

## REVIEW

## What is an 'extant' type specimen? Problems arising from naming mammalian species-group taxa without preserved types

Ronald H. PINE *Biodiversity Institute & Natural History Museum, University of Kansas, Lawrence, KS 66045, USA. Email: ronpine@mac.com*

Eliécer E. GUTIÉRREZ\* *Programa de Pós-Graduação em Biodiversidade Animal, Centro de Ciências Naturais e Exatas, Av. Roraima n. 1000, Prédio 17, sala 1140- D, Universidade Federal de Santa Maria, Santa Maria, RS 97105-900, Brazil and Division of Mammals, National Museum of Natural History, NHB 390, MRC 108, Smithsonian Institution, P.O. Box 37012, Washington, DC 20013-7012, USA. Email: ee.gutierrez.bio@gmail.com*

### Keywords

ICZN, illustrations, mammals, species descriptions, taxonomy

\*Correspondence author.

Submitted: 21 March 2017

Returned for revision: 21 April 2017

Revision accepted: 3 July 2017

Editor: DR

doi: 10.1111/mam.12108

### ABSTRACT

1. The International Code of Zoological Nomenclature allows the naming of new species without a type specimen ever having been preserved. This practice causes problems and is undesirable because if related, cryptic, sibling species are encountered later, it may not be possible either to allocate them with certainty to the earlier named species, or to determine them to be something different.

2. We hypothesised that examination of the instances in which mammalian species were named without preserved types would reveal certain problems that are not unique to them, but are encountered more frequently than when types are preserved. We also thought the Code's stipulation that preserved types are not required in the case of specimens that are no longer 'extant' would present special problems hitherto unremarked upon in the literature.

3. We conducted a review of cases involving putative new species of mammal named since 1900. These were analysed to see what special problems they present and the frequency of such problems.

4. We found that the Code's waiver of the requirement that a type specimen be deposited in a collection if the specimen is no longer extant presents numerous problems—in particular, that a living-at-large type specimen can still be 'extant' even if its whereabouts are unknown at certain times and/or it may no longer be alive. Illustrations alone being used to designate type specimens is especially problematic, owing to mammals' lack of meristic and other obvious distinguishing external characters. Hoaxes, the difficulty in determining that they are hoaxes, and various errors of taxonomic allocation appear to be especially common with names without preserved types. The Code should be revised to require preserved specimens as types for new names. Tissue samples alone for DNA analysis are not ideal for serving this purpose, but should be allowed to meet the requirement.

## INTRODUCTION

The type of secured material evidence to be deemed acceptable and sufficient when a new scientific name is assigned to an alleged new species is not a trivial matter. Such evidence must be re-examinable to serve as the linkage between the alleged new species and the new name. This linkage allows replication of the observations leading to conclusions, such replicability being one of the hallmarks of good, falsifiable science. The evidence in question should include a preserved type specimen—also known as an onymophoront (Dubois 2005)—which becomes the name-bearer of the species being described. Preserved type specimens (even if severely deteriorated) are tangible biological materials that, in most cases, allow access to information (via computerised tomography scanning, massive parallel DNA sequencing, etc.) that might not have been reported in the original description. Unfortunately, on occasion, the preserved type specimens have been lost (for reasons ranging from wars to natural disasters and even governmental negligence; see Gutiérrez & Lattke 2016). Regrettably, some species' descriptions have been published without a type specimen ever being preserved. This is detrimental to science for a number of reasons, among them are that it can (1) hinder identification (and therefore use) of additional specimens, especially if cryptic or very similar species exist (a possibility that cannot be ruled out *a priori*; Gutiérrez & Pine 2017); (2) prevent taxonomic descriptions of additional and phenotypically similar new species (see discussions presented by Peterson 2014 and Gutiérrez & Pine 2017); and (3) preclude assessments of the phylogenetic position of the alleged new species, which compromises its correct allocation into supraspecific taxonomic ranks (e.g. Jones et al. 2005, see Davenport et al. 2006). In the simplest case, if the taxonomic identity of an organism cannot be determined with confidence, due to the lack of preserved type specimens with which it could be compared thoroughly (if necessary), then that organism could not be used for certain research activities, or its use might decrease the reliability of the results obtained. This represents an impediment to the design and development of research in ecology, evolution, behaviour, conservation biology, parasitology, and public health (e.g. development of new medicines), among other fields.

These facts seem to have been ignored by Marshall and Evenhuis (2015), Pape et al. (2016), Thorpe (2017), and Garraffoni and Freitas (2017), who recently published arguments in favour of regarding species-group names as available, as they are under the current (fourth) edition of the International Code of Zoological Nomenclature (hereinafter, the Code; ICZN 1999), in cases in which a preserved specimen has never been, at any time, in existence to serve as a holotype. These are only four examples

of numerous published opinions of late, pro and con, on the desirability of doing this (e.g. Wakesham-Dawson et al. 2002, Jones et al. 2005, Landry 2005, Polaszek et al. 2005, Timm et al. 2005, Davenport et al. 2006, Dubois & Nemésio 2007, Peterson 2014, Amorim et al. 2016, Löbel et al. 2016, Santos et al. 2016, Dubois 2017, Rogers et al. 2017). We concur with the recent commentary by Ceriaco et al. (2016), contrary to this practice, and signed by 493 practitioners of museum-based research, and our discussion can be taken as supplementary to theirs. We document the relevance of this issue to mammalogy, with examples of mammalian species described without preserved type specimens since the beginning of the 20th century.

We also point out and document various other problems caused by the naming of new species or subspecies without preserved types. Some of these problems have been previously little discussed, and one serious issue, that of what constitutes an 'extant' type specimen, has never been discussed in depth to our knowledge, although the existence of some difficulties with the word has been noted by Dubois (2017). We predicted that if we examined all the cases that we could find in which new species-group names have been proposed for mammals, without preserved type specimens having been saved, since 1900, we would find a higher than usual frequency of problems associated with application of those names subsequent to publication.

