THE CHANGING SIGNIFICANCE AND DEFINITION OF THE BIOLOGICAL VOUCHER

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Abstract — A new definition of voucher specimen is proposed, based on a review of various functions of vouchers in science, and a reevaluation of the concept in modern biological research. The new definition accommodates a wider scope of museum research material, and includes primary vouchers and secondary vouchers. The primary vouchers usually represent traditional voucher material, whereas the secondary vouchers include a variety of derived products, such as specimen parts, special preparations, and forms of documentation. Support for the proposed "voucher system" is fundamental to the development of biodiversity research because it provides due recognition to the diversity of applications and products that are relevant to substantiating biological studies. In doing so, new dimensions for the management and care of vouchers are established, as well as an expanded role of natural history collections in serving society.

INTRODUCTION

Voucher specimens play an essential role in substantiating the conclusions of biological research. With changing technology, the definition of "voucher" needs to be revised to recognize the increasing role of derived products and documentary evidence.

The Oxford English Dictionary (Simpson and Weiner 1989) defines the word *voucher* as "a piece of evidence; a fact, circumstance, or thing serving to confirm or prove something; a guarantee." Likewise, the Merriam-Webster's dictionary defines *voucher* as "a piece of supporting evidence: proof" (Merriam-Webster Online 2004). Given that a voucher specimen serves as a piece of supporting evidence that vouches for the validity of scientific records, *voucher* was a suitable word to refer to special specimens. However, there remains a question as to when the term *voucher specimen* first appeared. It may be surmised that it evolved in academia, and that the generic word voucher was used to conceptualize the idea and practice in the early 20th century. The use of *voucher specimen* today is fairly common among biologists and collection care personnel.

Robinson (1975: 158) recommended that a *voucher specimen* be defined as "a specimen preserved to serve as a future reference for a published scientific name, or common name, or a figure of a previously described species." In this analogy with a type specimen that strictly functions as a reference for a scientific name, a voucher specimen serves as a taxonomic reference for a species used in non-taxonomic research, such as ecology and behavioral science. Although this definition is a very practical expression, reflecting biologists' responsibilities for taxonomic names cited in their publications, it does not address other applications.

In the meantime, Lee et al. (1982: 5) recognized the documentary function of a *voucher specimen* as:

> one [a specimen] which physically and permanently documents data in an archival report by (1) verifying the identity of the organism(s) used in the study; and (2) by so doing, ensures that a study which otherwise could not be repeated can be accurately reviewed or reassessed.

This definition was later rephrased by Duckworth et al. (1993: 92) as follows:

> any specimen identified by a recognized authority for the purposes of forming a reference collection; a specimen that physically and permanently documents data in an archival report by verifying the identity of the organism(s) used in the study and by so doing ensures that a study which otherwise could not be repeated can be accurately reviewed or reassessed.

This statement excludes specimens whose identifications are not validated by an expert, and hence may preclude a future reexamination of some specimens.

Lee et al. (1982: 5) recognized three types of vouchers as follows:

> (1) type specimens, upon which names of taxonomic units are based; (2) taxonomic support specimens – specimens of primary importance in taxonomic studies other than nomenclatural studies, such as range extensions, life-history studies and morphological variability; and (3) biological documentation specimens – representative organisms derived from studies or projects other than primarily taxonomic.

This categorization is based on different study purposes (i.e., descriptive studies, comparative studies, and all other biological studies). This differentiation of voucher material is an important precedent to the propositions that follow.

Another working definition for *voucher specimen* is provided by the National Park Service (1998: 1/37), which states:

> The voucher specimen is proof, as a single specimen or series of specimens, of the existence of a species at a particular time and space. The presence of a voucher supports the tracking of habitat and geographic expansion of a species, or the presence or absence of a species following changes in its habitat.

There is no reference to the innate and acquired data associated with a specimen. Because data play an important part in supporting the philosophy behind voucher specimens, the elimination of this key point makes the definition less useful, regardless of its conciseness. A clear difference also is exhibited with reference to an existence of a species in lieu of existence of an individual organism. The former phrase implies that an inference be made from a specimen(s) to the species where it belongs, yet with little regard for the very existence of the organism itself.

