Org Divers Evol (2010) 10:81–90
DOI 10.1007/s13127-010-0015-1

FORUM

ORGANISMS DIVERSITY & EVOLUTION

Nomenclatural rules in zoology as a potential threat against natural history museums

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Received: 2 October 2009 / Accepted: 16 January 2010 / Published online: 9 March 2010

Abstract Natural history museums store millions of organisms from the whole world that are of great use to understand the evolution, structure and problems of biodiversity. One of their main functions is to act as repositories of so-called type specimens or onomatophores. These allow long-term universality and stability of biological nomenclature through providing an objective and permanent link between the world of language and the world of organisms. Threats currently exist against this function, in two directions at least. (1) Recent changes to the nomenclatural rules put the emphasis on 'usage' of nomina and challenge 'priority' as the basic principle of nomenclature. This entails a shift from specimens to concepts or tradition for the establishment of the valid nomina of taxa. Beside its encouraging taxonomists to work carelessly and hastily, this attitude weakens the significance and importance of those specimens in taxonomy, undermining their important flag function for the image, funding and even the mere existence of natural history museums. To counter this tendency, any validation of junior synonyms or homonyms to protect usage should be strictly limited to nomina in well-documented very widespread use, not only in specialized systematic publications but in the general scientific and non-scientific literature and in society as a whole. (2) For the same reason, nomenclatural systems that rely not on onomatophores but on verbal definitions of nomina should not be encouraged. It is crucial that the unique value of onomatophores be highlighted, and that the institutions which care for their long-term conservation and scientific managing be recognised and permanently provided with appropriate funding and staff. Many other disciplines of biology do or will benefit from such a support to museums.

Keywords Nomen · Priority · Usage · Onomatophore · Type specimen · Flag function

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Introduction

Since the beginning of the 20th century, zoological nomenclature has been regulated worldwide by a set of rules now known as the International Code of Zoological Nomenclature (ICZN 1999; hereafter referred to as "the Code"). The International Commission on Zoological Nomenclature (ICZN) cares for the updating of the Code and the solving of problems regularly occurring in this field. The object of the Code is not to deal with the theory and practice of the classification of organisms (taxonomy), but to provide rules for the automatic and universal establishment of the unique valid scientific name or nomen (Dubois 2000a) of a given taxon within any given taxonomic frame (nomenclature). This is a three-step process involving first the nomenclatural availability of nomina, then their allocation to taxa, and finally their validity (Dubois 2005). Once made nomenclaturally available, a given nomen is unambiguously allocated to a given taxon in any given taxonomy not through any verbal definition or intension, but through a mechanism of ostension (Dubois 2006, 2007a, b, 2008; Keller et al. 2003), this nomen being attached to one or several specimens usually known as types (McNeill et al. 2006), name-bearing types (ICZN 1999) or better as onomato-

phores (Dubois 2000a, 2005; Dubois and Ohler 1997; Simpson 1940, 1961). Whenever, according to these rules, two or more nomina apply to the same taxon (synonyms), or are identical (homonyms), the valid one among these competing nomina used to be determined according to a simple principle, that of priority of publication. In the earlier versions of the Code, including the so-called third edition (ICZN 1985), this principle was a stringent one, except in very specific cases: When a given nomen had been used as valid for a taxon in many publications, whereas an earlier synonym had been ignored, the ICZN was entitled to make use of its 'plenary powers' to validate the junior nomen against the senior one. However, because this process was burdensome, it was restricted to at most a few cases per year.

In the fourth edition of the Code (ICZN 1999), currently in force, this principle was 'moderated' by a new one, that of "prevailing usage". When the nomen of a taxon has not been used as valid since 1899 (even if it was considered as available), and when a junior synonym or homonym has been used as valid in at least 25 publications, the new Code allows the validation of the junior nomen through reversal of precedence. As will be discussed in detail elsewhere (Dubois 2010), these arguably lax conditions encourage careless nomenclatural work in zoological taxonomy, and in the long run may threaten the universality of zoological nomenclature and cause a chaotic situation in this field, thus potentially favouring alternative nomenclatural systems. This would force zootaxonomists to divert part of their time and energy to renaming millions of animal taxa under the new system, a very bad idea at a time when taxonomic urgency calls for accelerating the procedure of describing the unknown species of the planet before they become extinct (Dubois 2010). Another consequence of this change in rules, which appears to have escaped the attention of many zoologists, needs to be pointed out: it tends to weaken the status of onomatophores in zoological nomenclature, and thus to act as an unexpected threat against natural history museums. This issue is explored in some detail below, as is the related question concerning proposals of new nomenclatural systems, alternative to the Code, that do not require onomatophores for the creation of new nomina.

The functions of natural history museums

Natural history museums are not universities or pure organs of research. They are specialized institutions with a very particular role, i.e. to preserve permanently many objects collected throughout the world, for purposes of scientific research, expertise, teaching, exhibition and testimony. These objects are representative samples of the diversity of our planet regarding living organisms (biodiversity), rocks and minerals (geodiversity), and human societies, cultures and products (anthropodiversity). Although some natural history museums have existed in Europe since the end of the 18th century, not all countries of the world have such institutions at this time. One of the reasons for this is the high cost of long-term storage and management of large collections, although a large proportion of the latter are used, for the purposes listed above, only from time to time, if not very rarely. Justification of this cost for society requires considering these museums as large scientific infrastructures, useful not only for basic science but also for many aspects of applied research, especially in the fields of conservation biology, agronomy and medicine. In recent decades, a growing number of biologists have become aware of the potential of these giant databases, and it can be predicted that such museum collections will be used more and more in various disciplines.

