large group and to subsume within it the taxa that make *Bufo* paraphyletic. This can be done either by reducing the rank of the smaller clades or using unranked taxa.

Frost et al. (2006*a*) favored the first option, dismantling *Bufo* into smaller genera. As quoted above, part of their justification is that recognition of a greater number of smaller genera is more "informative," meaning that more clades are named. However, the second option also results in at least as many named clades. Moreover, the second option contains more information: a larger genus *Bufo* is now monophyletic as are the smaller infrageneric taxa. Both subgenera and unranked infrageneric taxa have been used increasingly (e.g.,

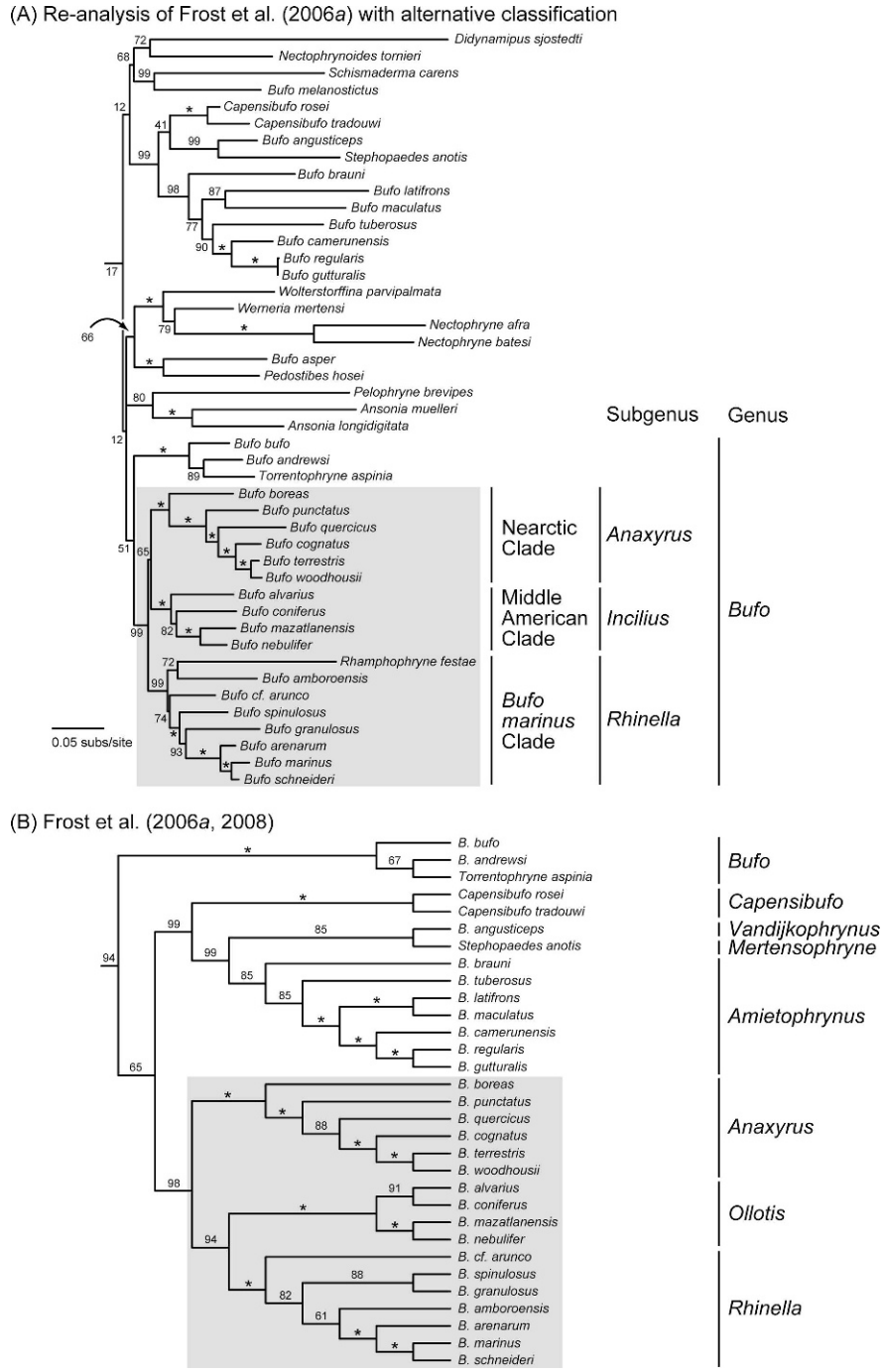

FIG. 1.—Phylogenies of *Bufo* from (A) a maximum likelihood re-analysis of Frost et al.'s (2006*a*) 12S–16S data for the bufonids and (B) Frost et al. (2006*a*). The likelihood analysis was conducted on a secondary structure based alignment. Support values are Bayesian posterior probabilities from 16,000 post burn-in trees. The Bayesian analysis used two runs of four Markov chains each with each run lasting ten million generations and trees sampled once every 1000 generations. In (B), support values are from a parsimony jackknife with 37% deletion of Frost et al's 12S–16S data for the bufonids (the deletion percentage was chosen to mimic Frost et al's. [2006*a*] analyses, although they did not report the specific

Brandley and de Queiroz, 2004; Hillis and Wilcox, 2005; Leaché and McGuire, 2006), and this solution maintains stability without sacrificing informativeness.

The solution espoused by Frost et al. (2008) for North American *Rana* is even more egregious in its subjectivity. Frost et al. (2008) arbitrarily divided the clade of Laurasian *Rana* species recovered by Hillis and Wilcox (2005) and Hillis (2007) into two genera, *Rana* and *Lithobates*. This action is not necessitated by the phylogenetic analysis, it does not remove any paraphyletic groups, it provides no new phylogenetic information beyond that in Hillis and Wilcox (2005), and it unnecessarily promotes taxonomic instability and confusion (Hillis, 2007; Smith and Chiszar, 2006). Furthermore, the clades called *Rana* and *Lithobates* by Frost et al. (2008) are both inconsistently supported across analyses of various data sets (as discussed by Hillis and Wilcox, 2005). In contrast, support for the monophyly of the two combined groups (*Rana* sensu Hillis, 2007) is consistent and strong.

Hillis (2007) suggested that *Rana* be retained for all North American ranids and that *Lithobates* be recognized as one of several subclades of *Rana*. This proposal retains the existing species names but also provides more information about the phylogeny of these frogs. Hillis and Wilcox (2005) originally defined *Lithobates* as a subclade equivalent to the *Rana palmipes* species group, and treated this taxon as a subgenus under the Linnean system. Moreover, this taxon concept of *Lithobates* is much more restricted than the genus called *Lithobates* by Frost et al. (2006*a*). The brief comments in Frost et al. (2008) give the reader no hint of these issues.

Alternative Proposals for Bufo *and* Rana

Interestingly, the various groups of authors within Crother (2008) chose very different taxonomic strategies. In contrast to Frost et al. (2008), de Queiroz and Reeder (2008) made the sensible decision to recognize the subclades of *Phrynosoma* proposed by Leaché and McGuire (2006). Thus, stability of the well-known genus is retained, but additional phylogenetic information is available (e.g., *Phrynosoma (Anota) solare*).

The proposal we advocate for *Bufo* and *Rana* is similar to that of Hillis (2007) and de Queiroz and Reeder (2008): a hybrid system using ranked scientific names to maintain stability, and unranked names to convey additional phylogenetic information. This approach combines features of the Zoological Code and of phylogenetic nomenclature (Cantino et al., 1999; de Queiroz and Gauthier, 1992). Authors who prefer completely ranked taxonomies can follow these same recommendations, treating the unranked names as taxa of infrageneric rank.

