THE HISTORICAL WOOD COLLECTION OF THE UNIVERSITY OF GENOA: REVISION AND ECONOMIC VALUE ESTIMATION

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ABSTRACT
The natural history collections housed in museums and universities are universally recognized as important resources from both a scientific and a social point of view. Consequently, they are increasingly being given an economic value by public authorities. Unfortunately, the operative criteria for the economic evaluation of natural history collections are still debated and the case studies concerning this issue are still scarce. Here we revised the wood collection of the Botanical Garden of the University of Genoa (Italy), assessing its economic value through the Total Economic Value approach. In particular, the feature of the samples, the botanical, geographical and historical provenance, and the conservation status were taken into account. Currently the collection consists of 583 samples referring to 287 taxa (identified at different taxonomical levels, i.e., genera, species, subspecies or variety), belonging to 74 families, split into 7 sub-collections. The economic value of the collection resulted quite low (being just over € 5,200), primarily due to the generally easy chance of reconstituting wood samples (resulting in a low base value) and their generally poor conservation status.

KEYWORDS: Botanical Garden, Herbarium, Natural History Collections, Total Economic Value, Wood Collection, Xylarium, Xylotheque

INTRODUCTION

It is widely accepted that the natural history collections housed in museums or universities play a fundamental role in almost all scientific and educational fields (Bradley et al., 2014; Rocha et al., 2014). Recently, a wider cultural value of natural history collections housed in museums and universities was emphasized as elements able to reinforce both social and institutional connections (Cornish et al., 2017) and to connect things and people through space and time (Gosden & Larson, 2007; Hill, 2004). The multidisciplinary importance of natural history collections and the costs for the acquisition and curation of samples are the basis for the economic evaluation of natural history collections (Suarez & Tsutsui, 2004), which is considered a fundamental step for their conservation and management (De la Torre, 2002; Cultural Heritage Agency, 2014). In recent years, scientific collections have been subjected to several types of challenges (Bradley et al., 2014). Nevertheless, they were increasingly recognized as valuable assets in the financial statements of public bodies that are housing them (Micallef & Peirson, 1997); in Italy, many public entities (including the University of Genoa) are addressing this issue.

Unfortunately, the operative criteria for achieving this result are still debated (Throsby & Withers, 1985; Nudds & Pettitt, 1997; Throsby, 2001; 2003; Kovacic, 2009; Landriani & Pozzoli, 2014), also because the main comparative estimates are referring to arts or antiques collections (Avanzini & Gios, 2012). In fact, the literature dealing with case studies about the economic assessment of natural history collections is still scarce, particularly for those of small to medium size. One of the most useful methods is the estimation of the total economic value (VET – Randall & Stoll, 1983), which has been used in some recent case studies in Italy (Galvan & Zanatta, 2002; Avanzini & Gios, 2012). The VET method tries to economically quantify all the functions of a given resource. The resource is considered under different aspects (use value, non-use value, uniqueness value, etc.) and it is possible to apply different estimation methods for each of them (Bishop & Romano, 1998). This is a great advantage since not all categories of the VET are easily transferable to all the natural history collections.

Xylaria are natural history collections of wood samples, usually placed in Botanical Gardens or Museums with both scientific and educational purposes; thus, the term xylarium (also known as xylotheque) establishes a conceptual separation between informal and scientific wood collections (Lamb & Curtis, 2005). Xylaria are widely used in scientific research in the field of wood anatomy and plant systematics, primary as reference collections (Wiemann & Espinoza, 2017; Vàsquez-Correa, 2017; Langbour et al., 2019), but also in new innovative applications (e.g., van Bergen & Poole, 2002; Ward et al., 2005; Haneca et al., 2009; Kagawa & Leavitt, 2009; Abe et al., 2011; Maniatis et al., 2011; Yokoyama, 2011; Yu et al., 2017; Gutiérrez Velayos et al., 2018). As other natural history collections, xylaria have also a cultural value, especially when characterized by an ancient constitution (Souto Bessa, 2009; Vàsquez-Correa, 2017). To increase the usability of xylaria (not only for scientific purposes), an increase of their digitization would be desirable (Souto Bessa, 2009; Wiedenhoeft, 2014; Gutiérrez Velayos et al., 2018; Langbour et al., 2019; von Baeyer & Marston, *in press*), as for herbaria and, in general, all natural history collections (Page et al., 2015). Unfortunately, only few wood collections and samples have been digitized to date (Lens et al., 2016). A very promising innovative method is the digitization of specimens by high-resolution 3D scanning, which has been successfully tested not only on woods (Herráez et al., 2017; Gutiérrez Velayos et al., 2018), but also welds (Rodríguez-Martín et al., 2016) and stones (Rodríguez-Gonzálvez et al., 2019). This modern technique can lead to a great increase of the usability of natural history collections, for both scientists and students, but requires instruments and expertise not always available to museums and universities.

