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Autor: Vos, Juuriaan M. de
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ACTES COLLOQUE ASCONA
USES, PRACTICES AND FUNCTIONS OF HISTORICAL HERBARIA

ASCRIBING AN UNKNOWN HISTORIC HERBARIUM TO JOHANN LUDWIG BUXTORF (1736-1804) OF BASEL, SWITZERLAND

JURRIAAN M. DE VOS[1]

Abstract
The rediscovery of an unknown historic herbarium in 10 fascicles at the Herbarium of the University of Basel (BAS), Switzerland, prompted an investigation to ascribe its contents and assess its significance. An early 20th-century effort was unsuccessful, dismissing the collection as « *of little scientific value, because collection localities are sometimes missing* ». The herbarium contains 1217 folio-sized, folded sheets, unbound, each with unmounted plants and one or multiple labels, plus ca. 500 loose labels from destroyed specimens and 48 illustrations. Identification of the scientific interaction network of the assembler via provenances of plants on labels (collection localities and origins of personal gifts), confirmed with handwriting comparisons, allowed me to identify the assembler as Johann Ludwig Buxtorf (1736-1804), Basel's chief physician from 1768 to 1804. Named plant donors are mostly either centred around the Societas Physico-Medicae Basiliensis (Basel, c. 1751-1777) or referred to as « friends », Swiss, and matriculated at the University of Leiden, The Netherlands around 1759, concurrent with Buxtorf. In addition, watermarks on mounted specimens of astounding craftmanship point invariably to 18th-century Basel. The most important other plant sources include botanical gardens (Leiden, Basel, Strasbourg, Utrecht, Amsterdam), various horticulturalists, and members of the Zwinger clan in Basel. The latter included Buxtorf's maternal grandfather Johann Rudolf (1692-1777) and other Professors of Anatomy and Botany who, in turn, acquired specimens from local and international correspondents and former students, including at least 226 specimens of the important naturalist Abraham Gagnebin (La Ferrière, 1707-1800). Thus, the Buxtorf herbarium has diverse origins spanning four generations of botanists, jointly revealing a complex 18th-century scientific interaction network, making it an invaluable resource for natural scientific and historical research.

Keywords: Basel, herbarium, Johann Ludwig Buxtorf, Abraham Gagnebin.

Résumé
La redécouverte d'un herbier historique inconnu en 10 fascicules dans l'herbier de l'Université de Bâle (BAS) en Suisse a donné lieu à une enquête visant à attribuer son contenu et à évaluer son importance. Les efforts déployés au début du XX[e] siècle n'ont pas abouti, la collection ayant été jugée « *de peu d'importance scientifique, car les localités de collecte sont parfois manquantes* ». L'herbier contient 1217 feuilles pliées

[1] Herbaria Basel, Department of Environmental Sciences, University of Basel, Schönbeinstrasse 6, 4056 Basel, Switzerland. Email: Jurriaan.devos@unibas.ch; Orcid 0000-0001-6428-7774.

de taille folio, non reliées, chacune avec des plantes non montées et une ou plusieurs étiquettes, plus environ 500 étiquettes détachées provenant de spécimens détruits et 48 illustrations. L'identification du réseau d'interaction scientifique de l'assembleur, par le biais des provenances des plantes sur les étiquettes (localités de collecte et origines des dons personnels), confirmée par des comparaisons d'écriture, m'a permis d'identifier l'assembleur comme étant Johann Ludwig Buxtorf (1736-1804), médecin en chef de Bâle de 1768 à 1804. Les donneurs de plantes nommés sont pour la plupart centrés autour de la Societas Physico-Medicae Basiliensis (Bâle, vers 1751-1777) ou désignés comme des « amis », suisses, et inscrits à l'Université de Leyde, aux Pays-Bas, vers 1759, en même temps que Buxtorf. En outre, les filigranes des spécimens montés, d'une facture étonnante, indiquent invariablement la ville de Bâle du XVIII[e] siècle. Les autres sources végétales les plus importantes sont les jardins botaniques (Leyde, Bâle, Strasbourg, Utrecht, Amsterdam), divers horticulteurs et les membres du clan Zwinger à Bâle. Parmi ces derniers figuraient le grand-père maternel de Buxtorf, Johann Rudolf (1692-1777), et d'autres professeurs d'anatomie et de botanique qui, à leur tour, ont acquis des spécimens auprès de correspondants locaux et internationaux et d'anciens étudiants, dont au moins 226 spécimens de l'important naturaliste Abraham Gagnebin (La Ferrière, 1707-1800). Ainsi, l'herbier de Buxtorf a des origines diverses s'étendant sur quatre générations, révélant conjointement un réseau complexe d'interactions scientifiques au XVIII[e] siècle, ce qui en fait une ressource inestimable pour la recherche en sciences naturelles et en histoire.

Mots-clés : Bâle, herbier, Johann Ludwig Buxtorf, Abraham Gagnebin.

