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The “true Boerhaave herbarium”: an analysis of the specimens of Herman Boerhaave (1668–1738) contained in the Van Royen collection at naturalis

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ABSTRACT

Collecting plants and making herbarium specimens was quintessential for an eighteenth century botanist. Studying the extant plant specimens from this period can give us valuable insights into how scholars approached the science of botany. Several dried plant specimens in the 18th-century Van Royen collection kept at Naturalis, Leiden, have at one time been recognised as originating from Herman Boerhaave (1668–1738). The aim of this study is to establish which specimens come from Boerhaave and try to answer the question why relatively few of these survived. We verified which specimens came from Boerhaave and updated the existing identifications of 88 specimens. We studied the way the specimens were mounted, the handwritings on the various labels and the use of decorations. We taxonomically identified them and linked the accompanying labels to the seed register of the Leiden Hortus Botanicus, where these specimens originated from. The transcription of the labels provided us with valuable information about the introduction and cultivation of indigenous and exotic, predominantly Mediterranean, plant species. Little effort has been put into connecting the contribution by Boerhaave with the living collection of the Leiden Hortus botanicus at the time, that is, the herbarium specimens we now know to have been described by Boerhaave. By studying these specimens we made his contribution visible.

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Introduction

After his death in 1738, one of his pupils, Albrecht von Haller (1708–1777), commemorated Herman Boerhaave as *Communis Europae praeceptor*, or “The Teacher of all of Europe” (Lindeboom 2007). Boerhaave (1668–1738) had been lecturer in the theory of medicine (since 1702), professor of botany (1709), professor of chemistry (1719), vice-chancellor of the Leiden University (in 1714 and 1730), while also running a busy doctor’s practice. His prowess in these fields was enhanced by his reputed enthusiasm, accessibility, friendliness, and his boundless energy (Schultens 1739). Boerhaave taught students from all over Europe – more than half of his students were from abroad (Lindeboom 2007) – and was primarily known for his clinical teaching. Recently, there has been increased attention for his botanical activities. Wesseling (2018) highlighted Boerhaave’s skills as a botanist in an accessible monograph and Thijsse and Wesseling (2020) published a survey of herbaria attributed to Boerhaave. Offerhaus et al. (2021) published about the Zierikzee herbarium (Collectie Stadhuismuseum 2022) with possible links to the Leiden Hortus Botanicus and Boerhaave’s botanical classification system in the beginning of the eighteenth

century. In 1709 Boerhaave was offered a professorship in botany. At that time, this professorship also included the post of prefect of the botanical garden, responsible for managing the living collection of plants in the garden. According to Boerhaave’s own statements, his knowledge of botany was flawed. A rhetorical figure of speech or an expression of his modesty, he nevertheless managed to describe and catalogue all 3700 species in the Leiden Hortus Botanicus within a year of his professorship (Boerhaave 1710; Lindeboom 1962; Karstens and Kleibrink 1982).

The authenticity of his publications and botanical collections has been the subject of ample discussion (Lindeboom 1974, 2007). During his life, Boerhaave was confronted by different publications that appeared under his name, but were not authorised by him (Lindeboom 2007). After his death, his collection of dried plant specimens underwent a similar fate. Several herbaria have been ascribed to Boerhaave, but hardly any of these can be linked directly to him, as shown by Thijsse and Wesseling (2020) in their survey of Boerhaave’s (actual and alleged) dried plant collections. Their conclusion that only the individual specimens in Leiden can be linked to him with

certainty is substantiated and further developed in this article. Recent research on two anonymous herbaria, the Zierikzee and the d'Oignies herbarium (in total 1116 plant specimens) concluded that based on the species, their descriptions, pre-Linnaean names, the use of cut-out paper vases, bows, and ribbons to embellish the plant specimens, and the mention of corresponding herbaria in contemporary auction catalogues, these herbaria came from a botanical garden in or near Leiden in the first half of the eighteenth century (Bertin 2016; Offerhaus et al. 2021, 2023). There are two herbaria carrying Boerhaave's name. Both have yet to be researched. One is kept at Naturalis Biodiversity Center in Leiden. Jacob Boerlage, one-time curator at the Rijksherbarium, had suggested that it was made by someone "not skilled in writing Latin". Veendorp and Baas Beeking (1938) added insult to injury by describing the author as "an uncultured person who was certainly not a botanist". The other herbarium is kept at the Natural History Museum as part of the Sloane collection (Jarvis 2016b). There is no reason why the study of these herbaria could not contribute to the understanding of botany in the early 18th century, specifically in and around the Leiden Hortus Botanicus, under the prefecture of Herman Boerhaave.

