

The book herbaria of Jacob Breyne (1637-1697) in the collection of Naturalis Biodiversity Center (Leiden, the Netherlands).

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Research Article

Keywords: historic herbaria, history of botany, Poland, Pomerania, Gdańsk

Posted Date: September 10th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-885416/v1>

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Abstract

Historic herbaria can provide a wealth of information on a diversity of topics, including the past occurrence of plants, their abundance, names and uses. The collection of Naturalis Biodiversity Center in Leiden, the Netherlands, contains two book herbaria by Jacob Breyne (1637–1697) of Danzig. These herbaria, dated 1659 and 1673, contain a total of 105 specimens in various states of intactness, and with or without original labels. The identity of the specimens in the Leiden Breyne herbaria had not been completely assessed. Here we discuss the taxa represented within these two historic herbaria as well as the information contained in the handwritten texts within them. The two Breyne herbaria combined were found to contain 62 species, representing 24 plant families. Both herbaria contain several species now rare around Gdańsk, including two species currently considered regionally extinct (*Swertia perennis* L. and *Dactylorhiza viridis* (L.) R.M. Bateman, Pridgeon & M.W. Chase). Labels with the specimens give a range of information on the collecting locations, ecology, abundance and/or use of the species. The Leiden Breyne herbaria reveal changes in the flora of northern Poland over the course of three centuries, as well as pre-Linnaean nomenclature, historic uses of plants and (international) correspondence between scientists.

Introduction

Historic herbaria are an important source of knowledge about the history of botany, and science in general. They can provide examples of pre-Linnaean nomenclature and systematics (Spalik, 2014; Pulvirenti & al., 2015; Costa & al., 2018, 2020; Bertin & al., 2019), give indications on the uses of plants in the past (Van Andel & Barth, 2018) and provide evidence for the historical occurrence of species in a certain area (Santos-Guerra & al., 2011; Pulvirenti & al., 2017; Stefanaki & al., 2018). Furthermore, these collections of dried plants can provide indications about international relations and communication among scientists at the time of their production (Thijsse, 2016; Offerhaus & al., 2020). They are a part of the cultural heritage of the places where their plants were collected, and as such should be made accessible to the people of these regions (Van Andel, 2017).

The collection of Naturalis Biodiversity Center (Leiden, the Netherlands) contains two book herbaria made by Jacob Breyne (1637–1697), a descendant of a Dutch trading family. Breyne was born and raised in Danzig, Prussia (now Gdańsk, Poland), where his father ran a business trading raw materials for paint and medicine production (Van Ooststroom, 1942; Kuijlen, 1982; Pękacka-Falkowska, 2018). From an early age, he was interested in natural history, received lessons in botany, and took regular trips in the Danzig countryside (Fleischer, 2019). Breyne published two major works on (mainly exotic) plants: *Exoticarum aliarumque minus cognitarum plantarum centuria prima* (1674–1678) and *Prodromus fasciculi rariorum plantarum* I & II (1680–1689), which he printed himself. He planned on writing works on local plants (*Pomerelliae Viridarius* and *Viridario Borussiaci*), but never finished them (Pękacka-Falkowska, 2018). His manuscripts on Prussian plants were later used by Gottfried Reyger, who wrote his *Tentamen Florae Gedanensis Methodo Sexuali Accomodatae* (1764) on the flora of the area around Danzig (Pękacka-

Falkowska, 2018). Breyne also corresponded extensively with personnel of the Dutch East India Company, thus gaining knowledge and specimens of tropical plants.

The two Breyne herbaria at Naturalis Biodiversity Center contain a source of information which is, as of yet, largely unexploited. It can show developments in plant nomenclature, both on a longer and shorter time span. The labels written by Breyne contain one or several pre-Linnaean author names such as Johann and Caspar Bauhin, Conrad Gessner and Mathias de l'Obel, as well as some local names. Then there are the labels added to the 1659 herbarium by De Monchy, of the Rijksherbarium in Leiden, in the early 20th century, and the article on the 1659 herbarium by Van Ooststroom (1942). These contain more recent binomials, but still 70 to 100 years old. These two 'generations' of names (as given by Breyne, and by De Monchy/Van Ooststroom) show some of the changes in nomenclature in the period between the 17th and 20th centuries, and between the early 20th century and today.

Furthermore, from Breyne's descriptions, we can trace the locations where he collected his specimens, and then see whether these species still occur there. The landscape around Gdańsk is bound to have changed over the three-and-a-half centuries since Breyne collected his plants, due to the expansion of the city and other changes in land use. Plants which may have been common in Breyne's days may now be very rare, or vice versa. Habitats visited on a 17th -century day out may now have disappeared altogether, along with their plants.

Breyne's notes in the herbaria could also give some indications of how the plants he collected were used in his day. Living in an era before artificially synthesized medicine, and a trader in the raw materials for dyes and medicines himself, Breyne is likely to have been interested in the practical uses of plants.

Finally, these herbaria are part of the cultural heritage of the area in which the plants were mostly collected (Pomerania province, northern Poland), but they are currently stored away in the Naturalis 'Rare Book Room', not accessible to the public. It is one of the aims of this research to open up this piece of Polish heritage, by adding the plants' details and digital images of the herbarium to the online Naturalis databases, where they can be easily and freely accessed.

While exploring the Breyne herbaria and their importance to science today, we wanted to answer the following questions:

- Which species are included in the two Breyne herbaria?
- Did Breyne use a particular arrangement in his herbaria? (by family/resemblance, by location, alphabetically)
- To which extent do the specimens in the herbaria represent European / Polish (Prussian) or exotic plants?
- Do the accompanying descriptions and labels give indications of the locations of collecting, and do these species still occur around the same locations?
- What does Breyne mention about possible uses of the plants in the herbaria?

- What do Breyne's notes and labels indicate about the abundance of these species, and what is their current conservation status?
- To which extent are the represented species discussed in Breyne's *Centuria*?
- How many species are also found in Gottfried Reyger's *Tentamen*?
- To what extent are the identifications performed by Van Ooststroom and De Monchy in the early 20th century correct or up-to-date?

Methods

Both Breyne herbaria in the Leiden (L) collection have been digitized, and high-resolution images were used for the identification of plant specimens. These images are freely available through www.biportal.naturalis.nl, and can be found by typing the associated barcode into the search field. When identification depended on details not visible on these images (e.g. hairs, small floral parts), the herbarium specimens were physically examined under a stereo microscope. To analyze the names, locations and uses stated by Breyne, transcriptions of the labels by Pękacka-Falkowska (2018) and Van Ooststroom (1942) were used.

The identification of plants from the Breyne herbaria was started using the *Heukels' Flora van Nederland* (24th ed.) (Duistermaat, 2020). This Dutch flora, however, did not contain all taxa found in the herbaria, which were mostly collected in and around Pomerania province (northern Poland). So, we additionally used floras of eastern Europe (Tutin & al., 1964; Mirek & al., 2002; Jäger, 2011; Seybold, 2011). The names provided by the identifications of De Monchy and Van Ooststroom were checked against the aforementioned works, as well as using the International Plant Names Index (IPNI; www.ipni.org) and Plants of the World Online (POWO; www.powo.science.kew.org). These sources were also used to find older synonyms of current names, to aid searching for these taxa in other literature sources.