The main costs for museums concern their storing and managing capacities, i.e. the conservation of samples of organisms (biodiversity). Each large museum keeps millions of complete or partial specimens of plants, insects and other animals that have been collected across the whole planet for more than two centuries. Such specimens are permanently preserved, ideally in climate-controlled rooms, in dried, stuffed or deep-frozen condition, or in alcohol, formalin or other preservatives. This requires considerable budgets to cover the costs of storage (often in the expensive centres of large cities) and human resources, to ensure proper conservation and management of these collections, including efficient access to the specimens, not to mention efforts to collect additional samples. In recent decades, many museums have faced financial problems because of increasing difficulties in convincing policy-makers of the social function and importance of these collections. This seems to be due in part to inadequate communication from museum people (Alberch 1993).

Many policy-makers think that museum collections only have an educational role. This function of museums is an important one, indeed. Even in our days of multimedia communication, museums provide an irreplaceable tool as they exhibit genuine natural history specimens and objects, rather than mere representations or image of, or statements about, them. Museum exhibits are not only educational tools but, just like art museums, also aim at the "enjoyment" (ICM 2006) of a wide audience, including scholars, students and laypersons.

However, if museums only had this one function, it would be difficult to understand why they have kept and should continue to keep millions of specimens that are not shown in exhibits, and that might be seen as 'duplicates' (but see below). Furthermore, except in a few cases where visitors have access to binocular magnifiers or screen

projections, museum exhibits mostly show specimens of large or medium size, or very spectacular (e.g. colourful, strange or rare) ones. Such 'exhibitable' samples are only a very small proportion of all specimens kept in museums, the bulk of which consists of obscure and colourless mites, beetles, shells and skeletons, etc., that would not attract much attention from visitors. Explaining the role of such huge, 'unattractive' collections requires highlighting that our knowledge of the biodiversity on our planet still is very incomplete, especially regarding its taxonomic inventory (taxonomic gap; Dubois 2010). A large part of the global biodiversity remains completely unknown, and unrepresented in museum collections. Even among the specimens already stored in collections, many have not been properly studied but will be of incalculable utility to understanding the biodiversity of our planet and coping with the various corresponding problems. Often, previously unknown species are discovered in museums and described on the basis of specimens collected decades or centuries ago; sometimes, the species involved have even become extinct in the wild in the meantime.

Beside their patrimonial value and pedagogical usefulness, biological specimens stored in natural history museums can have one or more of three distinct functions: a nomenclatural, a taxonomic and a general one. Understanding what follows requires remembering the distinction between taxonomy, the discipline of systematics which aims at recognising and defining taxa (i.e. the classificatory units of biodiversity), and on the other hand nomenclature, the discipline which provides rules allowing the allocation of a unique, universal and stable nomen to each taxon within a given taxonomic framework.

The nomenclatural function of natural history museum specimens is restricted to some of these specimens, the onomatophores. These specimens have a basic function in biology, that of providing a system for objective and unambiguous allocation of nomina to taxa, thus allowing universality in the use of nomina in scientific publications. In museums, onomatophores are often kept in special cabinets, or at least identified by red labels or other distinctive marks, listed in special catalogues, and often consulted by taxonomists from the whole world for taxonomic revisions and descriptions of new taxa. Although these specimens represent only a small proportion of the total collections of museums, they are usually considered as their most important holdings. In extreme situations such as wars or natural catastrophes, emphasis is put on the priority of preserving them before the rest of the collection.

Although often confused with the previous one, the taxonomic function of biological specimens is distinct. Here, specimens are considered and used not as nomen-bearers but as sign- or information-bearers, i.e. as semaphoronts (Hennig 1950, 1966). Specimens in collections provide a representative sample of the natural variability that exists within each living species. This intraspecific variability occurs both within and among populations of each species. Intrapopulational variation includes sexual dimorphism, ontogenetic variation (sometimes with complex life cycles involving larvae or several distinct stages as in, e.g., amphibians, insects and various parasites), the existence of different casts or morphs, and many other kinds of variability and polymorphism that can concern virtually all characters. Interpopulational variability includes geographic and temporal variation. One basic purpose of taxonomic research is to understand the nature and extent of intraspecific variation in order to be able to distinguish it from variation resulting from the existence of distinct species, i.e. of entities behaving as isolated or 'protected' gene pools because gene flow between them is normally absent or very limited. Proper study of this question often requires consulting large collections of specimens, including multiple representatives of a single species and population, none of which should thus be considered as a mere duplicate. Even after the publication of a taxonomic revision its material should not be discarded, as taxonomy is a never-ending process, and the next revision of the same group—whether after just a few years or after a century—may require re-examination of such specimens in light of additional material and new methods or concepts.

The third function of natural history specimens, the general one, is diverse. These specimens carry a plethora of information that can be useful for many purposes, in a virtually unlimited variety of domains (Alberch 1993; Winker 2004). To give just a few examples, the locality and date at which material has been collected carry information on the distribution of taxa at a given time (and hence potentially on dispersion, invasion, extinction, etc.) or allow the understanding of biological cycles of organisms (e.g. gonadal or external sexual character cycles) or populations (e.g. selection cycles). Specimens can provide information on stratigraphy, taphonomy, anatomy, growth, pathology, parasitology, predation or other aggressions (e.g. via wounds or environment-induced malformations), on feeding habits and prey availability in the habitat, on various molecules from the environment (e.g. pollutants), etc. Long after museum specimens have been collected and fixed, they can still tell a lot of stories, and provide unexpected answers to current and future burning questions, such as concerning the past distribution of species, the occurrence of hybridization over long periods or modifications of ecosystems in recent times.

Beside their nomenclatural function, another important role of onomatophores is that, because availability of a nomen according to the Code now requires designation and deposition in a collection of at least one specimen

(holotype), zootaxonomists who wish to describe a new species should collect and preserve at least one specimen of this species, even if the latter is considered as endangered (Dubois and Nemésio 2007). This is an important safeguard against the recent tendency of some taxonomists not to collect any specimen (Nemésio 2009). For the reasons given above, voucher specimens are of invaluable help for all biodiversity studies, and the information carried by even only a single specimen is of great importance for the future of comparative and evolutionary biology: The difference in value between zero specimens and one specimen is dramatically greater than that between one and any higher number of specimens (Dubois 2009).