Bufo.—The North American bufonids treated by Frost et al. (2008) as the genera *Rhinella*, *Ollotis*, and *Anaxyrus* form a well-supported clade termed the New World Clade by Pauly et al. (2004). The sister taxon to this clade, however, is not strongly supported in any study. Despite the apparently strong support values reported by Frost et al. (2006*a*), the support for relationships among these clades (Fig. 1) is an artifact of their unusual analysis parameters (low gap cost, treating gaps as a fifth character, and a jackknife deletion setting of 37%, all of which inflate support values relative to standard approaches such as the bootstrap and jackknife analysis with 50% deletion). Our reanalysis of their 12S–16S bufonid data (from D. C. Cannatella and G. B. Pauly, unpublished data; sequence data aligned in CLUSTALX with modifications based on secondary structure, as in Pauly et al. [2004] followed by model-based analyses in GARLI [Zwickl, 2006] and MrBayes 3.1.1 [Ronquist and Huelsenbeck, 2003]) suggests that *B. bufo* is the sister taxon of the New World Clade

←

value). This re-analysis was conducted on the identical sequence data as examined in (A), but the alignment is taken directly from Frost et al. (2006*a*). Asterisks indicate support values of 100. Classifications recommended by us (A) and by Frost et al. (2006*a*, 2008) (B) are shown. Shaded boxes denote the New World Clade (sensu Pauly et al., 2004). See Appendix I for synonymy of *Ollotis* with *Incilius*.

(Fig. 1A). Similarly, results from Pauly et al. (2004), Pramuk (2006), and Pramuk et al. (2007), indicate that (1) the New World Clade sensu Pauly et al. (2004) is very strongly supported; this clade includes all of the North American species of the list; and (2) the New World Clade is closely related to, or the sister-group of, the *Bufo bufo* species group.

Therefore, we delimit *Bufo* as minimally including the New World Clade (115 species) and the *Bufo bufo* species group (Fig. 1). Thus, a large number of the species names are returned to their previous combinations. Although our taxonomic action here recognizes a larger *Bufo*, no phylogenetic information is lost because we regard *Anaxyrus*, *Incilius* (see Appendix I for synonymy of *Ollotis* as *Incilius*), and *Rhinella* simultaneously as subgenera and named clades within *Bufo*. We defer formal definitions of the clade names pending a re-classification of all Bufonidae in progress. At the moment, the exhaustive content of *Bufo* as we delimit it is not clear, because of the uncertain phylogenetic position of some clades. But we note that Frost et al. (2006*a*) also retained about two dozen species as "*Bufo*" because of uncertain affinities. Our proposal is only partly satisfactory, and as taxon sampling and gene sampling is increased, it may be that other clades are returned to *Bufo*. Nonetheless, it is an improvement over the classification of Frost et al. (2006*a*, 2008) because taxonomic stability is enhanced without sacrificing phylogenetic information.

To be clear, our advocacy of a larger *Bufo* is not based on social conservatism (see above), sentimentality for paraphyletic groups (none are recognized), telling great stories, or a general preference for traditional approaches. Rather, it is motivated solely by the desirability for stability in classifications/taxonomies provided that such stability does not sacrifice phylogenetic information.

Rana.—For species of *Rana*, the taxonomy recommended by Hillis (2007:Fig. 2) is completely consistent with the Code (contrary to earlier concerns about some of these names reported by Frost et al. [2006*a*]). It is important to note that the different recommendations by Hillis (2007) and Frost et al. (2008) do not reflect any differences in phylogenetic results. Indeed, the phylogeny of virtually all species of North American *Rana* by Hillis and Wilcox (2005:Fig. 2A) and that from a much smaller sample of North American *Rana* by Frost et al. (2006*a*:Fig. 2B) differ in minor ways that do not affect either taxonomic proposal. Moreover, the clades Frost et al. (2006*a*) called *Rana* and *Lithobates* are two of the few named clades that are not consistently supported in phylogenetic analyses of North American ranids. The monophyly of these groups is controversial (especially with regard to the placement of *Rana sylvatica*; for a review of this issue, see Hillis and Wilcox, 2005). Use of *Lithobates* for the majority of North American *Rana* is not only unnecessary and destabilizing for taxonomy, it is also highly confusing. The only clear phylogenetic definition of the clade *Lithobates* was provided by Hillis and Wilcox (2005), who defined it as "The clade stemming from the most recent common ancestor of *Rana palmipes* Spix 1824, *Rana vaillanti* Brocchi 1877, *Rana bwana* Hillis and de Sá 1988, and *Rana juliani* Hillis and de Sá 1988." Under this phylogenetic definition and the phylogenies of Hillis and Wilcox (2005) and Frost et al. (2006*a*), no species in the clade *Lithobates* occur within the United States.

