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The early book herbaria of Leonhard Rauwolf (S. France and N. Italy, 1560–1563): new light on a plant collection from the ‘golden age of botany’

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Abstract

The sixteenth century was a golden age for botany, a time when numerous naturalists devoted themselves to the study and documentation of plant diversity. A very prominent figure among them was the German physician, botanist, and traveler Leonhard Rauwolf (1535?–1596), famous for his travel account and luxurious book herbarium containing plants from the Near East. Here, we focus on the less studied, early book herbaria of Rauwolf. These form a three-volume plant collection bound in leather and gold, which contains over 600 plants that Rauwolf collected between 1560 and 1563 in S. France and N. Italy when he was a student of medicine. We show the botanical value of Rauwolf’s early book herbaria, exemplified by two exotic American specimens, namely one of the oldest surviving specimens of tobacco (*Nicotiana rustica*), collected in Italy, and the oldest known French record of prickly pear (*Opuntia ficus-indica*). These well-preserved specimens indicate that Rauwolf was eager to collect exotic plants already in his early botanical steps. We further discuss Rauwolf’s professional botanical network during his student years and suggest that the famous Swiss botanist Johann Bauhin (1541–1613), friend and companion of Rauwolf during his field excursions and their medical studies in Montpellier, has played a significant role in the compilation of this precious historical plant collection. We also show that Leonhart Fuchs (and not Carolus Clusius) extensively annotated the three book herbaria. Finally, we reconstruct the story of making of the book herbaria, as evidenced through observations of paper watermarks and handwritten texts in the book volumes, and show that all four book herbaria of Rauwolf were probably bound between 1577 and 1582.

Keywords History of Botany · Historical collections · Tobacco · *Opuntia* · Johann Bauhin · Leonhart Fuchs

1 Introduction

During the sixteenth century, numerous scholars across Europe devoted themselves to the documentation, description, collection, and preservation of the natural world (Ogilvie 2006; Cooper 2007). Turning to nature in search for the plants described in antiquity, these sixteenth century naturalists discovered new plants, unknown to the ancient authors, and attempted for the first time in history to catalogue all then known species (Ogilvie 2006; Cooper 2007; Egmond 2018). They carried out field expeditions to collect plants, press-dried and glued them on paper sheets, compiling the oldest book herbaria that survive today. It was through these processes that botany diverged from a medicinal practice into a scientific discipline of its own (Stefanaki et al. 2019). In this so-called botanical Renaissance of the sixteenth century, no other naturalist exhibited the adventurous and

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pioneering spirit of the German physician, botanist, and traveler Leonhard Rauwolf (1535?–1596).

Rauwolf was born in Augsburg, a bustling merchant city in southern Germany, from a middle class family of iron traders. Later he became famous as the first early modern European to travel to the Near East up to Baghdad in search for new medicinal plants (Walter 2009; Ghorbani et al. 2018). This hazardous journey that lasted 3 years (1573–1576) is documented in detail in Rauwolf's printed travel account (Rauwolf 1583). This book was to become a bestseller at its time, having been published in multiple editions and translations (Walter 2009; Ghorbani et al. 2018). In the first lines of his travelogue, Rauwolf finely outlines the concept of sixteenth century botany, expressing his keen interest, since very early in his life, in the plants described by the ancient Greek and Arabic authors. He expresses his intention to acquire knowledge on these plants and see them in their native habitats in the Mediterranean. He also reports that the tales of Augsburg merchants had awakened in him the desire to travel (Rauwolf 1583). The output of this profound, life-long desire was a large collection of almost 900 dried plant specimens from France, Italy, Lebanon, Syria and today's Iraq bound in four book volumes.

Long before reaching fame as a traveler to the Near East, Rauwolf started the compilation of his plant collection while a young student of medicine. After a short time at the universities of Tübingen (1554) and Wittenberg (1556), he went to the medical university of Montpellier (Ganzinger 1963; Dannenfeldt 1968) (Fig. 1). There, from 1560 to 1562, he studied medicine as a student of the famous botanist, and pupil of Luca Ghini, Guillaume Rondelet (1507–1566) (Dannenfeldt 1968). During his student years, Rauwolf eagerly botanized in the surroundings of Montpellier, and also around Languedoc, Provence, Auvergne, and Rhône Alpes. The plants he collected formed the first two books of his plant collection. Rauwolf graduated in 1562 from the University of Valence, Dauphiné (Dannenfeldt 1968). In 1563, he carried out his

peregrinatio academica traveling through the Alps to N. Italy. On the way, he collected the plants that formed the third book herbarium. Rauwolf visited Padua, Verona, Mantua, Ferrara, Bologna, Florence, Modena, Piacenza, Parma, Milan, and Como, heading forward through Switzerland to Germany. During this homeward journey, Rauwolf visited Conrad Gessner (1516–1565) in Zurich, accompanied by his friend and classmate from Montpellier, Johann Bauhin (1541–1613) (Durling 1965). According to Legré (1900), that same year, Rauwolf met in Augsburg with Carolus Clusius (1526–1609), to which he presented the plants he had collected in France and Italy, and presumably accepted Clusius' annotations and corrections of several plant names. Doubting Legré's argument, Ganzinger (1963) attributed the numerous annotations and corrections found in Rauwolf's herbaria to Leonhart Fuchs (1501–1566), suggesting that Rauwolf, on his way back to Augsburg in 1563, also visited Fuchs, his former teacher in Tübingen. Ganzinger (1963) also observed that Fuchs had marked several plants with the phrase 'Soll gerissen werden', an indication to illustrator Jerg Ziegler to draw these plants for Fuchs' upcoming herbal (Seybold 1990; Kusakawa 2006). The latter was an impressive collection of over 1500 plant illustrations that remained unfinished due to Fuchs' death and only saw the light of publication in 2001 (Baumann et al. 2001).