## METHODS

Utilising our previous knowledge of the literature and also citations that we could find to publications outside of our previous knowledge, we amassed as many cases of new mammalian species-group names as we could that had been first published since 1900. In addition to our heuristic efforts to review the literature, we inquired of the community of mammalogists at large, concerning known cases matching our criteria. These inquiries were sent to Mammal-L (a mailing list for discussion of topics in mammalogy with 1075 members; <http://www.lsoft.com/scripts/wl.exe?SL1=MAMMAL-L&H=SI-LISTSERV.SIEDU>) and to the Neotropical Mammalogy Facebook group (a social media group for discussion and dissemination of information on research on Neotropical mammals, with more than 4000 members; <https://www.facebook.com/groups/192466010712/>), and dozens of colleagues were contacted via email. We then tracked, through the subsequent literature, the fate of those names and the history of the taxonomic determinations as to their applicability, looking especially for problems that arose in these cases. We also conducted 'thought experiments' concerning likely events that would have the potential to cause various problems as to the nomenclatural availability of names,

owing to the Code's use of the term 'extant' as it relates to type specimens.

## RESULTS

Table 1 lists species-group names we have found, in Mammalia, published since 1900, for which no preserved specimens were deposited in collections, not even tissue, including blood, at the time of the original description. Of the 12 supposed taxa that were named as full species, two were based on hoaxes, one almost certainly was, and one may have been; thus fully one third were or may have been hoaxes, and one quarter of the total number (16). Although hoaxes can be perpetrated whether specimens are saved or not, in cases where there have been preserved holotypes, they can be examined and shown to be bogus, while uncertainty is likely to reign when this has not occurred (*contra* Thorpe 2017). Examination of holotypes made the eventual discrediting of Piltdown Man and the Charlton Brimstone Butterfly possible, while discrediting *Ameranthropoides loysi* and ascertaining its identity (see Table 1) were more complicated. This last case was used in support of Nazi racism and this was apparently its motivation (Vilorio et al. 1998). The Piltdown Man hoax took such a long time to be exposed largely because access to the type material was made so difficult for so long, making the phony taxon, in effect, a named supposed species without a preserved holotype for a considerable period. Mammals, especially those in the family Hominidae, are especially likely to be hoaxed, for sensationalist reasons. We have not made an exhaustive search for cases of hoaxes with preserved type specimens since the time of Linnaeus, but we know only of Piltdown Man and the Charlton Brimstone Butterfly. However, in addition to the cases of the Minnesota Iceman *Homo pongoides* and *Ameranthropoides loysi*, two hoaxes perpetrated in the 20th century without preserved types, we have names of 10 mammals, two birds, at least 11 and possibly 14 fishes, a three-shelled animal, and three snails involved in hoaxes perpetrated by Audubon on Rafinesque in the 19th century (Woodman 2016). An apparently hoaxed parrotlet was also named from a photo in 2010 (see Donegan et al. 2011). The case of *Nessiteras rhombopteryx*, a name for the Loch Ness Monster, is notorious. Not only may fraudulent names be determined to be so if preserved type specimens were kept, but apparently the urge to perpetrate frauds is more frequently engaged in the absence of such specimens.

Half of the remaining cases listed, aside from the known, probable, or possible hoaxes, have also presented problems—a poor track record for 'typeless' taxa (Table 1, including footnotes). These include one junior synonym, one species deserving its own new genus but being put

in an unrelated and previously known genus until an actual specimen became available, two taxa proposed as subspecies but apparently representing new species, one for which the generic status is unknowable at this point, and one proposed provisionally and thus unavailable according to the Code. These constitute merely the problems which have become apparent as of this date. Others may yet become known of the remaining cases.

## DISCUSSION

According to the Code, Article 72.5.6., if there is a species-group name based on an illustration or description, the "...name-bearing type is the specimen or specimens illustrated or described (and not the illustration or description itself)." A specimen being illustrated and a specimen being described are thus listed, by the Code, in coordinate fashion. Therefore, it is clear, from this wording alone, that a mere description of a specimen, in the absence of an illustration, can be, in and of itself, enough to identify and legitimise a holotype, without that individual being saved as a specimen—at least according to the interpretation put on the Code by those who say that no specimen needs ever to have been preserved to serve as the holotype. After all, if this language of the Code permits a species to be named on the basis of a picture, with no preserved specimen being necessary, then that exact same language would apply to a mere description of an individual not saved as a preserved specimen as well. Thus, any individual animal observed in the course of someone's hike in the woods and briefly and inexactly described in print could legitimately be regarded as a holotype for an available name. This fact seems to have been widely overlooked. Presumably also, in the case of an illustration, any sort should serve, such as a rough sketch done from memory. In fact, as recently as in 2011, the shrew *Diplomesodon sonnerati* was named from an extremely crude pen-sketch and a brief text obtained from an unpublished manuscript written by the French naturalist Pierre Sonnerat, and based on observations he made in southern India from 1786 to 1813 (Cheke 2011, Table 1). Awareness that the current language of the Code has been used to justify species descriptions based on any sort of illustration, and that it could also be used to name species based only on verbal narratives is especially important because much of the controversy vis-à-vis descriptions naming species without a preserved type specimen seems, inexplicably, to treat the issue as if it concerns only photographs—and especially good ones at that. Much wasted verbiage has been published concerning the utility of photographs and whether or not the information provided about a particular individual is sufficient to make it serve as a holotype. The real issue is what the Code's minimum requirements should

**Table 1.** Species and subspecies of mammals described without preserved specimens\* since 1900. (This list is probably incomplete.)

Order	Name originally assigned	"Type Evidence"	Description	Currently accepted name	Source of currently accepted name
Eulipotyphla	<i>Diplomesodon sonnerati</i>	Sketch	Cheke (2011)	—	—
Primates	<i>Ameranthropoides loysi</i> [a hoax involving a species name, generic, and family names]	Photograph	Montandon (1929)	<i>Ateles hybridus</i>	Urbani and Vilorio (2008); not Kellogg and Goldman (1944) or Vilorio et al. (1998)
Primates [ichnotaxon]	<i>Anthropoidipes ameriborealis</i> [ichnospecies and ichnogenus ascribed to presumably faked "bigfoot" tracks]	Plaster casts and photographs	Meldrum (2007)	—†	—
Primates	<i>Avahi cleesei</i>	Photograph	Thalmann and Geissmann (2005)	<i>Avahi cleesei</i>	Rumpler et al. (2011)
Primates	<i>Cebus queirozi</i>	Photograph	Mendes Pontes et al. (2006)	<i>Cebus (Sapajus) flavius</i> ‡	de Oliveira and Langguth (2006)
Primates	<i>Cercocebus galeritus sanjei</i>	?	Mittermeier (1986)	<i>Cercocebus sanjei</i>	Ehardt and Butynski (2013)
Primates	<i>Homo pongoides</i> [hoax perpetrated on describer]	Drawings, photographs	Heuvelmans (1969)	— §	—
Primates	<i>Lophocebus kipunji</i>	Photograph	Jones et al. (2005)	<i>Rungwecebus kipunji</i>	Davenport et al. (2006)
Primates	<i>Macaca leucogenys</i>	Photograph	Li et al. (2015)	<i>Macaca leucogenys</i>	Fan et al. (2017)
Primates	<i>Macaca munzala</i>	Photograph	Sinha et al. (2005)	<i>Macaca munzala</i> ¶	Fan et al. (2017)
Primates	<i>Miopithecus ogouensis</i>	Coloured drawing	Kingdon (1997)	<i>Miopithecus ogouensis</i> **	Gautier-Hion (2013)
Primates	<i>Presbytis johnspinali</i>	Photographs found on Internet	Nardelli (2015)	? ††	—
Primates	<i>Saguinus fuscicollis cruzlimai</i>	Painting	HersHKovitz (1966)	<i>Saguinus (Leontocebus) cruzlimai</i>	Sampaio et al. (2015)
Primates	<i>Sciurocheirus makandensis</i>	Photographs	Ambrose (2013)	— ‡‡	—
Proboscidea	<i>Elephas maximus borneensis</i>	Photograph	Deraniyagala (1950)	— §§	—
Proboscidea	<i>Elephas maximus sondaicus</i>	Carving	Deraniyagala (1950)	— §§	—