It has long been an open question what evidence there is that Boerhaave collected plant specimens. Naturalis harbours a large, loose-leafed 18th century collection of vouchers that is named after two prefects of the Leiden Hortus Botanicus: Adriaan van Royen (1704–1779), who succeeded Boerhaave in 1730, and his nephew David van Royen (1727–1799), who succeeded Adriaan in 1754. This so-called "Van Royen collection" contains 8964 specimens, put together by the Van Royens, but also including specimens made by other botanists, such as Jacob Breyne (1637–1697) (De Jong et al. 2022), Paul Hermann (1646–1695), Herman Boerhaave (1668–1638), George Clifford (1685–1760) and Nicolaas Meerburg (1734–1814). The current Van Royen collection was assembled by Marc Sosef while working on the herbarium of the seventeenth century pharmacist Antoni Gaymans (ca. 1630–1680) (Heniger and Sosef 1989). Sosef brought to light a large number of eighteenth century specimens from within the collection of the then Rijksherbarium in Leiden (now part of the collection of Naturalis Biodiversity Center) and both Sosef and Heniger incidentally discovered specimens with labels in Boerhaave's handwriting. Thijsse and Veldkamp (2003) discovered many more specimens present in the Van Royen collection as originating from other botanists. In doing so they uncovered 86 specimens that they attributed to Boerhaave. Here we present evidence of 88 dried plant specimens (not overlapping with the 86 specimens identified by Thijsse and Veldkamp) that were supplied with a label written by

Boerhaave himself or were attributed to him. Despite this exciting discovery, that specimens made by the famous Leiden scientist have survived to this day, no study had focused on these specimens, the species they represent, the labels that accompany them and the decorations that adorn them. The identifications of these specimens were incomplete, 36 vouchers were identified to genus only and most names were outdated according to current nomenclature.

The aim of our research was to establish whether the specimens mentioned above were indeed connected to Boerhaave, by studying the handwritings, the labels and the order in which they were applied. We also completed and updated their identifications. In addition, we looked at the decorations to establish if they could tell us anything about the period in which the specimens were made. Finally, we wanted to answer the broader question as to why these Boerhaave specimens ended up in the Van Royen collection and why so few of them remained, where more would have been expected given the contribution that Boerhaave made in developing a concise botanical system with carefully described genera that encompassed all species then present in the Leiden Hortus Botanicus.

Methods

Verification of specimens as Boerhaave specimens

We downloaded from the Naturalis BioPortal digital images of all specimens that were registered as having been collected by Boerhaave. To obtain these images, we used the advanced search menu on Naturalis Bioportal by a) filling in the name of the collector (Boerhaave), b) selecting a specimen from the obtained list and c) copying the registration number (without the capital). We then pasted the copied number in the ID box of the search menu of the NBC Media library (<http://medialib.naturalis.nl/>), while removing the tick in the box "exact" before pressing "search". The format – indicated in the address bar – of the retrieved digital images was then changed from medium to large. When looking for Boerhaave specimens, we filtered out specimens that contained references to the "Boerhaave kliniek" and specimens collected by Boerlage but wrongfully registered as "Boerhaave". In the resulting list of specimens we also added specimens discovered by Heniger and Sosef (1989) and by Thijsse and Veldkamp (2003).

We verified specimens as Boerhaave specimens when they were accompanied by a label in his handwriting, when it was explicitly mentioned on the sheet by a later author that this particular specimen came from Boerhaave's collection or herbarium ("ex Coll. Boerhaave" or Herb.Boerhaave), or – in one case – when the text on the label referred directly to the seed