Many natural history museum specimens were collected in the 19th and 20th centuries in parts of the world that are now difficult to access, or in habitats that no longer exist. The evolution of human mentalities and laws has resulted in various new constraints on the collecting specimens in the field in many countries, so that it would now be difficult or impossible to make similar collections again if the existing ones were destroyed. Although initially the major purpose for their collection may have been to provide material for the study of taxonomy, relationships and distributions of organisms, these specimens have a much richer potential, which probably has been underexploited by biological research. Specimens collected primarily for taxonomic research should not be destroyed after such work has been performed once, since research is always ongoing, and because the heavy investment into building these collections should remain open to returns from various additional directions, some of which may even be unimaginable from today's point of view. Even though many specimens have not been looked at for a long while and might even prove to be of little use to research in the future, it is impossible to predict which ones will be used, and for which purpose; thus it would not be appropriate to throw away any of them (except some that are badly damaged or lack origin information).

The flag function of onomatophores

For all these reasons, natural history museums are crucial institutions for the study of biodiversity on our planet and for current and future research, both in basic domains like the study of organismal evolution and in applied domains such as conservation biology. In order for museums to continue playing this role in the future, they need permanent funding and staff, and this requires that governments and administrators understand their importance and necessity. For this purpose, a major role can be played by the nomenclatural function of onomatophores, which may act as flags for natural history collections. These red-labelled specimens are indispensable to the universal use of nomina in all disciplines and around the world. Should this stable international reference system disappear, there would be a great risk of the quick appearance of multiple nomenclatural systems, with different nomina then being used for the same organisms in different countries or disciplines. This would be the end of the unity and universality of organismal biology, with many potential dramatic consequences in various domains such as conservation biology, agriculture and medicine (e.g. the struggles against invasive species and diseases).

In my laboratory, we have been working for about 40 years on the taxonomy of frogs from South and Southeast Asia. One of the major, recurring problems we have had to face is that a given species was referred to by different nomina in India, Indochina and China. Before any study on distribution, phylogeny and evolutionary patterns could be performed, substantial work has been necessary to establish synonymies and reduce the number of valid nomina, so that the latter designate biological units rather than follow the borders of countries (e.g. Bossuyt and Dubois 2001; Chanda et al. 2000; Delorme et al. 2004; Dubois 1975, 1979a, b, 1980a, b, 1981a, b, 1987, 1992, 2000b, 2002, 2004; Dubois and Ohler, 1995, 1998, 1999, 2000, 2005; Humtsoe et al. 2008; Ohler 2003, 2007; Ohler and Delorme 2006; Ohler and Dubois 1999, 2006). This was possible only because of (1) the existence of an objective system of reference for the allocation of nomina to taxa (onomatophores), and (2) the Code's "Principle of Priority" automatically determining the valid nomen for a taxon among synonyms (without having to ponder whether, e.g., a Chinese nomen was 'better' than an Indian one or vice versa). As long as biologists from all countries follow the above two guidelines, they will accept (though often reluctantly) having to abandon nomina they proposed when older synonyms are demonstrated to exist. But if these basics are ignored or challenged too often, the risk exists that various colleagues might develop their own, separate sets of nomenclature.

It is therefore of great importance that the system of onomatophores, that is theoretically justified as an excellent system for universal and stable biological nomenclature (Dubois 2005), be kept as the unique reference system for the naming of all organisms, and that the use of this system be respected by all biologists, beginning with taxonomists. However, threats currently exist against the universality of this system, for two distinct reasons: (1) some systematists propose to discard onomatophores in some cases, thus weakening the universal function of onomatophores in nomenclature; (2) others go even further and propose to replace the ostensional system of onomatophores with intensional systems using verbal definitions of nomina. Both these recent developments should be countered, not

only on theoretical grounds (Dubois 2005), but also because they are a potential threat to the flag function of onomatophores, and consequently to the recognition, permanence and funding of natural history museums. This problem shall be exemplified in detail by a recent case in amphibian taxonomy.

Validating the mistakes of 'prominent' zoologists

The nomen *Rana cryptotis* Boulenger, 1907 was coined for a species of frog described from Angola on the basis of numerous specimens kept in the British Museum (now The Natural History Museum; London) and in the Museum of Comparative Zoology at Harvard University (Cambridge, MA, USA) (Barbour and Loveridge 1946). Since Passmore and Carruthers (1979), this nomen has been used in the combination *Tomopterna cryptotis* (Boulenger, 1907) as a catch-all nomen for some frogs occurring from South Africa to both western and eastern tropical Africa, and traditionally referred to the family Ranidae. Although local works have dealt with the genus *Tomopterna* Duméril & Bibron, 1841 in southern (Channing 2001; Passmore and Carruthers 1979) and eastern Africa (Poynton and Broadley 1985), no comprehensive revision of this genus using modern methods has been published recently. These frogs belong to a group of burrowing species that are highly similar morphologically, if not "mostly impossible to distinguish" (Channing 2001) without the use of bioacoustic and presumably other non-morphological criteria such as chromosomes or molecular data—which should sound as a warning to taxonomists against hasty synonymizations. A second nomen, *Chiromantis kachowskii* Nikolski, 1900, was originally proposed for a species from Ethiopia that has long been referred to the traditional tree-frog family Rhacophoridae. However, recent re-examination (Largen and Borkin 2000) of the two original specimens kept in the Museum of Saint Petersburg (Russia) has established that they also belong to the genus *Tomopterna*. In the absence of a recent revision of this genus, Largen and Borkin considered the corresponding nomen as a subjective synonym of *Rana cryptotis*. It would certainly have been more prudent to continue treating the former separately, pending a genuine revision. Only the latter could establish whether or not the Ethiopian and the Angolan representatives are conspecific (which seems quite unlikely in light of the taxonomy of other amphibian genera in Africa). At any rate, when the two nomina were treated as synonyms for a single taxon, adherence to the principle of priority would have required referring to this species as *Tomopterna kachowskii*.