The taxonomy of Frost et al. (2006*a*) not only destabilizes the names of well known species, it actually provides much *less* information on the phylogeny of North American ranids compared to the taxonomy proposed by Hillis (2007:Fig. 2); Frost et al. (2006*a*) recognized two named clades while Hillis (2007) recognized nine (Fig. 2). In addition, unlike the taxonomy proposed by Frost et al. (2006*a*), the named clades proposed by Hillis (2007) reflect groups that are strongly and consistently supported across multiple analyses and data sets. Therefore, the classification proposed by Hillis (2007) better fulfills both goals of biological classification (facilitating communication and reflecting evolutionary relationships).

Summary and Recommendations

Classifications are not the personal sandboxes of taxonomists. Promoting unnecessary name changes has a huge negative impact on the field of taxonomy and more generally on

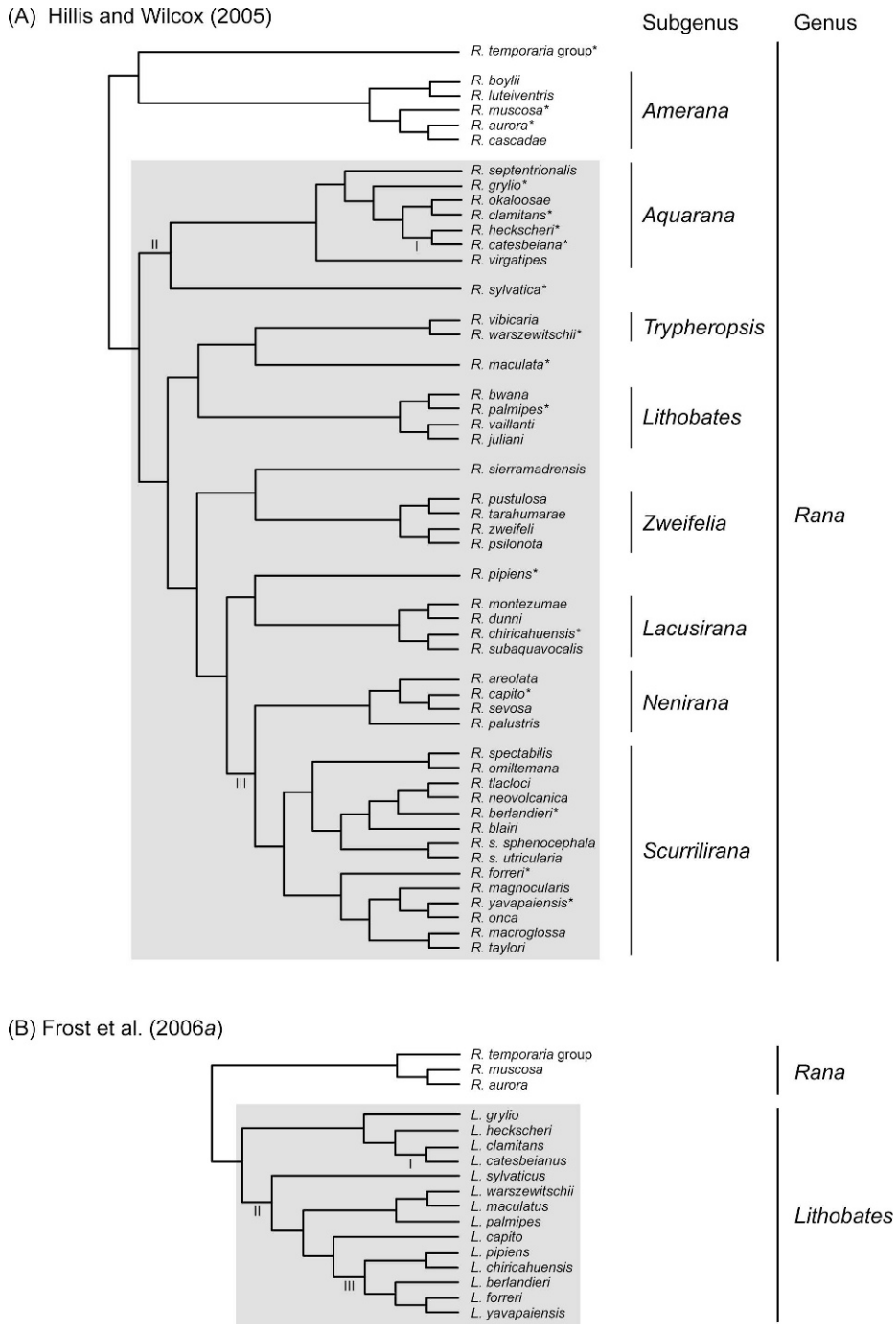

FIG. 2.—Phylogenies of *Rana* from (A) Hillis and Wilcox (2005) and (B) Frost et al. (2006*a*). Asterisks in (A) indicate those species that were sampled in both studies. Roman numerals denote those relationships that were reconstructed differently in the two studies. In (A), the phylogeny is from Hillis and Wilcox (2005), and the taxonomic recommendations follow Hillis (2007). Shaded boxes denote the clade that Frost et al. (2006*a*) termed *Lithobates*.

biology as a whole. It is a mistake to assume that nonsystematists have no interest or stake in scientific names. (In this context, one of us [DCC] recognizes that his previous position on changing generic names simply to have more "informative" taxa—recognizing *Siluriana* as distinct from *Xenopus* [Cannatella and de Sá, 1993]—was mistaken.)

Historically, a major rationale for using scientific names over common names was to promote efficient communication because common names varied widely among users, regions, and languages. Ironically, because of the recent flux in scientific names and the publication of standard lists for common names, common names often show more stability (at least for standard English names). Although *Lithobates catesbeianus* and *Rana catesbeiana* may confuse some, nearly all users recognize the American Bullfrog. If subjective and unnecessary changes to taxon names prevail, the result will be not only a great disservice to the science of taxonomy but also to all who use the results of taxonomy, from laypersons to professional biologists. Such changes have already brought the ire of many biologists (Godfray and Knapp, 2004) and only promote the increasing disregard of the field. In recognizing these concerns and objections, we take seriously the obligation of taxonomists to serve the larger community with stable and informative classifications.

