Studii şi Cercetări	Biologie	17	54-58	Universitatea din Bacău	Mai 2009

RECENT TAXONOMIC CHANGES IN HERPETOLOGY - IMPLICATIONS FOR THE CONSERVATION AND SYSTEMATICS OF AMPHIBIANS IN ROMANIA

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Keywords: *amphibia, taxonomy, systematics, nomenclature changes*

INTRODUCTION

Scientific names have provided the only means of communication between scientists worldwide since Linnaeus first introduced in 1758 the binomial nomenclature, the system of formally classifying and naming organisms according to their genus and species. Binomial names served as labels by which a species could be universally recognized. This naming system was implicitly hierarchical, as each species was classified within a genus and in higher taxa (e.g., family, order, class, phylum).

The binomial system rapidly became the standard for naming species, for both botanists and zoologists. Later, evolutionary biology made important philosophical modifications by requiring that a scientifically-based nomenclature consider phylogenetic relationships. While vital in providing continuity and precision for communication, scientific names must also keep pace with advancements in our understanding of relationships between species.

The classification of living organisms currently is undergoing major rearrangements, mostly due to the increased use of molecular techniques in defining species and phylogeny.

The focus of the changes introduced by molecular studies is establishing monophyly, thus leading to a conflict between traditional morphologically-based systematists and phylogeneticists. As Brummitt (2006) stated, “paraphyly is the most important issue debated in taxonomy today”.

This is caused by the incompatibility between the Linnaean classification system, which is based on recognizing ranked taxa (e.g., families, genera and species), and phylogeny, which recognizes only monophyletic taxa (clades) and does not recognize most higher classification categories of the Linnaean system.

The phylogenetic species concept allows species recognition based on any diagnostically distinct criterion, and has thus opened many potential opportunities for delimiting species. The result is that phylogenetic methods tend to inflate the number of species at a rate driven by the sophistication of the techniques used (Mace et al., 2003). This, in part, has caused traditional taxonomists to question philosophically the use of largely non-selective molecular traits in systematics (Dubois, 2007). Molecular phylogenetics generally have failed to provide a direct link to evolutionary relationships as established through selection and drift acting on expressed traits (Zander, 2008).

The result is that at the moment there are two competing systems for the formation of scientific names. The oldest and most widely used for animals is the *International Code for Zoological Nomenclature* (ICZN); for plants, it is the *International Code for Botanical Nomenclature*. Both of these nomenclatural codes are based on a non-evolutionary concept involving the designation of a type individual or species. The more recent *PhyloCode*, first elaborated in 2000, uses phylogenetic definitions for supraspecific taxa at any level in the hierarchy of the Tree of Life (Hillis, 2007).

SYSTEMATICS OF AMPHIBIANS

During the last decades, major changes occurred in the taxonomy and systematics of amphibians. The number of recognized species of amphibians has grown enormously in recent years, a 48.2% increase since 1985 (Frost et al., 2006). At the end of 2008, the increase in the number of species is greater than 60% (6,437 species listed on AmphibiaWeb as of December 27, 2008).

During the last decade of the 20th Century, 810 new amphibian species were described, more than three times the number of species descriptions compared with the same period 100 years earlier. Most new descriptions are new discoveries, since removal from synonymy represents only a small proportion (14%) of the newly recognized species (Köhler et al., 2008). The significant increase in described species does not have a direct impact on Romania’s amphibians, since most newly described species are tropical (Table 1).

Table 1. The increase in the number of known amphibian species in India and Sri Lanka during the last decade (Frost, 2008)

	1997-1998	2008	% increase
India	205	225	+12%
Sri Lanka	54	105	+95%

What is the reason for these changes? First, major technological advances allowed highly accurate and more sophisticated molecular and behavioral studies (e.g., nuclear and mitochondrial DNA, gene sequencing, call analyses), as well as data analysis and interpretation (e.g., the use of computers, GIS, internet facilities, new software and statistical approaches). Second, there is an increasing number of specialists throughout the world that work on amphibians. The increasing number of herpetological systematists and resulting publications is illustrated by the increase in the literature output: 25% of all the publications on amphibians ever published were put out during the last decade (Table 2). This in turn has created a "herpetologist effect", similar to the "botanist effect" (e.g., Pautasso and McKinney, 2007), whereby more amphibian specialists result in increased sampling and in the recognition and description of new species. With increasing attention to herpetology in South America, Asia and Africa, especially by resident scientists, the current high rate of species description is expected to be maintained into the future.