However, following the new 'philosophy' of zoological nomenclature outlined above, which favours recent usage over priority, the ICZN instead decided to validate the nomen *Rana cryptotis* through reversal of precedence (ICZN 2001). Justification of this action is clearly problematic, in view of two facts: (1) the nomen *Chiromantis kachowskii* has never been forgotten by systematists and thus does not qualify as a 'nomen oblitum', since it has been recorded in several lists of African frogs as an either available (Gorham 1974; Loveridge 1957) or even valid nomen (Ahl 1929, 1931; Noble 1924; Werner 1923); (2) the nomen *Tomopterna cryptotis* is similarly obscure, having appeared only in specialized taxonomic, phylogenetic and biogeographic publications, as is clearly shown by the list of no more than 11 references to its uses cited in the application for its validation as a 'nomen protectum' (Largen and Borkin 2000). To sum up this exemplary case, an obscure nomen completely unknown to most biologists and to persons outside a narrow specialist field was validated against its senior subjective synonym, simply in order to avoid correction of invalid usage by a few taxonomists before Largen and Borkin's (2000) work. That usage had resulted simply from insufficient work, otherwise the name-bearing specimens would have been examined, and the nomenclatural error corrected, long ago. In the future, if the Angolan and Ethiopian specimens are found to represent different species, the Ethiopian one will have to be called *Tomopterna kachowskii* after all, so no nomenclatural stability will have been achieved in the long run. In giving priority to the nomen *cryptotis* over *kachowskii*, the ICZN has circumvented the principle of priority, simply because a handful of zoologists did not like that an onomatophore represented a taxon different from the one it 'should have'. This amounts to negating the role of onomatophores as a structuring and basic system for the allocation and validity of nomina, which will encourage others to do the same in other cases. A highly caricatural recent example concerns the chelonian species *Testudo gigantea* Schweigger, 1812, for which supporters of usage (not established in this case) propose to discard the original holotype from Brazil and replace it by a neotype of another biological species collected in Aldabra, i.e. on the other side of the planet (Dubois et al. 2010; Frazier 2009).

In the *Tomopterna cryptotis*/*kachowskii* case, the ICZN (2001) took a decision reversing precedence in favour of usage even though this did not correspond to the conditions, as lax as these are, the same organisation had stated for such cases just 2 years earlier (ICZN 1999). Those conditions require that the senior synonym has not been used as valid since 1899 and that the junior synonym has been used as valid in at least 25 publications. The 'error' committed here, however, is not due to a lack of care but is clearly deliberate. As a matter of fact, this is not an isolated example, but rather is fully representative of a strong tendency of the ICZN to validate the mistakes of the zoologists of the past. Other examples in amphibian

taxonomy include the even more caricatural case of the nomina *Rana trilobata* Mocquard, 1899 vs. *R. megapoda* Taylor, 1942, already analysed in detail elsewhere (Dubois and Ohler 1997), as well as many other cases discussed elsewhere (Dubois 2003, 2005). Similar examples could be found easily in all other zoological groups.

Among the nomina thus validated by the ICZN in recent decades, some would no doubt be completely unknown to almost all participants in any World Congress of Zoology, not to mention biologists working in disciplines other than zoology or outside of science. Who could honestly deny that this would be the case for nomina like *Tomopterna cryptotis*, *Rana megapoda*, *Synapturanus* Carvalho, 1954 (see ICZN 1988) or Hemidactyliini Hallowell, 1856 (see ICZN 1997)? In the meantime, who was concerned about the invalidation, because of the discovery of overlooked senior synonyms, of similarly obscure nomina such as *Bufo fergusonii* Boulenger, 1892 (see Dubois and Ohler 1999), *Rana pileata* Boulenger, 1916 (see Ohler and Dubois 1999) or *Ololygon* Fitzinger, 1843 (see Duellman and Wiens 1992)? What can be the reason for such different treatments of similar cases? Could it be simply the fact that in some cases some 'prominent' zoologists wanted to preserve 'their' usage, whereas in other cases nobody was motivated enough to do so? Is this the way a basic discipline of biology should operate?

It is likely that the millions of onomatophores currently stored in the museums of the world still reserve a lot of 'surprises' to us. Hopefully, taxonomists will continue to revisit these specimens, not only morphologically and anatomically, but also more and more using nucleic acid sequencing or other new methods. In many zoological groups, these new approaches are likely to disclose more variability than documented by simple phenotypic surveys. This will result in separations of 'sibling' species and in challenges to the current taxonomic allocation of some specimens, with the corresponding nomenclatural consequences: some nomina will have to shift from one biological species to another, others will be invalidated or revalidated. Rather than being afraid of this or complaining about it, taxonomists should be delighted to have at their service a system, that of onomatophores, that allows objective, permanent and automatic allocation of nomina to taxa, a function that 'descriptions', 'diagnoses' or 'definitions' cannot perform.

The shift from specimens to concepts

But this is perhaps not the major drawback of this new nomenclatural philosophy. If the discovery that an onomatophore has been misidentified has no nomenclatural consequences, why should taxonomists care to examine those supposed standard voucher specimens? If nomina based on ill-identified or ignored specimens are invalidated whenever such a mistake is disclosed, why should museums care for keeping these old specimens, for having reliable catalogues, and for making this material available for study by researchers from the whole world? Why should they care for devoting space and facilities to collections, or for paying staff for this very specialized task? Was there a real need for the Saint Petersburg Museum to keep for a full century (including numerous wars, and the disintegration of the USSR) the original specimens of *Chiromantis kachowskii* from Ethiopia, if their careful study today has no nomenclatural consequences? Would the taxonomic function of these specimens as semaphoronts (for morphological or biogeographical work), or their potential general function for other purposes, be considered valuable enough in the eyes of administrators to justify those investments?