The xylarium of the University of Genoa is currently hosted in the Botanical Garden of Genoa (Northern Italy). It was established in the late 19th century and publicly presented by Ottone Penzig in 1892 during the inauguration of the new botanical institute (Penzig 1893a). Penzig was the Botanical Garden director from 1887 to 1929, and the wood collection reached the maximum development during this period. After Penzig's death in 1929, the interest for the wood collection of the University of Genoa declined, and the new acquisitions of wood samples were near to zero. Currently, the wood collection of the University of Genoa is not listed in the Index Xilariorum (Lynch & Gasson, 2010; Lens et al., 2016), and lies in abandonment without any kind of curation. The only published revision of the wood collection was made in 1990s, with the first compilation of the list of samples (Minuto & Peccenini, 1994), as part of a review of all historical collections of the Botanical Garden (Peccenini & Zanoni, 2003; Peccenini, 2008). However, methodological limits of said revision and the worsening of the samples' conservation status throughout the last decades urged us to compile a new revision, as a basis for the economic evaluation of the collection.

In the perspective of an economic, scientific, and social re-evaluation of the bio-cultural heritage assembled by the University of Genoa, we aimed to 1) inventory all wood collection samples, 2) assess its conservation, 3) estimate its economic value.

MATERIALS AND METHODS

Revision of the wood collection

As starting point of the present revision, all the wood samples found in the Botanical Garden were cleaned up. For each sample, all labels accompanying the sample were digitized via both photographic documentation and text transcription. Following a museological criterion (rather than a systematic order), the wood samples were divided according to their geographical and historical origin, making groups (hereafter 'sub-collections') that were homogeneous in terms of geographic provenance, year of accession and collectors/donors. A unique inventory code was assigned to each sample; the inventory codes were made by an alpha-numeric code: the first part of the code (one or two letters) identifies the sub-collection; the second part is a progressive numeration (starting from 1 for each sub-collection). The taxonomical identification of the samples was not reviewed, but in several cases a bibliographic research was made to assign a scientific name to those samples that were labeled with the plant's common name only. Finally, a systematic updating of all recorded species was made following the nomenclature of Plants of the World online database (POWO, 2019) and the systematic framework of Stevens (2001 onwards). All data were stored in a digital database (available by request to the authors).

Assessment of the economic value of the collection

The economic value of each wood sample was estimated following the VET approach (Randall & Stoll, 1983). Because of the difficulties of determining some VET components (e.g., indirect use value and non-use value) we assessed only the "direct use value" component (i.e., a value linked to the concrete use of the assessed good). Moreover, because the irreproducible geo-historical conditions in which a given sample was collected could make it irreplaceable, we assessed the "unicity value" component of each sample. Finally, negative features that can prejudice the completeness of data concerning the botanical, geographical or historical provenance of the sample were taken into account.

Operatively, the total value (V_{tot}) of each sample was obtained by multiplying a base value (Vb) in euros (€) by seven coefficients (Equation 1).

Equation 1 $$V_{tot} = Vb \times (1+\sum Sh) \times Sz \times (T) \times (1+U) \times A \times [1-C] \times DD$$

Where: Vb = Base Value; Sh = shape of the sample; Sz = size of the sample; T = threatened species according to the International Union for Conservation of Nature (IUCN) and the Convention on International Trade in Endangered Species (CITES); U = Unicity coefficient (i.e., linking to particular historical events or famous collectors); A = age of the sample; C =

damages of samples or labels; DD = data deficiency concerning botanical, geographical and historical origin of the sample.

To assess Vb we followed the approach of the "replacement value" (i.e., the base value equals the monetary cost that it would be necessary to face to re-obtain the wood sample). As the purchase cost of small wood samples is currently very low, the main cost is caused by the shipping fees, thus we assessed Vb according to the geographical origin of the sample which determines the shipping cost to Italy.

The other coefficients consider the direct-use value (coefficients Sh, Sz, T), the unicity value (coefficient U) and the mixed value (i.e., both direct-use and unicity value; coefficient A). Furthermore, potential negative features of the samples are taken into account to reduce their economic value (coefficients C and DD). We arbitrarily set the values of all the coefficients. For a detailed description of each coefficients and their numeric values, see Appendix 1. Such coefficients can increase (if the coefficient value is greater than 1) or decrease (if the coefficient value is lower than 1) the total value. The VET of each sub-collection was obtained by the sum of the VETs of all the samples belonging to it; finally, the VET of the xylarium was obtained by the sum of the VETs of all sub-collections.