In 1571, Rauwolf was appointed city physician of Augsburg, a position that he, as a devoted Protestant, lost 17 years later due to religious conflicts. For the city council had dismissed the old preachers who had found favor in the congregations and appointed new ones, an act of arbitrariness against which Rauwolf and others protested (Herde and Walter 2010). Thereby getting into financial difficulties, he decided to sell his herbaria, which he achieved for a remarkable price, 310 Reichstaler, which had to be paid to Rauwolf by the imperial chamber. The four book herbaria were bought in 1593 by a commissioner of the Habsburg Emperor Rudolf II (1552–1612) and became part of Rudolf's famous

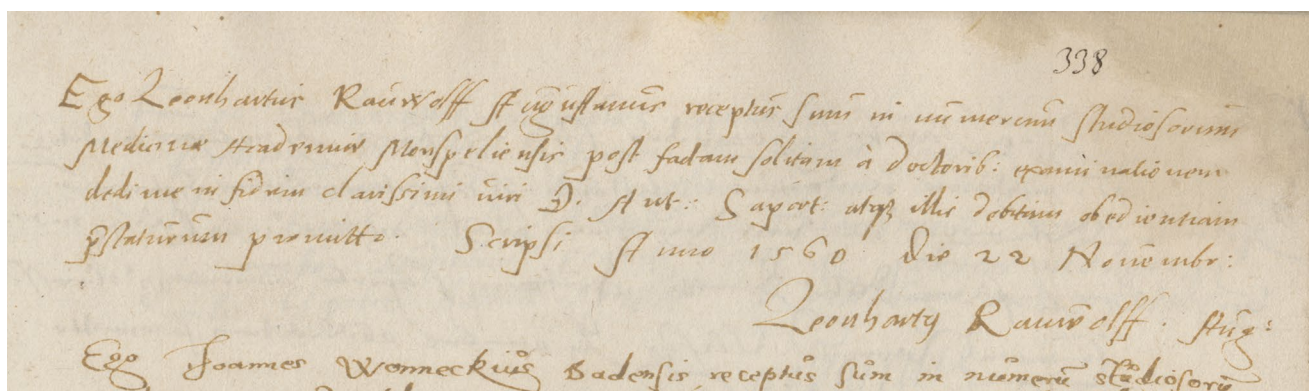


Fig. 1 Matriculation oath of Leonhard Rauwolf at the University of Montpellier in 1560. Credit: BIU de Montpellier. Service photographique

collections in Prague (Callmer 1973; Walter et al. 2021). They were later stolen by Swedish troops, and, together with the Italian En Tibi herbarium, which was also part of Rudolf's cabinet of curiosities, they were brought to Stockholm and handed to Queen Christina of Sweden (Callmer 1973; Stefanaki et al. 2019). There they came to the possession of the Dutch librarian Isaac Vossius (1618–1689). When Vossius died, his heirs sold Vossius' collection of books to Leiden University and the book herbaria finally came in 1690 to Leiden, where they are preserved to this day. The first herbarium is on display at the Boerhaave museum, and the remaining three herbaria are kept in the treasure room of Naturalis Biodiversity Center.

The botanical content of the fourth volume comprising the plants that Rauwolf collected in the Near East was recently studied by Ghorbani et al. (2017, 2018). Our work focuses on the first three volumes of Rauwolf's plant collection (hereafter Rauwolf's early book herbaria), compiled during his student years. Unlike Rauwolf's travels to the Near East, this early period of Rauwolf's botanical activity is hardly known. According to Dannenfeldt (1968) and Herde and Walter (2010), the best historical source for the travels of Rauwolf in France and Italy is Rauwolf's herbaria themselves, which have remained to date largely unexplored. Several attempts by J.G. Boerlage (1849–1900), former staff member of the Rijksherbarium in Leiden, to catalogue and identify the specimens of the book herbaria, have remained incomplete (Naturalis archives). Part of the botanical contents of the first and the second herbarium were published by Legré (1900), but the plant specimens of the third volume were never studied. Images of specimens contained in the herbaria have been published by Thijssse (2016), Stech et al. (2018) and Stefanaki and van Andel (2021). A full inventory of the plant species included in the herbaria is in preparation by some of the authors of this article. Here, we present some exotic specimens contained in the herbaria, discuss the professional botanical network of Rauwolf in the period when the herbaria were compiled, and elucidate the history of compilation of this precious historical plant collection.

2 Materials and methods

To demonstrate the botanical value of Rauwolf's early book herbaria, we focused on two specimens of exotic species, namely *Nicotiana rustica* L. (tobacco) collected in Italy, and *Opuntia ficus-indica* (L.) Mill. (prickly pear) collected in France. We searched for specimens of these two species in other surviving sixteenth century book herbaria from Italy, France and other European countries, namely the herbaria of U. Aldrovandi (Soldano 2000, 2001, 2002, 2003, 2004, 2005), A. Cesalpino (Caruel 1858), M. Merini (Chiovenda 1927), J. Girault (images of its index provided by

the National Museum of Natural History, Paris), C. Bauhin (<https://herbarium.unibas.ch>), F. Platter (<https://www.burgebib.ch/de/bestaende/privatarchiv/einzelstuecke/platter-herbarium>), C. Ratzenberger (Kessler 1870), H. Harder (Speta and Grims 1980; <http://daten.digital-sammlungen.de/~db/0001/bsb00011834/images/>), the Erbario Ducale Estense (Camus and Penzig 1885), the En Tibi herbarium (Stefanaki et al. 2018) and Erbario A and B (Penzig 1905).