Zusammenfassung

Die Wiederentdeckung eines unbekannten, historischen Herbariums in 10 Faszikeln im Herbarium der Universität Basel (BAS) veranlasste eine Untersuchung, um seinen Inhalt zuzuordnen und seine Bedeutung zu bewerten. Ein Versuch zu Beginn des 20. Jahrhunderts war erfolglos und die Sammlung wurde als « *von geringer wissenschaftlicher Wert, da Fundorte manchmal fehlen* » abgetan. Das Herbarium enthält 1217 ungebundene, folioformatige, gefaltete Blätter mit jeweils einer oder mehreren Beschriftungen, die Pflanzen ohne Einbettung zeigen, sowie ca. 500 lose Beschriftungen von zerstörten Exemplaren und 48 Abbildungen. Die Identifizierung des wissenschaftlichen Interaktionsnetzwerks des Sammlers anhand der Herkunft der Pflanzen auf den Etiketten (Sammelorte und Herkunft persönlicher Geschenke), die durch Handschriftenvergleiche bestätigt wurde, ermöglichte es mir, den Sammler als Johann Ludwig Buxtorf (1736-1804) zu identifizieren, der von 1768 bis 1804 Chefarzt in Basel war. Die genannten Pflanzenspender sind meist entweder mit der Societas Physico-Medicae Basiliensis (Basel, ca. 1751-1777) verbunden oder werden als « Freunde » bezeichnet, Schweizer, die um 1759 gleichzeitig mit Buxtorf an der Universität Leiden in den Niederlanden immatrikuliert waren. Außerdem weisen Wasserzeichen auf montierten Belege von erstaunlicher Kunstfertigkeit ausnahmslos auf das Basel des 18. Jahrhunderts hin. Zu den wichtigsten anderen Pflanzenquellen gehören botanische Gärten (Leiden, Basel, Straßburg, Utrecht, Amsterdam), verschiedene Gärtner und Mitglieder der Familie Zwinger in Basel. Zu letzteren gehörten Buxtorfs Großvater mütterlicherseits, Johann Rudolf (1692-1777), und andere Professoren für Anatomie und Botanik, die ihrerseits Belege von lokalen und internationalen Korrespondenten und ehemaligen Studenten erwarben, darunter mindestens 226 Belege des bedeutenden Naturforschers Abraham Gagnebin (La Ferrière, 1707-1800). Somit hat das Buxtorf-Herbarium verschiedene Ursprünge, die sich über vier Generationen erstrecken, und offenbart gemeinsam ein komplexes wissenschaftliches Interaktionsnetzwerk des 18. Jahrhunderts, was es zu einer unschätzbaren Ressource für naturwissenschaftliche und historische Forschung macht.

Stichwörter: Basel, Herbarium, Johann Ludwig Buxtorf, Abraham Gagnebin.

INTRODUCTION

The mid-18th century was a time of botanical revolution in Switzerland and, in fact, the scientific world. After Albrecht von Haller (1708-1777) published the first preliminary Flora of Switzerland (*Enumeratio methodica stirpium Helvetiae indigenarum*, HALLER, 1742), he continued working on a full edition (*Historia stirpium indigenarum Helvetiae inchoata*, HALLER, 1768), around the same time that Carl von Linné (Linnaeus; 1707-1778) published his most influential work, *Species Plantarum* (1753), which only gained importance in the ensuing years (STAFLEU, 1971). Critically, Linnaeus' introduction of the «nomen trivialis» in *Species Plantarum* effectively separated a species diagnosis from a species name, marking the birth of modern plant nomenclature (TURLAND *et al.*, 2018). In contrast, HALLER (1768), who had continued to have a dominating influence on the botanical scene in Switzerland, for instance, by funding botanical collecting expeditions (CHRIST, 1918; DE BEER, 1953), maintained a vast correspondence network (http://hallernet.org; BOSCHUNG *et al.*, 2002) and continued using polynomial plant names. Such names built upon BAUHIN's (1623) nomenclature, where a species' name corresponds to a diagnosis shortened to its essence in a systematic polynomial name of a few words (SELOSSE, 2005). For some years, these naming systems were in parallel use, leading to confusion, for instance, in semi-formal botanical correspondence (CHRIST, 1918) or in the way herbaria were organised, as Basel botanist Wernhard de Lachenal (1736-1800) organised his Swiss plants according to Haller and his foreign plants according to Linnaeus (DE CANDOLLE, 1901). Botany and plant species knowledge remained of central importance in the training of medical professionals throughout the 18th century (BURCKHARDT, 1917). For instance, since Haller and Linnaeus studied medicine (and practised as physicians), they were trained in botany, a body of knowledge essential to prescribing the plant-based medicines of the time (for the medical and botanical curricula in Basel; see BURCKHARDT, 1917). Importantly, in this era, natural science had already become a collaborative effort, with scientists maintaining extensive personal correspondence networks within which herbarium specimens were also exchanged (CHRIST, 1918; DE BEER, 1953; PORTMANN, 1964; BOSCHUNG *et al.*, 2002; SIGRIST & WIDMER, 2011; SIGRIST, 2013; HÄNER, 2017; BULINSKY, 2020; https://hallernet.org).

