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# REDISCOVERING THE SCIENTIFIC AND DIDACTIC VALUE OF MINOR HERBARIUM COLLECTIONS: THE SEEDS AND FRUITS COLLECTION BY GUSTAVO BONAVENTURA

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Abstract – Seeds and fruits collections are very important from a systematic point of view and represent useful references in several disciplines and research fields. The Herbarium of Sapienza University of Rome (RO) hosts a Spermoteque/Carpoteque, which was organized by Gustavo Bonaventura (1902–1976). The purpose of this paper is to describe the heritage of Bonaventura's collection. It consists of 42 wooden boxes, globally hosting 3411 glass tubes containing seeds, fruits, and other materials. The collection was first of all catalogued; then, analysis were conducted regarding taxonomic composition, temporal and geographic coverage, institutions of provenience, collectors, content, and preservation status. The specimens refer to 2740 taxa, belonging to 890 genera and 135 families. Many genera of agricultural interest are present, each one with different cultivars. The collection spans across 130 years (1843–1975) and hosts specimens coming from all over the world. Materials were provided by several herbaria, botanical gardens and agrarian institutes, and by 50 collectors. The Bonaventura's collection is still a useful reference collection, testifying biodiversity over times and thus being useful for diachronic studies; moreover, it documents the interests of collectors and the past network activity between institutions.

Keywords: Agronomy; Carpoteque; Cultivar; Cultivated species; Herbarium RO; Spermoteque; Reference collection; *Triticum*.

## Introduction

Seeds and fruits are very important for plants, because of their role in safeguarding the embryo and propagating the species; moreover, seeds can survive for a long time without losing their germination potential. Based on this ability, in the last decades many seedbanks have been established worldwide to store and conserve plant genetic resources, both of domesticated and wild species (Linington, 1997; Rossi et al., 2006; Magrini et al., 2012; Gratani, 2010). Seeds and fruits differ considerably from taxon to taxon and are thus good diagnostic tools for identifying different species (Moggi, 2009). For this reason, long time before the creation of seedbanks, seeds and fruits collections (Spermotheques/Carpoteques) were used to be set up to help in the identification of taxa; often, these minor collections represent a supplement to herbarium collections. Nowadays, these collections are still very important from a systematic point of view (Moggi, 2009), and represent useful references in several disciplines and research fields (Nesbitt et al., 2003; Martinetto et al., 2014). In fact, in agronomy, the identification of the weed-seed component plays an important role in seed-quality control. In archaeobotany, the identification of seeds is an essential tool for identifying remains of plants used by men and weed floras of ancient crops. The identification of seeds is also involved in studies of soil seed banks, of animal diet, of seed dispersal, of flowering plant evolution and classification, in forensic science and in the identification of food contaminants. Additionally, seeds are a common plant material for the analysis of aged and ancient

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DNA, since seed collections can be utilized to infer genetic relationships among obsolete cultivars, also in case of non-viable materials (Leino et al. 2009).
Many important seeds and fruits collections are present worldwide (see Martinetto et al. 2014 and references therein), mostly coming from the 19th and early 20th century. As for Italy, several Herbaria host "Spermoteche" and/or "Carpoteche" (Moggi, 2012): FI, FT, and FIAF (Firenze; Moggi, 2009), GE (Genova), MCVE (Venezia), PAL (Palermo), PORUN (Portici), SIENA (Siena), TO (Torino), and TR (Trento) (acronyms of herbaria follow Thiers, 2017). Other collections are stored in the Botanical Gardens of Padova (Dalan & Marcucci, 2016) and Modena (Bosi et al., 2013, 2017), and in Rome (Millozza & Petrocchi, 1998). Nowadays, modern carpological collections are under construction (e.g. Martinetto et al. 2014); this highlights the topic interest this type of materials represent.
In the Herbarium of Sapienza University of Rome (RO, Thiers 2017), hosting over 1 million of exsiccata from several historic and recent collections (Abbate et al. 2007), a Spermoteque/Carpoteque by Gustavo Bonaventura is present. The value of these collections was recently rediscovered and enhanced during the inventory and the cataloguing of the samples, which are the object of this paper.
The study of minor collections is of fundamental importance to value the cultural and scientific heritage of Botanical Museums, both for research purposes and for scientific dissemination. Thus, the purpose of this paper is to describe the heritage of Bonaventura's seeds and fruits collection; through the computerized cataloguing of the collection, data will be analysed regarding the numerical and taxonomic consistency, the collection period, the geographical origin, the institution of provenience, the collectors, the contents and the preservation status, with particular regards to agronomically important taxa.