To explore the botanical network of Rauwolf in the period of compilation of his early book herbaria, we identified the naturalists who contributed handwritings in the three book volumes. For this, we compared the handwritings of plant names, descriptions and annotations found next to the plant specimens and in the indices with samples of the handwriting of Rauwolf and that of other sixteenth century naturalists that are reported to have been connected to Rauwolf in the 1560s. These are (i) Carolus Clusius, of which we used autograph letters to various recipients held at the Special Collections of Leiden University Library, the Trew collection (www.trew-letters.com), and Clusius' correspondence: a digital edition-in-progress (<https://clusiuscorrespondence.huylgens.knaw.nl/edition/>); (ii) Leonhart Fuchs, of which we used two autograph letters to Joachim Camerarius the Elder, dated 24 November 1565 (<http://gateway-bayern.de/BV044375082>), and 27 May 1543 (Stübler 1928); (iii) Conrad Gessner (two autograph letters, to Hieronymus Frobenius dated 15 January 1561 and to Georg Cassander dated 09 October 1562, both held at the Special Collections of Leiden University Library), and (iv) Johann Bauhin (six autograph letters to Joachim Camerarius sent between 1578 and 1597, available from the University Library of Erlangen-Nuremberg, <https://ub.fau.de/>). For the handwriting of Rauwolf, we used two autograph letters, to Joachim Camerarius dated 27 March 1579 (<http://gateway-bayern.de/BV043447612>) and to Carolus Clusius dated 06 September 1584 (Special Collections, Leiden University Library; <https://clusiuscorrespondence.huylgens.knaw.nl/edition/entry/1428>).

To elucidate the history of making of Rauwolf's early book herbaria, we transcribed and translated the calligraphic text of the title pages of the three book volumes, and carried out observations of the watermarks and characteristics of the paper by means of transmitted light, using a thin, flexible electroluminescence sheet. We attempted to trace the watermarks found in the three books in the catalogue of the Memory of Paper database of the Bernstein project, www.memoryofpaper.eu/BernsteinPortal.

3 Results and discussion

The three early book herbaria of Rauwolf are large (32 × 21.5 cm), leather-bound volumes, which can be closed with metal, copper-colored clasps. Although several



Fig. 2 The second book herbarium compiled in S. France

conservation treatments have been performed in the past, the bindings are still mainly in their original state. The leather on the boards and the spine of the books show gold embossed decorations (Fig. 2). The three books have the same content arrangement, each one consisting of a calligraphic title page (Fig. 3; Table 1), followed by more than 200 plant specimens glued on both sides of the paper sheets, and an ascending index of plant names at the back of each book (Fig. 4). Strips of green-colored paper, decorated with silver embossed motifs are found attached to all margins of the herbarium sheets. These strips were added to protect the plant specimens from abrading each other. The strips were probably added by the book binder, as their embossed decoration appears to have been made by means of a roll, a known stamp tool in the bookbinder's workshop.

The three book herbaria demonstrate Rauwolf's skills as a botanist and his special interest in foreign species, hitherto largely unknown. The first and second herbaria contain mainly native species of S. France. The third herbarium mostly contains plants native to N. Italy and the Alps, and some exotic species. A number of plants contained in the third herbarium have been collected in Switzerland and Germany (Table 1).

3.1 Tobacco

Among the New World plants that are present in the book herbaria, we find a specimen of tobacco, *Nicotiana rustica* L., which Rauwolf collected in Italy in 1563 (Fig. 5). *N. rustica* is an Andean species that was cultivated by N. American colonists before common tobacco, *N. tabacum*, but was replaced by the latter because *N. tabacum* was preferred by European importers (Lewis 2011). *N. rustica* is distinguished morphologically from common tobacco by its

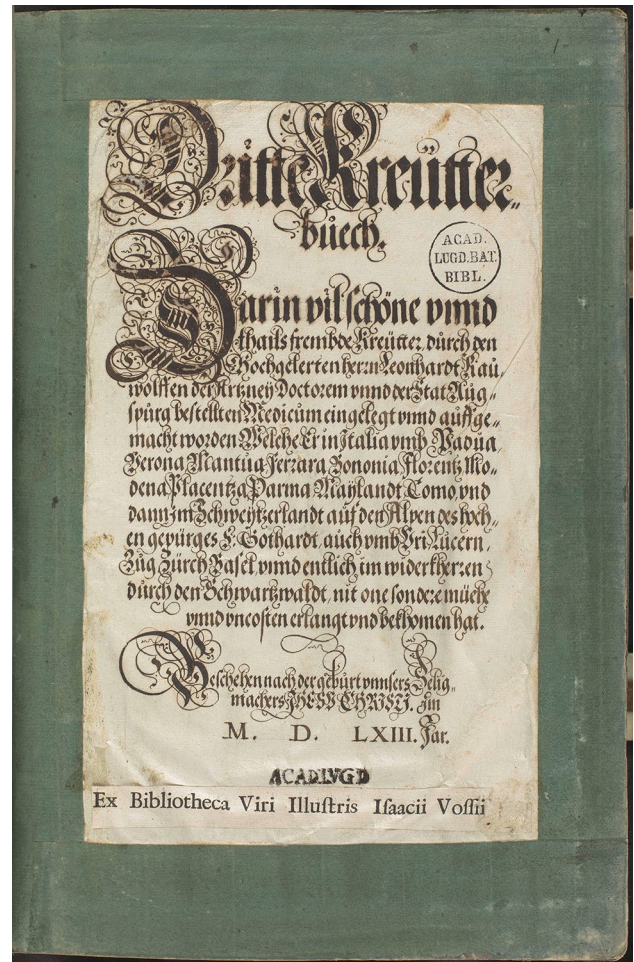


Fig. 3 Title page of the third book herbarium compiled in N. Italy

yellow flowers with wider corolla tubes slightly exceeding the calyx (Knapp et al. 2004). According to Meyer et al. (1999), *N. rustica* was first introduced in the Low Countries in the mid-1540s. In 1558, it was brought from Flanders to Portugal (Meyer et al. 1999), and according to De Toni (1940), through Portugal, it reached Italy around 1561. However, this latter introductory step might refer to *N. tabacum* (Vicentini et al. 2020a and references therein). Possibly, *N. rustica* was already cultivated in Italy the decade before, as Gessner remembers that in 1554 he had received seeds from either France or Italy (Kusukawa 2012). Since these statements are uncertain, we can at least infer from the fact that Rauwolf acquired his specimen during his visit to Italy in 1563 that *N. rustica* was most likely cultivated by that year in the country. Rauwolf knew tobacco already from France, as he calls it 'Priapeia', a name apparently used for *N. rustica* by Rondelet (Kusukawa 2012), Rauwolf's teacher in Montpellier. Besides the Rauwolf herbaria, the only Italian sixteenth century collection that contains specimens of *N. rustica* is the herbarium of Aldrovandi: one specimen from