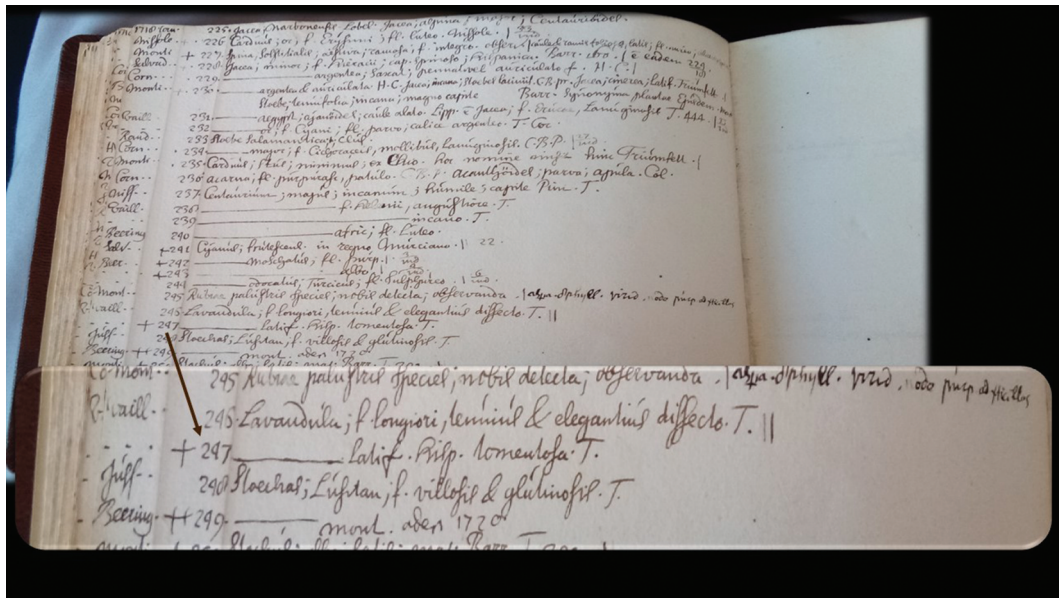


Figure 1. Seed register of the Leiden Hortus Botanicus from the year 1718, handwritten by Boerhaave. The names of the persons from whom he received seeds are shown in the left column. An example is given in the excerpt, *Lavandula latifolia* L. (L 0142070) sent to Boerhaave by Sebastien Vaillant.

register of the Leiden Hortus Botanicus kept by Boerhaave. We identified the handwriting of Boerhaave on labels alongside the plant specimens by comparing it with the handwriting in the seed register kept by Boerhaave from 1712 till 1727, the *Index Seminum Satorum*, which can be consulted at the Special Collections of the Leiden University Library (BPL 3654) (Figure 1). We studied the handwriting on other labels next to the plant specimens or occasionally the text written on the sheet itself to establish the authors of the different labels. For this we used Ek (2011), Jarvis (2016a) and Wijnands and Heniger (1991) and different handwritings on other specimens present in the Van Royen collection. We deciphered the labels on designated Boerhaave specimens. We compared the text of the labels with the text in Boerhaave's garden catalogues of the Leiden Hortus Botanicus (Boerhaave 1710, 1720) and the entries in his seed register (1712–1727). We studied the position of the label from Boerhaave vis-à-vis the other labels. We looked at the way the specimens were mounted. To assess the origin of the vases and ribbons, we looked for identical decorations in herbaria of eighteenth century botanists as discussed by Wijnands and Heniger (1991), Ek (2011), Thijsse (2018) and Offerhaus et al. (2021).

Species identification

We physically examined the specimens for the purpose of botanical identification. We revised the previous identifications and completed those that had been made at the genus level. For this we used floristic literature from the Netherlands (Eggelte 2007;

Duistermaat 2020), the Mediterranean (Blamey and Grey-Wilson 2008; Thorogood 2016, 2019), Europe (Tutin et al. 2001) and herbarium specimens available online at the Naturalis BioPortal (<https://bioportal.naturalis.nl/>, accessed 21 March 2022) and Europeana (<https://www.europeana.eu/nl/>, accessed 21 March 2022) as comparative material. We used Plants of the World online (POWO 2022) to check the current scientific name and geographical origin for each plant species.

Finally, we created an Appendix (Supplementary information) with all the relevant data, including the transcriptions of text on the labels. If no Boerhaave label was present, but mention was made by other authors that the relevant specimen came from Boerhaave's herbarium or collection, this was indicated separately. The ubiquitous “Herb.vRoyen” or “Hb.vRoyen” in a 19th century-style handwriting, present (frequently multiple times) on all herbarium sheets, was left out of the Appendix. Labels from the 19th century and later were not taken into account. The Van Royen collection is now kept in separate cabinets at Naturalis and is accessible via the collection managers. It has not yet been researched fully and new discoveries within the collection and in boxes with as yet not researched specimens from the 18th century are still being made.