\*Some species have been described and only hair, blood, or other tissue samples were preserved (for molecular analyses); the animals from which these samples were obtained were released (e.g. several lemurs; Thalmann & Geissmann 2005, Louis et al. 2006). This table does not deal with this type of case, and includes only taxonomic descriptions in which absolutely no biological material was preserved to serve as holotype.

†Original 'tracks' in sand not stabilised and saved. Name excluded from provisions of the Code because if the tracks were legitimate, they would be the work of an extant kind of animal—names for which are excluded if published after 1930—(Art. 1.3.6.).

‡See Gutiérrez and Marinho-Filho (2017 and references therein) for arguments in favour of using *Sapajus* as a subgenus of *Cebus* (contra Lynch-Alfaro et al. 2012a,b, 2014) as well as for arguments in favour of using *Leontocebus* as a subgenus of *Saguinus* (contra Sampaio et al. 2015, Rylands et al. 2016).

§The first author has seen correspondence between John R. Napier, Ivan T. Sanderson, S. Dillon Ripley II, and J. Edgar Hoover, stating that dog tissue was used in the construction of this otherwise non-animal-based fraudulent holotype, so the name can be taken to be a junior synonym of *Canis lupus familiaris*.

¶Biswas et al. (2011), before additional evidence became available concerning the status of this animal, stated that its name was a junior synonym of *Macaca assamensis*.

\*\*Apparently proposed conditionally and therefore not available.

††It is currently unresolved whether the name is based on artificially modified animals or individuals of a new or already known species, and to what genus the animals belonged. See Nardelli (2015), Butler (2015), Dasgupta (2015), Nijman (2015), Nardelli (2016).

‡‡Paper cited by author of name contains photograph but not designated as type; other individuals discussed.

§§We could not obtain a copy of Deraniyagala (1950), where, according to Cranbrook et al. (2007), were described both *Elephas maximus borneensis* and *Elephas maximus sondaicus*. Cranbrook et al. (2007) stated that Deraniyagala (1950) employed an illustration published by the National Geographic magazine and the following statement from Hubback (1942) to describe *Elephas maximus borneensis*: "...many, possibly most of the mature male elephants in Borneo have very straight tusks and do not conform with the usual curved tusks of *Elephas maximus*." Cranbrook et al. (2007) also stated that "...the now extinct Asiatic elephant of Java which was named *Elephas maximus sondaicus* by Deraniyagala (1950, in Deraniyagala 1951: 50) [...] choosing as type an illustration of a carving on the 8–9th century Buddhist monument of Borabudur." Whether the illustration just mentioned depicted a particular specimen is an open question (see Cranbrook et al. 2007). If so, then that specimen might represent the type of *sondaicus*.

be for a specimen, claimed to be a holotype, to make a name available. A hypothetical example of a designation by description, of a holotype, that could make a name available would be “Holotype: male with antlers at least 15 cm long and with two white spots on right haunch. Not captured: unable to take photograph.” A description of the same general sort would suffice for a fossil designated as a holotype and permanently left *in situ* in the field. One wonders if the current difficulties faced in many places by those seeking permits to collect fossils, along with squabbles over ownership of especially valuable and important ones, might result in such designations, if they haven’t already. A declaration published by Commissioners of the ICZN (2017) recommends certain actions, e.g. obtaining “comprehensive iconography” and consulting with specialists, when one is planning to describe a new species or subspecies without preserved specimens. However, these and similar comments (see Santos et al. 2016) are just suggestions that anyone is free to ignore, and doing so would not violate the current version of the Code. Unfortunately, nothing in this declaration of the ICZN’s Commissioners suggests that descriptions of new species or subspecies lacking preserved specimens will not be allowed in the upcoming fifth version of the Code (currently in preparation).

Although taxonomists are accustomed to thinking of the word specimen as applying to dead animals, to portions of them, or to never-previously-living ‘work’ or traces of animals, apparently as far as the current Code is concerned, a specimen, including a type specimen, can be a living animal. One early precedent is the wild ox known as the kouprey *Bos sauveli* Urbain 1937, which, when described, had, as holotype, a living animal in the Vincennes Zoo, Paris, France (Urbain 1937). A more recent example is Goodman’s mouse lemur *Microcebus lehilahytsara* Roos and Kappeler 2005, which, when described, had, as type series, nine living animals kept at the Zürich Zoo, Switzerland (Kappeler et al. 2005). In both examples, the animals that served as holotypes were clearly confined, but we can find nothing in the Code that says that the term specimen cannot be applied to a living animal at large. This fact was taken advantage of when the monkey called the kipunji, now known as *Rungwecebus kipunji* (Jones et al. 2005), was named in 2005, the holotype being declared to be a free-ranging, living animal depicted in a photograph (see Jones et al. 2005, Davenport et al. 2006). This is not the only primate species name based on no preserved holotype (Table 1), and recently, in a celebrated case, the bombyliid fly *Marleyimyia xylocopae* Marshall & Evenhuis 2015 was named with the holotype being a photographed and described individual which escaped before it could be killed and preserved. Animals in various other non-mammalian groups could also be

cited as having been treated similarly. The recently published declaration by Commissioners of the ICZN [International Commission on Zoological Nomenclature] (2017) recommends adding the following definition of “preserved specimen” to the glossary of the Code: “a non-living specimen that is deposited in a scientific collection with the intention to keep it for further study”. Regardless of whether this definition is added to the upcoming version of the Code, the addition would have no effect on the matter herein discussed unless the new version of the Code requires at least one preserved specimen for each name of a new species or subspecies.