Table 1 Transcription and English translation of the title pages of Rauwolf's early book herbaria

Herbarium	Transcription	Translation
One	Erste Kreütterbuech. Darin vil schöne vñd thails frembde Kreütter, durch den Hochgelehrten hern Leonharten Rauwolffen der Artzney Doctorn vñd der Stat Augspurg bes[t]ellten Medicum gar fleissig eingelegt vñd auffgemacht worden. Welche Er weil Er in Frankhreich gestudiret, vñd denen herum nach gerayset, nit allain in Savhoÿe vmb Genff vñd Delphinat vmb Lÿon Valentie etc. sondern auch in der Prouintz vmb Auignon, Arles, Marseille, Chalon de Crau, auf der rauchen dürren hayden: Fürnemblich aber in Languedocca, vmb Nîmes, Montpellier auf dem berge Leti [<i>sic</i>] am Meer ligent, vñd im hohen gebürge Auuergnia. nit ohne sondere müehe gefahr vñd vncosten erlangt vñd bekommen hat. Beschehen nach der geburt unsers Seligmachers JESU CHRISTI. im M. D. LX.[ten] vñd LXI. ten [vñd] LXII[ten] Jar. [Underneath printed Ex Libris:] Ex Bibliotheca Viri Illustris Isaaci Vossii	First herbal book. In which [there are] many beautiful and partly foreign herbs, which were very diligently put in and compiled by the highly learned Leonhard Rauwolf, doctor of medicine and town physician of Augsburg, while he studied in France and searched in the surroundings [for these plants], which he did not only acquire and receive in Savoyen around Geneva and Dauphiné and Lyon, Valence etc., but also in the Provence around Avignon, Arles, Marseille, Chalon de Crau on the rough dry heath, but above all in Languedoc near Nîmes, Montpellier on Mount Ceti by the sea and in the steeply mountains of Auvergne, not without special effort, danger and cost. He did that after the birth of our Savior Jesus Christ in 1560, 1561 and 1562.
Two	Andere Kreütterbuech. Darin vil schöne vñd thails frembde Kreütter, durch den Hochgelehrten hern Leonharten Rauwolffen der Artzney Doctorn vñd der Stat Augspurg bes[t]ellten Medicum, gar fleissig eingelegt vñd auffgemacht worden. Welche Er weil Er in Frankhreich gestudiret, vñd denen herum nach gerayset, nit allain in Savhoÿa vmb Genff vñd Delphinat vmb Lÿon Valentie etc.: sondern auch in der Prouintz vmb Auignon, Arles, Marseille, Chalon de Crau, auf der rauchen dürren hayden: fürnemblich aber in Languedocca vmb Nîmes, Montpellier, auf dem berge Ceti am Meer ligendt, vñd im hohen gebürge Auuergnia, nit ohne sondere müehe gefahr vñd vncosten erlangt vñd bekommen hat. Beschehen nach der geburt unsers Seligmachers JESU CHRISTI. Im M. D. LX. LXI vñd LXII. jar. [Underneath printed Ex Libris:] Ex Bibliotheca Viri Illustris Isaaci Vossii	Other herbal book. In which [there are] many beautiful and partly foreign herbs, which were very diligently put in and compiled by the highly learned Leonhard Rauwolf, doctor of medicine and town physician of Augsburg, while he studied in France and searched in the surroundings [for these plants], which he did not only acquire and receive in Savoyen around Geneva and Dauphiné and Lyon, Valence etc., but also in the Provence around Avignon, Arles, Marseille, Chalon de Crau on the rough dry heath, but above all in Languedoc near Nîmes, Montpellier on Mount Ceti by the sea and in the steeply mountains of Auvergne, not without special effort, danger and cost. He did that after the birth of our Savior Jesus Christ in 1560, 1561 and 1562.
Three	Dritte Kreütterbuech. Darin vil schöne vñd thails frembde Kreütter, durch den Hochgelehrten hern Leonhardt Rauwolffen der Artzney Doctorem vñd der Stat Augspurg bestellten Medicum eingelegt vñd auffgemacht worden. Welche Er in Italia vmb Padua, Verona, Mantua, Ferrara, Bononia, Florentz, Modena, Placentia, Parma, Maylandt, Como, vñd dann jm Schweytzerlandt auf den Alpen des hohen gepürges S. Gotthardt, auch vmb Vri, Lucern, Zug, Zürich, Basel, vñd endlich im widerkeren durch den Schwartzwaldt, nit ohe sondere müehe vñd vncosten erlangt vñd bekommen hat. Beschehen nach der geburt unsers Seligmachers JESU CHRISTI. Im M. D. LXIII. Jar. [Underneath printed Ex Libris:] Ex Bibliotheca Viri Illustris Isaaci Vossii	Third herbal book. In which [there are] many beautiful and partly foreign herbs, which were put in and compiled by the highly learned Leonhard Rauwolf, doctor of medicine and town physician of Augsburg, which he acquired and received in Italy around Padua, Verona, Mantua, Ferrara, Bologna, Florence, Modena, Piacenza, Parma, Milan, Como, and then in the Swiss land, in the Alps at the St. Gotthard massif, also around Uri, Lucerne, Zug, Zurich and Basel, and finally on his way home through the black forest, not without special effort and cost. He did that after the birth of our Savior Jesus Christ in 1563.