The specimens preserved in 18th-century herbaria are key to better understanding these revolutionary developments in botany at this time, how scientific interactions took place, how plants were exchanged, and how herbaria were used. The functions of herbaria were already very diverse, including documenting plant diversity so that local or regional flora (e.g. HALLER, 1742) and comprehensive species lists (e.g. LINNAEUS, 1753) could be compiled, as well as serving as instruments for familiarisation with plants, by assembling a personal compendium with notes on specimen provenance, species distribution, and (medicinal) uses or «virtues» of plant species (FLANNERY, 2023). Moreover, herbaria continued to represent considerable monetary value and provided their owners with scientific and societal status (HÄNER, 2017).

In the present day and age, the functions of herbaria are ever widening. The combination of new technological possibilities, a renewed interest in the past from both ecological and historical perspectives, and the societal challenges posed by the worldwide biodiversity crisis is so profound that it induced a second renaissance of herbarium-based research (BURBANO & GUTAKER, 2023; DE VOS & STÖCKLIN, 2023). Historic herbaria are gaining in relevance, but unlocking their potential is challenging because the annotations on individual specimens are often hard to interpret for present-day botanists, not least because the concept of what a specimen represents

and how a herbarium was best organised was not yet settled (Flannery, 2023). In particular, the distinction between a specimen documenting a specific act of collection in space and time (as is common today) and a specimen exemplifying and documenting the general properties of a species (as was common in 18th-century herbaria) is often hard to draw (Flannery, 2023). Therefore, interpreting such herbaria requires the joint assessment of labels, annotations, species composition, paper provenance, handwriting, etc., to correctly ascribe a herbarium to persons in space and time, as well as unlock their contents for broader scientific uses. This continues to be a challenging undertaking for 18th-century herbaria that frequently have particularly complex acquisition histories (e.g. Ward, 2007; De Natale & Celinese, 2009; Thijsse, 2018; Offerhaus *et al.*, 2021; Knittel & Nyffeler, 2021; Thijsse, 2021; Thijsse *et al.*, 2023; Wagner *et al.*, 2023).

The purpose of this article is to reveal the scientific and historic context of a newly discovered 18th-century herbarium at the Herbaria Basel, University of Basel, Switzerland (Index Herbariorum: BAS) by determining where and when it was assembled, by whom, and what the main sources of the material were. I present a preliminary interpretation of the content of ca. 1200 unbound folio specimens and ascribe it to Johann Ludwig Buxtorf (1736-1804), Basel's chief physician («Archiater») from 1768 to 1804, who was a user rather than producer of botanical knowledge (Bubb, 1942). The herbarium was previously dismissed as «*of little scientific value, because specimen provenances are sometimes missing*» and remained unidentified (Binz, 1908). In stark contrast to Binz's opinion, we show that Buxtorf's herbarium epitomises the botanical interaction networks of the era. Buxtorf was part of an elite, well-connected Basel family (including other Archiaters and the Zwinger clan of University Professors of Anatomy and Botany via his mother; Stroux, 2011abc), had studied and collected abroad, including in botanical gardens, and integrated other 18th-century herbaria. In addition to its relevance for understanding the early history of modern botany as a scientific discipline, ascribing the herbarium anchors the plant material in space and time, unlocking its content for contemporary studies in plant ecology and evolution, and revealing its exceptional value.

MATERIAL AND METHODS

No external reference to the herbarium in 18th- or 19th-century literature could be traced (Binz, 1908; Häner, 2017 and pers. comm.) nor did any specimen label apparently state Buxtorf's name as the person incorporating all material from diverse sources into a single curated collection (hereafter referred to as the «assembler» of the herbarium). Therefore, identifying him requires inference from the information that the herbarium itself contains. In particular, I emphasise materials and annotations (content, form, and style) over plant species identification, which, in isolation, do not contain direct evidence of the person's identity, their location, or the herbarium's age. Therefore, only cursory observations were made on its species content, postponing an in-depth analysis to a later date.

The paper used for labels and mounted specimens provides important evidence for its provenance and year of fabrication through its physical structure and marks. This provides a spatial and temporal window for the herbarium through the materials available to the assembler. The marks of these papers were assessed using Tschudin (1958) and Martin Kluge (pers. comm.), but marks of the paper enclosing unmounted plants were disregarded despite the paper being clearly historic: the original order of the specimens appeared to be lost due to Binz's «revisions». Finally, the label content provides very rich information, and I have scrutinised it carefully, obviously considering the label's factual content (determinations, literature, dates, and

where plants were collected or from whom they were received, etc.) but also their presentation of information (handwriting, organisation, revisions, etc.). Finally, I considered how persons acknowledged as donors of plant material were addressed, as it often included their social position relative to the assembler, including « friends » and « family ».

To identify J. L. Buxtorf from this set of clues, I created a tally of annotated material present, classifying its style (mounted plants, unmounted plants, and illustrations), years mentioned, and provenance. I focused on the way persons from whom plants were received were addressed and what place the plant was received from. The year of acquisition, where noted, was also recorded. Although there were many types of labels present, I focused on those in the most common handwriting, which were homogeneous in their presentation of information, because this handwriting is also present in corrections and additions to labels in other hands. Therefore, it presumably represents the handwriting of the person curating the collection. Finally, I tracked the biographic information of persons mentioned and sketched a correspondence and travel network in time that placed the assembler in the centre.