These problems are not unique to herpetology. All biology is faced with changing classifications and the difficulties of updating nomenclature. Taxonomic specialists are a tiny fraction of the users of the taxonomies, and specialists should be cognizant of the diverse user community and its needs. Most importantly, changes to classifications that attempt to maximize information content must minimize any negative impacts on utility. So in summary, we argue that taxonomic stability and monophyly are primary goals, but stability is not to be achieved at the expense of monophyly.

Below we make several recommendations; these are not exhaustive, but are intended to stimulate further discussion.

1. Because it is contrary to the letter and spirit of the Code, scientific societies should not regulate scientific names. Lists of names should not be treated as lists of officially accepted scientific names. To avoid confusion, sponsorship of a list should not be indicated by the word "official." However, name lists are important for stabilizing common names, so herpetological societies serve a vital function in promulgating such lists.
2. Stable taxonomies of scientific names are an important goal, and scientific societies should promote the discussion and interaction needed to achieve this. Systematists should accept responsibility for providing stable and informative classifications to the biological community, and the community of users should reject new classifications that destabilize names unnecessarily.
3. The scientific name of the species (genus-species combination) should only be changed when there is strong evidence that the changes are necessary to reflect evolutionary history.
4. Authors of lists should discuss alternative taxonomic proposals when these exist.
5. Authors working on taxa for which there are multiple recent or current proposed scientific names should explain the choice of names, i.e., their choice of taxon concept.
6. Name lists should not be used to restrict taxonomic freedom. Authors and editors should be aware that no requirement exists (in the Code or anywhere else) that the most recent taxonomic proposals be followed. Editors should not establish policies that a particular list or taxonomic revision be followed.
7. All name lists, and especially those promoted by scientific societies, should undergo extensive peer review. This will ensure rigorous scholarship, discussions of alternative proposals, and a broader consensus of the societies' members.