More generally, what is the usefulness of onomatophores if they can be, so to speak, 'cancelled' whenever they turn out to represent a different taxon than previously (and erroneously) assumed? Following this mode of thinking further would even result in abandoning all onomatophores, as under such an approach the latter would be useful only if they are found to coincide with the traditional usage of the nomina based on them. Such practice would revolutionize the basic philosophy of zoological nomenclature, shifting from a nomenclatural system based on objects (specimens) to a system based on concepts and 'tradition'. This would not only cause many problems for the proper allocation of many nomina to taxa, but it would also in the rather short run have disastrous consequences for all natural history museums, as it would sap their flag function as repositories of reference specimens on which the universality and objectivity of biological nomenclature rests. Under this perspective, the so-called principle of usage appears as a pernicious threat against natural history museums.

As discussed in detail elsewhere (Dubois 2010), the principle of usage as it is currently applied (i.e. in an indiscriminate way disregarding whether the nomen is used only in specialized systematic literature or is well-known in more than a limited field) appears mostly as a practice in support of the personal comfort of a few taxonomists. This additional burden to natural history museums is not welcome, especially in times that are already difficult for them. Taxonomists of today should adopt a more respectful attitude towards their predecessors, and pay proper attention to the work, publications and specimens that are the foundations of their discipline. Such procedure would allow the much-needed return to respect for the basic rules of the Code in taxonomic publications, and would bring support to natural history museums by pointing out the importance of their function as repositories of onomatophores.

Defining nomina with words, not with onomatophores

In recent years, several alternative nomenclatural systems have been proposed to replace the current Code. The most advertised of them, initially called "phylogenetic nomenclature" (de Queiroz and Gauthier 1990, 1994), will apparently soon be promulgated under the name "PhyloCode" (Cantino and de Queiroz 2007). The purpose here is not to come back to the many discussions about the pros and cons of the new system (references in Dubois 2005; Laurin et al. 2005, 2006; Pickett 2005a, b), but simply to point to the problems raised by this new philosophy of nomenclature regarding the use of onomatophores.

Under the ICZN Code, nomenclature is largely independent from taxonomy. The Code does not prescribe the use of any kind of definitions for taxa, so that the latter can be defined in many ways, phenetically, phylogenetically, or otherwise. The Code provides rules only for naming taxa once they have been defined by taxonomists, through a process of ostensional pointing to onomatophores. In contrast, under the PhyloCode the definition of taxa and nomina is simultaneous. Both are qualified by 'phylogenetic definitions'. Such definitions may rely on 'specifiers', which are defined as follows: "Specifiers are species, specimens, or apomorphies cited in a phylogenetic definition of a name as reference points that serve to specify the clade to which the name applies" (Cantino and de Queiroz 2007: 47). Specifiers are not equivalent to onomatophores for two distinct reasons.

First, under the Code, ostensional pointing to onomatophores only requires that an onomatophore be referred to a taxon (i.e. included in it) to allocate the nomen based on this onomatophore to this taxon. In the PhyloCode system, an additional condition is needed to allocate a nomen to a taxon, and this is the existence of a 'phylogenetic hypothesis' concerning the cladistic relationships among taxa. As pointed out repeatedly (e.g. Dubois 2005), that has an important consequence: If new organisms are discovered, or if significant (though not necessarily very important) changes are brought to cladistic hypotheses, a widespread and well-known nomen may have to shift from its traditional taxon to another one. The discovery of a single new species, basal to a clade, may require renaming the latter (Pleijel 2005). More generally, if the allocation of a nomen N to a taxon A (B + C) is governed by the definition 'the ancestor of A and B and all of its decendants', and if new data suggest the new cladistic relationship C (A + B), the nomen N has to apply to a taxon including A + B and excluding C, even though the content of the taxon A + B + C has not changed (Frost et al. 2006; Lidén et al. 1997). For this simple reason it would be appropriate to abandon the direct linkage between nomina and phylogenetic definitions of taxa in 'phylogenetic taxonomy': taxa could well be defined according to the principles of phylogenetic definitions of the PhyloCode, but the allocation of nomina to taxa should remain governed by ostensional pointing to onomatophores (Dubois 2007a, b, 2008).

There is a second reason why onomatophores should be substituted for specifiers in phylogenetic taxonomy, and this has to do with the flag function of museums. Although specifiers may be specimens or species (i.e. nominal taxa, ultimately also based on specimens; see Dubois and Ohler 1997), they may also be characters (apomorphies, i.e. concepts). This sounds like a reversal to the early days of taxonomy when the 'method of concepts' or of 'conceptual types' was used instead of the 'method of types' or of 'nomenclatural types' (Dubois 2005; Moore 1998). Thus, the PhyloCode is not a consistent specimen-based nomenclatural system. In accepting that nomina can be qualified by concepts, that system is, at least partly, a circular system inside language, dealing with abstractions (intensions), whereas the major strength of the current Code is its connection with the world of real animals through onomatophores (Dubois 2005; Dubois and Ohler 1997).

Of the two drawbacks of any nomenclatural system of specifiers as compared to one of onomatophores, the second one is certainly the most threatening for natural history museums. Other systems of phylogenetic nomenclature that have been proposed or could be conceived are susceptible to the same drawback. If nomina of taxa can be defined only through words (phylogenetic definitions), then in the long run phylogenetic nomenclature might well turn into a system relying only on concepts or, which would be almost equivalent for museums, on barcodes or gene sequences stored in GenBank, instead of on specimens. Just like the generalized substitution of usage for priority, this could have dramatic consequences for museums, not to mention the consequences to the science of taxonomy itself.