Current occurrence was checked using the online Global Biodiversity Information Facility (GBIF; www.gbif.org). A recent occurrence is defined here as the species being mentioned by at least five observations in Pomerania province after 2000 in GBIF. When Breyne mentioned the collecting location to be outside Pomerania province, the location as mentioned was used to check for current occurrence. Current conservation status was assessed using the red list for Gdańsk and the surrounding area (Markowski & Buliński, 2004).

Digital versions of Breyne's *Centuria* and *Prodromus* and Reyger's *Tentamen* were accessed using the Biodiversity Heritage Library (www.biodiversitylibrary.org). The presence of plants in these works was checked by searching for the pre-Linnaean names used by Breyne, and comparing descriptions with these names to the specimens in the herbaria.

The paper sheets used to construct the herbaria were checked for watermarks, to reconstruct the origins of the paper via the online Memory of Paper database (www.memoryofpaper.eu).

Results And Discussion

A brief biography of Jacob Breyne

Jacob Breyne (1637–1697) was a descendant of a Dutch trading family who fled the Southern Netherlands after the siege of Antwerp in 1576. A part of the family moved to Danzig, Prussia (now Gdańsk, Poland) to oversee the family trade in the raw materials for medicines and dyes, mainly Polish cochineal: a dye derived from a scale insect feeding on the roots of *Scleranthus perennis* L. (Kuijlen, 1982; Fleischer, 2019; Goeing & al., 2020). As common in those days, a professional interest in natural materials went together with an interest in natural history. The young Breyne took lessons in botany at the Danzig Academic Gymnasium, and made regular trips into the Gdańsk countryside to see and collect plants (Fleischer, 2019). Moreover, the Breyne family owned a house and garden along the river Motława, including a collection of exotic plants.

In 1653, Breyne visited the Dutch Republic, to be trained as a merchant by his uncle Pieter Breyne. While there, he visited several gardens (among which were the botanical gardens of Leiden and Amsterdam, and Lockhorst, the house and garden of politician and patron of botanists Hiëronymus van Beverningk), and he studied botany at Leiden University (Fleischer, 2019). Jacob wanted to continue his studies at the Leiden medical faculty, but was called home to take on the family business after his father's death. Years later, he was offered the position of professor of Botany at Leiden University, but Breyne declined, and the position was later filled by Paul Hermann (Van Ooststroom, 1942; Goeing & al., 2020).

Back in Danzig, Breyne continued botanizing locally, as well as corresponding with other botanists worldwide. He used his Dutch connections to contact people working for the Dutch East India Company (Vereenigde Oostindische Compagnie, VOC), and thus gain access to plants, seeds, bulbs and dried specimens from Asia and the Cape of Good Hope (Gunn & Codd, 1981; Pękacka-Falkowska, 2018; Fleischer, 2019; Goeing & al., 2020).

During his life, Breyne published two major works: the *Exoticarum aliarumque minus cognitarum plantarum centuria prima* (1674–1678), containing descriptions of exotic plants Breyne had seen or grown himself, as well as some local plants; and the two-volume *Prodromus fasciculi rariorum plantarum* (1680–1689), about plants from the Dutch gardens visited by Breyne during one of his many trips to the Netherlands (Fleischer, 2019; Goeing & al., 2020). Breyne printed all his works himself. He planned on writing works on local plants (*Pomerelliae Viridarius* and *Viridario Borussiaci*), but never finished them (Britten & al., 2017; Pękacka-Falkowska, 2018; Goeing & al., 2020; Jacob Breyne to James Petiver, n.d.). His work, and that of his son Johann Philip Breyne, on Prussian plants were later used by Gottfried Reyger, for his *Tentamen Florae Gedanensis Methodo Sexuali Accomodatae* (1764) on the flora of the area around Danzig (Pękacka-Falkowska, 2018).

Jacob Breyne is remembered in botany today for several things: he was one of the first Europeans to describe the tea plant (*Camellia sinensis* (L.) Kuntze), based on a description (and possibly dried plant parts) sent to him by Willem ten Rhyne (1649–1700) from Dejima, Japan (Gunn & Codd, 1981; Goeing &

al., 2020). He also coined the name *Mesembrianthemum* for a genus of plants in the Aizoaceae family, originating from the Cape region. According to Asa Gray (1880), Linnaeus adopted this name in his *Species Plantarum*, but misspelt it as *Mesembryanthemum*, which has become the official spelling. Finally, the genus *Breynia* in Phyllanthaceae was named after Breyne by Johann Forster (1776). Linnaeus also named a genus after Breyne (also called *Breynia*), but this has been synonymized with *Morisonia* (Capparaceae).

The Leiden Breyne herbaria

The Breyne herbaria in the Leiden collection are dated 1659 and 1673. They come from the collection of Hiëronymus van Beverningk (1614–1690), a well-known politician in the Dutch Republic and patron of botanists such as Paul Hermann (Van Andel & Barth, 2018). Breyne is known to have visited Lockhorst, Van Beverningk's estate near Leiden, and to have seen his collection of tropical plants (Van Ooststroom, 1942; Pękacka-Falkowska, 2018). Van Beverningk bequeathed his collection of herbaria to his nephew, and through successive inheritors, the herbaria eventually ended up at the Leiden University library. From there, they were transferred to the National Herbarium of the Netherlands, which is now part of Naturalis Biodiversity Center (Van Steenis-Kruseman, 1979; Pękacka-Falkowska, 2018). The 1659 herbarium was restored in 2012, reinforcing several pages and the binding.

The two herbaria combined contain a total of 105 plant specimens, although many more were originally present, judging from the remains of plants, labels and pages. The 1659 herbarium consists of two bundles of loose, thick paper sheets, folded over to produce a book-like structure. It lacks a cover of its own, but has been wrapped in an early 20th -century cover with the Dutch title "*Herbarium door JACOB BREYNE verzameld in de omgeving van Danzig. Anno 1659*" [Herbarium by Jacob Breyne, collected in the surroundings of Danzig. Anno 1659]. It contains 48 specimens, one or several per page, although a large number of empty sheets with remains and imprints of plants suggest there were once more. The second last sheet of the herbarium contains a watermark in the shape of an elephant with a 'B' on its body (Fig. 1). This watermark is not represented in the 'Memory of Paper' database. Hence, the origin of the paper is yet unknown.

The 1673 herbarium is bound into a book with the title "*Plantae Rariores Borussiacae et Cassubicae anno 1673*". It contains 57 specimens, generally one per page, and seems to be missing fewer plants than the 1659 herbarium: at least ten plants seem to be missing, and twelve pages have been cut out. Breyne is known to have made a 'duplicate' of the 1673 Leiden herbarium, which he sent to James Petiver in England, and which is now in the collection of the Natural History Museum in London, but not yet digitally available (Britten & al., 2017; Goeing & al., 2020; Jacob Breyne to James Petiver, n.d.).