RESULTS AND DISCUSSION

Revision of the wood collection

The wood collection of the University of Genoa is made of 583 wood samples, 540 of which have complete data (i.e., both botanical identification and historical provenance) and 43 with only known historical provenance (Table 1; Appendix 2). Despite the lack of a full botanical identification for some samples (e.g., only the Genus or the vernacular name is known), 287 taxa (belonging to 74 families) were identified (Appendix 3). The majority of taxa are Angiosperms (i.e., 93%); the most represented families were Fabaceae and Myrtaceae (i.e., 53 and 26 taxa, respectively), while among the Gymnosperms the most represented family is Cupressaceae (i.e., 12 taxa). Regarding the geographical origin of taxa, the majority of them are native to Central and Southern America (i.e., 37%), Australia (i.e., 23%), Europe (i.e., 12%) and Asia (i.e., 10%). Unfortunately, for several hundred samples, information concerning both the botanical and the geo-historical origin are totally lacking: these samples are not listed in the present revision. Because the wood samples were found in several places and repositories of the Botanical Garden, it is possible that other samples will be occasionally found in the future. The current numerical consistency of the xylarium is in line with the estimation made in the early 1970s, that amounted to about a thousand samples (Guido M.A. personal communication – unfortunately no catalogue was preserved from that period), and with the revision made during the 1990s (Minuto & Peccenini, 1994) which is the only complete revision of the wood collection before the present research. Nevertheless, the proportion of indeterminate samples (from a botanical or geo-historical perspective) is strongly increased. It follows that, in the last two decades, the lack of curation of the wood collection determined a severe loss of information (primary because of the destruction of labels), rather than a loss of samples. Moreover, in the revision of Minuto & Peccenini (1994) the wood samples were listed following a systematic criterion neither respecting their geo-historical origin nor assigning them a unique inventory number in addition to the

Durand's genera numeration (Durand, 1888), which was used when the collection was founded. For these reasons, also because of the worsening of the conservation status of the collection, the unequivocal identification of many samples recorded in the list of the 1994 is currently impossible. The period of greatest development of the xylarium was immediately following its foundation, occurred in 1892 in occasion of the inauguration of the new building, current site of the Botanical Garden. This period coincided with the direction of the Botanical Garden by Ottone Penzig (1887-1929), when the xylarium benefited from the contributions of famous explorers, such as the ethnographer and geographer Guido Boggiani (Leigheb & Cerutti, 1992; Bonati, 2006) and the botanist Ferdinand von Mueller (Morris, 1974), and historical events, such as the expositions of the Columbian Commemorations (AA. VV., 1893). As occurred to several other xylaria, whose existence relied on single researchers in an institution (Wiedenhoeft, 2014), Penzig's death marked the beginning of the decline of the xylarium. Moreover, the incendiary bombardments of the Second World War caused the partial destruction of the Botanical Institute of Genoa and a severe loss of important historical collections.

Table 1. Main features of the wood collection and estimated economic value.

Sub-Collection	**N° of samples**	**Geographic origin**	**Year**	**Collector**	**Economic value €**
G. Conti	11	Europe	1888	G. Conti	70.25
Boggiani	34	Argentina	1891	Guido Boggiani	378.93
Penzig	18	Eritrea	1891	Ottone Penzig	289.08
Columbian Celebrations	141	Colombia, Honduras, Argentina	1892	South American Catholic missions	2,097.03
von Mueller	32	Australia	1893	Ferdinand von Mueller	844.20
Orto Botanico Hanbury	294	Botanical Garden of Genoa	from last decades of '800 to first decades of '900	Various	1,228.85
Queensland Forest Service	25	Australia	unknown (probably from the last decades of '800 to the first decades of '900)	Queensland Forest Service	269.07
Others	28	Various	from 1875 to current day	Various	79.28
Total Wood Collection	**583**	**Europe, America, Africa, Australia**	**From 1875 to current day**	**Various**	**5,265.69**

After the War, a new interest for the Herbarium of the University of Genoa arise; unfortunately, the same wasn't true for the other collections of the Botanical Garden, among which the wood collection. In fact, the xylarium suffered from the general decline of institutional wood collections lamented since the 1970s (Stern, 1973), which led nowadays the wood collection activity of hobbyists to overcome that of professional botanists (Wiedenhoeft, 2014). Currently, the xylarium of the University of Genoa is a small collection, mainly characterized by the linkage of most wood samples to historical events or locally famous collectors. These features provide a mainly local importance to the collection, despite the large number of samples from other continents attributes international significance to the collection. Unfortunately, the generally poor conservation compromises the usability of most of the collection and make the adoption of *ad hoc* curating strategies very urgent. Nevertheless, at least some parts of the collection would be still usable and exploitable for museum or educational purposes.