Conclusions

The flag function of natural history museums as repositories of type specimens or onomatophores is an important one for the image, funding and even the very existence of natural history museums as particular institutions distinct from art museums and from universities or research facilities. The recent tendency of the ICZN to challenge priority as the basic principle of zoological nomenclature, in favour of usage, not only encourages taxonomists to work carelessly and hastily, but also weakens the significance and importance of these specimens in taxonomy, thus posing a threat to natural history museums. To counter this

tendency, validation of invalid junior synonyms or homonyms to protect usage should be strictly limited to nomina that have a documented widespread use, not only in specialized systematic publications but in the general scientific and non-scientific literature and in society as a whole, i.e. to 'sozonyms' as defined by Dubois (2005, 2010). For the same reason, alternative nomenclatural systems that do not rely on onomatophores should not be encouraged. As stressed by Dubois and Ohler (1997) and Dubois (2005, 2007a, b, 2008), the theory-free nomenclatural system of onomatophores provides the best device for nomenclatural stability by allowing an objective and permanent link between the world of language (nomina) and the world of real organisms (specimens). It is crucial that the unique value of these specimens be highlighted, and that the institutions caring for their long-term conservation and scientific management be recognized and permanently provided with sufficient funding and staffing. Many other disciplines of biology do and will benefit from such a support to museums (Alberch 1993; Winker 2004), as will the world at large.

Acknowledgements I am grateful to Prof. Olaf Bininda-Emonds and two anonymous reviewers for the constructive comments they offered on a previous version of this paper.

References

Ahl, E. (1929). Zur Kenntnis der Baumfroschgattung *Chiromantis* Peters. *Zoologischer Anzeiger, 80*, 27–37.

Ahl, E. (1931). Anura III. Polypedatidae. *Das Tierreich*, *55*, i–xvi + 1–477.

Alberch, P. (1993). Museums, collections and biodiversity inventories. *Trends in Ecology & Evolution, 8*, 372–375.

Barbour, T., & Loveridge, A. (1946). First supplement to typical reptiles and amphibians. *Bulletin of the Museum of Comparative Zoology at Harvard College, 96*, 59–214.

Bossuyt, F., & Dubois, A. (2001). A review of the frog genus *Philautus* Gistel, 1848 (Amphibia, Anura, Ranidae, Rhacophorinae). *Zeylanica, 6*, 1–112.

Cantino, P. D., & de Queiroz, K. (2007). International code of phylogenetic nomenclature. Version 4b. 1–97. http://www.ohio.edu/PhyloCode. Accessed 22 January 2010.

Chanda, S. K., Das, I., & Dubois, A. (2000). Catalogue of amphibian types in the collection of the Zoological Survey of India. *Hamadryad, 25*, 100–128.

Channing, A. (2001). *Amphibians of central and southern Africa*. Ithaca: Cornell University Press.

de Queiroz, K., & Gauthier, J. (1990). Phylogeny as a central principle in taxonomy: phylogenetic definitions of taxon names. *Systematic Zoology, 39*, 307–322.

de Queiroz, K., & Gauthier, J. (1994). Toward a phylogenetic system of biological nomenclature. *Trends in Ecology & Evolution, 9*, 27–31.

Delorme, M., Dubois, A., Kosuch, J., & Vences, M. (2004). Molecular phylogenetic relationships of *Lankanectes corrugatus* from Sri Lanka: endemism of South Asian frogs and the concept of monophyly in phylogenetic studies. *Alytes, 22*, 53–64.

Dubois, A. (1975). Un nouveau sous-genre (*Paa*) et trois nouvelles espèces du genre *Rana*. Remarques sur la phylogénie des Ranidés (Amphibiens, Anoures). *Bulletin du Muséum national d'Histoire naturelle, (3) 324 (Zool. 231)*, 1093–1115.

Dubois, A. (1979a). Notes sur la systématique et la répartition des Amphibiens Anoures de Chine et des régions avoisinantes. I. *Rana exilispinosa* Liu & Hu, 1975 et *Rana (Paa) paraspinosa* Dubois, 1975. *Bulletin mensuel de la Société linnéenne de Lyon, 48*, 649–656.

Dubois, A. (1979b). Notes sur la systématique et la répartition des Amphibiens Anoures de Chine et des régions avoisinantes. II. *Rana blanfordii* Boulenger, 1882, *Rana polunini* Smith, 1951 et *Rana yadongensis* Wu, 1977. *Bulletin mensuel de la Société linnéenne de Lyon, 48*, 657–661.

Dubois, A. (1980a). Notes sur la systématique et la répartition des Amphibiens Anoures de Chine et des régions avoisinantes III. *Rana maculosa* Liu, Hu & Yang, 1960, *Rana (Paa) arnoldi* Dubois, 1975 et *Rana maculosa chayuensis* Ye, 1977. *Bulletin mensuel de la Société linnéenne de Lyon, 49*, 142–147.

Dubois, A. (1980b). Notes sur la systématique et la répartition des Amphibiens Anoures de Chine et des régions avoisinantes IV. Classification générique et subgénérique des Pelobatidae Megophryinae. *Bulletin mensuel de la Société linnéenne de Lyon, 49*, 469–482.

Dubois, A. (1981a). Notes sur la systématique et la répartition des Amphibiens Anoures de Chine et des régions avoisinantes V. *Megophrys oshanensis* Liu, 1950 et *Leptobrachium minimum* Taylor, 1952. *Bulletin mensuel de la Société linnéenne de Lyon, 50*, 182–192.

Dubois, A. (1981b). Liste des genres et sous-genres nominaux de Ranoidea (Amphibiens, Anoures) du monde, avec identification de leurs espèces-types: conséquences nomenclaturales. *Monitore zoologico italiano, (n. s.) 15 (suppl.)*, 225–284.

Dubois, A. (1987). Miscellanea taxinomica batrachologica (I). *Alytes, 5 ("1986")*, 7–95.