Cato et al. (2003: 368) presented the definition of *voucher* as "a specimen and its associated data that physically document the existence of that organism or object at a given place and time." This definition has been accepted widely as it was presented at the culmination of the 1994 joint meeting of the Society for the Preservation of Natural History Collections and the Association of Systematics Collections (Hoagland 1994;

Society for the Preservation of Natural History Collections 1994). Recent literature (Duckworth et al. 1993; Hoagland 1994; Lee et al. 1982; Society for the Preservation of Natural History Collections 1994) implies that the use of vouchers and *voucher specimens* basically is interchangeable. However, Cato et al. (2003) were the first to suggest that voucher was a more inclusive, and a broader term than *voucher specimen,* namely a *specimen and its associated data* rather than simply a specimen. The term voucher specimen does merit further use because it is reasonably clear to those outside the biological sciences. However, for purposes of this discussion, the term *voucher* is used because of its inclusiveness.

There are five major applications of a voucher that are relevant. Specifically, a voucher is used for (1) proof of identification, (2) representation of material examined in a study, (3) supporting material for conclusions reached in a study, (4) reference for related research, and (5) a future resource as preserved material for new studies. Although these traditional functions are significant, the authors propose that vouchers serve as the foundation of a much greater concept than recognized previously.

Figure 1 schematically represents how vouchers traditionally are positioned in relation to the synthesis of biological science. Biology includes supra-organismic and infra-organismic scopes of study (i.e., biosphere, ecosystem, community, species, population, organ, tissue, cell, genome, and molecule). The schematic is simplified for clarity, because other fields are linked tightly with the hierarchical structure of biology. Figure 1 illustrates how a voucher can represent an individual organism with integrity. The twisted arrows on the sides of the triangles indicate that all levels of biological research, from molecular to environmental, address the scientific underpinning of the original biological entity.

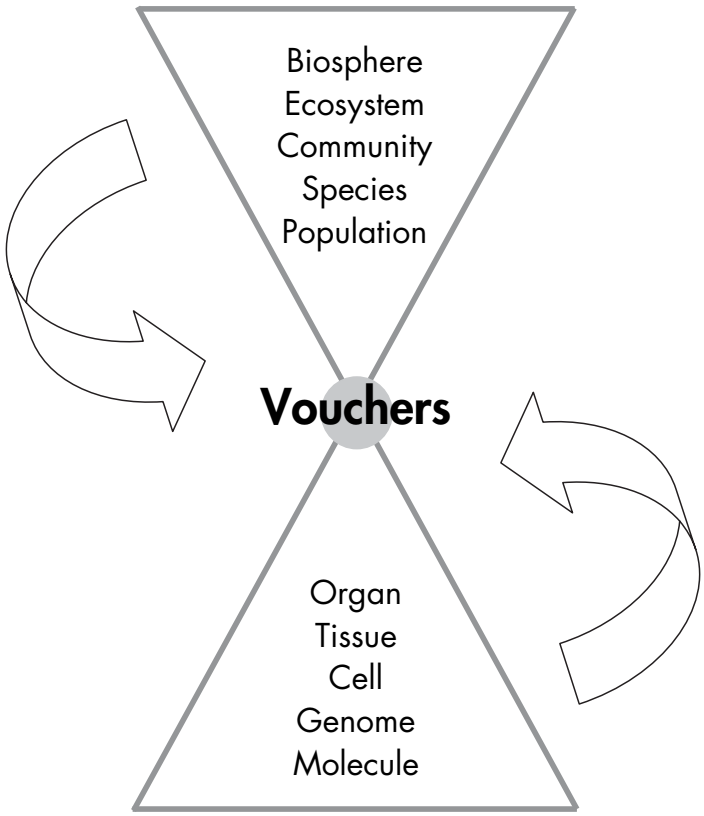

Figure 1. Double-triangular model of traditional vouchers illustrating how vouchers support, and are supported by, supra-organismic and infra-organismic biological research.

