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Duszynski, Donald W., "Revisiting the Code: Clarifying Name-Bearing Types for Photomicrographs of Protozoa" (1999). *Faculty Publications from the Harold W. Manter Laboratory of Parasitology.* Paper 150.
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J. Parasitol., 85(4), 1999 p. 769–770
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CRITICAL COMMENT . . .

Revisiting the Code: Clarifying Name-Bearing Types for Photomicrographs of Protozoa

John Corliss, a vocal proponent of the type-concept, was among the first to scold protozoologists publicly for their lack of attention to the concept of submitting type specimens (Corliss, 1962). His comments are timely today, more than 3 decades later:

> "But even less attention has been paid to the concept of *type-specimens* for our species. News of this. . .neglect is always received with disbelief, . . .even horror, by vertebrate systematists. Indeed, it was my genuine worry when attending the meetings of the Colloquium on Zoological Nomenclature in London in July, 1958, vastly outnumbered as I was as a protozoologist, that some provision of the new Code would render the name of practically all protozoa invalid by making the designation of type-specimens mandatory for recognition of any species"

Although Corliss (1962) fully recognized the difficulties protozoologists face, between examining protozoa as fresh wet mounts under oil immersion of a compound microscope, to getting them fixed, stained, and mounted on a slide (this cannot be done for all protists, see below), he continued:

> "Nevertheless, indolence and ignorance have also played a part in keeping us in the dark ages of taxonomy, and we should make every effort to stabilize our science in this important respect. . ..The value of subsequent investigators' being able to make direct comparisons of material in their taxonomic revisory work cannot be emphasized too strongly." And, "All types in the species-groups are to be regarded as 'the property of science' and are to be kept safely preserved, clearly marked, and accessible to any competent worker needing temporary use of them for legitimate research purposes. There is no reason why many of us—including the writer—should not take this matter of type-specimens more seriously in the future than we have done in the past."

For more than 2 decades after these statements, few who worked with the coccidia (Eimeriidae) made any attempt to heed his recommendations. In 1988, however, Bandoni and Duszynski argued that individuals involved in the taxonomy and systematics of the coccidia should become familiar with the 3rd edition of the Code of Zoological Nomenclature (Ride et al., 1985) and tried to reiterate the importance and utility of designating some form of type specimens and archiving them in appropriate museums. Their intent was to create an awareness among biologists working with coccidia (or other protists) of the value of designating type specimens. In the decade since their admonition, bench scholars working with coccidia, and journal editors to whom they submit their work, have begun to endorse the "type concept" by requiring that some form of type specimen be submitted before new species names and descriptions are published. Although some authors still submit samples of oocysts preserved in standard fixatives (for reasons why this option is less than optimal, see Duszynski and Gardner [1991]), the majority submit photomicrographs of sporulated oocysts as their type species to various accredited museums. The issue that arises is what to call these kinds of type specimens.

The Code is explicit on the rules governing type-bearing names but, as Corliss (1962) hinted, there seems a strong vertebrate orientation to many of these rules. It is relatively easy to prepare a mammal or bird skin, skull, and skeleton, or preserve a frog, fish, or snake carcass in liquid preservatives and have such specimens remain intact, in well curated museums, for centuries. The same may be said now for most multicellular invertebrates that also can be preserved, stored, and archived fairly simply.

The water gets muddy pretty quickly, however, when thinking about protists and especially the coccidia: Which stage is the adult stage and how does one preserve and archive it in perpetuity? Given that the vast majority of described coccidia species (certainly >95%) are based almost entirely on the structures in and on the sporulated oocysts, I suggest for now that we concentrate on this stage in the coccidia life cycle as the most practical one to anchor the "species." Central to the species concept, as per the Code, is the **holotype,** "the single specimen upon which a new nominal species-group is based in the original description" (Art. 73(a), p. 149). To date, there are no satisfactory techniques to preserve sporulated oocysts intact and, even if such a magic technique was available, it would be difficult or impractical, with current technology, to archive 1 oocyst. Given the conclusion of Bandoni and Duszynski (1988) that illustrations may be considered legitimate replacements for type specimens under the 3rd edition of the Code, there is the problem with how coccidiologists draw sporulated oocysts. For an illustration to serve as a type specimen, the Code implicitly requires that the illustration be based on a single individual: "Designation of an illustration of a single specimen as a holotype is to be treated as designation of the specimen illustrated" (Art. 73(iv), p. 149); however, line drawings that illustrate new coccidia species are composite drawings and, thus, cannot be considered holotypes. Bandoni and Duszynski (1988) proposed that good quality photomicrographs of several sporulated oocysts, chosen carefully to illustrate as many features of the new species as possible and mounted on archiveable poster board, be submitted as type specimens. They also suggested that certain host and locality data accompany the mounted photomicrographs; these data should include, at least, the most pertinent data recommended in the Code (Rec. 73C(1–10), p. 151). But, what do we call the photomicrographs we submit as type specimens?