Specimen composition

Both herbaria contain a large diversity of plants. A complete list of taxa present can be found in Appendix I (for the 1659 herbarium) and II (for the 1673 herbarium). The combined total of 105 specimens in both herbaria consists of 62 species from 24 families, including two Lycopodiaceae species and one fungus. Well-represented families are Asteraceae (29 specimens, 13 spp.) and Apiaceae (nine specimens, 5 spp.);

11 species were found in both herbaria. The same number of species were represented more than once within one of the herbaria (6 spp. in the 1659 herbarium, 5 spp. in the 1673), with *Helichrysum arenarium* (L.) Moench (6x) (Fig. 2) and *Antennaria dioica* (L.) Gaertn. (4x) standing out by their number of 'duplicates'. Breyne may have strived to document the diversity within these species, as his descriptions point at differences in flower color, leaf shape, etc. Of *A. dioica* both male and female plants are represented, although Breyne did not add a remark on this difference, which would not have been widely considered until the acceptance of the Linnaean classification system based on plant reproductive organs.

Removal of specimens

From the 1659 herbarium at least 60 specimens have been removed, as indicated by the remains of plants, labels and glue (Fig. 3). At least ten plants were removed from the 1673 herbarium. The removal seems to have taken place before the 20th century: Van Ooststroom (1942) mentioned only the plants currently present, and there seem to be no traces of De Monchy having identified plants that are no longer present. This means that any of the owners between Breyne himself and, eventually, the Rijksherbarium, could have removed (part of) the missing specimens.

Some plants have left impressions in the paper, giving indications of their shape and size. Determining species just from this imprint was, however, almost impossible. Where a plant had been removed, but labels and/or written text on the sheet remained, a tentative identification was attempted, such as in a case where Breyne mentioned 'nidus avis', and described a plant with stem, flowers, leaves and roots in a single, pale color. The name, together with the mentioned color pattern indicate that a specimen of the Bird's-Nest Orchid (*Neottia nidus-avis* (L.) Rich.) was once present here. The same has been done for other pages with missing plants. Names deriving from these tentative identifications have been put in brackets in Appendices I and II.

In a few instances, only the label had been removed, while the corresponding specimen is still in place. This indicates a certain interest for the labels specifically, as well as the specimens themselves. It is unclear why someone removed these labels from the herbarium rather than simply copying the information on them.

On several pages, plants' names have been written, but there is no indication that plants and/or labels were once present on these same pages. Fifteen such situations are found in the 1659 herbarium. Although plants may have been removed from these pages, leaving no traces, it is more likely that these pages never contained any plants, and that these names were just notes by Breyne, indicating species he was planning to include in the herbaria. From the 1673 herbarium, twelve pages have been cut out. These may or may not have contained plants. Again, it is not known who cut out these pages, and why.

Both herbaria seem to have had their pages ordered differently in the past, as indicated by the page numbers written in the top right corner. The original numbers in the 1673 herbarium have been crossed

out, and new numbers were written underneath. Why the order of the pages was changed, and who changed the page numbers in the 1673 herbarium, is yet unknown.

Order of specimens

The plants within the 1659 herbarium do not seem to follow any particular order with regards to family, habitat, alphabetic or otherwise. Within the four sections of the 1673 herbarium, however, plants are arranged according to family, although Breyne most likely did not use the system of plant families as we know it today, but arranged his plants according to their resemblance, either observed by himself or by previous authors (Table 1). An exception is a mixing-up of Cyperaceae and Juncaceae in Sect. 2. Breyne used the name 'Gramen' (grass) for most of these species (2 Cyperaceae, 2 Juncaceae and 2 Poaceae; for one Cyperaceae species, Breyne uses 'Juncus' (rush)), indicating that he considered them to be of the same group. Possibly, the differences between Cyperaceae, Juncaceae and Poaceae were not yet (completely) known in Breyne's time.

Plantae rariores...

The 1673 herbarium bears the title 'Plantae Rariores Borussicae et Cassubicae', indicating it would mainly contain rare plants from this region (modern Pomerania and Kashubia). In spite of the title, Breyne did not mention the abundance of taxa in this herbarium, something he regularly did in the 1659 herbarium. Some of the indications of abundance associated with Breyne's collected taxa have changed over time. While *Daucus carota*, which Breyne mentioned as being found 'everywhere', is still considered Least Concern, *Dactylorhiza viridis* (L.) R.M. Bateman, Pridgeon & M.W. Chase, which flowered 'in great abundance' in Breyne's days, is now considered Regionally Extinct on the Red List for Gdańsk and surroundings (Markowski & Buliński, 2004). A white-flowered form of *Veronica officinalis* is reported as being rare by Breyne, while the normal (blue) form is common.

The Red List for the surroundings of Gdańsk (Markowski & Buliński, 2004) mentions 26 taxa also present in Breyne's collections, with two taxa considered Regionally Extinct (*Swertia perennis* L. and *Dactylorhiza viridis*; Fig. 4). One species is Critically Endangered (*Pulicaria dysenterica* (L.) Bernh.), while five are Endangered (*Anthoxanthum nitens* (Weber) Y.Schouten & Veldkamp, *Bupleurum longifolium* L., *Gentiana cruciata* L., *Silphiodaucus prutenicus* (L.) Spalik, Wojew., Banasiak, Piwczynski & Reduron and *Thesium ebracteatum* Hayne). Two of these species are currently threatened also at a national scale, namely *Swertia perennis* (EN) and *Thesium ebracteatum* (VU) (Kaźmierczakowa et al., 2014). The 1673 herbarium contains fewer (currently) rare plants than the 1659 herbarium (Table 2).

Exotics

Breyne's herbaria contain 34 species not known to (currently) occur in the region around Gdańsk (see Appendix III). These may have been collected on trips further afield, or sent to Breyne by one of his many correspondents. One such exotic is a specimen of *Laportea canadensis* (L.) Wedd. in the 1659 herbarium (Fig. 5). This plant is native to the eastern parts of North America, and not known to have been introduced

or escaped into the wild in Europe (Chew, 1969). Judging from the small size of the specimen (two single leaves and a small inflorescence, rather than an entire plant), it may have been sent to Breyne in a letter, either from North America, or from a plant in cultivation. Sadly, Breyne did not label this specimen, leaving us to guess at its origins.

Other plants not currently known from the Gdańsk region include several alpine species, such as *Buphthalmum salicifolium* L. Although the Gdańsk region is not particularly high-elevated (the highest point is 329 m above sea level (Urząd Statystyczny w Gdańsku, 2020)), Breyne mentions many of his collecting sites as being located between heather on hilly grounds, where some alpine species may have found a home too.

Ecological notes

On the labels of many specimens in the 1659 herbarium, Breyne provides notes on the collecting location. These notes often include the name of a town, but also some ecological remarks, the detail of which is remarkable for an early herbarium such as this. Many plants have been collected 'inter ericas', i.e. between heather. Some plants were collected in woodlands or meadows, many in hilly or mountainous surroundings. One specimen was collected 'in a lush forest', a second 'in a dark forest', while another was collected 'in a valley, at the side of running fountains'. According to his labels, Breyne collected multiple specimens in the grasslands around the Danzig gallows. The ecological notes in Breyne's herbaria can give us clues on the historical occurrence of ecosystems at the associated collecting locations. They show the occurrence of (possibly quite extensive) heather-covered hills in the Gdańsk area, as well as peatland ecosystems at 'Insula Neringa' (Mierzeja Wiślana), judging from specimens of *Eriophorum vaginatum* L. and *Vaccinium uliginosum* L. collected there.