The Code seems to take for granted that any figure of a kind of animal must be a picture of an actual individual or individuals of that species—an individual or individuals which could be designated as a type or types. That this is not so is illustrated by the name *Elephas maximus sondaicus* Deraniyagala. According to Cranbrook et al. (2007: 98) this name is based on Deraniyagala’s “choosing as type an illustration of a carving on the 8–9th century Buddhist monument of Borabudur.” The type would presumably be the animal depicted in the carving, but it is highly probable that no particular individual was figured by the sculptor, it being merely his or her impression of what an elephant looks like, based on many elephants seen during his or her lifetime. If one wishes to accept this assumption, then there was no actual type designated.

Also according to the Code, Article 16.4., “Every new [...] name published after 1999 [...] must be accompanied in the original publication [...] where the holotype or syntypes are extant specimens, by a statement of intent that they will be (or are) deposited in a collection and a statement indicating the name and location of that collection...” We see no alternative but to interpret the word ‘extant’ in this statement to mean extant at the time of publication. Santos et al. (2016) confounded the concept of an extant type specimen with an extant taxon, when they wrote that Article 16.4 of the Code states that “... only holotypes of extant taxa should be housed in a public scientific collection [sic]. *Marleyimyia xylocopae* is obviously an extant species. Accordingly, its type specimen should be deposited in a scientific collection.”

The word extant means, unequivocally, still existing. The Code itself, in the glossary, defines the word, as it applies to a specimen, as one “still in existence.” If a living animal, in captivity or in the wild, can be a specimen, and, more to the point, a type specimen, then that individual will certainly be extant until it dies. In the rules of nomenclature, dead individuals can be specimens, and, more to the point, they can be type specimens. Therefore, after death, an animal can remain a specimen until such time as it is completely eaten and digested,

including its hard parts, by a predator or scavenger; consumed by fire; completely decomposed to unidentifiable morphological components; etc. Thus, according to the language of the Code, a holotype may continue to exist, in nature, for an interminable period of time, outside of the ken of any scientists. Also, although roaming free, an individual animal designated as a holotype may have a unique combination of features making it unequivocally identifiable. It may have been tagged or supplied with a radiotelemetry device; it may be of such a size, or have such indestructible hard parts, or be so limited in its home range by environmental requirements or physical barriers, or be so frequently observed by wildlife managers, that the likelihood of it ending up as a specimen in a designated museum could be assured, and the intention for this to happen could be stipulated in its description. This scenario is especially plausible in the case of medium-sized to large terrestrial members of the class Mammalia. Also, specimens, both living or dead, or living and then dead, can be thought to be irretrievably lost or destroyed, but then be recaptured or found again at a later date. Or there may be reason to believe that they may have been lost or destroyed but no one has any basis to form a firm opinion concerning this. Although someone may argue that the authors of the Code may have intended “not extant” to mean “stated by the authors, in the original publication, to be and presumably still believed to be, at the time of publication, permanently lost, irretrievable, or completely destroyed”, the Code says no such thing. Marshall and Evenhuis (2015) simply discount the actual meaning of the word extant as it is defined by the Code itself, and state that extant means not “lost, escaped, or purposely released”, in order to justify their positions and actions. Ride (1999: p. XXVII), in the non-binding Introduction to the Code, mistakenly thought that extant was simply a synonym for preserved, when he wrote “When the name-bearing type of a species-group taxon proposed after 1999 consists of a preserved specimen or specimens, the proposer is required to include a statement naming the collection in which the name-bearing type is or will be deposited.” This statement was taken by Wakesham-Dawson et al. (2002: 283) as showing that “a dead type specimen is not essential under the Code.”

Many authors refuse to accept the definition of “not extant” as used by Marshall and Evenhuis (2015) and, logically enough, believe that holotypes that have been released into nature alive continue to be extant after release. They demonstrate this by equipping the released holotypes with identifying marks or tags so that they can be recognised in future. Lei et al. (2015) marked the released, living portion of their dwarf lemur holotype (tissues were saved) with a subcutaneous microchip so that the animal could be identified if captured again. Gentile and

Snell (2009) marked the released, living portion of their holotype of a new species of iguana by branding it and equipping it with a transponder. They note that “These redundant, permanent identification marks will insure identification of the Holotype” [sic]. They also state that if the population of their new species appears to be increasing, the holotype will be recaptured and kept in captivity until it dies, at which time it will be deposited in a collection that they have already designated (see Dubois 2009 for a further discussion of this case). Clearly these authors take seriously the introduction to the Code (p. XXVII), where it says “After 1999 the proposal of a new species-group nominal taxon must include the fixation for it of a name-bearing type (a holotype or expressly indicated syntypes) in a manner that enables the subsequent recognition of that type.”

The Code nowhere requires that a new species-group be provided with a holotype. Syntypes, of any number, will serve. Therefore, an entire herd of free-living ungulates could be photographed and all declared to be syntypes. Does anyone seriously believe that as soon as the photograph is taken, that herd ceases to be extant? In the Salish Sea, North America, there are pods of orcas known as Pods J, K, and L. They comprise what is known as the “Southern Resident Community” of orcas. At last count, there were 80 individuals in the community. Each individual is recognisable from photographs and has been assigned a number by those studying and monitoring this community. If a photograph of each one appeared in a publication naming them as a new species or subspecies, a proposition not completely out of the question based on what is now suspected about the lack of conspecificity in what is now called *Orcinus orca* (Pitman & Ensor 2003, Morin et al. 2010), and all were designated as syntypes, would they then become non-extant? Any scientist regularly monitoring this population would regard such a designation as preposterous, and we do as well.

With regard to the names above, based, in part, on preserved blood or other tissue samples, we see no option but to regard those as being sufficient to serve as physical, morphological or anatomical type specimens. This kind of physical specimen is clearly far from being ideal, as it does not allow morphological diagnoses; however, it would be impractical for the Code to try to specify how much of an animal would have to be preserved to constitute a saved specimen. Samples that have been completely destroyed in the process of sequencing would no longer be extant, however.