Samples of handwriting were compared to letters and manuscripts at the University Library of Basel, and the authenticity of material by Abraham Gagnebin (1707-1800) was confirmed by Rosella Baldi and Marcel S. Jacquat (pers. comms.).

RESULTS

Physical description and unity of the herbarium

The herbarium consists of 10 fascicles made of cardboard, paper, and leather, with a Linnean class as a title that did not necessarily correspond to the specimens, indicating that the original order was lost, presumably during Binz's revisions. Each fascicle contains between 84 and 181 loose, approximately folio-sized sheets once folded, usually with the fringed, right margin cut, for a total of 1217 folded sheets. The paper of the folded sheets is highly heterogeneous and of mixed quality (e.g. some sheets are strongly stretched with wool fibres, others not at all), pointing to diverse sources in the 18th century. Each folded sheet typically contains at least unmounted plants, plants affixed to a label with slits, or plants glued to other paper, usually complemented with one or multiple loose labels, and rarely with illustrations. Almost always, the material within a single folded sheet represents all the material present for a single species, even when multiple plants are present and/or labels indicate that it was acquired from multiple sources. This suggests that a folded sheet represents a « specimen » of reference material for a whole species, rather than a single occurrence in space and time. Indeed, folded sheets contain a polynomial or usually binomial species name written on the outside in one hand, although it often does not match the species in the folder, presumably due to later « revisions », in particular by Binz (1908). The handwriting on the folded sheets conformed to that most frequently encountered on labels (figs 1, 2), often written in a curious red pencil, which was also occasionally encountered for label revisions (strike-through or additions to labels written otherwise in ink; figs 3, 7). Jointly, the congruence between handwriting on folio papers, on many labels, and as label revisions indicates that the entire herbarium is one collection assembled by a single person during his or her life from a multitude of sources, rather than consisting of multiple unrelated or posthumously united herbaria.

The herbarium's rich annotations indicate that the assembler integrated material from many sources, including other herbaria. Across the 1217 folded sheets, there are 2315 elements in total containing annotations, as well as 48 illustrations. In total, 541 plants were glued to paper with annotations directly

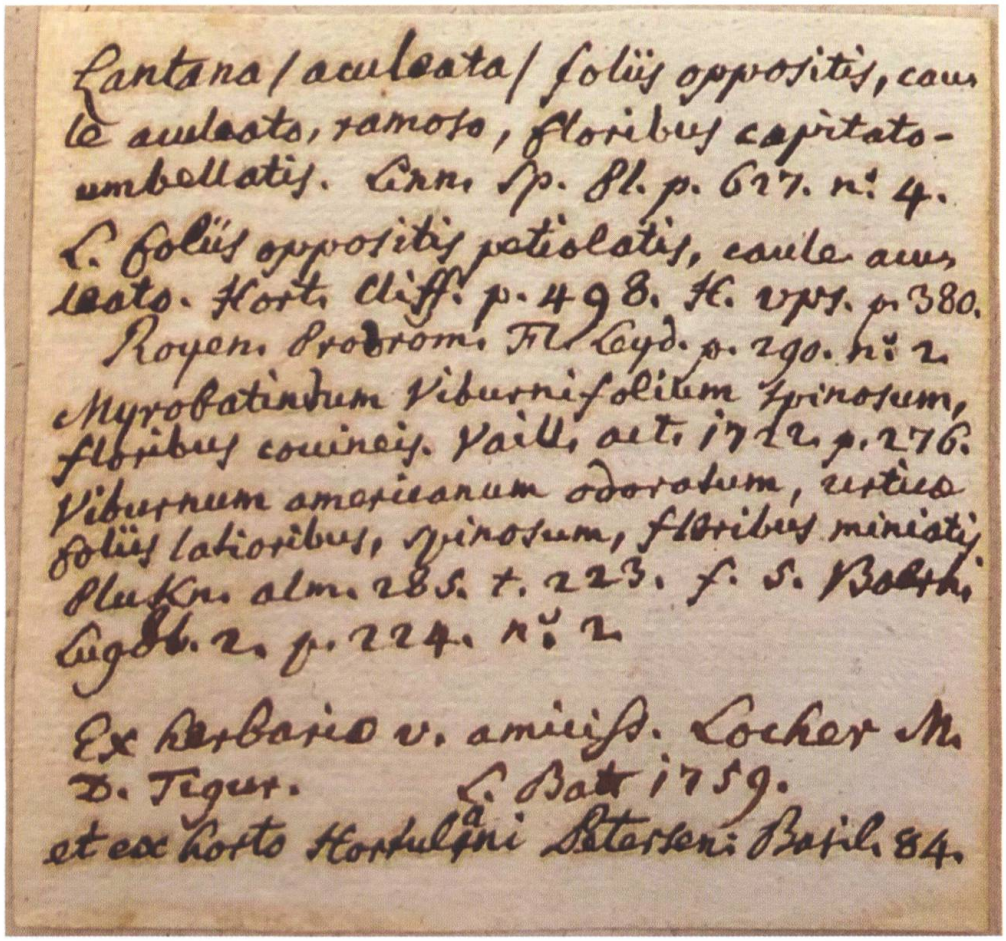

Figure 1. *Lantana aculeata* L., a representative standard label revealing its acquisition history. The Linnean species name is provided with diagnosis, along with various synonyms and an indication of how Buxtorf obtained the material: «*Ex herbario v. amiciss. Locher M. D. Tigur. L. Bat. 1759. et ex horto Hortulani Petersen: Basel. 84*», revealing that his friend the medical doctor Locher of Zurich donated the material from his herbarium, presumably in 1759 while in Leiden, but further material was obtained from Petersen, the head of the botanical garden of Basel in 1784.