Acknowledgments.—We sought comments and feedback from numerous individuals. Although not everyone agreed entirely with our opinions, we are grateful to all of the following for their helpful discussions and comments: A. J. Abrams, J. M. Brown, C. M. Edwards, O. Flores-Villela, D. M. Green, M. Guerra, J. Hanken, T. R. Jones, V. León-Règagnon, A. Larson, J. B. Losos, E. J. Routman, M. J. Ryan, J. C. Santos, M. J. Sredl, B. L. Stuart, J. N. Stuart, S. Swenson, R. Symula, R. J. Wassersug and

especially to R. M. Brown, F. T. Burbrink, B. I. Crother, K. de Queiroz, R. W. McDiarmid, P. C. Rosen, H. M. Smith, M. Vences, and D. B. Wake. Preparation of this paper was supported by a University of Texas Continuing Fellowship to GBP and NSF grant EF 0334952 to DCC and DMH.

Literature Cited

American Ornithologists' Union. 1998. Check-list of North American Birds, 7th ed. American Ornithologists' Union, Washington, D. C., U.S.A.

Ashlock, P. D. 1979. An evolutionary systematist's view of classification. Systematic Zoology 28:441–450.

Benton, M. J. 2000. Stems, nodes, crown clades, and rank-free lists: Is Linnaeus dead? Biological Reviews 75:633–648.

Brandley, M. C., and K. de Queiroz. 2004. Phylogeny, ecomorphological evolution, and historical biogeography of the *Anolis cristatellus* series. Herpetological Monographs 18:90–125.

Cannatella, D. C., and R. O. de Sá. 1993. *Xenopus laevis* as a model organism. Systematic Biology 42:476–507.

Cantino, P. D., H. N. Bryant, K. de Queiroz, M. J. Donoghue, T. Eriksson, D. M. Hillis, and M. S. Y. Lee. 1999. Species names in phylogenetic nomenclature. Systematic Biology 48:790–807.

Collins, J. T., J. E. Huheey, J. L. Knight, and H. M. Smith. 1978. Standard common and current scientific names for North American amphibians and reptiles, 1st ed. SSAR Herpetological Circular 7:1–36.

Conant, R., F. R. Cagle, C. J. Goin, C. H. Lowe, Jr., W. T. Neill, M. G. Netting, K. P. Schmidt, C. E. Shaw, and R. C. Stebbins. 1956. Common names for North American amphibians and reptiles. Copeia 1956:172–185.

Cope, E. D. 1863. On *Trachycephalus*, *Scaphiopus*, and other American Batrachia. Proceedings of the Academy of Natural Sciences of Philadelphia 15:43–54.

Cope, E. D. 1889. The Batrachia of North America. Bulletin of the United States National Museum 34:1–525.

Crother, B. I. (Ed.). 2000. Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. SSAR Herpetological Circular 29:1–82.

Crother, B. I. 2007. Standard language (insert language of choice) names versus common names. Herpetological Review 38:143.

Crother, B. I. (Ed.). 2008. Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding, 6th ed. SSAR Herpetological Circular 37:1–84.

de Queiroz, K. 1988. Systematics and the Darwinian Revolution. Philosophy of Science 55:239–259.

de Queiroz, K. 1997. The Linnean hierarchy and the evolutionization of taxonomy, with emphasis on the problem of nomenclature. Aliso 15:125–144.

de Queiroz, K., and J. Gauthier. 1992. Phylogenetic taxonomy. Annual Review of Ecology and Systematics 23:449–480.

de Queiroz, K., and T. W. Reeder. 2008. Squamata: Lizards. Pp. 24–45. *In* B. I. Crother (Ed.), Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. SSAR Herpetological Circular 37.