## Materials and Methods

### Biography of the Author

Gustavo Bonaventura (Florence 1902 – Rome 1976) graduated in Agricultural Sciences in 1926 at the University of Pisa and became volunteer assistant at the faculty of Plant Pathology and Agricultural Bacteriology of the same University in 1926-1927. From 1927 to 1931 he taught Agricultural and Rural Economics at the Agricultural Institute of Scandicci, Florence. In 1930, he was appointed assistant at the Agronomy Chair of the University of Pisa, where he was entrusted with the management and supervision of the experimental garden, of the agrarian museum, of the herbarium, and of the seed analysis service. In 1939, he took office at the Institute of Pathology of the Book in Rome, of which he was Director from 1961 to 1963; he was the initiator for Italy's propaganda for the fight against termites, causing enormous damage to libraries; the law for anti-termites fight was issued in 1952. He retired in 1971 (Bonaventura, 1971 ds.). The interest of Bonaventura in the study of seeds (and fruits) is testified not only by the collection we are dealing to, but also by the papers he published (Bonaventura 1949, 1950). In his papers, he remarked the scientific and applied importance of studies regarding seeds of cultivated and weed species, as recently underlined (Fanfarillo et al., 2017). As we can read in his works, he used the word "seeds" ("sementa" and "semi") in agronomic terms, implying both a real seed and a fruit, the latter sometimes accompanied by parts of flowers or by inflorescence, or by cloves. Moreover, Bonaventura contributed to enrich floristic knowledge of Lazio, but unfortunately his herbarium was lost (Millozza, 2011).

### Collection description

RO Herbarium purchased Bonaventura's collection in 2004. The main part of the collection consists of 42 wooden boxes measuring 31,5×20,5×4 cm, globally hosting 3411 glass tubes containing seeds, fruits, and other materials (Figure 1). The specimens are arranged in alphabetical order for families and genera. Each box contains between 18 and 143 glass tubes of 8,5×1–2,5 cm closed with aluminium caps and organised in two rows. Information on plant species and cultivars to which the material inside belongs, its origin, the collector/donor, and the date of collection/donation are usually reported on the label of each tube. In this paper, we focus on this part of the collection.
The other part of the collection, here not illustrated, is organized in 40 wooden boxes measuring 28×18,5×2,5 cm, each hosting a card on which seeds and fruits are glued. A grid with cells numbered from 1 to 100 is drawn on the card; so, each box corresponds to a "Centuria". In some cases, cells are empty or the materials were lost. The materials present on the card are checked by a red mark on an original typed catalogue. The catalogue reports the Centuria numbers written on the boxes and the alphabetically arranged names of families and species. Additionally, 10 not numbered boxes are present, not included in the catalogue.

### Data collection and analysis

All data available on the label were entered into a FileMaker Pro 13 Advanced database. Primary data collected from the label of each specimen were: taxon; provenience or locality of collection; date of collection; collector; observations.


**Figure 1.** Specimens from Bonaventura's seeds and fruits collection: the wooden boxes host glass tubes containing seeds, fruits, and other materials.

The following data were added to the database: ID number; denomination of the box; family; genus; country; content; status of conservation. The used nomenclature is the original one; arguably, Bonaventura followed Fiori (1923–1929) for Italian species and Index Kewensis for foreign ones, as he did in one of his studies (Bonaventura, 1949). Data for scientific purposes are available under request and can be retrieved from the corresponding author.

Basic statistics and analysis were conducted regarding taxonomic composition, temporal and geographic coverage, institutions of provenience, collectors, content, and preservation status.