Results

Botanical Content of Boerhaave's specimens

Our initial query resulted in 100 “Boerhaave” specimens. While browsing on Naturalis Bioportal and through the folders containing Boerhaave specimens

in the Van Royen collection, the first author discovered three more Boerhaave specimens (L 0077176, L 0224014 and L 0328454). After applying our filter criteria, we were left with 88 specimens that could be attributed with certainty to Boerhaave: 81 specimens were identified as Boerhaave's based on the presence of a label in Boerhaave's handwriting, six based on a written statement that the specimen came from his collection or his herbarium and one based on a copy of an entry to Boerhaave's seed register of the year 1717 written by Adriaan van Royen. In the seed registers Boerhaave (1712-1727) mentioned when he sowed the seeds, which seeds caught on, under which number they were listed in his catalogue, and occasionally, what the plants that grew out of the seeds looked like. He stated from whom he received the seeds and how they were described by the correspondent, and from 1712 till 1717 to whom he sent and from whom he received letters. The year and registration number on 22 labels corresponded with the year and number in the seed register. The specimens are expected to be fully searchable in Naturalis Bioportal in the second half of 2022.

Our taxonomic identification resulted in updated names for 57 of the 88 specimens. All 88 specimens belong to 71 species, distributed over 19 families (Appendix). Most of these species are Mediterranean (36), 33 species have a wider geographical distribution (Temperate Eurasia), two are from the Americas, two from the Indian subcontinent, one from South Africa, and one is a green alga with a global distribution (POWO 2022). The dominant family was the Lamiaceae with 38 specimens and 28 species (43% of all specimens), more than half of which come from the Mediterranean. The Fabaceae and Brassicaceae were represented, with seven species each, and 16 families were represented by one to five species. 23 specimens could be linked to a correspondent, but not necessarily linked to a geographical area of origin, since in general most seeds came from botanists associated with botanical gardens, where exotic plant species were also cultivated. In the preface to his 1710 and 1720 catalogue, Boerhaave indicated that a line beneath a plant number signified the medicinal character ("officinalem") of the species. This allowed us to establish that only five of the specimens, *Teucrium chamaedrys* L. (L 0142406 and L 0142408), *Trigonella foenum-graecum* L. (L 0140058), *Dictamnus albus* L. (L 0140230) and *Lavandula latifolia* L. (L 0142070) were considered medicinal by Boerhaave. This does not mean that other species were not considered as such, but that this was not the case in Leiden in Boerhaave's time.

Below we provide three examples that illustrate the kind of information present on the specimens' labels and how we worked on them. The text on Boerhaave's label next to the specimen of *Clinopodium nepeta* (L.) Kuntze (L 0142106), reads "*Calamintha; praealta*" (a very tall Calamint), and "*sicula Bocc.*", with "*sicula*"

(Sicilian) referring to the title of the book "Museo di piante rare della Sicilia, Malta, Corsica, Italica, Piemonte, e Germania" (Boccone 1697), and "Bocc." referring to its author, Paolo Boccone (1633–1704). Boccone describes how he found the plant in Veneto, near lake Annecy and in the Savoy (1697). The description of this species we find in Boerhaave's catalogue under no 6 of the genus *Calamintha* (1720 I, 175). This identification was followed by David van Royen, as shown by one of the other labels in his handwriting, who cited the Linnaean name from the second edition of "*Species Plantarum*" (Linnaeus 1762-1763, p. 828), but the label written by his predecessor Adriaan refers to the first species in the genus *Calamintha* from the catalogue of Boerhaave (1720 I, 175) and reads "*Calamintha; magno flore*", "a large-flowered Calamint", later incorporated by Linnaeus as source for *Melissa grandiflora* L. (Linnaeus 1753, p. 592/3), a different species, currently synonymized under *Clinopodium grandiflorum* (L.) Kuntze (Figure 2). A non-flowering shoot of *Lavandula*



Figure 2. A Boerhaave specimen of *Clinopodium nepeta* (L.) Kuntze (L 0142106) adorned with elegant ribbons. The "discussion" between the prefects as to what species the plant belongs to is evident on the labels: *Clinopodium nepeta* (L.) Kuntze or *Clinopodium grandiflorum* (L.) Kuntze.