In one particular case, Breyne mentions on his label the co-occurrence of another species. About a specimen of *Pyrola rotundifolia* L., Breyne mentions it growing where 'Calceolus Mar.' also grows. This name could refer to *Calceolus marianus*, now a synonym of *Cypripedium calceolus* L., the Lady's Slipper Orchid.

On the labels of many specimens, Breyne mentions the flowering time. The months May, June, July and August are mentioned, suggesting Breyne collected mainly in these months.

Collecting locations

On many labels in the 1659 herbarium, the location of collecting is mentioned (no place names are mentioned in the 1673 herbarium, except for Kashubia and Austria). Breyne used the German names of Prussian towns, and often with a deviating spelling. Many places are in the direct surroundings of Danzig, such as Bahrenwinkel (now Niedźwiednik), Jasken / Jaskendahle (Jańskową Doliną), Bringenz (Brętowo) and Miggauw (Piecki-Migowo) (Fig. 6). Another popular collecting location was near the monastery at Oliwe (Oliwa). Two locations are further from Danzig: Beren / Beeren (Kościerzyna) and Neeringh / Insula Neringa (Mierzeja Wiślana). One town in central Poland is mentioned (Torunia; now known as Toruń), from which Breyne was sent a specimen of *Pulsatilla*.

Uses

With four specimens in the 1659 herbarium, Breyne mentioned that the plants were used by people. For two specimens of *Rhododendron tomentosum* Harmaja (pages 6 and 27), the use of this plant in brewing beer was mentioned. Breyne notes that the Swedish had imported 20 'voeder' (cartloads) of this plant from the 'Neering' (Frische Nehrung, Mierzeja Wiślana) to add to their soldiers' beer, 'because it makes for furiousness'. Leaves of *R. tomentosum* (known as Labrador Tea) are still used in the production of alcoholic beverages today, although its use has been banned in the past for causing aggressive behavior (Dampc & Luczkiewicz, 2015).

Next to a specimen of *Huperzia selago* (L.) Bernh. ex Schrank & Mart. on page 5, Breyne writes "dese Muscus drijefft soo sterck als Sabina" ['this Muscus expulses as strong as Sabina']. Muscus was a name used for Lycopodiaceae (and other spore-bearing plants) by apothecaries (International Plant Names Index, n.d.; Watson, n.d.); Sabina probably refers to *Juniperus sabina* L., a plant known to have been used as an abortifacient (Riddle, 1997). This indicates the application of *H. selago* as an abortifacient drug; a use indeed known from other parts of Europe (Hatfield, 2004; Watson, n.d.).

Breyne also mentioned the consumption of the berries of *Vaccinium uliginosum* (a specimen on page 5), and how eating a large amount can cause drunkenness, 'as if one had drunk much wine'. The berries of this species are still eaten, and are known in German as Trunkelbeere ('drunk-berries') (Jäger, 2011). Page 5 of the 1659 herbarium also contains a specimen of *Scleranthus perennis*. This is the host plant of *Porphyrophora polonica* (Linnaeus, 1758), the scale insect used to produce the dye known as Polish cochineal. Breyne and his family traded in Polish cochineal, so Breyne most likely knew the use of this plant in his trade. Nevertheless, he did not mention it on the label attached to the specimen.

The only reported use in the 1673 herbarium is that of *Anthoxanthum nitens*. Breyne mentioned that the plants were harvested in the mountains only, and that they were given in bundles to young ladies in the spring, because of their scent. *A. nitens* is known for its scent, and was used as a strewing herb. As such, it was commonly used in churches, and even used as an alternative to incense (RBG Kew, 2021). In this context, it was dedicated to Mary, which explains Breyne's use of the name Gramen Mariae.

Van Ooststroom and De Monchy's identifications

Van Ooststroom identified all 48 specimens currently found in the 1659 herbarium, while De Monchy did so for 15. Of Van Ooststroom's identifications, 43 were correct, with 6 names being synonyms of the currently accepted names. Five identifications were incorrect, although most were still within the correct genus. Of De Monchy's determinations, 10 were correct (3 synonyms) and 5 incorrect. Again, most incorrect identifications were within the correct genus.

Previous owners of the herbaria

Both herbaria seem to have been sent to correspondents of Breyne. It is known that both herbaria were in the possession of Hiëronymus van Beverningk (Pękacka-Falkowska, 2018), but it is unknown whether he

was the original receiver, or he acquired them later. Within the handwritten texts of the 1659 herbarium, the abbreviation UE ('U Edele' = Your Honor) is found on three sheets (pages 2, 11 & 12), along with indications that certain plants could be seen in other people's gardens (p. 11 & 12; '...kunt UE zijn bij...' ['... Your Honor can see at...']), or that the specimen was sent to Breyne by this unknown 'Your Honor' (p. 2; '... die UE sende...' [...'that Your Honor sent me...']). On the frontispiece of the 1673 herbarium, three handwritten lines indicate that it was once part of a '*Bibliothecae Latinae Publicae*'. The handwriting is the same as that used in the *Codex Vossianus*, which includes several 16th -century book herbaria held in the library of Leiden University (Stefanaki & al., 2019). This makes it likely that the handwriting was added when this herbarium became part of the university library collection.

Authors mentioned

Along with the diverse plant names mentioned on the labels come those of their authors. The most commonly mentioned names in both herbaria combined are those of brothers Caspar (39x) and Johann Bauhin (29x). Other authors include Carolus Clusius (12x), Joachim Camerarius the younger (8x), Mathias de l'Obel (7x), Ioanne Thailo (4x), Jacobus Tabernaemontanus (4x), and Conrad Gesner (2x). The names of Pietro Mattioli, Jaques Dalechamps, Rembertus Dodonaeus, Euricius Cordius, Pierre Belon, Leonhard Fuchs and Hieronymus Bock are all mentioned once.

Other people mentioned

Next to authors of scientific works, several other names are mentioned in the 1659 herbarium. On page 11, Breyne writes that 'this species with broader leaves Your Honor can see with Sr. Hermanus van den Burch'. It is currently unknown who Hermanus van den Burch is, but he may have owned a garden in the Dutch Republic. The plant that went with the text is no longer present.

On the next page (p. 12), the name of 'my cos. [cousin] Johan Breynne' is mentioned, stating he had a form of the plant with narrow leaves, which is no longer present in the herbarium. Jacob Breyne had a cousin called Johannes Breyne, who lived in Amsterdam. Johannes traded in drugstore supplies, and may have had a garden of his own.

On the label of a specimen of *Pilosella lactucella* (Wallr.) P.D.Sell & C.West on page 20, the collecting location mentioned is 'in a meadow behind the Oliwe not far from Ambrosie's court, where the various Satyria stand'. Ambrosie could refer to the Dutch Mennonite distiller Ambrosius Vermöllen (also written as Vermeulen or Vermoellen), who had a distillery in Danzig in the early 17th century (Niemantsverdriet, 1996), and may have had a garden outside the city near Oliwa, perhaps for growing the herbs used to make his *Danziger Goldwasser*. Satyria may refer to orchids in general, or to what is now known as *Dactylorhiza viridis*, previously known as *Satyria viridis* (cf. herbarium specimen L. 0076018 in the general Naturalis herbarium).