Some may argue that there is a big difference between the extent to which a released fly and a monitored community of orcas can be considered extant. However, one rule would have to hold for both, because all degrees of being extant could exist between those extremes, and the

Code could not draw lines between classes of that condition.

The Code clearly states that if a type specimen is extant, and the author does not provide the name and location of a collection in which the specimen is housed, or state his or her intention to deposit the specimen in such a designated collection, the name is unavailable. We see no escape from the conclusion that the Code is saying, among other things, that if there is a living or dead, but not completely destroyed, extant holotype out there in nature somewhere, and the describer fails to state that it is his or her intention to recapture the individually recognisable (same) specimen or find its remains and donate it or them to some designated collection in some designated location, then the name is unavailable. This means that various names that have been based on living individuals left at liberty (deliberately or not) for which no such statement was provided are unavailable, unless it can be shown somehow that the individual died and decomposed completely or was otherwise obliterated before the name was published. Uncertainties with regard to such events are such that they cannot, in almost all cases, be sorted out, and expending efforts to do so would be absurd. The fact that such unavailable names are now being accepted as available in the literature — unaccountably with the support of some of the Commissioners of the ICZN (see Pape et al. 2016), and some names have been so treated for some time — presents serious problems for the stability and integrity of nomenclature. It is clear that the current language of the Code, coupled with the practice of naming animals without preserved specimens having been in existence at any time, has created an untenable situation.

Let us suppose that the author of a species-group name has released into the wild an animal to be designated as the type specimen, and that the fact of its no longer being in sight at the time that the description is published is claimed, in and of itself, sufficient for the specimen to meet the definition of no longer being extant. Therefore, the Code's requirement that the holotype be said to be destined for preservation in a specified collection is to be waived. This author would have us regard his or her name as being available. But then suppose that someone encounters this holotype alive and well or very freshly dead subsequent to the description being published and demonstrates, beyond question, that it is the same individual, and perhaps even then preserves it for deposition in a museum. Clearly, the holotype has now been shown to have actually been extant at the time of publication, and now everyone would seem to have no choice but to regard that name as unavailable. Such a scenario is not in the least unlikely in the case of, say, a fair-sized vertebrate, especially one in a small population in a circumscribed area, perhaps one that has come to be under intense

observation owing to its appearing to be endangered. Of course, the author of a species-group name for an animal that has been released can always state, in the animal's description, that it is his or her intent to deposit the specimen in a specified collection, even in cases in which the author knows that this event will be impossible or exceedingly unlikely, and thereby assure that the name will not be regarded as unavailable owing to the failure to express such an intent.

Here is a specific example of the sort of problem that can arise as the result of the current language of the Code. Van Roosmalen and van Hooft (2013) named a supposedly new species of large South American caviomorph rodent *Agouti silvagaraciae*. In the original description, it was stated that the holotype, a severed head preserved in spirit, which then became a skull, was in the possession of hunters in a remote village in the Amazon Basin of Brazil. As we understand it, owing to difficulties with the Brazilian authorities, van Roosmalen himself is forbidden to visit the village to retrieve the specimen, although if it is still in the possession of the hunters, someone else could presumably do so one day. Van Roosmalen and van Hooft did not specify a museum to which it was their intent that the specimen would be donated. So is the name available? If it can be shown that the hunters had, say, eventually thrown the skull in a fire, to dispose of it, before the name was published, then the name is available. If, however, it can be shown that it was still extant at the time of publication, then the name is unavailable. If, at some time in the future, it seems clear that the specimen is no longer extant and it is unclear whether it became so before or after the name was published, then its status would be undeterminable—and its status is unknown today.

In an informal non-binding asseveration by the International Commission on Zoological Nomenclature (ICZN, unknown year of publication) concerning what is allowable under the Code, and, in answer to the question “Can a photograph or holograph [presumably meaning a hologram] be a type specimen?” we read, as a justification for an actual preserved specimen never having been necessary at any point in history when one is naming a new species, a statement that cites the irrelevant fact that current existence of such a specimen is unnecessary. The text goes on to say that:

“While it is highly desirable to have a type specimen or part of a specimen permanently deposited in a museum or other publicly available collection, very occasionally it may be impractical, for example if it is unethical to kill or injure a highly endangered mammal. Other forms of evidence e.g. photographs, sonograms, may contribute to an original description in demonstrating that a type specimen existed, where

the type specimen has to be released live. In these situations it is not necessary to deposit types in a Museum—the statement of intent to deposit types in a collection required for new species names published after 1999 is only necessary where types are extant.”

What is it that keeps any author, say one opposed to any killing of any animal for any reason, from claiming that all of his or her new species, including ones that are clearly under no threat whatsoever, are highly endangered and therefore no preserved holotypes are necessary? Who is empowered to adjudicate the legitimacy of such claims? Why can't we wait until dead pieces of the animals become available somehow or just use vernacular names until then? According to the current wording of the Code, and according to the interpretation given to that wording by some, anyone, for any reason, stated or unstated, can claim that his or her new species-group name is available, based on an individual animal or animals at large, described or figured in even the most perfunctory fashion. No justification needs to be provided for this action, in relation to endangerment or anything else.

Article 16.4 of the Code, insofar as it says that a described or illustrated animal can serve as a type, whether or not the specimen is still extant, has been taken by many to refer to a dead and preserved specimen that was in existence but has been lost or destroyed, and not to a free-living animal in nature. However, the Code does not restrict the definition of a specimen to preserved dead animals; its Glossary defines a specimen as “An example of an animal, or a fossil or work of an animal, or of a part of these. See Article 72.5 for the kinds of specimen eligible to be name-bearing types of nominal species-group nominal taxa”, and there is nothing in Article 72.5 that precludes a living animal from serving as a type.

The current flurry of publications (both original research articles and in correspondence) dealing with the issue of new names without preserved types has no doubt called it to the attention of many zoologists who were previously unaware of the possibility and/or the unfortunate arguments being made in its favour (e.g. Donegan 2008, Marshall & Evenhuis 2015, Pape et al. 2016, Garraffoni & Freitas 2017, Thorpe 2017). It seems likely that this will result in a substantial increase in the percentage of new names published without preserved types, especially as the Anthropocene, with its increased rate of animals becoming endangered, will seem to make the arguments for releasing types into nature more compelling. Thus, zoologists will be wilfully creating countless unfortunate situations, actually recognised as such by the Code, and for which the Code's prescribed remedy is the designation of neotypes. Neotypes are to be designated for the express purpose of remedying the situation of there being no preserved types,

clearly an unsatisfactory situation according to the Code, although its creation is condoned by the Code. There are certain “qualifying conditions” when neotypes are to be regarded as validly designated, but in many and perhaps most cases these conditions would be met. In many cases, whether they had been or not would be debatable, and this would cause unfortunate uncertainties and a lack of consensus. One could only hope that authors of the burgeoning neotype-designation literature would, in most cases, choose the same species for a neotype as that chosen in the original description (see Gutiérrez & Pine 2017 for a discussion as to why this might be difficult). We can now foresee a plethora of new neotype designations, as dead individuals become available.