Figure 3. a. Boerhaave's specimen of *Lavandula latifolia* L. (L 0142070) with spatulate leaves. b. The same species with both spatulate and more elongated leaves present in the Clifford herbarium (BM000628950), kept at the Natural History Museum, London (Jarvis 2016a). Permission to publish was granted by the Board of trustees of the Natural History Museum, London and is subject to licence CC-BY. c. A more recent specimen from the Leiden Hortus Botanicus displaying more typical, linear leaves (L 3711461), kept at Naturalis Biodiversity Center, Leiden (Naturalis BioPortal 2022).

latifolia L. showed us that it can sometimes be quite difficult to identify a specimen (Figure 3(a-c)). On Boerhaave's label (Figure 3(a)) it is correctly described, but the absence of an inflorescence and the atypical morphology of the leaves (broadly spatulate) did not point to this species. Another specimen of a non-flowering shoot of *L. latifolia* L. that has both spatulate and more typical acute elongated leaves is present in the Clifford Herbarium (Figure 3(b)). Even though the specimens in the Clifford Herbarium do not contain any information about the period in which they were acquired or sown, it can be assumed with good reason – given the morphological correspondence between these two specimens – that Boerhaave gave this particular specimen to George Clifford (1685–1760). In the preface to the Hortus Cliffortianus, Linnaeus writes that Boerhaave laid the foundation for the garden by contributing to it with many plants (Linnaeus 1737; Wijnands and Heniger 1991). No year or number was indicated on the label of this Boerhaave specimen, but we found an entry in the seed register of the Leiden Hortus Botanicus of 1718 under number 247, containing a matching description: “*Lavandula latif. Hisp. tomentosa T.*”. These seeds were sent to Boerhaave by Sebastien Vaillant in 1718 (Figure 1) and may be the source of the Boerhaave specimen referred to herein. The Boerhaave label next to a specimen of *Thymbra spicata* L. (L 0142254) (Figure 4) reads “*Salvia; hispanica; Lavandulae folio.*

T.181”, “a Spanish sage with lavender leaves”, corresponding with a description in his catalogue of 1720 (I, 167: 19. *Salvia; Hispanica; folio lavandulae. T.181.H*). There is, however, nothing Spanish about this species, as it occurs in the eastern Mediterranean, from Iran to Greece. There is nothing sage-like to it as well. It actually is a species with oregano essential oils and used as a spice in East Mediterranean countries, as an ingredient of the spice-mix “Za’atar” (Stefanaki et al. 2018; Stefanaki and Van Andel 2021). The nomenclature of *Thymbra* was rather muddled in the 17th century, as this species was arranged under *Thymum* by Leonard Plukenet, under *Hyssopum* by Jean Bauhin and under *Satureja* by Denis Dodart, sources listed by Linnaeus in his *Species Plantarum* (Linnaeus 1753, p. 569), but it was never listed under *Salvia*. Boerhaave listed the species we now know to be *Thymbra spicata* L. under the genus *Hyssopum*. In his garden catalogue we read: 5.*Hyssopum; montanum; Macedonicum; Valerandi Dourez.J.B.3.276.H.*’ (Boerhaave 1720 I, 160), which roughly translates as ‘the fifth *Hyssopum*, a Macedonian mountain hyssop described by Jean Bauhin in the third part of his *Historia Plantarum* based on a collection of plants, given to him by Valerand Dourez (whereby “Macedonicum” then indicated a far wider area than present-day Macedonia). The plant needs a hibernaculum (H), a protective case to ensure the plant survives the low temperatures in the winter.



Figure 4. A Boerhaave specimen of *Thymra spicata* L. (L 0142254). This is one of the 37 specimens attached with paper strips. The Boerhaave label (“Salvia ...”) accidentally glued on this sheet was originally intended for another plant specimen.

Boerhaave received seed of a species described as *Thymbra; spicata; verior; Hispanica. Barr.* from Sébastien Vaillant in 1718. It was registered under no 273. Based on the above Boerhaave must have known what *Thymbra spicata* L. looked like. Linnaeus uses the same source reference in *Species Plantarum* (Linnaeus 1753, p. 569) for this species.