Redefining Voucher

Today it is common and sometimes recommended to preserve parts of a specimen in different forms, including, but not limited to, frozen tissues, fluid-preserved organs, karyotype slides, and DNA extracts. Evidence of the past or present existence of study organisms also is documented in multiple fashions, such as photographs and sound recordings. This allows various kinds of information to be derived from a single individual. As a result, the museum community increasingly has been required to accommodate diverse preservation methods in collections. In light of the conventional relationships expressed with Figure 1, this suggests that the demarcation between traditional vouchers and nontraditional research material (i.e., ancillary or "non-voucher") is becoming less meaningful and perhaps less beneficial. Rather, it seems that the word *voucher* is evolving and will acquire new meaning. The concept of voucher now seems to be much broader and worthy of redefinition. In recognition of this, a *voucher* is redefined as follows: *A specimen, a sample, or product thereof, and its associated data, that documents the existence of an organism at a given place and time in a manner consistent with disciplinary standards, to ensure the repeatability of research which otherwise could not be adequately reviewed or reassessed.*

In this definition, the word "sample" is given equal status with "specimen" to encompass such substances as those that constitute only a small portion(s) of a specimen, as well as those that do not form the core of an organism's body structure (e.g., spores, stomach contents, sediments). Similarly, "product" was added to include various man-made media that record tangible and intangible information (e.g., casts, documents, images). The samples or products may not physically prove the presence of an organism. For this reason, the word "physically" was removed from the definition of a voucher. Instead, these samples or products can serve as evidence only when they are documented to a time and place. In other words, data are an inextricable part of the concept of voucher, and the phrase referring to "associated data" coordinates with any item, and enhances the meaning of this definition. A sample or a product without complete provenance or phenetic identity has little research value. The exception is that type specimens described in the past often are accompanied by imperfect provenance by today's standards, yet they undoubtedly have immense research value.

Once a specimen is designated as a voucher, it immediately takes on special properties, and must be maintained for future reexamination. Any specimen, including a sample experimentally isolated from an organism at the cellular or molecular level, should be non-ephemeral, stabilized, and stored "in a manner consistent with disciplinary standards" to be considered as part of the voucher collection. Finally, the phrase "to ensure the repeatability," is used in the proposed definition in recognition of this important function of vouchers in science.

Primary and Secondary Vouchers

Two subdivisions of vouchers are proposed, specifically *primary vouchers* and *secondary vouchers*. The former is a voucher that physically and visually documents the existence of an organism. The latter includes a wide range of derived products that typically provide supplemental information about an organism other than its physical appearance. In essence, there is no rank in value or importance between *primary* and *secondary* vouchers, unlike a holotype and a paratype in taxonomic nomenclature. In other words, *secondary* does not necessarily mean "less important" or "subordinate." Prioritization of one type of voucher over another is determined arbitrarily based on the purpose of each research project, collection, or institution. Criteria for judging whether a given object belongs to the category of primary voucher, secondary voucher, or is not qualified to be a voucher, rely on its physical attributes and information properties. Standards are expected to differ substantially from one discipline to another, one taxonomic group to another, and one point in time to another. Additionally, these two

categories are not contrasting, or definitive counterparts. Instead, they are relative and complementary to each other in their meaning and functions.

The *primary voucher* is nearly equivalent to a traditional voucher. A primary voucher typically represents the whole part or major body plan of an organism or its equivalent. Traditional collecting, preparation, and preservation protocols have been established in each field of natural science collections. Because the human cognitive system relies on visual information, a primary voucher is expected to meet a conventional visual identification purpose. As a result, a primary voucher is intended to show as much as possible of the original physical integrity that an organism possessed when it was part of the natural environment.