Description of the sub-collections

According to the geographical and historical provenance of the samples, eight sub-collections were identified (Table 1). In most cases, samples belonging to the same sub-collection are quite homogeneous in term of shape, size and type of labels, which eased the attribution of many samples despite their poor conservation status. The main features of each sub-collection are here described (Additional information concerning each sample is reported in Appendix 2; further details and photographs can be requested to the authors).

- *Sub-collection "G. Conti" – inventory code from GC1 to GC11 – 11 samples – 1888 - Europe*. Small tables (4×14.5×1 cm). Rectangular labels, heading "R. Istituto Botanico – Genova", showing scientific name, family, collector (as "G. Conti", unknown), year (1888). Generally good conservation status of the samples, but labels are seriously damaged.
- *Sub-collection "Boggiani" – inventory code from B1 to B34 – 34 samples – 1891 – Argentina*. Various shapes and sizes. Rectangular labels with rounded corners and red edge, heading on opposite sides "R. Università di Genova" and "Istituto Botanico Hanbury", showing various information about the sample. Sometimes, a further historical label (heading "Republica Argentina") or a nailed metal plate are present. The name of the naturalist Guido Boggiani (1861-1901) is never reported in the labels, but both his presence in Argentina in 1891 and his relationships with Penzig are well documented (Savelli, 1930). Generally poor conservation status of both samples and labels.
- *Sub-collection "Penzig" – inventory code from P1 to P18 – 18 samples – 1891 – Eritrea*. Longitudinally sectioned branches with the halves hinged together (except P6). Rectangular labels, heading "R. Università di Genova - Istituto Botanico Hanbury", showing species name, family, detailed locality of collection, year and Penzig's signature. The samples were collected during a well-documented botanical expedition in Eritrea (Penzig, 1891; 1893b, Béguinot, 1937). Generally mediocre conservation status of both samples and labels. In particular, *Barbeya oleoides* Schweinf. and the collection of its specimens (sample P14) was reported by Penzig during the meeting of the Società Botanica Italiana (Italian Botanica Society) held on 10 April 1892 in Florence (AA. VV., 1892); the species was described in the same year by Schweinfurth in the journal Malpighia, directed by Penzig himself (Schweinfurth, 1892).
- *Sub-collection "Columbian Celebrations" – inventory code from C1 to C141 – 141 samples – 1892 – South America*. Various shapes and sizes. Various labels, generally heading "Esposizione delle Missioni Cattoliche – 1892", showing variable information, but often reporting the common name and some indication about the technological use of the wood. Several pencil writings on the wood samples. This sub-collection is related to the Columbian Celebrations organized in Genoa in 1892, when South American Catholic

missions created an exhibition of typical South American woods, although no documentation about the accession of these wood samples to the Botanical Garden is preserved. Generally good conservation status of the samples, but labels are seriously damaged.

- *Sub-collection "von Mueller" – inventory code from M1 to M32 – 32 samples – 1893 – Australia*. Tablets (mostly 18×11×2.5 cm). Rectangular labels, heading "R. Università di Genova – Istituto Botanico Hanbury", compiled and signed by Penzig, showing species, family, locality, collector, year. On the back of samples, pencil writings showing species and author names and collection locality are present. Notably, 9 samples are concerning species described by the Baron Ferdinand von Mueller, who is the collector of this sub-collection. Generally good conservation status of the samples, but labels are seriously damaged.
- *Sub-collection "Orto Botanico Hanbury" – inventory code from OB1 to OB294 – 294 samples – from last decades of '800 to first decades of '900 – Botanical Garden of Genoa*. Various formats (mostly cross sections) and generally small size. Oval labels with light blue edge, showing species and author names (and, sometimes, Penzig's signature). No precise indication about the year of the collection or the collector name is reported. Interestingly, this sub-collection provides indirect information about the living collection of the Botanical Garden, for which no species lists of such period are preserved. Generally bad conservation status of both samples and labels.
- *Sub-collection "Queensland Forest Service" – inventory code from Q1 to Q25 – 25 samples - unknown year (probably from the last decades of '800 to the first decades of '900) – Australia*. Tablets (10×6×0.5 cm) with one glossy surface. Rectangular printed labels, heading "Queensland Forest Service, Brisbane", showing both common and scientific name. Generally good conservation status of the sample, but some labels are damaged.
- *Sub-collection "Others" - inventory code from A1 to A28 – 28 samples – from 1875 to current day – various geographic origin*. Various shapes and sizes. Various labels. Generally mediocre conservation status of both samples and labels.

