Toward exorcism of the ghost of W. T. Thistleton-Dyer: a comment on "over-duplication" and the scientific properties, uses and values of natural science specimens

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Introduction

This essay responds to suggestions (Walters, 1993; Hedberg & Walters, 1996; following Clifford & al., 1990) to "rationalise" herbaria by disposing of "duplicate" specimens. The commentary by Clifford & al. (1990) began with pertinent questions, then floundered in misrepresenting the nature of biology and the relevance of plant specimens to botany. Justifiably, it received lively and damning rebuttals (Stevens, 1990, and five accompanying letters to *Nature*). My title refers to the folly by which a major botanical collection was partly rationalised in this sense. To quote from Stevens's (1990: 223) rebuttal of Clifford & al. (1990): "Almost 100 years ago, a director of Kew, W. T. Thistleton-Dyer, suggested a similar course of action to the one they propose. He accepted variation, but thought that only a single specimen of each species, representing the typical morphology of the species, was needed in the herbarium. A number of 'duplicates' were [sic] removed from the collection at Kew, and some sent to Berlin – where they were described as new species". In the same vein were the deaccessioning actions of Robert E. Woodson at the Missouri Botanical Garden from 1948 to 1963 described in a previous issue of *Taxon* (Solomon, 1998).

Continued preservation of natural science specimens, botanical and other, is undeniably expensive, and support to maintain and expand the resources of biological systematics (collections and the skills to research and maintain them) are limited and declining. These problems afflict biological systematics and impinge on all biology. Although this situation has generated a cottage industry in publishing (Anonymous, 1994; Cotterill, 1995, 1997a, b, 1999; Davis, 1996; Hoagland, 1996; Anonymous, 1997, 1998; Butler, 1998 – and references therein), the scientific relevance of natural science specimens awaits widespread appreciation. Indeed, the controversy over "duplicate" specimens appears symptomatic of a serious ignorance: the crux of the problem, fuelled by rampant misconceptions, is an unfamiliarity with how essential natural science specimens are within the epistemology of biology.

Properties of specimens

Toward clarification, it is important to distinguish the properties of a specimen – the entirety of its genotypic and phenotypic constitution – from its uses. Contemporary and future uses respectively determine existing and potential values which collectively influence the future of collections where specimens are preserved. Whether past, present or future, each use of a specimen involves derivation and application of its preserved information – reliant on an epistemology unique to biology.

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Specimens preserve complex information. – Each multicellular organism is unique (Mayr, 1997) and each biological specimen is an original sample from a population comprising organismal biodiversity. In its preserved form, a specimen is the best known means to preserve the complex information represented in its genetic and phenotypic traits (Cotterill, 1995, 1997a). New opportunities to study previously inaccessible properties of specimens (especially their preserved molecules) now allow unprecedented insights into biological variety. These continue to be facilitated by technological developments, and given novel accessibility to the properties of specimens, it is difficult to predict future uses and thus categorise values of specimens based solely on current uses.

Historical information preserved in collections ramifies through biology. – The individual constitution, together with a singular origin in time and space, confers a unique historicity on each specimen and makes its replacement impossible. Different groups of specimens, originally studied within their respective sub-disciplines, are equally essential in many other life sciences. For example, present uses of botanical specimens extend beyond floristics, as sources (and refutable vouchers) of biogeographical, systematic, ecological, and biochemical information which interrelate with numerous other domains of biological knowledge.

Information derived from natural science specimens maintains biological knowledge. – In addition to the myriad of uses of specimens throughout the life sciences, their preservation maintains data quality. This is critical. For biologists to disseminate knowledge about organisms, such as individual plant species, taxonomies allow disparate facts to be collated, compared, synthesised, and also refuted. In epistemological terms, taxonomies maintain consensibility (see Ziman, 1991) across the life sciences and wherever else biological knowledge is applied. Here, types vouch for Linnaean binomials to allow universal communication of disparately derived data. Underpinning the construction and maintenance of taxonomies, preserved specimens are fundamental to authenticate independently derived facets of information – whether an identity, relationship or other property published about an organism and its circumstances of existence. These epistemological functions, where specimens are sources of historical information and underpin a web of consensible knowledge about the living world, firmly establishes the unique role of specimens in science.

"Duplicate" specimens and quiescent typological thinking

A glaring weakness in the notion that any biological collection is "overduplicated" is its grounding in typological (essentialist) beliefs. These were widespread until overturned by the neo-Darwinian synthesis of evolutionary biology, in which population thinking (sensu Mayr, 1997) is a keystone. Nevertheless, obsolete typological views characterise recent arguments against scientific collecting of organisms (especially vertebrates, see Winker, 1996) or endorsing so-called rationalisations of biological collections. Cognisance of population thinking places critical prescriptions on biological investigations: given the historically derived properties of organisms, and thus their uniqueness, duplicate biological specimens simply do not exist. For example, even multiple cuttings from the same plant might appear identical, but each specimen is phenotypically distinct and preserves different samples of parasites.

