Zootaxa 4269 (4): 455–459
http://www.mapress.com/j/zt/
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Correspondence

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.4269.4.3
http://zoobank.org/urn:lsid:zoobank.org:pub:EFAE2360-00AA-4E64-BC97-1022E4BAACDE

Images are not and should not ever be type specimens: a rebuttal to Garraffoni & Freitas

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Note. This original form of this rebuttal was submitted to *Science* on 3 March 2017 (limited to 300 words as per *Science* editorial policy) but rejected on 13 March 2017. Herein, we elaborate on our original *Science* submission in order to more fully address the issue without the length limitations. This rebuttal is followed by the list of the signatories who supported our original submission.

Correspondence. Garraffoni & Freitas (2017) recently made a plea for "a revision of the Code to allow museum deposits of good-quality photographs or movies as primary types for meiofaunal organisms whose material types will be inevitably lost" believing to not do so hinders biological progress. Specifically, they were concerned about soft-bodied meiofaunal animals such as small invertebrates that live in marine and freshwater sediments because they more easily "deteriorate and most of their diagnostic characteristics vanish soon after preservation." Garraffoni & Freitas (2017) specifically cite the example of a photograph-based description of a dipteran, where the unique type specimen had escaped (Marshall & Evenhuis 2015).

Under the current (1999) International Code of Zoological Nomenclature (Code), only actual specimens (organisms) can be type specimens, even if represented solely by an extant image, be it a line drawing or a photograph. Garraffoni & Freitas (2017) regard this requirement for actual specimen/s as a particular flaw in the Code. The Code, however, has always made clear provision for the growth of knowledge or loss/deterioration of specimens. If, for some reason, the identity of a named species becomes indeterminate based on the loss or inadequacy of its holotype specimen or supporting data, the Code allows for neotype selection and other actions under its plenary powers (Article 75). In many cases, original descriptions of species are sufficiently detailed to distinguish them from congeners and so do not require neotypes, but this may change as close and/or cryptic relatives of any given species are discovered. This flexibility in the Code serves us very well in the face of changing knowledge as well as conservation needs.

Garraffoni & Freitas (2017), however, move well beyond this to propose that the images themselves become the primary name-bearing standard, not the specimen(s) (live or dead) that they represent. This creates an inherent data deficiency problem: images cannot contain all morphological data or any genetic data possessed by actual specimens and therefore have limited utility in the face of growing knowledge. When imaging standards change and new characters are discovered—what then? Furthermore, cryptic species are common and cannot be identified from pictures (Jörger & Schrödl 2013). We would certainly expect that cryptic meiofaunal species exist. If specimens are not retained or have deteriorated, clearly no other data can be extracted, and the permanence of the "type" images precludes neotype designation.

Although problematical and the subject of considerable debate (e.g., Cianferoni & Bartolozzi 2016; Löbl *et al*. 2016; Aguiar *et al*. 2017; Orrico 2017; Thorpe 2017), the recent article describing a new fly species from a photograph (Marshall & Evenhuis 2015) still treats the actual animal in the photo as the holotype (which escaped and must be considered lost). This means that should doubts arise about the identity of the species, at the very least, a neotype specimen can be designated subsequent to the species description.

In cases of major conservation concern, there may be justifications for not killing and preserving the type

Accepted by A. Minelli: 31 Mar. 2017; published: 24 May 2017

specimen(s). Existing practices (Article 73.1.4) allow types of endangered species to remain alive and the specimen represented by an illustration or photograph, even if not collected (Dubois & Nemésio 2007, Rocha *et al.* 2014). The collection and preservation of types is recommended (Recommendation 16C) but an uncollected type specimen is not in itself grounds for invalidating a species description. Regardless, the organism is the type, not an image or DNA sequence derived from the organism. Thus, the Code's flexibility accommodates both changes in knowledge over time and potential conservation needs.

Philosophical arguments aside, the proposal by Garraffoni & Freitas does not in any way advance the speed or precision of taxonomic work, or the cause of conservation. In reality, it would reduce the value of type specimens and their descriptions, creating taxonomic hearsay at best. Regarding detailed imaging of specimens that deteriorate easily, such as the cited meiofauna or larger organisms like ctenophorans, specimens still must be killed and prepared, so there is no efficiency or conservation gain in Garraffoni & Freitas' (2017) proposed practise. These quickly deteriorating organisms may still have DNA available from the remains. So body deterioration does not necessarily imply a complete destruction of a type specimen's characters. Their proposal at best muddies the waters by offering benefits that already exist and worse, would impede science by locking-in immutable images as biological standard bearers, rather than the organisms they represent.

The use of photographs as representatives of uncollected type specimens is not new and has been treated previously (reviewed in Ceríaco *et al.* 2016). However, this is very different from the proposal put forth by Garraffoni & Freitas. Their proposal apparently stems from perceived rather than actual limitations of taxonomic practise, and is based on a fundamental misunderstanding of taxonomy: either the proponents do not understand the scientific method or they think that taxonomy is not a science (see Linsley & Usinger 1959; Lipscomb *et al*. 2003; Wheeler 2004; Will & Rubinoff 2004; Dayrat 2005; Will *et al*. 2005). Actual specimens are testable, tangible, and verifiable data sources, something that photographs are not (Rocha 2014). Anyone can examine a type specimen and test the claims made by the original author(s).

While our main concern pertains to data quality and reproducibility, fraud is also a potential problem. Photographs and similar images are derivative of the actual organism and too easily manipulated; hence, they should not be made the primary standards. The issue is not new. John James Audubon intentionally made images of imaginary fish and mammals, which Rafinesque (1818, 1820) unwittingly described as new species (Markle 1997; Woodman 2016). Although not taxonomic in content, examples of altered images include those from two papers retracted from *Science* (McNutt 2014) and "enhanced" images of collembolans supposedly living in human skin (Christiansen & Bernard 2008, Shelomi 2013). Recently, two variants of the same photograph were discovered to be published in two different books (d'Udekem d'Acoz & Verheye in press); one was obviously correct and the other skilfully manipulated, presumably in order "to repair" a structure that the authors erroneously believed to have been broken. Should photographs be allowed as types, the very definition of the identity of newly described species may be compromised, either intentionally or unintentionally (see also Aguiar *et al*. 2017).

Photographs and other images are useful, important, and excellent tools. Photographs can serve as proxys for the types (as many old illustrations do) and aid in their interpretation. Photographs and video recordings, however, cannot and should not BE type specimens. Biological type specimens must exist in actual, not virtual reality.

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APPENDIX. Signatories to "Photos are not type specimens: a rebuttal to Garraffoni & Freitas, by Rogers *et al*." submitted to *Science* 3 March 2017

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