Dunn, E. R., and M. T. Dunn. 1940. Generic names proposed in herpetology by E. D. Cope. Copeia 1940:69–76.

Frost, D. R., T. Grant, J. Faivovich, R. H. Bain, A. Haas, C. F. B. Haddad, R. O. De Sá, A. Channing, M. Wilkinson, S. C. Donnellan, C. J. Raxworthy, J. A. Campbell, B. L. Blotto, P. Moler, R. C. Drewes, R. A. Nussbaum, J. D. Lynch, D. M. Green, and W. C. Wheeler. 2006*a*. The amphibian tree of life. Bulletin of the American Museum of Natural History 297:1–370.

Frost, D. R., T. Grant, and J. R. Mendelson, III. 2006*b*. *Ollotis* Cope, 1875 is the oldest name for the genus currently referred to as *Cranopsis* Cope, 1875 (Anura: Hyloides: Bufonidae). Copeia 2006:558.

Frost, D. R., R. W. McDiarmid, and J. R. Mendelson, III. 2008. Anura: Frogs. Pp. 2–12. *In* B. I. Crother (Ed.), Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. SSAR Herpetological Circular 37.

Gaffney, E. S. 1979. An introduction to the logic of phylogeny reconstruction. Pp. 79–111. *In* J. Cracraft and N. Eldridge (Eds.), Phylogenetic Analysis and Paleontology. Columbia University Press, New York, New York, U.S.A.

Godfray, H. C. J., and S. Knapp. 2004. Introduction. Philosophical Transactions of the Royal Society of London, Series B 359:559–569.

Hillis, D. M. 2007. Constraints in naming parts of the Tree of Life. Molecular Phylogenetics and Evolution 42:331–338.

Hillis, D. M., and T. P. Wilcox. 2005. Phylogeny of the New World true frogs (*Rana*). Molecular Phylogenetics and Evolution 34:299–314.

International Commission on Zoological Nomenclature. 1999. International Code of Zoological Nomenclature, 4th ed. International Trust for Zoological Nomenclature, London, U.K.

Kellogg, R. 1932. Mexican tailless amphibians in the United States National Museum. Bulletin of the United States National Museum 160:1–224.

Kennedy, J., R. Hyam, R. Kukla, and T. Paterson. 2006. Standard data model representation for taxonomic information. OMICS 10:220–230.

Leaché, A. D., and J. A. McGuire. 2006. Phylogenetic relationships of horned lizards (*Phrynosoma*) based on nuclear and mitochondrial data: evidence for a misleading mitochondrial gene tree. Molecular Phylogenetics and Evolution 39:628–644.

Mayr, E. 1982. The Growth of Biological Thought: Diversity, Evolution, and Inheritance. Harvard University Press, Cambridge, Massachusetts, U.S.A.

Mayr, E., E. G. Linsley, and R. L. Usinger. 1953. Methods and Principles of Systematic Zoology. McGraw-Hill Book Company, New York, New York, U.S.A.

Pauly, G. B., D. M. Hillis, and D. C. Cannatella. 2004. The history of a Nearctic colonization: Molecular

phylogenetics and biogeography of the Nearctic toads (*Bufo*). Evolution 58:2517–2535.

Pramuk, J. B. 2006. Phylogeny of South American *Bufo* (Anura: Bufonidae) inferred from combined evidence. Zoological Journal of the Linnean Society 146:407–452.

Pramuk, J. B., T. Robertson, J. W. Sites, Jr., and B. P. Noonan. 2007. Around the world in 10 million years: biogeography of the nearly cosmopolitan true toads (Anura: Bufonidae). Global Ecology and Biogeography 17:72–83.

Ronquist, F., and J. P. Huelsenbeck. 2003. MRBAYES 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19:1572–1574.

Ross, H. H. 1974. Biological Systematics. Addison-Wesley Publishing Company, Reading, Massachusetts, U.S.A.