Furthermore, there are very few populations of organisms (including vertebrates and plants) for which existing specimens adequately represent geographical, non-

geographical, and temporal variation. Although herbaria at temperate latitudes may store an apparent "surplus" of specimens, each is a singular historical record. Where they do exist, unusually large collections from one population or finite habitat (overduplication in Hedberg & Walter's terminology) actually constitute historical samples of the variety of population(s) in space and time. Their continued preservation maintains irreplaceable information (otherwise unobtainable) from landscapes that have since changed radically in both developed and developing countries. Pruning collections (botanical or other) of "duplicate" specimens weakens historical data sets. The typical herbarium specimen undoubtedly restricts the scope of botanical investigations, especially of tropical plants, but does not belittle its fundamental scientific properties. Modern uses of specimens far exceed those deemed relevant by typological taxonomists in centuries past. The contemporary relevance of specimens is founded in their existence as original samples from a changing world; this complex information, preserved in microbial, fossil, animal and plant specimens, ramifies through the natural sciences. Explicit articulation of these informational properties of specimens is comparatively recent and this development awaits wider appreciation. Its positive benefits extend beyond institutions housing collections to underpin a consilience (sensu Wilson, 1998) of scientific knowledge about the complexities of biodiversity.

So should any specimens be discarded?

Within the context of a specimen's unique properties, "overduplication" is a nonconcept. Concern over duplication falls away given that herbaria and natural history museums are places where preserved samples of organismal biodiversity are studied, and such activities underlie their corporate mission. How then should organismal diversity be sampled such that the resulting specimens represent the variation of traits in studied populations? Biological literature abounds with statistical tools and methodologies for sampling populations and estimating their variation. Perhaps, such methodologies await broader application in taxonomic botany?

There are no grounds – on scientific criteria – for rationalising collections. Economic imperatives and bureaucratic nescience may eclipse the future of natural science collections, but the primary roles of specimens in biological epistemology obviates attempts to rank their scientific values to fit prevailing economic criteria and political whims. Furthermore, prospective donors of "surplus" specimens to herbaria in developing countries might consider the stark reality that many such institutions fare poorly for funds in competition with education, health, and especially state security. In my experience, support for African biology declines despite the hyperbole surrounding the Earth Summit treaties. Equally alarming is the widespread decline (tantamount to an extinction) of experienced professionals, coupled with high turnovers of younger recruits.

Science versus non-science

Endorsements to rationalise collections fuel pseudoscientific agendas to reduce, yet further, support for biological systematics and collections-based research. The impacts on the integrity and future of biological knowledge appear extreme. The essence of the problems facing biology and especially biological systematics and organismal biology (manifested in the decline of resources for biological systematics) is a failure to differentiate between science and non science (Cotterill, 1997b), and in

the late 20th century far too few humans seem capable of this most critical of distinctions (Moore, 1982; Wolpert, 1993). Scientific illiteracy is illustrated by attitudes which try to turn biological research programmes into cost-recovery operations – prescribing an immediacy of returns which defy material reality. It might logically be extended, beyond "rationalising" resources for biological systematics in herbaria and museums, to the equally ridiculous suggestion of shutting down schools and library services. The dwindling support for biological systematics awaits the serious response it deserves. The prevailing climate appears defeatist, with the biological fraternity yet to expound on the far-flung impacts of declining support on biological knowledge and society at large.

Biological imperatives

Preservation and interpretation of natural science collections, as research libraries of biological variety, is often acknowledged as the mandate for existence of corporations housing collections. The slogan "museums and herbaria are places where collections are studied" is often stated but insufficiently supported. Many of these institutions have latterly reinterpreted long-standing traditions, based on historical interests and collections, in the ideal of international research on biodiversity. But, there has yet to be a complementary realignment of budgets and administrative priorities in many of these institutions to meet these ambitions. The scope of collections and biological systematics is global, but often conflicts with those administrations and budgets of national, if not parochial, jurisdiction. Unprecedented support for biodiversity science (sensu Cracraft, 1995) antedates an improved understanding of biodiversity – knowledge that will only accrue if the resources of biological systematics are secured and expanded.