In a piece of text written on an unnumbered sheet, Breyne states he has received 'Pulsatilla caerulea odoratissima' from Jacobus Hase, from Thorunia (Torún). It is unknown who Jacobus Hase was, and how he related to Breyne.

Centuria, Prodrumus and Tentamen

Out of all species represented by specimens in both herbaria, only one is mentioned in Breyne's *Centuria* (1674: p.130). This concerns a most likely double-flowered form of Water Avens (*Geum rivale*). The *Centuria* contains an image of this plant, showing its multi-petaled flowers. None of the species present in the herbaria were mentioned in the *Prodrumus*. Of the species in the 1659 herbarium, 12 are mentioned with a matching name and description in Gottfried Reyger's *Tentamen* (1764), while three species match partially (i.e. a very similar name with a matching description). For the 1673 herbarium, nine species match in name and description, while seven do so partially. (Appendix IV). With seven specimens, Breyne mentioned his planned works *Pomerellia Viridario* and *Viridario Borussiaci*, which he never finished. Possibly, Breyne had already decided to include these species in his manuscripts, and used these specimens to base his illustrations and/or descriptions on.

Origin of specimens and function of the 1659 herbarium

Although most specimens in the 1659 herbarium have indications of their collecting location, and were thus most likely collected by Breyne himself, there are indications that some plants were sent to Breyne by others. In Breyne's days, a network of scholars exchanged knowledge (and for botanists: plant specimens) through letters. This network was known as the Republic of Letters, and included intellectuals from all over the world (Daston, 1991). Moreover, Breyne may have corresponded with garden owners and nurserymen, exchanging knowledge as well as specimens.

For some of the specimens in the 1659 herbarium we may suspect that they came to Breyne through this Republic of Letters. Firstly, with two specimens Breyne actually mentioned the plants being sent to him. The specimen of *Swertia perennis* on page 2 was sent by 'UE' ('Your Honor', see above). In a piece of text without a plant on an unnumbered sheet, it is mentioned that a specimen under the name of 'Pulsatilla caerulea odoratissima' was sent from Thorunia (Torún) by Jacobus Hase.

Furthermore, the specimens of *Laportea canadensis* on page 13 may have been sent to Breyne as well, from North America or from a plant in cultivation. This species is not known to occur naturally in Europe, so it is unlikely that Breyne would have encountered it on his countryside trips. Secondly, the small size of the specimens allows them to be included with a letter. Sadly, the *Laportea* specimens were not labelled by Breyne, leaving us without further clues as to their origin.

Although some references to a receiver ('UE', see above) would indicate that the 1659 herbarium was meant as a gift, the large number of pages without indications of plants being present would suggest a different use of (part of) this herbarium. Perhaps, Breyne used these sheets to (temporarily) store plants he received from, or was going to send to others, or that he was planning to discuss with fellow botanists. The 1673 herbarium was most likely made as a gift, judging from the large and elaborately arranged specimens.

Miscellaneous remarks by Breyne

Many specimens in both herbaria come with remarks on collecting location, flowering time, but with some specimens, Breyne placed other remarks.

In the 1659 herbarium:

- Page 2, with *Swertia perennis*: Collected in 1659. There are two types, different in the 'decency' of the flowers. One has large and sharply pointed flowers, and was sent by 'Your Honour'. The other grows locally, and has smaller, more bluntly tipped flowers. The colors also differ, pale, blue and brown. Clumps are usually of a single color.
- Page 5, with *Huperzia selago*: this plant has grains ['granula'] between its leaves.
- Page 6, with *Thesium ebracteatum*: plants near the town of Bringenzen grow up to half a cubit [i.e. $\pm 25\text{cm}$] in height.
- Page 6, with *Dianthus carthusianorum*, & page 8 and 3, with *Origanum vulgare*: collected near the gallows. Both plants grow 'in herbs' [i.e. a herbaceous vegetation] between shrubs.
- Page 8, with *Epilobium angustifolium*: a white-flowered form, which is rarely found.
- Page 15, with *Pyrola chlorantha*: found in ravines ['spelunca'] where 'Calceolus mar.' [*C. marianus* ? = *Cypripedium calceolus* L.] grows, and also found in the woods at Jasken.
- Page 20, with *Calocera viscosa* or *Clavulinopsis corniculata*: this Manninol is found in three colours: No. 1, which is this one, is yellow, No. 2 is gray and No. 3 is white [possibly different species]. (Fig. 7).
- Page 23 and page 12, with *Chaerophyllum hirsutum*: a nicely aromatic plant.
- Page 25, with *Eriophorum vaginatum*: should know that it is not *Linum pratense*.
- Unnumbered sheet (after page 27), with the name *Pulsatilla ranunculi folio obtusiore*: added this year (1659). Flowers are blue and fragrant. Flowers in the mountains around Thorunia [Torún, central Poland], and was sent to me by Jacobus Hase, under the name *Pulsatilla caerulea odoratissima*. Also found in the heather at Beren.
- The same sheet, with the name *Lichen petrae...*: found laden with its circles [covered in fruiting bodies?]
- The same sheet, with the name *Pulsatilla flore clauso caeruleo*: Also found with black-brown flowers and one which is ash-grey with the front tips of the leaves [petals?] brown.
- Page 4, with *Veronica officinalis*: the flowers are white, but turn pink during drying.
- Page 6, with *Vicia sylvatica*: flowers elegantly striped, 'ut in Geranio Virgineum' [It is unknown what Breyne meant here. He possibly compared the striation of the flowers to a plant he called *Geranium Virgineum*, or the collected *Vicia* grew in amongst such a plant]
- Unnumbered sheet (after page 6), above a removed plant: When still flowering and standing at its best, this *Nidus avis* has the same pale color it has now, as root, stem, foliage and flower are of a single color.

- Page 11, next to removed plant and label: NB: this species with broader leaves Your Honor can see with Sr. Hermanus van den Burch [An as of yet unknown contact of Breyné's] .
- Page 12, next to removed plant and label: NB: this species with narrow leaves Your Honor can see with my Cos. [cousin] Johan Breynne. [Jacob Breyné's cousin Johannes Breyné]

Remarks from the 1673 herbarium:

- Page 67, with *Rhododendron tomentosum*: 'cum fructibus' [i.e. in fruit]
- Page 69, with *Geum rivale*: a double-flowered form.
- Page 48, with *Astragalus arenarius*: rare in Austria according to Clusius. It is common in sandy locations in Cassubia.
- Page 55, with *Anthoxanthum nitens*: the illustration as provided by Caspar and Johannis Bauhin is not very informative. The plant has variable glumes. It is collected only in the mountains, and is often found in Prussia. In spring, bunches of the plant [its rhizomes?] are harvested because of their fragrance and given to young ladies.
- Page 24, with *Helichrysum arenarium*: the color of the plant is between the lemon-yellow of the previous and the fire-color [orange] of the following plant.
- Page 33, with *Antennaria dioica*: Caspar Bauhin described it as 'Gnaphalium with long flowers and narrow leaves', but his brother Johannis thought there to be nothing special about the leaves, while the flowers are short or long, as confirmed.
- Page 44, with *Centaurea stoebe*: varies between locations, Clusius distinguishes a short and a tall species.