Schmidt, K. P. 1953. A Check List of North American Amphibians and Reptiles, 6th ed. University of Chicago Press, Chicago, Illinois, U.S.A.

Simpson, G. G. 1961. Principles of animal taxonomy. Columbia University Press, New York, New York, U.S.A.

Smith, H. M., and D. Chiszar. 2006. Dilemma of name-recognition: Why and when to use new combinations of scientific names. Herpetological Conservation and Biology 1:6–8.

Stuart, J. N. 2008. Book Review: Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in our Understanding, Sixth Edition, by the Committee on Standard English and Scientific Names (Brian I. Crother, committee chair). Bulletin of the Chicago Herpetological Society 43:1–3.

Turtle Taxonomy Working Group [J. W. Bickham, J. F. Parham, H.-D. Philippen, A. G. J. Rhodin, H. B. Shaffer, P. Q. Spinks, and P. P. van Dijk]. 2007. Turtle taxonomy: methodology, recommendations, and guidelines. Pp. 73–84. *In* H. B. Shaffer, N. N. Fitzsimmons, A. Georges, and A. G. J. Rhodin (Eds.), Defining Turtle Diversity: Proceedings of a Workshop on Genetics, Ethics, and Taxonomy of Freshwater Turtles and Tortoises. Chelonian Research Monographs, 4. Chelonian Research Foundation, Lunenburg, Massachusetts, U.S.A.

Vences, M. 2007. The Amphibian Tree of Life: Idealogie, chaos, oder biologische realität? Zeitschrift für Feldherpetologie 14:153–162.

Zwickl, D. J. 2006. Genetic Algorithm Approaches for the Phylogenetic Analysis of Large Biological Sequence Datasets under the Maximum Likelihood Criterion. Ph.D. dissertation, The University of Texas at Austin, Austin, Texas, U.S.A.

Accepted: 20 May 2009
Associate Editor: Frank Burbrink

Appendix I

The Taxonomy of Middle American Bufo

Frost et al. (2006*a*) resurrected *Cranopsis* Cope 1875 for the clade of Middle American *Bufo* identified by Pauly et al. (2004:Fig. 1A). Later, Frost et al. (2006*b*) pointed out their oversight: that *Cranopsis* was preoccupied, that Cope himself had realized this (1889) and proposed the replacement name *Cranophryne*, and that *Ollotis* Cope 1875 had priority as the valid name for the genus.

The story continues because another name, *Incilius* Cope 1863, is relevant. Cope (1863) did not designate a type-species for *Incilius*. Frost et al. (2006*a*:222), acting under the First Reviser principle (Article 24) designated *Bufo cognatus* Say 1823 as the type-species of *Incilius* Cope 1863 to ensure that *Incilius* would be a synonym of *Anaxyrus* (i.e., the Nearctic *Bufo* sensu Pauly et al. [2004], which includes *Bufo cognatus*: see Fig. 1A). However, Frost et al. (2006*a*) were apparently unaware that a type-species for *Incilius* had already been designated. As indicated by Dunn and Dunn (1940), Kellogg (1932:29) designated *Bufo coniferus* Cope 1862, one of the species originally included in the genus, as the type-species of *Incilius*. *Bufo coniferus* is in the Middle American Clade (sensu Pauly et al., 2004), which is treated as *Ollotis* by Frost et al. (2008).

Under Article 70.2, Kellogg's fixation of type-species takes precedence over that of Frost et al. (2006*a*). Therefore, *Incilius* has priority over *Ollotis* as the older available name for the genus comprising species in the Middle American Clade of *Bufo*. However, readers should not construe our statement about priority of *Incilius* over *Ollotis* as being a taxonomic action (see Article 8.3 of the Code) or "synonymy by implication." We do not recognize *Ollotis* or *Incilius* as the valid genus name for the Middle American Clade, in order to avoid the 33 new combinations that would result. Rather, as discussed and depicted in Figure 1, we consider these species in the Middle American Clade to be part of *Bufo*.