Administrators and funding agencies may trot out the standard retort that systematics resources compete for a thinner slice of the proverbial funding cake, with dwindling funding allocated to collections-based research and "whole organism" biology. A key reason for this neglect is that biologists have yet to articulate a unified explanation for the socio-economic values of such research and how resources for biological systematics engender it. Biodiversity science deserves significant chunks of funding cake, because this knowledge is increasingly required by society. Its importance equals medical knowledge as it extends to supporting socio-economies whose survival requires scientific understanding of biodiversity. The goal is to obtain a reliable knowledge of the complexity of biodiverse landscapes. Here, the broader mandate of biodiversity science encompasses molecular biology – increasingly vital to elucidate phylogenies and research ecological complexes.

The crux of this argument boils down to maintaining the ecological integrity of landscapes – where integrity is the persistence of ecological benefits to human societies, including fertile soils and potable water. It is especially pertinent to minimise impacts by parasites and predators on human beings and their domesticated species. Thus, ultimately, the future of socio-economies (funding cakes inclusive) decrees unprecedented investments to understand the multifarious properties of biodiversity. Such relevance of biodiversity knowledge obviously abets the uses of resources for biological systematics. Natural science collections (especially herbaria, given that they archive specimens of photosynthesising organisms) are quintessential to activities seeking to elucidate the dynamic properties of the biosphere – explaining how organismal and ecological biodiversity are inter-linked; and how ecological com-

plexes persist despite stress and disturbance. Irreplaceable historical data in natural science collections underpin the credibility and consilience of existing knowledge and form the foundations for its expansion. This endorses growth of existing collections, perhaps establishing new repositories with the infrastructure to synthesise historical information through synoptic reviews of available specimens. The ultimate justification for their preservation rests in epistemological functions of specimens as sources and vouchers of complex information about a changing world. With a unique role in science, natural science collections have incomparable values as libraries of life's variety.

Literature cited

Anonymous, 1994. *Systematics agenda 2000: charting the biosphere*. New York.

– 1997. International accord on the value of natural science collections. Pp. 211-214 *in:* Nudds, J. R. & Pettitt, C. W. (ed.), *The value and valuation of natural science collections*. London.

– 1998. *The Darwin declaration*. Canberra.

Butler, D, 1998. Museum research comes off list of endangered species. *Nature* 394: 115-120.

Clifford, H. T., Rogers, R. W. & Dettman, M. E. 1990. Where now for taxonomy? *Nature* 346: 602.

Cotterill, F. P. D. 1995. Systematics, biological knowledge and environmental conservation. *Biodivers. & Conservation* 4: 183-205.

– 1997a. The second Alexandrian tragedy, and the fundamental relationship between biological collections and scientific knowledge. Pp. 227-241 *in:* Nudds, J. R. & Pettitt, C. W. (ed.), *The value and valuation of natural science collections*. London.

– ["Cotterill, W."] 1997b. The growth of the WCCR or the extinction of biosystematic resources? Beyond the Second World Congress on Natural History Collections. *I.C.O.M. Nat. Hist. Conservation* 11: 7-11.

– 1999. The socio-economic values of biodiversity collections and the challenges of measuring organismal and ecological biodiversity. in: *Proceedings of the Second World Congress on Natural Science Collections*. Cambridge, U.K. (in press).

Cracraft, J. 1995. The urgency of building global capacity for biodiversity science. *Biodivers. & Conservation* 4: 463-475.

Davis, G. M. 1996. Collections of biological specimens essential for science and society. *Assoc. Syst. Collect. Newslett.* 24: 77-78, 88-90.

Hedberg, O. & Walters, S. M. 1996. Optimizing the use of herbarium resources. *Taxon* 45: 93-94.

Hoagland, K. E. 1996. The taxonomic impediment and the Convention on Biodiversity. *Assoc. Syst. Collect. Newslett.* 24: 61-62, 66-67.

Mayr, E. 1997. *This is biology: the science of the living world*. Cambridge, MA.

Moore, J. A. 1982. Evolution and public education. *Bioscience* 32: 606-612.

Solomon, J. C. 1998. Specimen deaccessions from the Missouri Botanical Garden Herbarium during the tenure of Robert E. Woodson (1948-1963). *Taxon* 47: 663-680.

Stevens, P. F. 1990. In defence of taxonomy. *Nature* 347: 222-223.

Walters, S. M. 1993. Herbaria in the 21st century: why should they survive? *Webbia* 48: 673-682.

Wilson, E. O. 1998. *Consilience: the unity of scientific knowledge*. New York.

Winker, H. 1996. The crumbling infrastructure of biodiversity research: an avian example. *Conservation Biol.* 10: 703-707.

Wolpert, L. 1993. *The unnatural nature of science*. London.

Ziman, J. 1991. *Reliable knowledge. An exploration of the grounds for belief in science*. Cambridge, U.K.