Connection to Boerhaave’s Seed Registers (1712-1727)

Boerhaave was part of a network of correspondents, that consisted of botanists from all over Europe and even the Ottoman empire. His surviving specimens provide us with a tangible insight into his network. In his seed register, the *Index Seminum Satorum* (Boerhaave 1712-1727), Boerhaave listed which seeds he received and from whom. He assigned the seeds a number, added the enclosed description from his correspondent and listed when he sowed them. Afterwards he on occasion added information on

how the seedlings looked like after flowering and under which number the species was listed in his garden catalogue. A total of 24 Boerhaave specimens was accompanied by labels on which the year was written, from 1717 until 1721, in which Boerhaave had sown the seeds, and the registration number assigned to these seeds (Figure 1). Two specimens were accompanied by a label on which a year and a date was written, but no registration number. This information enabled verification in Boerhaave’s seed register and revealed the correspondents he received the seeds from. For instance, in 1718 Boerhaave received seeds of *Scrophularia frutescens* L. (L 0142777; L 0142778), a West Mediterranean species, from both Sébastien Vaillant (Paris) and Bernard de Jussieu (Paris) and listed them under nos. 410 and 416. He received seeds of *Salvia sclarea* L. (L 0142238) from William Sherard (Izmir (Smyrna)/London) in 1717 and listed them under no 182, while in 1718 he received seeds of *Salvia verbenaca* L. (L 0142240) from Johann Beeringer or Beringer (Würzburg) and listed them under no 293. Vaillant features nine times in the list of correspondents, followed by Beeringer, Isaac Rand (Chelsea), Bernard de Jussieu (Paris), Michelangelo Tilli (Pisa), William Sherard (Izmir/London), Guillaume Nissole (Montpellier), Hans Sloane (London) and Joan Salvador i Riera (Barcelona). A specimen of *Pardoglossum cheirifolium* (L.) E.Barbier & Mathez, registered as no 223 in his seed register of 1720, reveals no correspondent, but has “HM” as provenance. This probably refers to *Hortus meus*, the prefect’s own garden next to his house in the Leiden Hortus Botanicus (See Appendix).

The Seed Register before 1712 and after 1727

The earliest surviving register dates from the year 1712, but the registry numbers 118 and 119 from this year describe a *Trifolium* species with reference to the years 1709 and 1711. The labels that were added by Adriaan and David van Royen mention dates later than 1727 and numbers connecting the specimens to a seed register. For example, a label by Adriaan van Royen glued next to a Boerhaave specimen of *Fibigia clypeata* (L.) Medik., mentions “1735” and the registration number “344” (L 0224085). Another example is a specimen of *Rogeria longiflora* (D.Royen) J.Gay ex DC collected by David van Royen (L 0003350), with 473/63 on one of the labels, indicating it was sown in the year 1763 and listed in the seed register under no 473. These show that before 1712 and after 1727 records were kept. Unfortunately, but for these references all evidence of these records has been lost. Having received the seeds Boerhaave had no way of knowing what the plants that grew out of these sometimes exotic seeds would look like, other than the descriptions his correspondents presented him with.

Once the seed had germinated and turned into a recognisable plant, the dried specimen of the plant would have been provided with a descriptive label. In 19 of the 23 cases the text on the labels turned out to be identical to the text in the seed register, suggesting that Boerhaave copied the seed register entries and used them for the labels belonging to his specimens. There were exceptions: in 1717 he received a seed from Hans Sloane, described as a conically shaped, darkish seed (*semen conicum fuscum*) and entered it as no 57 on a separate list of plants sown with manure. The label that can be linked to this entry, is placed next to a specimen of the plant that grew out of this seed, *Scoparia dulcis* L. (L 0077176) and contains a rather elaborate description based on Boerhaave's own observation of the plant.

Connection to the Garden Catalogue

The description of 55 out of 84 Boerhaave labels corresponded to an entry in the garden catalogue (Boerhaave 1710, p. 20). However, there are eight descriptions on the Boerhaave labels that refer to species that do not yet have a corresponding description in the catalogue of 1720, but are allotted a higher number than the other species arranged under the same genus in this catalogue. Evidently, Boerhaave started preparing a new edition of the garden catalogue based on the presence of new species he described and the higher numbers he accorded them within the genus, but there is no evidence if he ever published a third edition of the garden catalogue. In the 1720 catalogue, Boerhaave listed various sources while describing a species, but ultimately selected one source to begin the entry with. Descriptions within the seed register and on the Boerhaave label correspond to a high degree with the catalogue text, but they also differ from it (L 0142240 and L 0223361). While writing the catalogue, Boerhaave made choices in plant names that differed from the descriptions present in the seed register and on the labels (See Appendix)