on the paper («mounted plants»). Of these, a set of 438 mounted plants were homogenous in their form; rather than being from a single plant, they were amalgamated from multiple, individually dried plant parts, aesthetically and very skilfully arranged and glued to high-quality paper, annotated with various Latin polynomials and German common names, and subsequently cut out rather tightly («Arranged and mounted plants»; figs 4, 5). A second set of 19 mounted plants contained annotations in the rather distinct handwriting of Abraham Gagnebin (1707-1800; see below) and were glued to different, lower quality papers («Gagnebin's mounted plants»; fig. 6). A final set of 84 mounted plants did not clearly match Gagnebin's nor the arranged and mounted plants. In addition, 226 labels contained slits through which plants were physically associated with the label and richly annotated in Gagnebin's handwriting in French («Gagnebin's labels»;

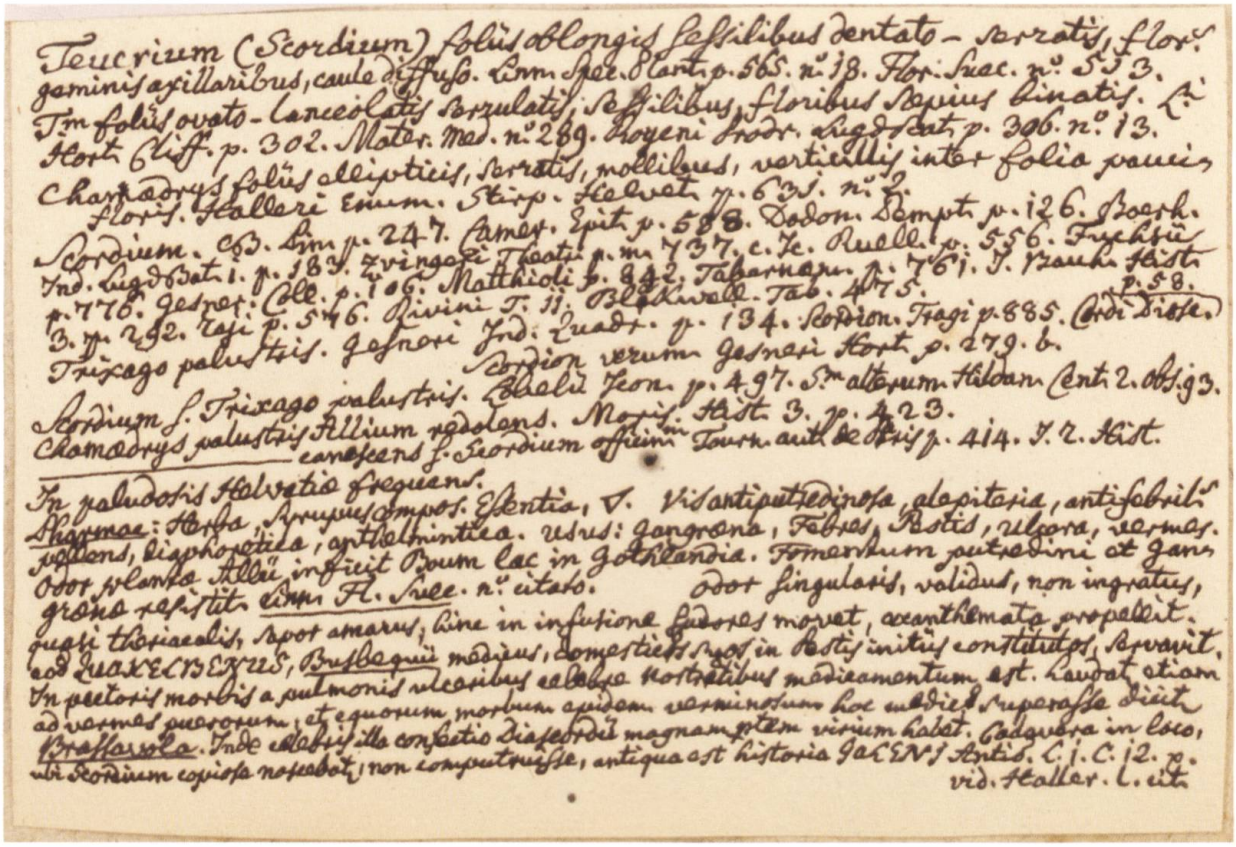

Figure 2. *Teucrium scordium* L., a representative standard label of a plant with medical uses. In addition to extensive literature references and a statement on species provenance «*In paludosis Helvetiae frequens*», the label documents the various medicinal uses of the plant. Specimen BAS-BUX-10-089, herbarium J. L. Buxtorf, Herbaria Basel, University of Basel.