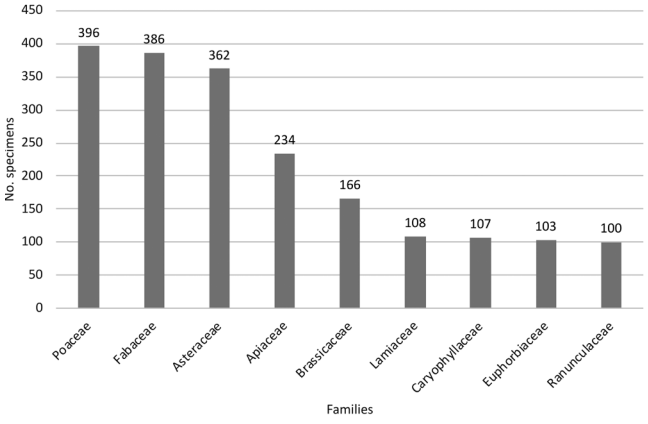


**Figure 2.** The most represented families

## Results

### Taxonomic composition

The collection contains 3411 specimens referred to 2740 taxa, belonging to 890 genera and 135 families. Six samples are missing of labels and therefore were excluded from the following analysis, thus dealing with 3405 specimens.

The collection is very rich in Poaceae (Graminaceae), Fabaceae (Leguminosae), Asteraceae (Compositae), Apiaceae (Umbelliferae), Brassicaceae (Cruciferae), Lamiaceae (Labiateae), Caryophyllaceae, and Ranunculaceae

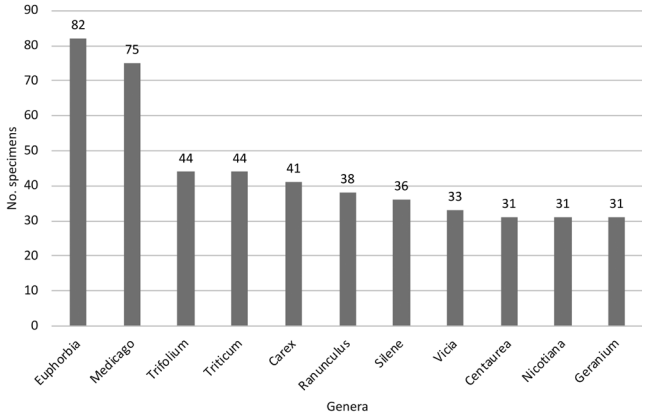


**Figure 3.** The most represented genera

(Figure 2); the most represented genera are *Euphorbia*, *Medicago*, *Trifolium*, *Triticum*, *Carex*, *Ranunculus*, *Silene*, *Vicia*, *Centaurea*, *Geranium*, and *Nicotiana* (Figure 3).
Many of the specimens belong to agronomically important genera of the Poaceae family, such as *Triticum* (44 samples), *Oryza* (34), *Sorghum* (13), *Avena* (11), *Zea* (10), and *Hordeum* (7). Samples of *Nicotiana* (31), *Vitis* (11), and *Coffea* (4) are also present.

## Temporal and geographic coverage

We know the exact date of collection for the majority of the specimens (74%). The oldest specimen dates from 1843, and the latest one from 1975, one year before Bonaventura's death. Among the dated samples, a very subordinate part (3%) was collected during the 19th century. The majority of the specimens (97%) dates back to the 20th century, and in particular to the '30s, the '60s and the '50s (Figure 4).
The collection hosts specimens coming from all over the world (Figure 5). The account of the collection sites points out that most of the samples were collected in Europe (45%); a subordinate part (8%) originated from other continents (Africa, America, Asia and Oceania). In the European context, the specimens come from 28 countries (Table 1): Italy is the most samples-rich country, representing the 38% of the entire collection; other well-represented countries are France, Sweden, Romania and Germany. Unfortunately, for almost half of the specimens (47%) the geographic provenience is unknown.