Conclusion

The two Breyné herbaria in the Leiden collection contain 62 species from 24 families, represented by a total of 105 specimens. While the specimens do not seem to have been placed in any particular order in the 1659 herbarium, a family-like arrangement is found in the 1673 herbarium. Many taxa are native to eastern Europe; the 34 represented taxa not locally native may have been sent to Breyné through his contacts in the Republic of Letters or collected on trips further afield. All of Breyné's collecting locations were reconstructed using his writing on the labels, yielding locations mostly near Gdańsk.

Many taxa are rarer today than they were in Breyné's day, as indicated in his handwritten texts on the labels. Out of all taxa in both herbaria, 24 are represented on a Red List for Gdańsk and surroundings and two in the Polish Red List. The species *Swertia perennis* and *Dactylorhiza viridis* are now considered

regionally extinct, even though *D. viridis* was mentioned by Breyne as ‘flowering in great abundance’. This shows the importance of historical herbaria in the reconstruction of the past distribution of plants, and the changes in the landscape around Gdańsk over the past three centuries.

Breyne mentioned uses of four taxa, as a strewing herb, for brewing and consumption, and as an abortifacient drug. Only one taxon represented in the herbaria is also mentioned in Breyne’s 1674 *Centuria* (*Geum rivale*); none are mentioned in the *Prodromus*. Reyger (1764) mentioned multiple taxa from Breyne’s herbaria in his *Tentamen*.

The Breyne book herbaria give us an insight into the state of botany in the second half of the 17th century. After identification of the specimens, the names as given by Breyne, which he cited from the works of many other botanical authors, can be attributed to a modern binomial. Both herbaria, but especially the 1659 herbarium with its references to collecting locations, contain evidence for the historical occurrence of plant species, informing us on land use change, and allowing for informed decisions in the possible reintroduction of species. They show changes in the abundance of plants over time, including local extinction. Both works give us an insight in cultural phenomena of the 17th century, such as the use of folk medicine, the growth of the botanical sciences, and the functioning of the Republic of Letters.

As biodiversity worldwide declines further and further, it is important to know what once was there, so that we can know what is already lost, and what we need to protect, or possibly restore. Herbaria in general have an important role to play in this process, but historical herbaria even more so. They can provide evidence of the occurrence of plants in pre-industrial times, showing parts of the vegetation of the area in which they were collected, before modern human interference. In addition, historical herbaria can provide information on the connections between plants and humans, in times when this was much more important in everyday life, than it is (or, rather, seems to be) today. Further research into the contents and producers of historical herbaria may help us in our aims to preserve biodiversity, as well as provide insights into the history of science and society in general.

Declarations

Author Contributions

TvA drafted the study and supervised the plant identification and writing. MdJ and LD identified the specimens. AS translated Greek and Latin writing on labels. MdJ further designed and performed the study and wrote the paper. All authors read and commented on drafts.

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Acknowledgements.

The authors wish to thank Louisa-Dorothea Gehrke (University of Leipzig) for help with Breyné's life and correspondence, Aleksander Dembiński and Justyna Wiland-Szymańska (University of Poznań) for finding the modern equivalents of historical place names, Hans Adema (NBC) for the identification of a fungal specimen and Henk Porck for looking at the paper watermark.

An earlier version of this article formed the research internship report for MdJ's M.Sc. education at Utrecht University.

Conflicts of Interest Statement

The authors declare that they have no conflicts of interest

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Tables

Table 1: Plant families in the 1673 herbarium

Section	Family name	# specimens
1	Santalaceae	1
	Cornaceae	1
	Ericaceae	2
	Rosaceae	1
2	Fabaceae	3
	Cyperaceae	1
	Juncaceae	2
	Cyperaceae	2
	Poaceae	2
	Apiaceae	4
	Ranunculaceae	1
3	Asteraceae	20
4	Boraginaceae	3
	Brassicaceae	1

Table 2: Threatened and regionally extinct species from the Breyne herbaria mentioned on the red list for Gdańsk and surrounding area (Markowski & Buliński, 2004).

Herbarium	Conservation status	Species name
1659	VU	<i>Helianthemum nummularium</i> , <i>Pyrola rotundifolia</i> , <i>Hypochaeris maculata</i> , (<i>Pulsatilla pratensis</i>).
	EN	(<i>Gentiana cruciata</i> ,) <i>Anthoxanthum nitens</i> , <i>Thesium ebracteatum</i> , <i>Silphiodaucus prutenicus</i> .
	CR	<i>Pulicaria dysenterica</i> .
	RE	<i>Swertia perennis</i> , <i>Dactylorhiza viridis</i> .
1673	VU	<i>Viscum album</i> , <i>Antennaria dioica</i> , <i>Alyssum alyssoides</i> .
	EN	<i>Anthoxanthum nitens</i> , <i>Bupleurum longifolium</i> .

Appendices

- Appendix I: Plants included in the 1659 herbarium
- Appendix II: Plants included in the 1673 herbarium
- Appendix III: Current occurrence of species from the Breyne herbaria in Pomerania
- Appendix IV: Plants mentioned in Breyne's *Centuria* and/or Reyger's *Tentamen*