CATALOGVS quod in hoc con.		PLANTARVM Nomenclat. Libr.	
1. Onobrychis	1.	1. Nasturtium	31.
2. Calamagrostis	2.	2. Nasturtium	32.
3. Plantago	3.	3. Nasturtium	33.
4. Plantago	4.	4. Nasturtium	34.
5. Plantago	5.	5. Nasturtium	35.
6. Plantago	6.	6. Nasturtium	36.
7. Plantago	7.	7. Nasturtium	37.
8. Plantago	8.	8. Nasturtium	38.
9. Plantago	9.	9. Nasturtium	39.
10. Plantago	10.	10. Nasturtium	40.
11. Plantago	11.	11. Nasturtium	41.
12. Plantago	12.	12. Nasturtium	42.
13. Plantago	13.	13. Nasturtium	43.
14. Plantago	14.	14. Nasturtium	44.
15. Plantago	15.	15. Nasturtium	45.
16. Plantago	16.	16. Nasturtium	46.
17. Plantago	17.	17. Nasturtium	47.
18. Plantago	18.	18. Nasturtium	48.
19. Plantago	19.	19. Nasturtium	49.
20. Plantago	20.	20. Nasturtium	50.
21. Plantago	21.	21. Nasturtium	51.
22. Plantago	22.	22. Nasturtium	52.
23. Plantago	23.	23. Nasturtium	53.
24. Plantago	24.	24. Nasturtium	54.
25. Plantago	25.	25. Nasturtium	55.
26. Plantago	26.	26. Nasturtium	56.
27. Plantago	27.	27. Nasturtium	57.
28. Plantago	28.	28. Nasturtium	58.
29. Plantago	29.	29. Nasturtium	59.
30. Plantago	30.	30. Nasturtium	60.

Fig. 4 The index of the first book herbarium compiled in S. France

c. 1554–1560 is named as ‘Hyoscyamus Gallicus’ (Soldano 2003) implying a French provenance, and a second specimen (c. 1563–1568) did not come from a plant grown in Italian ground, but was sent to Aldrovandi from Jean de Brancion from Mechelen, Flanders (Soldano 2004). Three specimens of *N. tabacum* included in the Aldrovandi herbarium are all of Italian provenance and dated c. 1565–1580 (Soldano 2004), and one specimen contained in the Erbario Estense is dated 1570–1598 (Camus and Penzig 1885; Vicentini et al. 2020a, b). A plant specimen named ‘Priapeia’ in the French Girault herbarium (1558) probably belongs to either *N. rustica* or *N. tabacum*. Other early tobacco specimens are found in German herbaria compiled later in the sixteenth century (Ratzenberger, 1592: *N. rustica*, *N. tabacum*; Harder, c. 1576–1594: *N. tabacum*, c. 1599: *N. rustica*, *N. tabacum*).

3.2 Prickly pear

Another interesting exotic plant included in Rauwolf’s early book herbaria is a specimen of prickly pear or Indian fig, *Opuntia ficus-indica* (L.) Mill. This specimen, consisting



Fig. 5 Specimen of tobacco, *Nicotiana rustica* L., from the third book herbarium (N. Italy, 1563)

of a large leaf and a flower, shows the excellent specimen preparation technique of Rauwolf, with the succulent tissue carefully removed and the skin without spines firmly glued on the paper (Fig. 6). There is textual evidence that Rauwolf was also horticulturally familiar with *Opuntia*: on 10 May 1581, Johann Aicholz († 1588), professor of medicine and Clusius’ landlord in Vienna, reported to his Nuremberg colleague Camerarius that he had received instructions on how to care for his ‘Opuntia’ from Rauwolf (<http://gateway-bayern.de/BV043425098>). This Mesoamerican species, which Rauwolf collected between 1560 and 1562 in S. France, was probably first introduced to Seville, Spain (Casas and Barbera 2002). It was observed growing wild in Rome, Italy, as early as 1549 by Johannes Kentmann, but was still unknown to local physicians (Eggle et al. 2018). Kentmann made an illustration of prickly pear and reported the later testimony of a Venetian apothecary that this plant was abundant in the Indies where it produced small sweet figs, and therefore, it was then named by Italians as Indian fig (Kentmann 1549). One year later, in 1550, Aldrovandi also reported seeing the plant in Rome (Soldano 2000), and in 1553, he included two