The issue of a preserved holotype seems to be of special relevance to mammals. They have few or no meristic characters, no characteristic scale patterns, no wing venation, and no plumage that may show marked differences. The lack of diagnostic external features of genera and species, coupled with the frequency of considerable individual variation in the quality and colour of pelage, owing to many factors, maximises the possibility of additional species, indistinguishable externally from a merely figured or described holotype, eventually being recognised. Specialists on many groups of small mammals, in particular, should find this statement undeniable. To name new species of Neotropical sigmodontine rodents, in many genera, on the basis of descriptions or figures alone would clearly be sheer folly. Hershkovitz (1960), a pre-eminent authority on Neotropical mammals, though in possession of both skins and skulls, treated what are now recognised as several genera and numerous species of sigmodont rodents (see Musser et al. 1998, Weksler et al. 2006) as constituting a single species, '*Oryzomys capito*,' and he was followed in this by a number of subsequent authors.

## RECOMMENDATIONS

We recommend that new species-group names be regarded as available only for animals for which there is or has been a preserved anatomical specimen, designated as a type in the description; or a living animal in captivity at the time of publication, designated as the type, and from which an anatomical specimen can be almost certainly be assured in the future (but see Dubois & Nemésio 2007, p. 13); or an unrestrained individual animal, designated as the type, and from which an anatomical specimen will almost surely become available in the future. For preserved anatomical specimens already deposited in a collection, the name and specified location, such as a city, of the institution must be given. In all other cases, except for no longer existing preserved anatomical specimens, the description must contain a statement of intent that the

specimen will become part of a collection of a designated institution in a specified location, such as a city. If they are ever needed, exceptions to this proposed regulation might be implemented either via plenary powers of the International Commission of Zoological Nomenclature (see Faúndez 2017), or with the establishment of an international body of experts to evaluate specific justifications, on a case-by-case basis, of authors' petitions for exceptions (Dubois & Nemésio 2007, Dubois 2017). Recourse to such alternatives should be avoided as much as possible. Supposedly new species could be referred to by vernacular names until a preserved specimen becomes available and can serve as a holotype (Ceríaco et al. 2016), thus enabling proper taxonomic description without further taxonomic work being potentially obstructed (Gutiérrez & Pine 2017).

## ACKNOWLEDGEMENTS

We thank Robert M. Timm (University of Kansas, USA) for having made suggestions for the manuscript, Beverly A. Morey of Lawrence, Kansas, for helping with other aspects of the manuscript; and Guilherme S. T. Garbino (Universidade Federal de Minas Gerais, Brazil), Kristofer M. Helgen (University of Adelaide, Australia), Darren Naish (University of Southampton, UK), and Neal Woodman (USGS Patuxent Wildlife Research Center, Maryland, USA) for pointing out useful literature.

## REFERENCES

- Ambrose L (2013) *Sciurocheirus makandensis* sp. nov. Macandé squirrel galago Fr. Galago de la Makandé; Ger. Makande Buschwaldgalago. In: Butynski TM, Kingdon J & Kalina J (eds) *Mammals of Africa, Vol. II Primates*, 421–422. Bloomsbury, London, UK.
- Amorim DS, Santos CMD, Krell FT, Dubois A, Nihei SS, Oliveira OMP et al. (2016) Timeless standards for species delimitation. *Zootaxa* 4137: 121–128.
- Biswas J, Borah DK, Das A, Das J, Bhattacharjee PC, Mohnat SM, Horwich RH (2011) The enigmatic Arunachal macaque: its biogeography, biology and taxonomy. *American Journal of Primatology* 73: 1–16.
- Butler RA (2015) Bird market photo yields an unknown monkey species in Indonesia. [Published on the Internet by Mongabay on 23 October 2015; retrieved on 4 March 2017 from <https://news.mongabay.com/2015/10/bird-market-photo-yields-an-unknown-monkey-species-in-indonesia/>].
- Ceríaco LMP, Gutiérrez EE, Dubois A, 490 signatories (2016) Photography-based taxonomy is inadequate, unnecessary, and potentially harmful for biological sciences. *Zootaxa* 4196: 435–445.
- Cheke A (2011) Sonnerat's shrew—evidence for a new and possibly extinct species in an early 19th century manuscript (Mammalia: Soricidae). *Journal of the Bombay Natural History Society* 108: 95–97.
- Cranbrook E, Payne J, Leh CMU (2007) Origin of the elephants *Elephas maximus* L. of Borneo. *Sarawak Museum Journal* 84: 95–125.
- Dasgupta S (2015) 'New' monkey species or an 'artificially colored' monkey? Scientists debate status of 'unknown' langur species discovered in Indonesian bird market photo. [Published on the Internet by Mongabay on 21 December 2015; retrieved on 4 March 2017 from <https://news.mongabay.com/2015/12/new-monkey-species-or-an-artificially-colored-monkey/>].
- Davenport TRB, Stanley WT, Sargis EJ, De Luca DW, Mpunga NE, Machaga SJ, Olson LE (2006) A new genus of African monkey, *Rungwecebus*: morphology, ecology, and molecular phylogenetics. *Science* 312: 1378–1381.
- Deraniyagala PEP (1950) The elephant of Asia. *Proceedings of the Ceylon Association of Sciences* 3: 1–18.
- Deraniyagala PEP (1951) *Elephas maximus*, the elephant of Ceylon. Part I. *Spolia Zeylanica* 26: 21–68.
- Donegan TM (2008) New species and subspecies descriptions do not and should not always require a dead type specimen. *Zootaxa* 1761: 37–48.
- Donegan T, Quevedo A, McMullan M, Salaman P (2011) Revision of the status of bird species occurring or reported in Colombia 2011. *Conservación Colombiana* 15: 4–21.
- 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 (2009) Endangered species and endangered knowledge. *Zootaxa* 2201: 26–29.
- Dubois A (2017) The need for reference specimens in zoological taxonomy and nomenclature. *Bionomina* 12: 4–38.
- 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.
- Ehardt CL, Butynski TM (2013) *Cercocebus sanjei* sanje mangabey Fr. Mangabé sanje; Ger. Sanje Mangabe. In: Butynski TM, Kingdon J & Kalina J (eds) *Mammals of Africa, Vol. II Primates*, 177–180. Bloomsbury, London, UK.
- Fan P, Liu Y, Zhang Z, Zhao C, Li C, Liu W, Liu Z, Li M (2017) Phylogenetic position of the white-cheeked macaque (*Macaca leucogenys*), a newly described primate from southeastern Tibet. *Molecular Phylogenetics and Evolution* 107: 80–89.
- Faúndez EI (2017) Photography-based taxonomy: is it necessary to reform the Code, and what that exactly means? *Zootaxa* 4247: 332–332.