The *secondary voucher* is intended to encompass many of those elements maintained in collections, but not explicitly acknowledged as traditional vouchers (i.e., preserved organisms). Museums increasingly are maintaining collections resulting from research products, including those that are beyond the conventional category of vouchers. The proposed subcategory of the voucher allows for the recognition of this new range of museums resources. Typically, a secondary voucher is a portion, piece, or sample derived from an organism, and its associated data; thus, potential secondary vouchers include the materials related more closely to the study subjects represented in the lower triangle in Figure 1. In contrast to a primary voucher, a secondary voucher may not be readily identifiable or verifiable by visual observation. However, given that a secondary voucher agrees with the definition of a voucher, it serves to corroborate the past or present existence of an organism. A secondary voucher in fact may provide more readily available biological information than a complementary primary voucher. For example, a small part of an animal or plant representing a particular state of variable characters could be included in the category of secondary vouchers. Preparation of a secondary voucher often requires special procedures to meet specific experimental designs. Nontraditional samples generated in laboratories, such as microscopic preparations and biochemical compounds, also belong to this group as long as they are physically and chemically stable.

Another important function of secondary vouchers is destructive analysis. The wisdom of preserving various forms of vouchers has alleviated the dilemma between use and preservation of traditional voucher material. As a matter of fact, the whole justification of starting "ancillary collections," such as frozen tissue collections may have been that vouchers in the conventional sense would not be subject to sampling. According to the proposed concept of voucher, sampling of secondary vouchers is preferable to resampling of primary vouchers, and should be emphasized in the future as a legitimate means of reassessing previous studies.

It is possible that a primary voucher can become a secondary voucher. In the case of very small specimens, the entire body of a primary voucher may be destroyed for DNA sequencing. In spite of the loss of an original primary voucher, an unused portion of the DNA sample can be an important component of a secondary voucher. This coupled with DNA sequence data, complete and accurate field notes, as well as graphic data (e.g., photographs, illustrations), reinforce identification information for secondary vouchers. Collectively, this suite of secondary voucher material can serve as a basis for attesting the past existence of the individual organism.

A small number of duplicate secondary vouchers sometimes can be obtained from the same individual. This is another reason that consumptive use of secondary vouchers can be allowed under certain conditions. However, having additional secondary vouchers at repositories does not mean infinite availability of materials for destructive sampling; it just postpones the inevitable decision to deny access.

The concept of secondary vouchers can be more relevant as primary vouchers increasingly become less commonly available in the field. Today's naturalists seek alternative means of collecting and documenting biodiversity resources with less impact on the environment. In this sense, appendage parts, molted skin, or tissue samples (e.g., blood) are legitimate secondary vouchers. In such cases, the sample in question may be the sole material evidence of the source organism. Even in this situation, gathering other corroborative evidence for the

presence of the potential primary voucher, such as images and parasites, is encouraged strongly. The concept is particularly applicable to living collections, such as zoos, botanical gardens, and culture collections.

Images, sound recordings, films, and other forms of photographic and electronic documentation are classified as secondary vouchers. A merit of referring to photographs and videos as secondary vouchers lies in the fact that they can serve not only as substantiating evidence of whole organisms, but also as records of ecological and behavioral information about living primary vouchers. Morphological data that cannot be retrieved from traditional non-living specimens, can be captured in these types of secondary vouchers. Monk and Baker (2001: 1) recently introduced an *e*-voucher as "a digital image of a specimen that is made available to researchers and the public through electronic communication technologies." Once a digital representation is created, an e-voucher easily can be acknowledged as a special group of secondary vouchers. Regardless of the society's growing dependence on computer technology, the acceptance of electronic materials as vouchers demands a new understanding and approach to preservation. This is because of the loss of information inherent in technological obsolescence, media material deterioration, or reformatting processes.