fig. 7). Of the labels without plants directly attached to them, the majority (1048 labels) were highly homogeneous in layout and size (mostly ca. 16 × 10 cm, though smaller versions are also present) and with a single handwriting identical to that of the species names on the folded sheets (hereafter: «standard labels»; figs 1, 2). Standard labels contain no revisions or notes in another hand, except for adding a Linnean name when the label starts with a Haller reference or adding an additional provenance (fig. 3), always in the same hand. Therefore, I conclude that these labels are in the hand of the assembler of the whole herbarium. The other 500 loose labels were highly diverse in multiple handwritings. Importantly, however, like on the mounted plants, illustrations, and Gagnebin specimens, these other labels often contained annotations, additions, and corrections in the same hand as the standard labels, suggesting that they come from other collections later integrated into the herbarium, reinforcing the integrity of the whole herbarium as a single curated collection (figs 3, 5, 7 contain such corrections; fig. 1 contains an addition). In addition to the folded sheets, I discovered ca. 500 additional labels belonging to this herbarium in the safe of the botanical institute building of the University of Basel, where the herbarium was stored until 2016, presumably originating from folded sheets of which the plant remains were discarded by Binz. These were not yet further tallied.

Figure 3. *Trifolium angustifolium* L., a representative specimen with a label in the hand of Theodor Zwinger (1658-1724; black) with annotations of J. L. Buxtorf later than 1753 (in red). The label indicates that the material comes from the herbarium of J. J. Scheuchzer (1672-1733). Specimen BAS-BUX-08-109, herbarium J. L. Buxtorf, Herbaria Basel, University of Basel.

Figure 4. *Solanum lycopersicum* L., a representative arranged, mounted specimen integrated into the Buxtorf herbarium. Note that the plant consists of multiple arranged stem and leaf segments and carries flowers and fruits simultaneously. The annotation ends with the German common names «*liebesäpfel*» and «*geldtäpfel*». Specimen BAS-BUX-08-119, herbarium J. L. Buxtorf, Herbaria Basel, University of Basel.

Finally, the arranged and mounted plants are glued to paper, which can be confidently dated to the 1730s and the paper mill Heusler in Basel. Among the arranged and mounted specimens that contain watermarks, only a single motif was discovered: the Basel heraldic staff in a Laurel wreath (often fragmented, entire in, e.g. *Liparis ovata*, fig. 8), with smaller marks closely resembling those of paper mill Heusler (mark 320 in TSCHUDIN, 1958; fig. 8). Moreover, the paper does not contain lenticular enclosures, suggesting that it was made after an improved paper-making method was introduced in Basel around 1710 (so-called «Holländern»; pers. comm. Martin KLUGE).

The floristic composition has not yet been fully investigated because the first focus is on the provenance of the herbarium. About

91 % are angiosperms, with other plants (1 % gymnosperms, 4 % pteridophytes, 4 % bryophytes, and a single alga) are occasionally represented. It is evident that the herbarium has a Central European focus, including some strictly alpine (e.g. *Poa alpina, Soldanella alpina*) or Mediterranean plants (e.g. *Trifolium angustifolium*, fig. 3), but there are also many extra-European exotics, such as crops (including coffee, rice, and tomato, fig. 4) and ornamentals.

Identifying J. L. Buxtorf from label content

Because relying on matching a handwriting type alone is challenging, I first focused on the rich content of the 1048 homogeneously structured standard labels (figs 4, 5). The extensive synonymy usually starts with a Linnean name from *Species Plantarum* (1753) or occasionally from *Hortus Cliffortianus* (1737); alternatively, it starts with a name from HALLER (1742). If indicated, the nomen trivialis is written between slashes or in brackets, separating the diagnosis from the genus name. Then, following other literature references, sometimes including a German name, the label ends with the general distribution and/or habitat of the species, sometimes with a remark on abundance or flowering time. In about half of the cases, one or more specific provenances are mentioned, mostly as a reference to another person's herbarium (e.g. «ex herb. [name]»; 185 cases, representing 18 persons; fig. 1) or a person's or an institution's botanical garden (e.g. «ex hort. [name/city]»; 403 cases, representing 20 gardens in Switzerland, France, and the Netherlands; table 1; fig. 1). Some standard labels indicate a collection locality or collection expedition (notably, a 1757 expedition to Mont Ballon in the French Vosges mountains) or, more frequently, a general qualification of occurrence (e.g. fig. 2, «In paludosis Helvetiae frequens» meaning common in swampy areas of Switzerland). The year of acquisition is indicated on 396 standard labels and ranged from 1756 to 1761, with peaks in 1757 (136 specimens) and 1760 (169 specimens), as well as single mentions of 1784 (fig. 1) and 1803. For plants with particular medical virtues, the uses may be extensively documented (fig. 2, from «Pharmae» onward).