- Garraffoni ARS, Freitas AVL (2017) Photos belong in the taxonomic code. *Science* 355: 805.
- Gautier-Hion A (2013) *Miopithecus ogouensis* northern talapoin monkey (Gabon talapoin monkey) Fr. Talapoin du nord; Ger. Nordliche Zwergmeerkatze. In: Butynski TM, Kingdon J & Kalina J (eds) *Mammals of Africa, Vol. II Primates*, 253–256. Bloomsbury, London, UK.
- Gentile G, Snell H (2009) *Conolophus marthae* sp.nov. (Squamata, Iguanidae), a new species of land iguana from the Galápagos archipelago. *Zootaxa* 2201: 1–10.
- Gutiérrez EE, Lattke JE (2016) Venezuelan crisis takes toll on natural history museum. *Herpetological Review* 47: 710–711.
- Gutiérrez EE, Marinho-Filho J (2017) The mammalian faunas endemic to the Cerrado and the Caatinga. *ZooKeys* 644: 105–157.
- Gutiérrez EE, Pine RH (2017) Specimen collection crucial to taxonomy. *Science* 355: 1275.
- Hershkovitz P (1960) Mammals of northern Colombia, preliminary report no. 8: Arboreal rice rats, a systematic revision of the subgenus *Oecomys*, genus *Oryzomys*. *Proceedings of the United States National Museum* 110: 513–568.
- Hershkovitz P (1966) Taxonomic notes on tamarins, genus *Saguinus* (Callithricidae, Primates), with descriptions of four new forms. *Folia Primatologica* 4: 381–395.
- Heuvelmans B (1969) Note préliminaire sur un spécimen conservé dans la glace, d'une forme encore inconnue d'Hominidé vivant: *Homo pongoides* (sp. seu subsp. nov.). *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique* 45: 1–24.
- Hubback TR (1942) The Malayan elephant. *Journal of Bombay Natural History Society* 42: 483–509.
- ICZN [International Commission on Zoological Nomenclature] (1999) *International Code of Zoological Nomenclature*, 4th ed. International Trust for Zoological Nomenclature, London, UK.
- ICZN [International Commission on Zoological Nomenclature] (2017) Declaration 45 – addition of recommendations to Article 73 and of the term “specimen, preserved” to the glossary. *The Bulletin of Zoological Nomenclature* 73: 96–97.
- ICZN [International Commission on Zoological Nomenclature] (unknown year of publication). Can a photograph or holograph be a type specimen? Accessed on 10 December 2016 from the ICZN's website: <http://iczn.org/content/can-photograph-or-holograph-be-type-specimen>
- Jones T, Ehardt CL, Butynski TM, Davenport TRB, Mpunga NE, Machaga SJ, de Luca DW (2005) The highland mangabey *Lophocebus kipunji*: a new species of African monkey. *Science* 308: 1161–1164.
- Kappeler PM, Raoloarison RM, Razafimanantsoa L, Walter L, Roos C (2005) Morphology, behaviour and molecular evolution of giant mouse lemurs (*Mirza* spp.) Gray, 1870, with description of a new species. *Primate Report* 71: 3–26.
- Kellogg R, Goldman EA (1944) Review of the spider monkeys. *Proceedings of the United States National Museum* 96: 1–45.
- Kingdon J (1997) *The Kingdon Field Guide to African Mammals*. Academic Press, London, UK.
- Landry SO (2005) What constitutes a proper description? *Science* 309: 2164.
- Lei R, McLain AT, Frasier CL, Taylor JM, Bailey CA, Engberg SE et al. (2015) A new species in the genus *Cheirogaleus* (Cheirogaleidae). *Primate Conservation* 29: 43–54.
- Li C, Zhao C, Fan PF (2015) White-cheeked macaque (*Macaca leucogenys*): a new macaque species from Medog, southeastern Tibet. *American Journal of Primatology* 77: 753–766.
- Löbel I, Cibois A, Landry B (2016) Describing new species in the absence of sampled specimens: a taxonomist's own-goal. *Bulletin of Zoological Nomenclature* 73: 83–86.
- Louis EE Jr, Engberg SE, Lei R, Geng H, Sommer JA, Randriamampionona R et al. (2006) Molecular and morphological analyses of the sportive lemurs (Family Megaladapidae: genus *Lepilemur*) reveals 11 previously unrecognized species. *Texas Tech University Special Publications* 49: 1–49.
- Lynch-Alfaro JW, Boubli JP, Olson LE, Fiore AD, Wilson B, Gutiérrez-Espeleta GA et al. (2012a) Explosive Pleistocene range expansion leads to widespread Amazonian sympatry between robust and gracile capuchin monkeys. *Journal of Biogeography* 39: 272–288.
- Lynch-Alfaro JW, Silva JS Jr, Rylands AB (2012b) How different are robust and gracile capuchin monkeys? An argument for the use of *Sapajus* and *Cebus*. *American Journal of Primatology* 74: 273–286.
- Lynch-Alfaro JW, Izar P, Ferreira RG (2014) Capuchin monkey research priorities and urgent issues. *American Journal of Primatology* 76: 705–720.
- Marshall SA, Evenhuis NL (2015) New species without dead bodies: a case for photo-based descriptions, illustrated by a striking new species of *Marleyimyia* Hesse (Diptera, Bombyliidae) from South Africa. *ZooKeys* 525: 117–127.
- Meldrum DJ (2007) Ichnotaxonomy of giant hominoid tracks in North America. In: Lucas SG, Spielmann JA & Lockley MG (eds) *Cenozoic Vertebrate Tracks and Traces. New Mexico Museum of Natural History and Science Bulletin*, 42: 225–231.
- Mendes Pontes AR, Malta A, Asfora PH (2006) A new species of capuchin monkey, genus *Cebus* Erxleben (Cebidae, Primates): found at the very brink of extinction