Figure 2 illustrates a tree-analogy conveying the central concept of primary vouchers, secondary vouchers, and their relationship with voucher information. It also shows how scientific research progresses as primary vouchers make the central core of the axis, and the secondary vouchers form multiple layers, or growth rings, resulting in a thicker and stronger axis. The number of outer layers corresponds to the number of different kinds of secondary vouchers. Data derived from the primary and secondary vouchers, creates the outermost layer of the axis. As defined previously, primary and secondary vouchers continue to be sources of new information. In this conceptual framework, ongoing research adds to the length and girth of the axis. Alternatively, without the axis core, or primary vouchers, the research foundation would be weak and less supportive of future studies. Although the lack of primary vouchers may weaken the axis, the outer layers (secondary vouchers), can still contribute to the research structure. Overall, the number of vouchers stored and cataloged is proportional to the amount of data ultimately available for research.

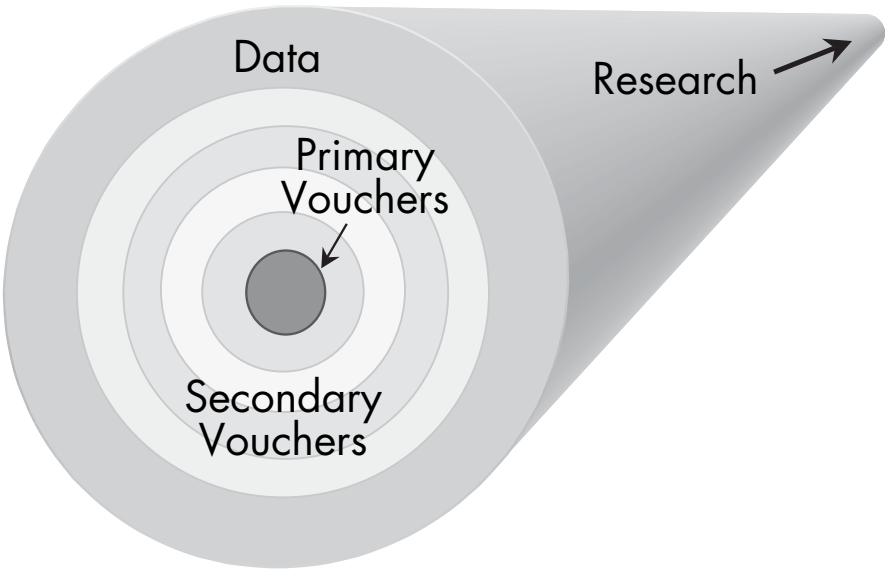

Figure 2. The central concept of primary and secondary vouchers, and their relationship with voucher information, is analogous to the growth rings of a tree.

The "Voucher System"

The system of academic and professional practices involving vouchers can be referred to as the *voucher system*, and it can be viewed as a multidimensional structure. The *voucher system* encompasses vouchers, people, and museums. It also encompasses the interactions among all elements involving vouchers occurring within the system, such as institutional missions, ethics, professional duties, collection policies and procedures, societal infrastructures, and public access. Overall development of the *voucher system* is the focus of concerted efforts. As recipients and permanent caregivers of vouchers, natural history collections must be acknowledged as public service voucher repositories.

Conclusions

The concept of primary and secondary vouchers can be viewed as a broad approach to vouchers in biological research. Primary vouchers physically and visually document the existence of a study organism, whereas secondary vouchers provide a wide range of information about an organism other than the physical appearance that primary vouchers typically express. Voucher information unambiguously associates secondary vouchers derived from an individual organism with one another as well as with their complementary primary vouchers. In this way, research data are accumulated in a desirable manner.

Improved understanding of the natural environment and biological evolution can be linked to the voucher system, in which vouchers are collected, preserved, cataloged, and used by researchers and museum staff. This is because of the need to conduct research in conformity to the modern paradigm of science, where knowledge of the natural world is based on evidence. The authors envision an increasing role of vouchers in modern scientific research, as well as an expanding role of museums in society, as permanent guardians of vouchers. Revising the concept of a voucher can facilitate enhanced appreciation of museum resources. A broadened concept of vouchers applies to existing, as well as future, research material. This should promote recognition of the immense research potential of materials placed outside of what conventionally are viewed as vouchers. This in turn, should empower collaborations between scientists and society that will lead to a new understanding and appreciation of natural history collections.

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