The references to persons and places and the time frame of the 1750s-1760s point to Johann Ludwig Buxtorf (1736-1804) of Basel as the person who assembled the herbarium from its many sources. Not only does the handwriting match (University Library Basel, shelf mark K-III-32), but the content confirms it for the following reasons. First, geographically, the most common provenances indicate close ties to Switzerland, especially Basel, where Buxtorf spent most of his life, and the Netherlands, especially Leiden, where he studied (see Discussion for biographical notes). Basel is evident via mention of the botanical garden (85 cases), Wernhard Lachenal of Basel (1736-1800; 58 cases; strikingly as a friend, i.e. «amici»), and various nearby geographic designations. That Lachenal was considered a friend may relate to the fact that Buxtorf's sister (Margarthe Buxtorf, 1738-1814) married Lachenal's older brother Johan Jakob (1732-1785). Leiden is a prominent source, via not only the botanical garden (e.g. «ex hort. Lug. Bat»; 129 cases), but also because L. B. (Lugdunum Batavorum = Leiden) is frequently mentioned in conjunction with three persons who also qualified as friends, namely Johann Scheuchzer (1738-1815, Zurich, 8 cases), (Johann) Georg Locher (or Lochar, 1739–1787, Zurich, 18 cases, fig. 1), and Johann Caspar Stockar de Neuforn (1741-1801, Schaffhausen, 14 cases; table 1). Importantly, all three stem from Swiss-German dialect-speaking areas and enrolled at the University of Leiden (on 8 Aug. 1757, 28 Dec. 1758, and 26 Sep. 1757, respectively, DU RIEU, 1875). This is congruent with the time that J. B. Buxtorf studied in Leiden (enrolled 22 Sept. 1759), and he was the only medical student from Basel who enrolled in Leiden between 1757 and 1760. It is plausible

Table 1. Components of the Buxtorf herbarium

Herbarium component	Provenance reference type	Number of labels[1]	Contributing sources
1, Annotated with standard labels by J. L. Buxtorf	Collected in institutional gardens	256	Leiden NL (129x), Basel CH (85x), Strasbourg F (27x), Utrecht NL (8x), Amsterdam NL (7x)
	Collected in other gardens (excluding those of friends and family)	137	Own (65x); Willem van Hazen, Leiden NL (31x); Jacob Risler 1731-1770, Mulhouse F (24x); Nikolaus Petersen, Basel CH (5x); « Schuurmans » (4x), others (8x).
	Received from friends	105	W. Lachenal (58x), Locher (18x), Stockar de Neuforn (14x), J Scheuchzer (11x), others or unknown (4x)
	Received from others (excluding friends and family)	27	« Staehelin » (10x), A. Gagnebin (6x), « Fortuyn » (3x), « Honerlag » (2x), others (6x)
	No provenance reference	460	Personal collections?
2, Buxtorf / Zwinger Family	Received from family (standard label)	63	J. Buxtorf (50x), J. R. Zwinger (13x)
	Received from family (non-standard label)	326	J. R. Zwinger (179x), T. or J. J. Zwinger (147x)
3, Abraham Gagnebin	Unmounted, affixed through label slits	226	A. Gagnebin (226x)
	Mounted	19	A. Gagnebin (19x)
4, Arranged mounted plants	None	465	Unknown
Illustrations	None	48	Unknown
Other / unclear	Non-standard labels, no provenance reference	174	Suspected to include A. von Haller, J. C. Ramspeck, many others

Footnotes. 1: Refers to the number of labels, except that standard labels with multiple provenances are counted multiple times. Note that one specimen (i.e. the material contained within a single folded sheet) may contain multiple elements. Thus, the number of labels much exceeds the number of specimens.

Figure 5. *Adonis vernalis* L., a representative arranged, mounted specimen of unknown provenance. The annotations in the hand of J. L. Buxtorf include the Linnean name (bottom) and reference to Caspar Bauhin's Pinax for the name Helleborus niger tenuifolius Buphthalmi flore. Note that the petals of the flowers are individually glued to the paper. Specimen BAS-BUX-08-119, herbarium J. L. Buxtorf, Herbaria Basel, University of Basel.

Figure 6. *Campanula latifolia* L., a mounted specimen annotated in the hand of Abraham Gagnebin (1707-1800), referencing its intended publication in the *Acta Helvetica* volume 4 (1760). Specimen BAS-BUX-05-001, herbarium J. L. Buxtorf, Herbaria Basel, University of Basel.

that among these men, a similar age, cultural background, and societal status induced a lasting friendship, reinforced by bonding over the shared interest in plants and medicine, substantiated through the exchange of gifts in the form of plant material.

Second, person references strikingly indicate that family members (Stroux, 2011abc) of the assembler also possessed and donated herbaria (e.g. «ex herb. honoratiss. avi» and «ex herb. honoratiss. parentis» in 1757; 56 cases). Specifically, his father (J. Buxtorf, 1702-1768) who preceded J. L. Buxtorf as Archiater (chief physician) of Basel had married Agnes Zwinger (171?-1781), becoming allied to the Zwinger clan in Basel. The family produced multiple Professors of Botany and

Figure 7. *Primula farinose* L., an unmounted specimen affixed to a label by Abraham Gagnebin (1707-1800), with corrections in the characteristic red pencil of J. L. Buxtorf (see also fig. 3). Note that Gagnebin refers to himself in the 3rd person and references provenances from 1730 in the French Alps (Dauphiné) and from 1760 in the Bernese Alps. Specimen BAS-BUX-05-008, herbarium J. L. Buxtorf, Herbaria Basel, University of Basel.