Figures

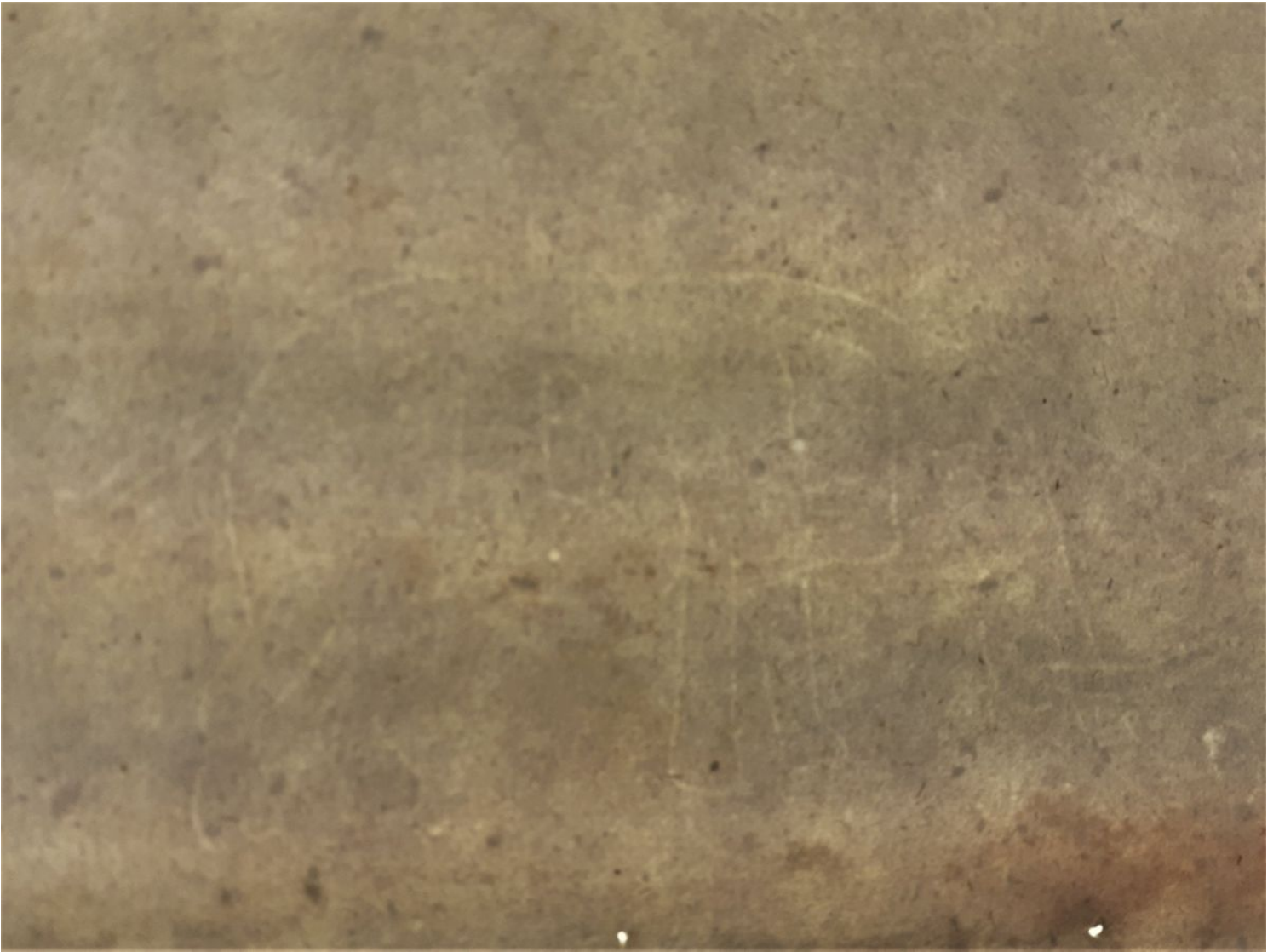


Figure 1

Watermark of an elephant with the letter B, in the second last sheet of the 1659 Breyne herbarium. It is yet unknown which paper producer is associated with this mark.

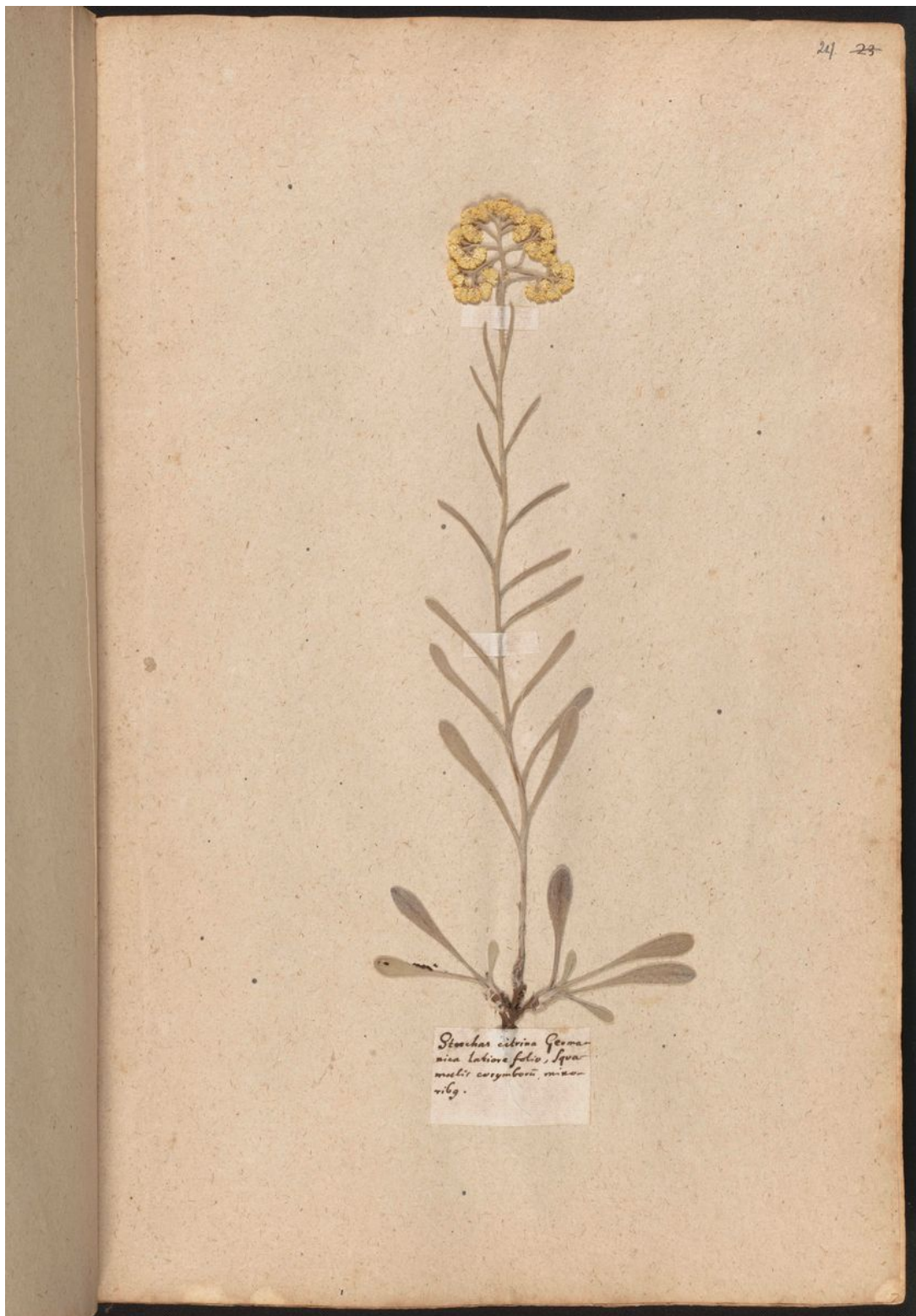


Figure 2

a specimen of *Helichrysum arenarium* from the 1673 herbarium. This species is represented by six specimens in this herbarium.



Figure 3

page 3 of the 1659 herbarium, showing the imprints of three removed specimens, as well as remains of their labels



Figure 4

Two specimens from the 1659 herbarium, representing species now considered regionally extinct (RE) around Gdańsk. A: *Swertia perennis*, with a label by De Monchy. B: *Dactylorhiza viridis*, with an original label by Breyne.



Figure 5

two leaves and an inflorescence of *Laportea canadensis* (above) and a specimen of *Lycopodium* sp. (below). *Laportea canadensis* is not known to occur in Europe, and so may have been sent to Breyne from its natural range in North America, or from a plant in cultivation.