## Institutions of provenience and collectors

Several specimens (40%) come from other herbaria, botanical gardens and agrarian institutes. The most represented institutions are Orto Botanico Palermo (263 samples) and Orto Botanico Roma (231). Many samples come from institutions that were directly linked to Bonaventura. For example, as regards Pisa, the samples come mostly from the Botanic Garden, the Agronomic Institute, and the Seed Analysis Laboratory. Moreover, 48 samples come from the Institute of Pathology of the Book in Rome.
The collection contains only 281 specimens (8%) for which the collector is clearly declared on the label; the registered collectors are 49 overall. The remaining part of the samples has no indication about the collector. However, considering that we are dealing with a private collection, we can attribute many of the unsigned specimens to Gustavo Bonaventura himself, who probably collected the Italian unsigned specimens dated between '20 and '60 of 20th century. The unsigned samples coming from other foreign countries were arguably donated to him by other botanists and institutions.
Apart from Bonaventura, the most active contributors result to be Alfredo Cacciato, Giuliano Montelucci, and Adriano Fiori. Namely, Alfredo Cacciato (1907-1986) provided 103 specimens between 1932 and 1964, mostly collected in Italy and France; Giuliano Montelucci (1899-1983) collected 75 specimens dating back from 1936 to 1965 and coming from Italy; Adriano Fiori (1865-1950) provided 23 specimens from 1882 to 1959, mostly collected in Italy and France.

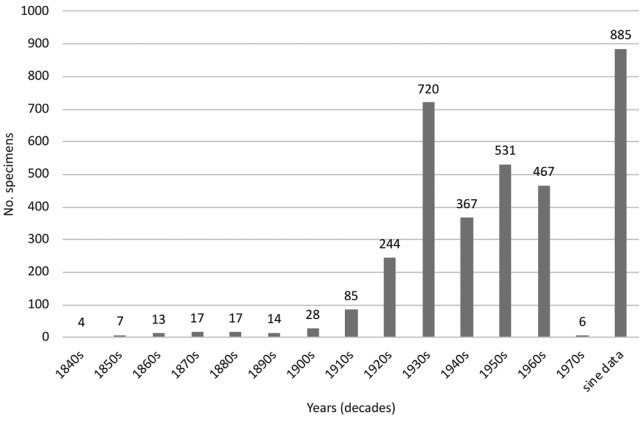


**Figure 4.** Collecting periods (decades)

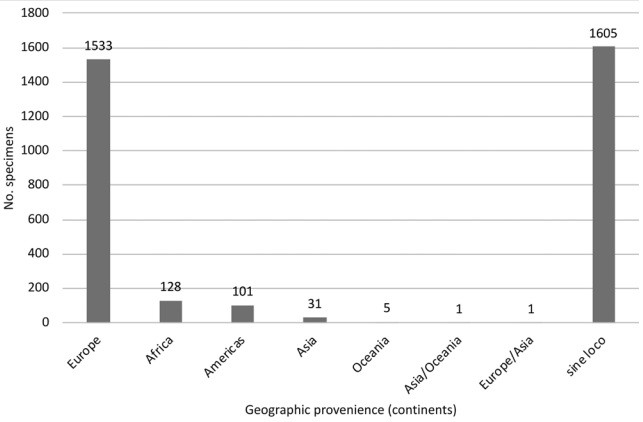


**Figure 5.** Geographic provenience of the specimens

### Materials and preservation status

2115 tubes contain fruits and the remnant 1599 tubes contain seeds. Other kinds of materials are also present, e.g. flowers or parts of flowers, inflorescences, infructescences, and bulbils. Different materials belonging to the same species are often present in the same tube; for example, 401 tubes contain both seeds and fruits. The morphology of fruits and seeds was extremely variable: both dehiscents and indehiscents fruits were found, with anemocorous, hydrocorous, and zoocorus dispersion.

Most of the specimens display an excellent morphological preservation; only few samples (1%) are partly or completely damaged by mould or insects. Some tubes are broken, and their content is stored in paper bags inside the respective box, some others are free of cap, and a cotton ball prevents the release of the contents. Some tubes contain impurities, sands or white powder (probably naphthalene). Currently, the collection is stored in the climate-controlled rooms of RO Herbarium.

**Table 1.** Geographic provenience of the specimens from Europe.

| Countries | No. specimens |
|---|---|
| Austria | 4 |
| Belgium | 1 |
| Bosnia and Herzegovina | 1 |
| Bulgaria | 1 |
| Croatia | 7 |
| Czech Republic | 1 |
| Denmark | 2 |
| Finland | 5 |
| France | 126 |
| Germany | 10 |
| Greece | 4 |
| Hungary | 2 |
| Italy | 1289 |
| Netherlands | 1 |
| Portugal | 1 |
| Romania | 21 |
| San Marino | 1 |
| Slovenia | 2 |
| Spain | 3 |
| Sweden | 41 |
| Switzerland | 5 |
| Ukraine | 2 |
| ? | 3 |
| Total | 1533 |

## Discussion

Bonaventura's collection, hosting over 3400 specimens belonging to many taxa, makes available in a small space a very high number of samples; thus, it is useful to easily observe the morphological variability in fruits and seeds of vascular plants and to appreciate the variability of genera within families and of species within genera. Moreover, the materials come from all over the world, making it possible to compare samples of the same species collected in several localities, also far from Italy.