Table 2. The dynamics of systematic literature on amphibians, as a percentage of the total number of publications during the 250 years since Linnaeus started his classification system (Frost, 2008)

Period	Amount of time (%)	Percentage of systematic publications on amphibians
1758-1939	72.4	25
1939-1979	16	50
1979-1999	8	75
1999-2008	3.6	100

A major turning point in the taxonomy of amphibians was represented by the publication by Frost et al. (2006) of the *Amphibian Tree of Life*, in which the authors proposed major changes in the systematic relationships among amphibians based primarily on molecular studies. Most of the taxonomic changes proposed do not affect the names of amphibian species inhabiting Romania, but simply addressed examples of non-monophyly that have been previously known or suspected (e.g., the non-monophyletic origin of the species within the genera *Triturus*, *Bufo* and *Rana*). The proposals made by Frost and co-workers were highly criticized (e.g. Wiens, 2007; Dubois, 2007) and a key web initiative in the field, AmphibiaWeb, states that "we argue that there are clear advantages to maintaining the traditional names for many of these taxa", and recommends caution in adopting the many new changes.

AMPHIBIAN DECLINES

Knowledge of amphibian taxonomy is of critical importance in estimating and predicting their global decline and extinction. Global status and trends estimation can be made on the basis of species number (i.e., Stuart et al., 2004) or population trends (i.e., Houlahan et al., 2000). The Global Amphibian Assessment estimates that the number of species that have become extinct since 1980 may be as many as 122 (Stuart et al., 2004). Areas with rapidly declining species are in Asia, Africa, South America, and Australia (Stuart et al., 2004). A precise estimation of the rate of amphibian species extinction is difficult because the largest number of newly described species is in areas where concurrent massive extinctions were recorded. Another difficulty in developing an estimate of the extent of species loss and population decline is the quality of the data available. Long-term monitoring projects on amphibian populations are uncommon even in developed countries, whereas short-term and often anecdotal reports are the only information available for many of the areas were massive species loss has occurred. Many amphibian species are cryptic or do not have aquatic larval stages, making sampling difficult. This increases the probability of non-detection (i.e., believing the species absent when in fact it is present), especially if sampling is inadequate. Thus, there have been a few recent reports about rediscoveries after many years of believing species were "extinct." An example is the case of many *Atelopus* species, such as *A. mucubajiensis* from the Venezuelan Andes, last seen in 1994 but "rediscovered" in 2004 (Lampo et al., 2006).The major causes of amphibian decline are those linked to various forms of habitat loss and fragmentation (Cushman, 2005), pollution, the introduction of nonindigenous species (Kats and Ferrer, 2003; Ficetola et al., 2007), emerging infectious diseases, climate change and increased UV-B radiation; often these factors interact synergistically (Pounds et al., 2006; Wake and Vredenburg, 2008).

Another potential factor is overexploitation (Stuart et al., 2004). In Europe, amphibians are negatively affected by habitat loss and fragmentation (Stuart et al., 2004), and recent evidence suggests that at least three European species may be pushed to extinction because of the amphibian chytrid fungus *Batrachochytrium dendrobatidis*. The fungus has been reported from many European countries and several amphibian species (Garner et al., 2005). Although none of the amphibian species in Romania are threatened with extinction, the negative effects of human induced changes in habitat quality on populations was already documented (e.g., Hartel et al., 2009).

TAXONOMIC CHANGES AFFECTING AMPHIBIAN SPECIES IN ROMANIA

With amphibians declining rapidly due to multiple causes, urgent conservation and management measures are required. These might be hampered and delayed by taxonomic instability and make regional and international cooperation difficult due to misunderstandings concerning the names of priority species. Such a situation was reported by Daugherty et al. (1990) concerning the highly endangered tuatara in New Zealand.

The taxonomic changes proposed by Frost et al. (2006) affect three genera present in Romania (*Triturus, Rana* and *Bufo*) out of seven genera (43%), and seven species out of 19 (37%). The newt genus *Triturus*, comprising 13 species, was confirmed as a non-monophyletic group, and the different lineages recently were classified as four distinct genera (Garcia-Paris et al., 2004; Litvinchuk et al., 2005; Steinfartz et al., 2007). These changes were included within Frost et al. (2006). Generic reallocation directly affects three newt species inhabiting Romania: *Triturus vulgaris* and *T. montandoni* are now in the genus *Lissotriton*; *T. alpestris* is the sole species within the genus *Mesotriton.*