Frizzell (1933) was among the first to try to clarify and unify the terminology of types and defined phototype as a photograph of a type specimen, but noted that because it was not the type specimen itself, it is ". . .consequently, omitted from nomenclatural consideration." Corliss (1962), in discussing nomenclatural practices by protozoologists and how they pertained to the 2nd edition of the Code, listed and briefly defined what he considered the 6 possible kinds of name-bearing types: holotype, syntype, paratype, lectotype, paralectotype, neotype. Under lectotype he wrote, "It is interesting to note that a *figure* may, in effect, be designated as lectotype (Art. 74)." The 3rd edition of the Code (Ride et al., 1985) defined 4 categories of name-bearing types: "holotype [Art. 73a], lectotype [Art. 74], neotype [Art. 75], or syntype series [Art. 73b]" (Art. 72(a)(ii), p. 141). And later, "Holotypes, syntypes, lectotypes, and neotypes are the bearers of the scientific names of all animal taxa. They are the international standards of reference that provide objectivity in zoological nomenclature. They are held in trust for science by all zoologists and by persons responsible for their safe keeping (Art. 72(g), p. 145–146)." Between these statements, however, it expands these categories for protozoologists: "in extant species of protozoa, if the name cannot be interpreted by reference to a single animal or part of an animal, a number of directly related individuals mounted in one or more preparations or a suite of preparations of directly related individuals representing differing stages in the life cycle (hepantotype). . .are eligible to be a name-bearing type of a nominal species-group taxon" (Art. 72(c)(iv), p. 143–144). Williams (1986), whose idea has been largely ignored by coccidiologists, saw this statement as a reasonable solution to some problems of parasite nomenclature, including those of the coccidia. I concur.

It is not my presumption to create or clutter the literature with new terminology. My intent is only to add the prefix photo- to appropriate terminology already sanctioned by the Code to help clarify existing terminology. Because increasing numbers of photomicrographs are being submitted to accredited museums to archive new species, there seems a need for precise definitions, so those who submit photomicrographs of sporulated oocysts and/or other life cycle stages of coccidia will know, unambiguously, how to define their name-bearing type specimen. The following suggestions are made based on the above discussion and the established definitions within the current edition of the Code.

Photoholotype: The single specimen (phototype) upon which a new nominal species-group taxon is based in the original publication. It is unlikely this term would ever be used, as descriptions of new coccidia species are (almost) never based on 1 sporulated oocyst.

Photoparatype: A paratype is part of the series from which the holotype was selected: "After the holotype has been labelled (sic), any remaining specimens of the type series should be labelled (sic) 'paratype,' in order to identify the components of the original type series" (Art. 73(a), Rec. 73D, p. 151). Although initially it seems reasonable to call a series of 3–4 photomicrographs of oocysts photoparatypes, it

is technically incorrect, given the precise definition of the Code, because a holotype or photoholotype must exist first. Thus, this term, probably, should not be used.

Photosyntype: "If a nominal species-group taxon has neither holotype [Sect. a] nor lectotype [Art. 74], all the specimens of the type series are syntypes of equal value in nomenclature and collectively constitute the name-bearing type" (Art. 73(b), p. 151). Thus, photosyntype may be the best term to use when a series of several photomicrographs of different sporulated oocysts, representing the same new species, is submitted to a museum as part of the original publication and naming process.

Photolectotype: "If a type series contains more than one specimen and a holotype has not been designated, any author may designate one of the syntypes as the lectotype by use of that term or an equivalent expression (e.g., "the type"); that specimen thereby becomes the unique bearer of the name. . ." (Art. 74(a), p. 153). It would be unusual for an author to single out 1 oocyst from a photosyntype series and declare it *the* type specimen. However, photolectotype could be used in situations where a photosyntype was found to consist of oocysts of more than 1 species.

Photoneotype: ". . .an author may designate another specimen to be the type (neotype) of a nominal species-group taxon if no holotype, lectotype, syntype, or prior neotype is believed to exist (for protozoa, see Article 72c (iv))" (Art. 75(a), p. 157). The vast majority of descriptions of coccidia before the 1990s were represented only by line drawings. Often, when examining host animals, oocysts are found that clearly can be identified to a known species for which only a line drawing exists. If photomicrographs of these sporulated oocysts are submitted to a museum by any author, the first inclination is to call them photoneotypes. However, the precise language of the Code is that a neotype must be a single specimen, not a series. Thus, this term probably should not be used. A more precise term for photomicrographs of oocysts that document a previously described species, by any subsequent worker, is a photoneosyntype series.

Photohapantotype: This would be a series of photomicrographs, together with other preparations representing differing stages in the life cycle. For example, photomicrographs of sporulated oocysts along with tissue sections of endogenous developmental stages prepared by standard histological methods, together, would form the name-bearing type. Finally, because so few protozoa are represented by type materials, photoneohapantotypes ". . .will be necessary to solve complex zoological problems involving species with complicated life cycles." as noted by Williams (1986).

I am deeply grateful to J. Ralph Lichtenfels, ARS, USDA, BARC, Beltsville, Maryland and to Steve J. Upton, Kansas State University, Manhattan, Kansas for their enlightened reviews of prior versions of this missive. Supported by a PEET grant, NSF, DEB, 95-21687.

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DATE OF PUBLICATION
Volume 85, No. 3, was mailed 10 August 1999