- in the Pernambuco Endemism Centre. *Zootaxa* 1200: 1–12.
- Mittermeier RA (1986) A global overview of primate conservation. In: Else JG, Lee PC (eds) *Primate Ecology and Conservation*, vol 2, 325–340. Cambridge University Press, Cambridge, UK.
- Montandon G (1929) Singe d'apparence anthropoïde en Amérique du Sud. *Comptes Rendus de l'Académie des Sciences, Paris* 188: 815–817.
- Morin PA, Archer FI, Foote AD, Vilstrup J, Allen EE, Wade P et al. (2010) Complete mitochondrial genome phylogeographic analysis of killer whales (*Orcinus orca*) indicates multiple species. *Genome Research* 20: 908–916.
- Musser GG, Carleton MD, Brothers EM, Gardner AL (1998) Systematic studies of oryzomyine rodents (Muridae: Sigmodontinae): diagnoses and distributions of species formerly assigned to *Oryzomys "capito"*. *Bulletin of the American Museum of Natural History* 236: 1–376.
- Nardelli F (2015) A new Colobinae from the Sundiac region: the Golden-crowned Langur *Presbytis johnaspinalli*, sp. nov. *International Zoo News* 62: 323–336.
- Nardelli F (2016) A new Colobinae from the Sundiac region: the Golden-crowned Langur *Presbytis johnaspinalli*, sp. nov. Updated report. *International Zoo News* 63: 2–3.
- Nijman V (2015) Newly described golden-crowned langurs *Presbytis johnaspinalli* are most likely partially bleached ebony langurs *Trachypithecus auratus*. *International Zoo News* 62: 403–406.
- de Oliveira MM, Langguth A (2006) Rediscovery of Marcgrave's capuchin monkey and designation of a neotype for *Simia flavia* Schreber, 1774 (Primates, Cebidae). *Boletim do Museu Nacional, Rio de Janeiro* 523: 1–16.
- Pape T, 34 signatories (2016) Taxonomy: species can be named from photos. *Nature* 537: 307.
- Peterson AT (2014) Type specimens in modern ornithology are necessary and irreplaceable. *The Auk* 131: 282–286.
- Pitman RL, Ensor P (2003) Three forms of killer whales (*Orcinus orca*) in Antarctic waters. *Journal of Cetacean Research and Management* 5: 131–140.
- Polaszek A, Grubb P, Groves C, Ehardt CL, Butynski TM (2005) What constitutes a proper description? *Science* 309: 2164–2166.
- Ride WDL (1999) Introduction. In: ICZN [International Commission on Zoological Nomenclature] (eds) *International Code of Zoological Nomenclature*, 4th ed, XIX–XXIX. International Trust for Zoological Nomenclature, London, UK.
- Rogers DC, Ahyong ST, Boyko CB, D'acoz CD, 73 signatories (2017) Images are not and should not ever be type specimens: a rebuttal to Garraffoni & Freitas. *Zootaxa* 4269: 455–459.
- Rumpler Y, Hauwy M, Fausser J-L, Roos C, Zaramody A, Andriaholinirina N, Zinner D (2011) Comparing chromosomal and mitochondrial phylogenies of the Indriidae (Primates, Lemuriformes). *Chromosome Research* 19: 209–224.
- Rylands AB, Heymann EW, Lynch Alfaro J, Buckner JC, Roos C, Matauschek C, Boubli JP, Sampaio R, Mittermeier RA (2016) Taxonomic review of the New World tamarins (Primates: Callitrichidae). *Zoological Journal of the Linnean Society* 177: 1003–1028.
- Sampaio R, Röhe F, Pinho G, Silva-Júnior JS, Farias IP, Rylands AB (2015) Re-description and assessment of the taxonomic status of *Saguinus fuscicollis cruzlimai* Hershkovitz, 1966 (Primates, Callitrichinae). *Primates* 56: 131–144.
- Santos CMD, Amorim DS, Klassa B, Fachin DA, Nihei SS, de Carvalho CJB et al. (2016) On typeless species and the perils of fast taxonomy. *Systematic Entomology* 41: 511–515.
- Sinha A, Datta A, Madhusudan MD, Mishra C (2005) *Macaca munzala*: a new species from western Arunachal Pradesh, northeastern India. *International Journal of Primatology* 26: 977–989.
- Thalmann U, Geissmann T (2005) New species of woolly lemur *Avahi* (Primates: Lemuriformes) in Bernaraha (central western Madagascar). *American Journal of Primatology* 67: 371–376.
- Thorpe SE (2017) Is photography-based taxonomy really inadequate, unnecessary, and potentially harmful for biological sciences? A reply to Ceriaco et al. (2016) *Zootaxa* 4226: 449–450.
- Timm RM, Polaszek AP, Nomenclature Committee of the American Society of Mammalogists [including six additional signatories] (2005) What constitutes a proper description? *Science* 309: 2163–2164.
- Urbain A (1937) Le kou-prey ou bœuf gris cambodgien. *Bulletin de la Société Zoologique de France* 62: 305–307.
- Urbani B, Vilorio AL (2008) *Ameranthropoides Loysi Montandon 1929: The History of a Primatological Fraud [:] La Historia de un Fraude Primatológico*. LibrosEnRed, Buenos Aires, Argentina.
- Van Roosmalen M, van Hooft P (2013) New species of living rodent, the giant paca (Mammalia: Agoutidae). In: Van Roosmalen MGM (eds) *Barefoot Through the Amazon—On the Path of Evolution*, 380–387. CreateSpace, North Charleston, SC, USA. [https://www.create-space.com/4177494]
- Vilorio AL, Urbani B (1998) François de Loys (1892–1935) y un hallazgo desdeñado: la historia de una controversia antropológica. *Interciencia* 23: 94–100.
- Wakesham-Dawson A, Morris S, Tubbs P (2002) Type specimens: dead or alive. *Bulletin of Zoological Nomenclature* 59: 282–284.

Weksler M, Percequillo AR, Voss RS (2006) Ten new genera of Oryzomyine rodents (Cricetidae: Sigmodontinae). *American Museum Novitates* 3537: 1–29.

Woodman N (2016) Pranked by Audubon: Constantine Rafinesque's description of John James Audubon's imaginary Kentucky mammals. *Archives of Natural History* 43: 95–108.