Poaceae, Fabaceae, and Asteraceae, together with *Vicia*, *Medicago*, and *Carex*, which resulted to be the most abundant families and genera within the collection, are well represented families and genera also in other similar collections (Moggi, 2009; Dalan & Marcucci, 2016), revealing a common interest in the same taxonomic groups and testifying the importance of these taxa in different scientific and applied context.

The several cultivars occurring in the collection are highly interesting too and attest Bonaventura's attention to cultivated species. As regards wheat, which results to be the samples-richest among agricultural important genera, many of the taxa represent important steps in the history from local landraces to modern cultivars (Scarascia Mugnozza, 2005). This is the case of the well-known 'Senatore Cappelli', a pioneer cultivar of *Triticum turgidum* subsp. *durum* selected in 1915 and still cultivated nowadays, to which lineage most of the modern varieties can be traced back (Kabbaj et al., 2017). As regards *Triticum aestivum*, important Italian cultivars preserved over times are also present, e.g. 'Mentana', 'Villa Glori', and 'Damiano Chiesa', selected by N. Strampelli, and 'Gentil Rosso' and 'Gentil Bianco', two Tuscan local races. There are also samples of *T. turgidum* subsp. *dicoccum*, *T. monococcum*, and *T. aestivum* subsp. *spelta*. The collection includes also many cultivar of *Oryza sativa*, such as 'Bertone', 'Bologna', 'Cimone', 'Chinese', 'Giapponese Bianco', 'Giapponese Nero', 'Giapponese Rosso', 'Mantova', 'Maratelli', 'Mortara', 'Novarese', 'Nuovo Maratelli', 'Ostiglia', 'Vialone', 'Vialone Nano', and 'Vialone Nero'.

The partial or complete lack of information about date and site of collection, evidenced for a quarter and half of the specimens, respectively, is a common issue for other spermoteques and carpoteques too (e.g. Bosi et al. 2013; Dalan & Marcucci, 2016). The lack of this piece of information is arguably linked to the educational purpose this type of collections were mainly set up for; the morphological identification of the materials plays a predominant important role, while the knowledge about their temporal and geographic provenience seems to be less important.

When present, data collections and proveniences are really an important piece of information for both scientific and

historical analysis. In fact, the temporal coverage analysis highlighted the historical value of the collection: despite the majority of the specimens dates back to the 20th century, the collection spans across 130 years and hosts specimens coming from the earlier 19th century too. The proveniences are very important too, as they allow diachronic observations, over a century, about plant diversity characterizing harvest sites, especially in cases where they have undergone significant environmental alterations; in fact, while many species are still present, other ones have become rare or extinct in time. Moreover, the sampling locations document the study trips of the collectors or the main places where they lived and worked. The fact that several specimens come from other herbaria, botanical gardens and agrarian institutes, testifies the important material exchange existing among the different institutions, and the widespread interest towards the establishment of seeds and fruits collections.
Given the good preservation status, it could be interesting to verify in the future the viability of the seeds.

## Conclusions

To conclude, the cataloguing of Bonaventura's spermoteque/carpoteque allowed us to rediscover and enhance the important historical and scientific value of this kind of collections. The computerized cataloguing of the materials allows a quick extrapolation of information for multiple research and didactic purposes. Thanks to its taxonomic width, it is useful as a reference collection to name unknown materials. With its wide geographical and temporal coverage, it testifies the biodiversity over times and could be useful for diachronic studies. It also documents the interests of collectors and the network activity between institutions in the last two centuries. Even if it is not a seed bank, the collection could be useful for the restoration of old crops. Open source catalogues and photographs of the materials will be able to facilitate in the future the consultation and fruition of the collection for educational purposes and could be used for virtual themed paths, in line with the University's Third-Mission.

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