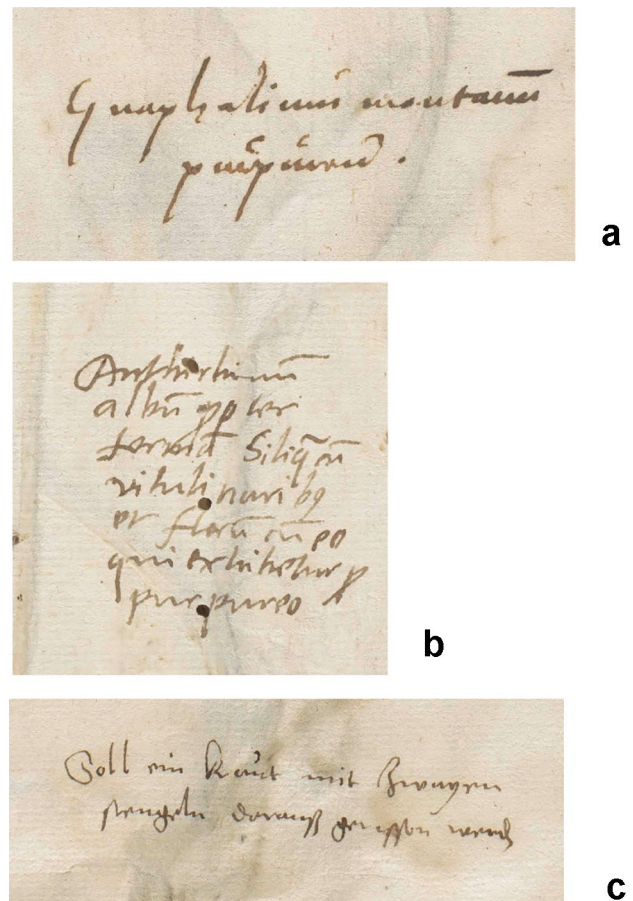


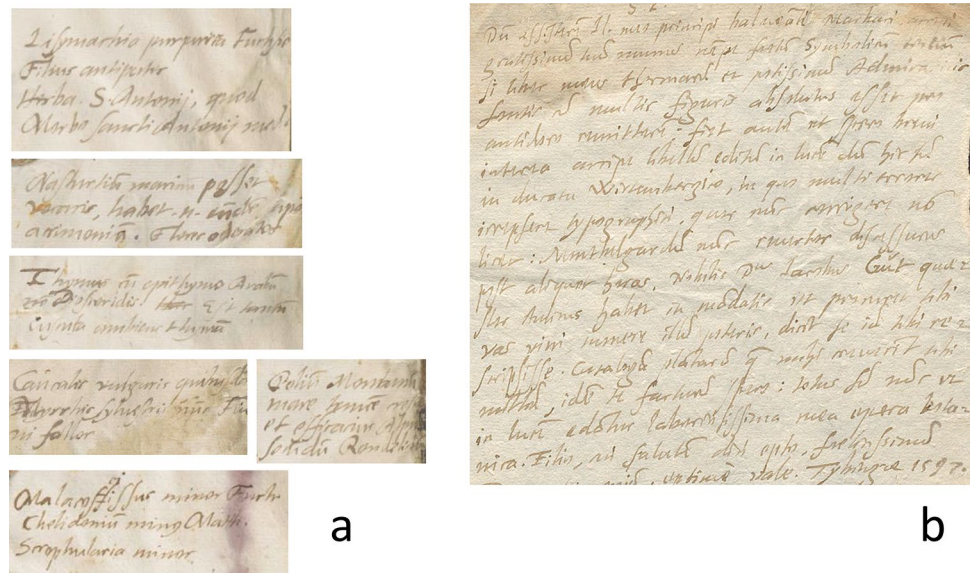
Fig. 7 Examples of handwritings from the three book herbaria: Leonhard Rauwolf (A); Johann Bauhin (B); Leonhart Fuchs (C)

information on sixteenth century professional botanical networks, evidenced by the various handwritings present in the three book volumes. We have identified three different hands that contributed plant names and annotations, of which one was matched to Rauwolf (Fig. 7A) in his autograph letters to Camerarius and Clusius from 1579 and 1584, respectively.

3.3 Handwritings and Rauwolf's botanical network in the 1560s

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Fig. 8 ‘Unknown’ handwriting in the first and the second book herbarium (a); Johann Bauhin’s handwriting in his autograph letter to Joachim Camerarius from 09 July 1597, University Library of Erlangen-Nuremberg, [urn:nbn:de:bvb:29-bv043-548830-1](https://nbn-resolving.org/urn:nbn:de:bvb:29-bv043-548830-1) (b)



Resource 1). The only noteworthy dissimilarity we could observe between the book herbaria and the autograph letters was in character ‘h’ (Online Resource 1). Legré (1900) had probably also noticed the presence of another handwriting than that of Rauwolf but not to its actual extent, since he referred to many of Bauhin’s annotations as if they belonged to Rauwolf. Closer observations, however, leave no doubt that the two handwritings, identified herein as Rauwolf’s and Bauhin’s, belong to two different hands (Fig. 7A, B).

This new finding about the relationship between Rauwolf and Bauhin clearly demonstrates an active involvement of the young Swiss fellow student in the making of the early book herbaria of Rauwolf. Bauhin wrote most of the Latin plant name(s) appearing next to the specimens of the first and the second herbarium, and for some plants, he also noted down French and German names in Gothic characters. Here and there, he even added remarks on a plant’s morphology, biology, habitat or abundance. Bauhin’s thorough annotations show his emerging scholarly interest in the study of plants, which would later be revealed through his *Historia Plantarum Universalis*, Bauhin’s posthumously published *opus magnum* which described thousands of plants. It is remarkable that Rauwolf hardly ever mentioned Bauhin in his later life, at least he did not in his surviving mail correspondence. On the other hand, Bauhin referred to Rauwolf in several plant descriptions in *Historia Plantarum Universalis* (Bauhin and Cherler 1650–1651), showing his esteem for his old field companion.

The making of a plant collection was a personal practice that all students of medicine would learn from Rondelet in Montpellier. It is, therefore, remarkable that the collection of Rauwolf has such an evident contribution of another student. Therefore, it can be assumed with good reasons that in France, Rauwolf was still a beginner in botany and asked for

the help of his classmate Bauhin, while later in Italy, he had advanced enough to prepare the third herbarium by himself. In the third herbarium, the dominant handwriting belongs to Rauwolf and the handwriting of Bauhin is absent. It is also likely that Bauhin did not accompany Rauwolf in his plant collections around N. Italy, although he also lived in Italy in 1563 (Cristofolini et al. 1993) and did join Rauwolf in the journey of return from Italy, as we know that the two signed together the *Liber amicorum* of Gessner in Zurich in May 1563 (Durling 1965). By the time that Rauwolf headed to the Near East, he had become a master in methodically identifying and describing plants, even exotic ones; the plant names appearing in his travelogue and fourth book herbarium are botanically and lexicologically flawless (Walter et al. 2021). Bauhin also had his own herbarium, which he had presented to Conrad Gessner (see Gessner to Benedictus Aretius, 24 November 1565, www.aerztebriefe.de/id/00016205). These plants may now be part of the herbarium of his younger brother Caspar Bauhin kept in Basel (Cristofolini et al. 1993).

A third handwriting (Fig. 7C) of small spidery letters that frequently appears in all three herbaria has been noticed also by previous authors, who attributed it to either Carolus Clusius (Legré 1900) or Leonhart Fuchs (Ganzinger 1963). Based on our comparison with autograph letters of both botanists, this handwriting was undoubtedly matched with Fuchs’ characteristic handwriting. It appears in a total of 162 plant specimens, which is a bit more than the 148 cases that Ganzinger (1963) had observed. Among Fuchs’ annotations, the indication ‘Soll gerissen werden’ to illustrator Jerg Ziegler appears in 56 of the herbarium folia. Most of the plants that Fuchs indicated to be illustrated are contained in the first and the second herbarium (20 and 27, respectively) compiled in France. Only nine plants were indicated to be illustrated

in the Italian third herbarium. Therefore, it was primarily the French plants that were of interest to Fuchs, rather than those collected in Italy, the latter having been frequently botanized by N. European sixteenth century naturalists.