Two anuran genera split by Frost and co-workers previously contained some of the largest number of species in the world, with 283 toad species in the genus *Bufo* and 258 species in the genus *Rana.* The six frogs of the genus *Rana* occurring in Romania were split in two genera, with true (brown) frogs remaining in *Rana*, and the water frog complex transferring to the genus *Pelophylax.* Thus, *Rana ridibunda* becomes *Pelophylax ridibundus*, *R. esculenta* – *P. esculentus* and *R. lessonae* – *P. lessonae*. The two toad species in the genus *Bufo* inhabiting Romania were separated, with the common toad keeping its name (*Bufo bufo*) and the green toad transferring to the genus *Pseudepidalea*. The green toad is widespread throughout Eurasia and parts of northern Africa and has a highly complex genetic structure, including polyploidy (Stöck et al., 2006). Additional changes in green toad taxonomy are expected in the near future.

RECOMMENDATIONS

These nomenclatural changes in amphibian taxonomy are supported by much data, but more changes are likely in the future as additional data are gathered and analyzed. While there is a necessity for nomenclature to incorporate advances in our knowledge of phylogeny, nomenclatural stability is at stake. What can be done in this situation, when species names become volatile and the role of taxonomy in providing a clear communication system is eroded? Providing taxonomic stability in conservation is necessary for effective legislation, regulation and management of protected areas. Smith and Chiszar (2006) have proposed a compromise solution by incorporating the subgenus category in the case of partitioned genera, an approach which is acceptable to ICZN rules. As such, the name of the newts would be *Triturus (Lissotriton) vulgaris* and *Triturus (Mesotriton) alpestris*, for example.

We strongly support this approach. The present taxonomic chaos affects the legal conservation status, which has not been updated, making it difficult for managers and administrators of protected areas to access scientific information. To provide for some form of stability, we recommend accepting only some of the changes proposed by Frost et al. (2006) and, at least for the moment, ignore others that are not final (Table 3). Periodic updating of legislation is vital in order to keep up with our advancing understanding of species relationships and provide consistent data to decision-makers and conservationists.

ACKNOWLEDGEMENTS

We are grateful to Ken Dodd for his comments on the manuscript and the English corrections.

ABSTRACT

The last decades brought major changes both in the number of species and in the reappraisal of the amphibian's systematic, world wide. This situation is due to perfecting of available tools: techniques of molecular and behavioural analysis, data processing, larger geographic cover and a larger number of researchers. The result is an explosion of publications and taxonomic reappraisal that determines instability of nomenclature and it creates a chaotic situation in legislation and conservation. These taxonomic modifications are necessary, it keeps up with our increased capacity of knowledge, but they are probably not final. This is the reason why, in order to maintain stability in the nomenclature, we recommend the acceptance of only some of the proposed nomenclature reappraisal, respectively of the most well argued.

Table 3. Updated classification of Romanian amphibian species and comments on the proposed changes. Old species names are those included in national legislation and Red Lists, whereas new names are those proposed by Frost et al. (2006). Stability is assessed based on the probability of nomenclatural changes in the near future, as new data are forthcoming

OLD NAMES	NEW NAMES	TAXONOMIC STABILITY	PROPOSED NAME
Salamandra salamandra	Same	High	*Salamandra salamandra*
Triturus cristatus	Same	High	*Triturus cristatus*
Triturus dobrogicus	Same	High	*Triturus dobrogicus*
Triturus vulgaris	*Lissotriton vulgaris*	High	*Triturus (Lissotriton) vulgaris*
Triturus montandoni	*Lissotriton montandoni*	High	*Triturus (Lissotriton) montandoni*
Triturus alpestris	*Mesotriton alpestris*	High	*Triturus (Mesotriton) alpestris*
Bombina bombina	Same	High	*Bombina bombina*
Bombina variegata	Same	High	*Bombina variegata*
Pelobates fuscus	Same	Moderate	*Pelobates fuscus*
Pelobates syriacus	Same	Moderate	*Pelobates syriacus*
Hyla arborea	Same	High	*Hyla arborea*
Bufo bufo	Same	High	*Bufo bufo*
Bufo viridis	*Pseudepidalea viridis*	Low	*Bufo (Pseudepidalea) viridis*
Rana temporaria	Same	High	*Rana temporaria*
Rana dalmatina	Same	High	*Rana dalmatina*
Rana arvalis	Same	Moderate	*Rana arvalis*
Rana ridibunda	*Pelophylax ridibundus*	Moderate	*Rana (Pelophylax) ridibunda*
Rana esculenta	*Pelophylax esculentus*	Moderate	*Rana (Pelophylax) esculenta*
Rana lessonae	*Pelophylax lessonae*	Moderate	*Rana (Pelophylax) lessonae*

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