Dubois, A. (1992). Notes sur la classification des Ranidae (Amphibiens, Anoures). *Bulletin mensuel de la Société linnéenne de Lyon, 61*, 305–352.

Dubois, A. (2000a). Synonymies and related lists in zoology: general proposals, with examples in herpetology. *Dumerilia, 4*, 33–98.

Dubois, A. (2000b). The influence of man on the distribution of amphibians in the Himalayas of Nepal: an example of critical evaluation of biogeographical data. *Marburger geographische Schriften, 135*, 326–345.

Dubois, A. (2002). The taxonomic status of *Scutiger mokokchungensis* Das & Chanda, 2000 (Amphibia, Anura). *Amphibia-Reptilia, 22*, 499–506.

Dubois, A. (2003). The relationships between taxonomy and conservation biology in the century of extinctions. *Comptes rendus Biologies, 326*(suppl. 1), S9–S21.

Dubois, A. (2004). Amphibians of Nepal: a few words of caution. *Alytes, 21*, 174–180.

Dubois, A. (2005). Proposed rules for the incorporation of nomina of higher-ranked zoological taxa in the International Code of Zoological Nomenclature. 1. Some general questions, concepts and terms of biological nomenclature. *Zoosystema, 27*, 365–426.

Dubois, A. (2006). Naming taxa from cladograms: a cautionary tale. *Molecular Phylogenetics and Evolution, 42*, 317–330.

Dubois, A. (2007a). Phylogeny, taxonomy and nomenclature: the problem of taxonomic categories and of nomenclatural ranks. *Zootaxa, 1519*, 27–68.

Dubois, A. (2007b). Naming taxa from cladograms: some confusions, misleading statements, and necessary clarifications. *Cladistics, 23*, 390–402.

Dubois, A. (2008). Phylogenetic hypotheses, taxa and nomina in zoology. *Zootaxa, 1950*, 51–86.

Dubois, A. (2009). Endangered species and endangered knowledge. *Zootaxa, 2201*, 26–29.

Dubois, A. (2010). Zoological nomenclature in the century of extinctions: Prority vs. usage. *Organisms Diversity & Evolution*.

Dubois, A., & Nemésio, A. (2007). Does nomenclatural availability of nomina of new species or subspecies require the deposition of vouchers in collections? *Zootaxa, 1409*, 1–22.

Dubois, A., & Ohler, A. (1995). Frogs of the subgenus *Pelophylax* (Amphibia, Anura, genus *Rana*): a catalogue of available and valid scientific names, with comments on name-bearing types, complete synonymies, proposed common names, and maps showing all type localities. *Zoologica Polonica*, *39 ("1994")*, 139–204.

Dubois, A., & Ohler, A. (1997). Early scientific names of Amphibia Anura. I. Introduction. *Bulletin du Muséum national d'Histoire naturelle, 4*(18), 297–320.

Dubois, A., & Ohler, A. (1998). A new species of *Leptobrachium (Vibrissaphora)* from northern Vietnam, with a review of the taxonomy of the genus *Leptobrachium* (Pelobatidae, Megophryinae). *Dumerilia, 4*, 1–32.

Dubois, A., & Ohler, A. (1999). Asian and Oriental toads of the *Bufo melanostictus*, *Bufo scaber* and *Bufo stejnegeri* groups (Amphibia, Anura): a list of available and valid names and redescription of some name-bearing types. *Journal of South Asian Natural History, 4*, 133–180.

Dubois, A., & Ohler, A. (2000). Systematics of *Fejervarya limnocharis* (Gravenhorst, 1829) (Amphibia, Anura, Ranidae) and related species. 1. Nomenclatural status and type-specimens of the nominal species *Rana limnocharis* Gravenhorst, 1829. *Alytes, 18*, 1–50.

Dubois, A., & Ohler, A. (2005). Taxonomic notes on the Asian frogs of the tribe Paini (Ranidae, Dicroglossinae). 1. Morphology and synonymy of *Chaparana aenea* (Smith, 1922), with proposal of a new statistical method for testing homogeneity of small samples. *Journal of Natural History, 39*, 1759–1778.

Dubois, A., Ohler, A., & Brygoo, E.-R. (2010). Comments on the proposed conservation of usage of *Testudo gigantea* Schweigger, 1812 (currently *Geochelone (Aldabrachelys) gigantea*; Reptilia, Testudines). *Bulletin of Zoological Nomenclature*.

Duellman, W. E., & Wiens, J. J. (1992). The status of the hylid frog genus *Ololygon* and the recognition of *Scinax* Wagler, 1830. *Occasional Papers of the Museum of Natural History of the University of Kansas, 151*, 1–23.

Frazier, J. (2009). *Testudo gigantea* Schweigger, 1812 (currently *Geochelone (Aldabrachelys) gigantea*; Reptilia, Testudines): proposed conservation of usage of the specific name by maintenance of a designated neotype, and suppression of *Testudo dussumieri* Gray, 1831 (currently *Dipsochelys dussumieri*). *Bulletin of Zoological Nomenclature, 66*, 34–50.

Frost, D. R., Grant, T., Faivovich, J., Bazin, R. H., Haas, A., Haddad, C. F. B., et al. (2006). The amphibian tree of life. *Bulletin of the American Museum of Natural History, 297*, 1–370.

Gorham, S. W. (1974). *Checklist of world amphibians up to January 1, 1970*. Saint John: The New Brunswick Museum.

Hennig, W. (1950). *Grundzüge einer theorie der phylogenetischen systematik*. Berlin: Deutscher Zentralverlag.

Hennig, W. (1966). *Phylogenetic systematics*. Urbana: University of Illinois Press.

Humtsoe, L. N., Bordoloi, S., Ohler, A., & Dubois, A. (2008). Rediscovery of a long known species, *Ixalus lateralis* Anderson, 1871. *Zootaxa, 1921*, 24–34.