Observing the numerous annotations of Fuchs in the book herbaria, it becomes evident that the famous German botanist showed a rather disrespectful attitude to the young and yet unknown Rauwolf. Fuchs ‘corrected’ Rauwolf’s herbaria as if they were a student essay, even crossing out some of Rauwolf’s and Bauhin’s plant names, replacing them with his own suggestions and adding numerous annotations not addressed to Rauwolf but to Fuchs’ illustrator. Moreover, Fuchs never officially named Rauwolf’s herbaria as a material source for his illustrated manuscript, although he did mention in 1563 to Camerarius that he included Rauwolf’s material in his manuscript (Meyer et al. 1999). Even worse, many suggestions of plant names that Fuchs provided were actually less accurate than the names originally given by Rauwolf and Bauhin. This can be shown for example in two specimens of marigold (*Tagetes erecta* L.), another American species that Rauwolf collected in Italy (third herbarium, folia 19–20). Rauwolf’s reasonable name ‘*Tagetis*’ was crossed out and corrected to ‘*Betonica*’ by Fuchs. More examples of such inaccurate corrections are provided by Légré (1900; erroneously referring to Clusius). Nevertheless, Rauwolf humbly accepted this and most of the suggestions of his former teacher, discarding his own plant names when he later wrote the book indices.

Légré (1900) incorrectly attributed Fuchs’ handwriting in the Rauwolf herbaria to Carolus Clusius, claiming as evidence Clusius’ handwriting in his personal archival annotations found on his preserved letters at the Leiden University Library. Based on our observations, the handwriting of Clusius is not present in any of the three book volumes. Légré’s hypothesis that Clusius annotated the herbaria is also historically flawed. When Clusius visited Augsburg in 1563, he was not yet a famous botanist, so it was unlikely that Rauwolf would seek a meeting with him to show him his plant collection. Moreover, in 1582, Clusius reported in a letter to Joachim Camerarius that he did not know Rauwolf personally yet (Walter et al. 2021). Clusius, like Rauwolf, had studied botany in Montpellier with Rondelet, it is, therefore, unlikely that a good botanist with knowledge of the local flora would have made erroneous plant identifications. On the other hand, Fuchs, although also a good botanist, was not a well-traveled man and he was unfamiliar with the Mediterranean flora as he had never been to the south. This may be the reason why he desired that plants from Rauwolf’s herbaria were illustrated for his herbal in preparation.

Rauwolf must have shown his freshly compiled plant collection to Gessner too during his stay in Zurich in 1563 (Walter et al. 2021). But although the name of Gessner as author of plant names does appear a few times in the book

volumes, written by the hand of Bauhin or Rauwolf, Gessner himself did not make any annotations in Rauwolf’s herbaria, as his handwriting could not be found in any of the three volumes.

3.4 Watermarks and the story of making of Rauwolf’s early book herbaria

Various types of paper can be distinguished in the three book herbaria (Table 2). The first and the second herbarium compiled in France appear to have paper with the same three watermarks: the types ‘fish & crown’, ‘hand/glove & flower’, and ‘helmet-like’ (Table 2; Fig. 9). Good matches for these watermarks could not be found in the Bernstein ‘Memory of Paper’ watermark catalogue. The third herbarium compiled in Italy shows a very different paper composition, including the watermark types ‘serpent & coat of arms’, ‘triple mountain & cross’, and ‘letter B & trefoil’ (Table 2; Fig. 9). Only for the ‘triple mountain & cross’ type, corresponding watermarks were found in the Bernstein catalogue. The most similar ones, registered in paper used in the city of Padua in 1553–1554 (see e.g., <https://www.wasserzeichen-online.de/wzis/detailansicht.php?id=34847>), appear to confirm an Italian origin. Padua is one of the places that Rauwolf visited in 1563 (Table 1), and it seems likely that he acquired this paper there. Paper with other types of watermarks is present in the books’ indices and title pages. These differences in the paper and watermark types show that Rauwolf was gradually buying stacks of paper while progressively enlarging his collection. He apparently went to Italy with some paper leftover from France (the one with the ‘helmet-like’ watermark type, present in all three book herbaria, and the one

Table 2 Watermark types present in the three book herbaria. Watermarks of the numbered folia are indicated with ‘x’

Watermark	Herbarium		
	One	Two	Three
‘Fish & crown’	x	x	
‘Hand/glove & flower’ ^a	x	x	
‘Helmet-like’	x	x	x
‘Heraldic eagle & crown’ ^b		x	x
‘Serpent & coat of arms’			x
‘Triple mountain & cross’			x
‘Letter B & trefoil’			x
‘Letters AR & lily’	Index, sheet after title page	Index, title page	
‘Heraldic eagle, small’ ^b	Title page		
‘Heraldic eagle & nimbus’ ^b			Index