Mounting, Decorations, general Display, and other Labels

As far as mounting is concerned, the specimens fall into two categories: 51 specimens were glued to a neatly trimmed piece of paper, that in turn was glued to a more recent herbarium sheet, making it impossible to look for watermarks to date the paper accurately. However, small dark-coloured spots were visible in the paper, that were possibly caused by metal particles derived from clothing or papermaking equipment, causing it to bear resemblance to the paper of the specimens listed as collected by Boerhaave's successor, Adriaan van Royen. The hot glue that was used to secure the specimens was probably based on fish,

bones or gelatin, as is known from the restoration of contemporary herbaria (Offerhaus et al. 2021). 37 specimens were attached to the more recent herbarium sheets by way of paper strips (Figure 4). All but one of those 51 glued specimens were embellished with decorations, such as vases and ribbons. These particular decorations were designed and executed by the Leiden painter Hieronymus van der My and engraver Johannes van der Spijk, the first active from 1710 (Krikke-Frijns 1989), the second from 1716 onwards (Waller 1938). Identical decorations are used in the the d'Oignies herbarium (Figure 5(a)), on a Boerhaave specimen (Figure 5(b)) and in the herbarium of George Clifford (Figure 5(c)). Prints of a copperplate engraving, signed by Van der Mij and Van der Spijk and preserved in the Naturalis archives (Thijsse 2018), reveal vases, ribbons and an ornamental frame, five of which were used to decorate the Boerhaave specimens. The execution of one of these vases was slightly adapted, but still displayed the same design. Given that these decorations were used from 1712 until well into the eighteenth century, claiming a time period based on their presence is problematic. Here we are presented with decorations together with labels that point to a period between 1712 and 1721. If the decorations were not added later, they date back to this period. The plant specimens in the Zierikzee and the D'Oignies herbarium are partly embellished with the same decorations, and are displayed in an identical fashion to the Boerhaave specimens: most plants have been mounted individually in the middle of a single page, with the leaves alternately reversed to show the abaxial as well as the adaxial side, and separate leaves decorated with bows and ribbons positioned on either side of the plant (Figure 6(a-c)). Next to the labels by Boerhaave, labels are present that were written by Adriaan and/or David van Royen (see Appendix). Both Adriaan and David sometimes write on the Boerhaave label itself. In 10 cases, the *older* label by Boerhaave is secured with glue on top of the *younger* labels by Adriaan or David van Royen (Figure 7). Therefore, the labels must have been preserved unattached alongside the sheet and were later glued to the herbarium sheet or on top of younger labels, some as recent as 1913. Several labels revealed handwritings that did not belong to either Adriaan or David van Royen, but we were unable to establish to whom these handwritings belonged.

Discussion

Why so few specimens from Boerhaave survived is a mystery. It is hard to imagine Boerhaave managing a garden with thousands of species, writing catalogues with botanical descriptions based on critical thinking and not having a substantial herbarium to consult. It seems that these Boerhaave specimens within the Van



Figure 5. a. D'Oignies herbarium, book 6, 29 (*Chrysosplenium alternifolium* L.), kept at Naturalis Biodiversity Center, Leiden. b. Boerhaave specimen in the Van Royen collection, L 0141836 (*Pardoglossum cheirifolium* (L.) E. Barbier & Mathez.). c. Clifford herbarium BM000557874 (*Echium vulgare* L.), kept at the Natural History Museum, London (Jarvis 2016a). Permission to publish was granted by the Board of trustees of the Natural History Museum, London and is subject to licence CC-BY.



Figure 6. a. *Salvia viridis* L. from the Boerhaave specimens in the Van Royen collection (L 0142255). b. *Leonurus cardiaca* L. from the d'Oignies Herbarium, book 2, 13 (L 3961004), kept at the Naturalis Biodiversity Center, Leiden (Naturalis BioPortal 2022). c. *Cynoglossum officinale* L. from the Zierikzee herbarium (no 116), kept at the Stadhuis museum, Zierikzee (Collectie Stadhuis museum 2022).