ICM = International Council of Museums (2006). Development of the museum definition according to ICOM statutes (1946–2001). icom.museum/hist_def_eng.html. Accessed 14 July 2006.

ICZN = International Commission on Zoological Nomenclature. (1985). *International code of zoological nomenclature* (3rd ed.). London: International Trust for Zoological Nomenclature.

ICZN. (1988). Opinion 1513. *Synapturanus* Carvalho, 1954 (Amphibia, Anura): *Synapturanus mirandaribeiroi* Nelson & Lescure, 1975 designated as the type species. *Bulletin of Zoological Nomenclature, 45*, 243.

ICZN. (1997). Opinion 1873. Hemidactyliini Hallowell, 1856 (Amphibia, Caudata): conserved. *Bulletin of Zoological Nomenclature, 54*, 140–141.

ICZN. (1999). *International code of zoological nomenclature* (4th ed.). London: International Trust for Zoological Nomenclature.

ICZN. (2001). *Rana cryptotis* Boulenger, 1907 (currently *Tomopterna cryptotis*; Amphibia, Anura): specific name given precedence over that of *Chiromantis kachowskii* Nikolsky, 1900. *Bulletin of Zoological Nomenclature, 58*, 243–244.

Keller, R. A., Boyd, R. N., & Wheeler, Q. D. (2003). The illogical basis of phylogenetic nomenclature. *The Botanical Review, 69*, 93–110.

Largen, M. J., & Borkin, L. J. (2000). Case 3134. *Rana cryptotis* Boulenger, 1907 (currently *Tomopterna cryptotis*; Amphibia, Anura): proposed precedence of the specific name over that of *Chiromantis kachowskii* Nikolsky, 1900. *Bulletin of Zoological Nomenclature, 57*, 32–35.

Laurin, M., de Queiroz, K., Cantino, P., Cellinese, N., & Olmstead, R. (2005). The PhyloCode, types, ranks and monophyly: a response to Pickett. *Cladistics, 21*, 605–607.

Laurin, M., de Queiroz, K., & Cantino, P. D. (2006). Sense and stability of taxon names. *Zoologica Scripta, 35*, 113–114.

Lidén, M., Oxelman, B., Backlund, A., Andersson, L., Bremer, B., Eriksson, R., et al. (1997). Charlie is our darling. *Taxon, 46*, 735–738.

Loveridge, A. (1957). Check list of the reptiles and amphibians of East Africa (Uganda; Kenya; Tanganyika; Zanzibar). *Bulletin of the Museum of Comparative Zoology, Harvard, 117*, 153–362.

McNeill, J., Barrie, F. R., Burdet, H. M., Demoulin, V., Hawksworth, D. L., Marhold, K., et al. (Eds.). (2006). *International code of botanical nomenclature (Vienna Code) adopted by the seventeenth international botanical congress, Vienna, Austria, July 2005*. Königstein: Koeltz.

Moore, G. A. (1998). A comparison of traditional and phylogenetic nomenclature. *Taxon, 47*, 561–579.

Nemésio, A. (2009). Nomenclatural availability of nomina of new species should always require the deposition of preserved specimens in collections: a rebuttal to Donegan (2008). *Zootaxa, 2045*, 1–14.

Noble, G. K. (1924). Contributions to the herpetology of the Belgian Congo based on the collection of the American Museum Congo expedition, 1909–1915. Part III. Amphibia. *Bulletin of the American Museum of Natural History, 49*, 147–347. pl. 23–42.

Ohler, A. (2003). Revision of the genus *Ophryophryne* Boulenger, 1903 (Megophryidae) with description of two new species. *Alytes, 21*, 23–44.

Ohler, A. (2007). New synonyms in specific names of frogs (Raninae) from the border regions between China, Laos and Vietnam. *Alytes, 25*, 55–74.

Ohler, A., & Delorme, M. (2006). Well known does not mean well studied: morphological and molecular evidence for existence of sibling species in the Javanese gliding frog *Rhacophorus reinwardtii* (Amphibia, Anura). *Comptes rendus biologies, 329*, 86–97.

Ohler, A., & Dubois, A. (1999). The identity of *Elachyglossa gyldenstolpei* Andersson, 1916 (Amphibia, Ranidae), with comments on some aspects of statistical support to taxonomy. *Zoologica Scripta, 28*, 269–279.

Ohler, A., & Dubois, A. (2006). Phylogenetic relationships and generic taxonomy of the tribe Paini (Amphibia, Anura, Ranidae, Dicroglossinae), with diagnoses of two new genera. *Zoosystema, 28*, 769–784.

Passmore, N. I., & Carruthers, V. C. (1979). *South African frogs*. Johannesburg: Witwatersrand University Press.

Pickett, K. M. (2005a). The new and improved PhyloCode, now with types, ranks, and even polyphyly: a conference report from the First International Phylogenetic Nomenclature Meeting. *Cladistics, 21*, 79–82.

Pickett, K. M. (2005b). Is the PhyloCode now roughly analogous to the actual codes? A reply to Laurin et al. *Cladistics, 21*, 608–610.

Pleijel, F. (2005). Le projet de "Phylocode" et la nomenclature des taxons supérieurs. *Biosystema, 23*, 67–71.

Poynton, J. C., & Broadley, D. G. (1985). Amphibia Zambesiaca. 2. Ranidae. *Annals of the Natal Museum, 27*, 115–181.

Simpson, G. G. (1940). Types in modern taxonomy. *American Journal of Science, 238*, 413–431.

Simpson, G. G. (1961). *Principles of animal taxonomy*. New York: Columbia University Press.

Werner, F. (1923). Zur Systematik der Amphibiengattung *Chiromantis* Peters. *Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, 72*, 62–66.

Winker, K. (2004). Natural history museums in a postbiodiversity era. *BioScience, 54*, 455–459.