Examples of the watermarks are shown in Fig. 9

^aSeveral variants, ^bShape not clear

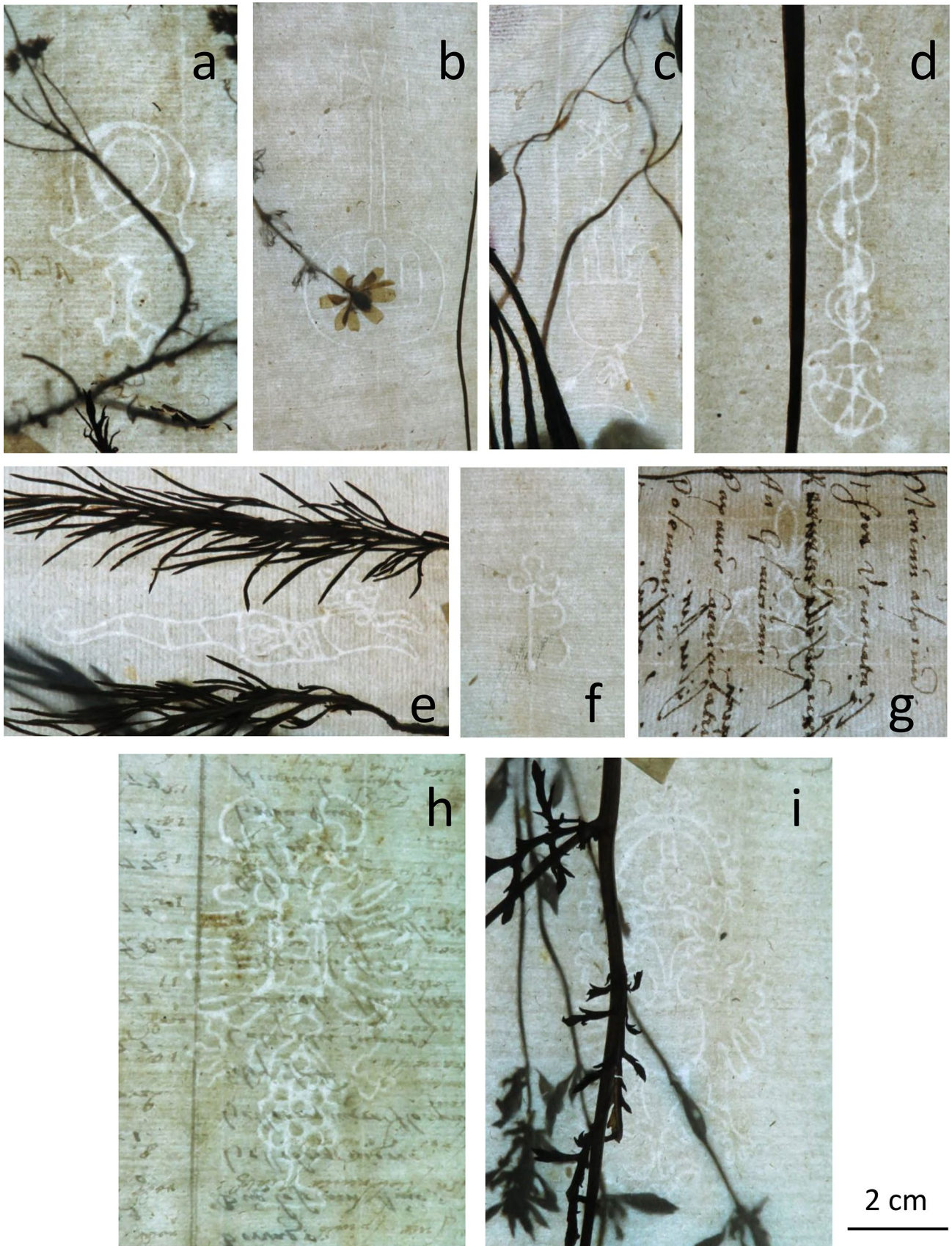


Fig. 9 Watermarks present in the book herbaria: ‘Helmet-like’, 3:9–10 (a); ‘Triple mountain & cross’, 3:151–152 (b); ‘Hand/glove & flower’, 2:175–176 (c); ‘Serpent & coat of arms’, 3:41–42 (d); ‘Fish & crown’, 2:119–120 (e); ‘Letter B & trefoil’, 3:205–206 (f); ‘Letters AR & lily’, 2:index (g); ‘Heraldic eagle & nimbus’, 3:index (h); ‘Heraldic eagle & crown’, 3:45–46 (i)

with the ‘heraldic eagle & crown’ watermark, present in the second and the third herbarium; Table 2), and continued to gradually acquire more stacks of paper in Italy while progressing the plant collections. The books’ title pages, indices, and endpapers have also paper of different quality and watermarks (Table 2), a fact that shows that the title pages, indices, and binding were probably made at a later stage.

For several years, Rauwolf must have kept the plants he had collected in France and Italy on loose paper sheets. The indices found at the back of the three herbaria, all written by the hand of Rauwolf, were probably made around 1564, as Rauwolf has written in the index of the second herbarium. In that year, Rauwolf was still fresh back in Augsburg, unmarried and without employment. He probably had hardly to deal with patients, as newly graduated doctors were generally avoided. Rauwolf may, therefore, have had not enough money to have his book herbaria bound, but probably plenty of time to put the plants in order and prepare the indices. Although Rauwolf’s early book herbaria are smaller in size and less luxurious than the masterpiece fourth herbarium, all four books share the same calligraphic style in the title pages, numbered in series as Erste, Ander, Dritte, and Vierte Kreütterbuch, similarities that indicate that the four herbaria were probably bound in the same period. The title pages of the four books were produced by distinguished specialists. Augsburg, where Rauwolf lived, was one of the richest cities in Germany, with excellent craftsmen and artists available. The four books were probably not bound before 1571, because in the title pages Rauwolf is named as the city doctor of Augsburg, a position that he only acquired in 1571. Interestingly, on 30 August 1577, Rauwolf declared that he was still rearranging the plants that he had collected in the Orient and glued them in the ‘right order’ on paper (www.aerztebriefe.de/id/00000167). Rauwolf worked on his travelogue until 1582. His decision in 1584 to sell his herbaria due to financial difficulties makes it unlikely that he would have had the books rebound in a time-consuming and expensive process. We, therefore, suggest that all four volumes were probably bound between late 1577 and 1582.

4 Conclusion

The early book herbaria of Leonhard Rauwolf are a valuable source of information on Early Modern students of medicine botanizing in the field in France and Italy. They contain

some of the earliest records of useful plants, such as tobacco and prickly pear discussed herein, adding to our knowledge of introduction of these exotic species to Europe. This collection is also an important source of information on professional networking of sixteenth century naturalists. Studying the different handwritings present in the three books, we follow the relationships of Rauwolf with other famous sixteenth century botanists. The study of watermarks and handwritten texts in Rauwolf’s early book herbaria allowed us to elucidate the making process of this collection, demonstrating the benefits of interdisciplinary research when studying historic plant collections. The remarkable number of watermarks present in the book herbaria, to which no similar ones could yet be found in the existing watermark databases, shows the value of Rauwolf’s early book herbaria also for the study of the history of paper. The next step of our research is the botanical inventory of Rauwolf’s early book herbaria, expected to reveal more of the botanical importance of this precious historical plant collection.

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