Royen collection are only remnants of a once larger collection by Boerhaave that was scattered or lost in the course of time. The specimens were originally accompanied by unattached labels. In the course of

time and of necessity, these loose labels went missing, thus making the specimens liable to be identified incorrectly, as was most likely the case with *Thymbra spicata* L. (L 0142254) (Figure 4), or to be appropriated



Figure 7. Boerhaave specimen of *Teucrium chamaedrys* L. (L 0142404) with Boerhaave's label (*chamaedrys; fruticosa; Creticum; flore purpureo.T.*) glued on top of a later label by David van Royen (*Teucrium massiliense* LSp.(2) 789). This shows that the labels were attached to the herbarium sheets at a later stage: the older label was applied on top of a younger one.

by other collectors. This sheds a different light on the origin of the anonymous Zierikzee and D'Oignies herbaria, which Offerhaus et al. (2021) argued to have been partly produced by a gardener of the Leiden Hortus Botanicus in the beginning of the 18th century. With labels that went missing and descriptions that were added later we are left with vouchers that resemble the specimens by Boerhaave and the Van Royens to such a degree that a common tradition, a “Leiden school” of mounting specimens, or even a common origin is possible (Figure 6(a-c)).

The high percentage of Lamiaceae among the Boerhaave specimens (38 out of 88) also raises questions. Did these specimens survive for a particular reason? This high representation may be understood if we assume that the Zierikzee herbarium, the d'Oignies herbarium and the Boerhaave collection were all part of the same herbarium made in the

Leiden Hortus Botanicus. Then Boerhaave's Lamiaceae (38) could be complementary to the ones in the Zierikzee- (37) and the d'Oignies herbarium (51).

Considering the possibility that more Boerhaave specimens may have been incorporated into the Van Royen collection, it is necessary to continue scanning the extant 8964 specimens in order to find more specimens with clear indications (handwriting, comments) relating them to Boerhaave. While browsing through some folders with unclassified eighteenth century specimens in search of the Gaymans specimens, Sosef (pers. Comm.) found four Boerhaave specimens (L 0367485, L 0142052, 0142054 and 0142055) and suggested the possibility that there are still more hidden in this residual collection of 18th century herbarium specimens in Naturalis. Even though the Van Royen collection has been scrutinised for type specimens (Jarvis 2007), it has not been researched thoroughly and its specimens are insufficiently identified. A critical look at the specimens would certainly yield interesting data. Currently, only the type specimens are available on the Naturalis Bioportal, but the online publication of all digital images – would greatly facilitate this research.

Boerhaave's seed registers can be consulted *in situ* at the University Library in Leiden, but they are not digitised and thus cannot be consulted online. Together with the material that is kept at the Leiden archive (Erfgoed Leiden en Omstreken: Archive nr. NL-LdnRAL-1658/I Herman Boerhaave/I.B.5,27), where Boerhaave registered the location of the species in the botanical garden, these documents give an interesting insight in the functioning of a botanical garden at the beginning of the 18th century and they certainly deserve more scientific attention. In these unpublished sources, the invisible hand of the gardeners comes to light. Weeding, watering, digging, planting, fertilising, propagating: all was done by gardeners. These activities must have generated knowledge, that was in turn transferred to the prefect of the garden, the professor of botany. Therefore, it is essential that their role is given more scholarly attention, as they facilitated the flourishing science of botany in the 18th century (Shabin 1989; Hickman 2019; Berkhout 2020). The bound “Boerhaave herbarium” kept at Naturalis, as well as a bound “Boerhaave herbarium” in the Sloane collection in the Natural History Museum in London (Jarvis 2016b) have never been studied but deserve proper scientific attention. The fact that they are supposedly not made by Boerhaave is in a sense not that relevant, as they are witnesses to a period and a place in which the science of botany was at its heyday.

Conclusions

Our research showed that 88 of 100 presumed Boerhaave specimens in the Van Royen collection can be safely attributed to Herman Boerhaave. Seeds related to these specimens were sent to Boerhaave by various correspondents around Europe and possibly Izmir, then part of the Ottoman empire. Comparing these specimens with specimens in the contemporary herbaria of D'Oignies and Zierikzee we noticed remarkable similarities in their mounting, arrangement, and decorations. More research on the D'Oignies and Zierikzee herbaria is expected to shed light on the potential common origin of the three collections hypothesized herein, in relation to the Leiden Hortus circles around the time of Herman Boerhaave.

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Author contributions

AO and TvA conceived and designed research. AO and AS taxonomically identified specimens. AO analyzed data and wrote the paper. All authors commented on and approved the final version of the manuscript.

Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article and its Appendix (Supplementary material). Digital images of the herbarium specimens this study was based on will soon be publicly available through Naturalis Bioportal. <https://bioportal.naturalis.nl/>

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