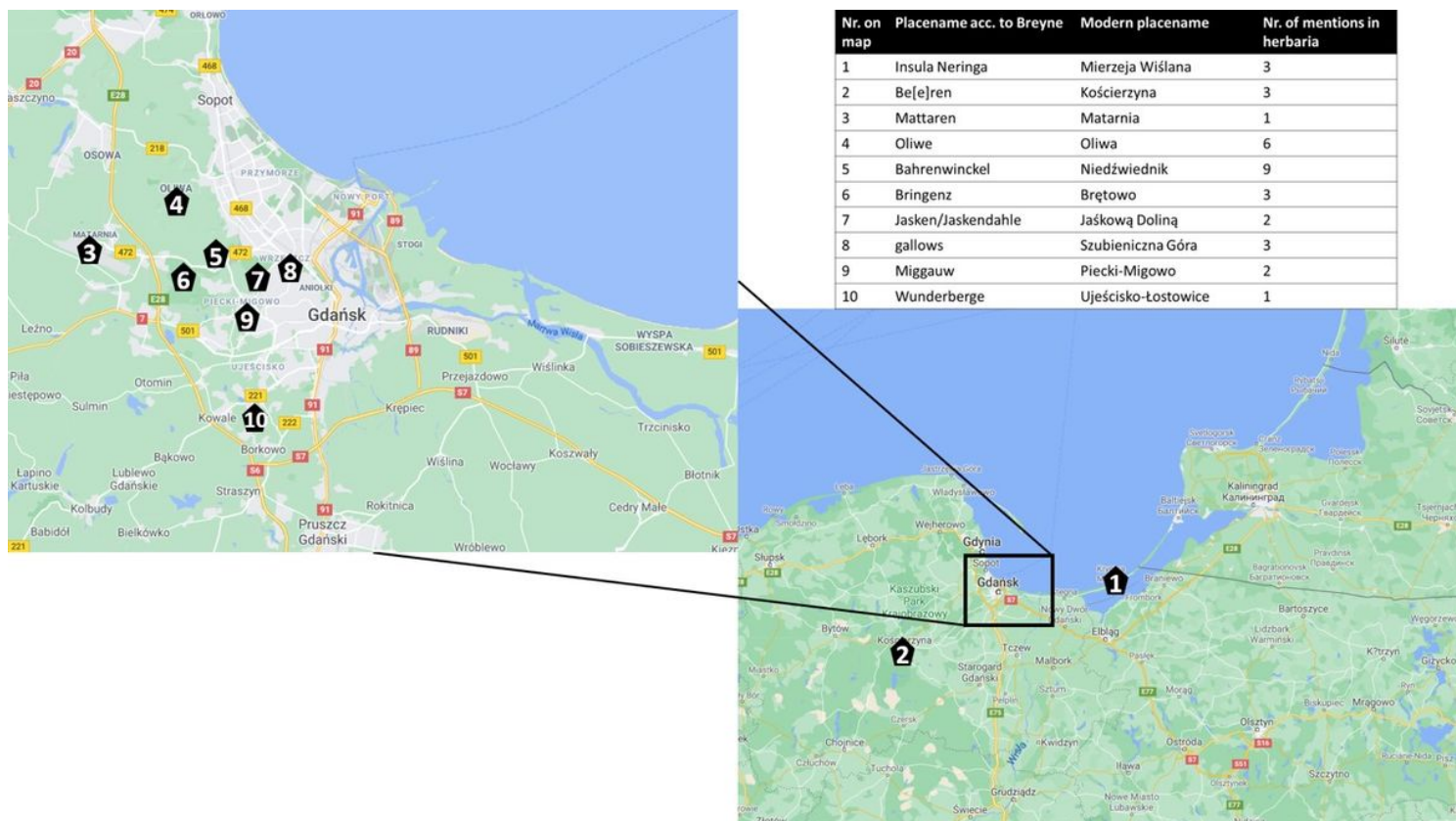


Figure 6

Map of northern Poland and a detail of Gdańsk and surrounding area, showing the collecting locations mentioned in the Leiden Breyne herbaria. The town of Torún, mentioned once, lies south of the reach of this map.

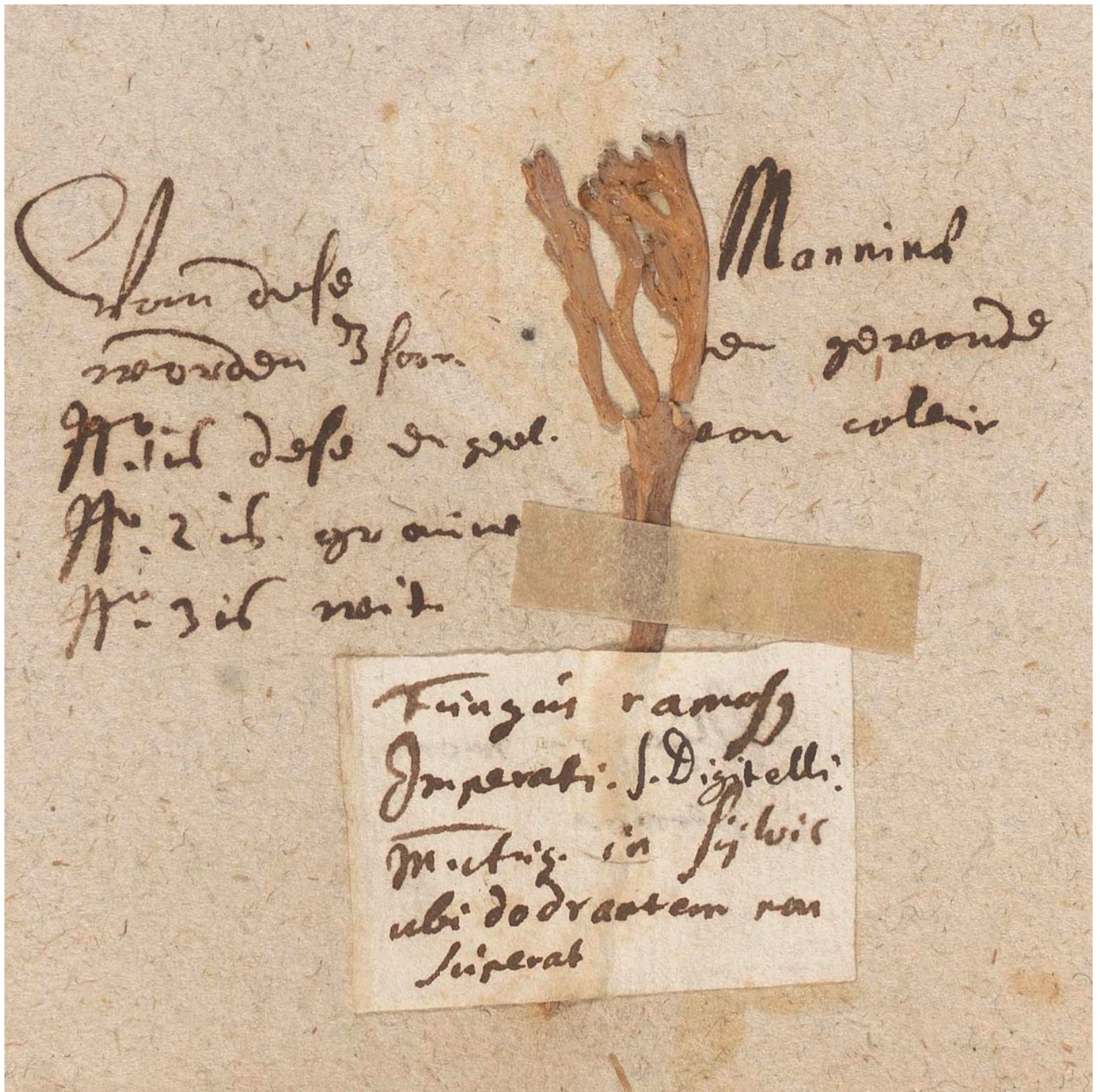


Figure 7

a fungal specimen (*Calocera viscosa* or *Clavulinopsis corniculata*) on page 20 of the 1659 herbarium.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [AppendixI.docx](#)
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