Assessment of the economic value of the collection

The estimated economic value of the wood collection of the University of Genoa was 5,265.69€, ranging from about 70€ to over 2,000€ for each sub-collection (Table 1). The main factor determining the differences in the economic value among sub-collections were the number of samples (ranging from 11 to 294) and the conservation status of both samples and labels. However, in case of similar number of samples, some factors became decisive in composing the value of the sub-collection, first of all the linkage between the samples and historical events (e.g., AA.VV., 1893) or famous collectors, in particular Guido Boggiani (Leigheb & Cerutti, 1992; Bonati, 2006), Ferdinand von Mueller (Morris, 1974) and Ottone Penzig (Savelli, 1930).

In other cases, the application of the VET method to assess the economic value of a natural history collection resulted in a very high monetary value (Teruzzi, 2007; Avanzini & Gios, 2012). This was true also for several collections (fossil Algae collection, fossil Phyllites collection, palaeo-ethnological collection) housed in the University of Genoa, that were recently subjected to an economic evaluation using a similar methodology (Bonci 2011a; 2011b; 2011c). In particular, their evaluation was done using a base value increased according to some parameters (e.g., presence of type material, microscopic preparations, citation of the collection in scientific papers, etc). In contrast to the valuation of the wood collection, the conservation and the lack of information did not dictate a decrease in the value of the objects, as they were generally in good or excellent condition and with complete information. In addition, the higher base value (obtained from the market price of this type of natural history objects), the higher number of samples, the presence of numerous types, and the fact that a large part of the collections were cited in scientific publications explain the large difference in monetary value. Conversely, the economic value of the wood collection is strongly lower (by one or two orders of magnitude). This is primarily determined by the easier chance of reconstituting wood samples (except in the case of extinct species) with respect to fossils or paleo-ethnological findings, which determines a much lower base value. In addition, the wood collection is composed by a relatively low number of samples, is cited in too few published papers and is affected by a generally poor conservation status.

The main advantages of the VET approach are the wide range of factors that can be used to determine the economic value, the flexibility of the method, and the possibility of evaluating the various index components with different methods. These features make the VET method easily usable for the economic assessment of museums' natural history collections. Moreover, the index used for the xylarium of Genoa is characterized by a high speed of application, not requiring precise measurements. Finally, the choice to decrease the effect of some factor that can strongly influence the usability of the wood sample for scientific research or educational purposes (e.g., the botanical origin or the format and size of the sample) and to increase those factors concerning the geo-historical provenance of the sample make the index used here particularly appropriate for historical collections, rather than recent collections that are still active for scientific or educational purposes.

Unfortunately, we are still too far from achieving an established methodology for the economic evaluation of natural history collections through the VET method. In particular, the main limit consists in the difficulty to quantify the contribute of some VET components, such as the non-use value, which is mainly described for environmental goods (Gios & Notaro, 2001; Gios et al., 2002) rather than for natural history collections, or the cultural value (in the broader sense) of the collection, which is unstable and difficult to express according to any quantitative or qualitative scale (Throsby, 2003). For example, non-use value is often calculated through the public's willingness to pay not to use a resource in order to preserve it for the future; this approach, while valid for natural and landscape resources, is less applicable to natural history collections unless assuming a destructive use of specimens. Other bias could arise from the lack of a clear delimitation between some VET components and from the lack of terms of comparison with regard to market values, which are often estimated in analogy with those of art objects and antiques, despite they are often not transferable to the natural history collections (Avanzini & Gios, 2012). Nevertheless, considering that the various components can be calculated independently of each other and with different *ad hoc* methods (Bishop & Romano, 1998), the VET method is probably the most promising approach for the economic assessment of the natural history collections. Thus it is necessary to increase the number of case studies in which different

VET components are quantified for natural history collections, being the only way to obtain a large set of terms of comparison of monetary values for natural history objects of various types and in various conditions. This is necessarily to create a framework that can serve as a guide for public bodies and museums to enhance their collections. Quantifying the monetary value of collections, in fact, means that they are given greater consideration in the financial strategies of their managing bodies. This can lead to improving their conservation and usability for both the scientific community and the public.

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