Anatomy, including J. L. Buxtorf's maternal grandfather Johann Rudolf, great-uncle Friedrich (1707-1776), and great-grandfather Theodor (1658-1724). Moreover, another great-uncle (Johann Jacob, 1685-1708) died young, but his correspondence with J. J. Scheuchzer of Zurich indicates that he was also a keen plant collector. That Buxtorf at some point obtained the herbaria of various Zwingers and integrated them into his own collection is further supported by J. L. Buxtorf's handwriting superimposed on some labels otherwise of Johann Rudolph, who contributed to 179 cases, and Theodor or probably Johann Jacob, who contributed to 147 cases (fig. 3). The integrated Zwinger collections,

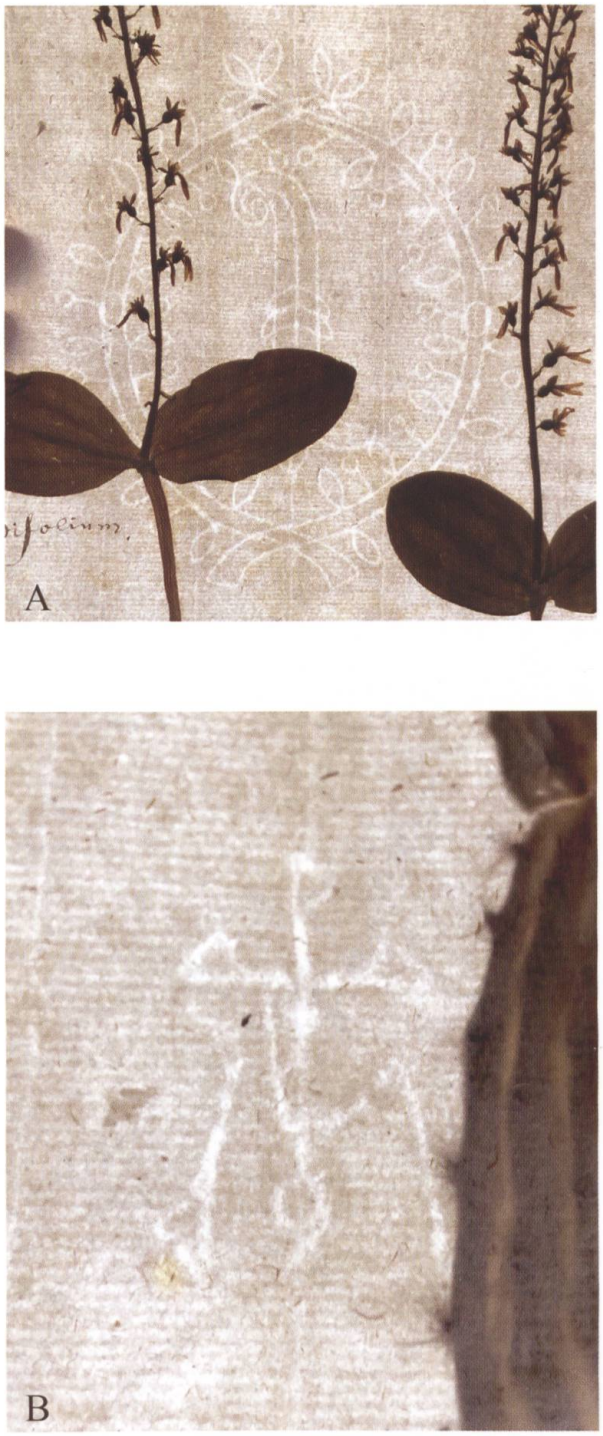

Figure 8. Watermarks in the mounted and arranged specimen of *Listera ovata* (L.) R.Br., revealing a Basel staff in a Laurel wreath (A), and minor sign (B) pointing to the Basel paper mill Heusler in the 1730s. Specimen BAS-BUX-06-155, herbarium J. L. Buxtorf, Herbaria Basel, University of Basel.

in turn, bear evidence of plants donated by various other botanists, including members of the Scheuchzer clan (fig. 3), W. Sherard (1659-1728), J. C. Ramspeck (1722-1797), A. von Haller, and A. Gagnebin. Overall, many (indirect) contributors were members of the Societas Physico-Medicae Basiliensis (Basel, c. 1751-1777), which was founded by J. L. Buxtorf's maternal grandfather J. R. Zwinger, evidenced by a list of its members published in its journal the *Acta Helvetica Physico-Mathematico-Anatomico-Botanico-Medica* in 1760. Moreover, at least some of the illustrations appear to be originals from figures printed in this journal (e.g. *Cactus triangularis* L.; Risler, 1762).

DISCUSSION

Relevance of a newly discovered 18th-century herbarium

The purpose of this paper is to summarise the scientific context and content of the previously unidentified Basel herbarium of Johann Ludwig Buxtorf (1736-1804). Remarkably, herbaria from this era continue to be generally poorly known, but they are being rediscovered and described, enabling the dissemination of their contents (e.g. Knittel & Nyffeler, 2021; Offerhaus *et al.*, 2021; Thijsse, 2021; Thijsse *et al.*, 2023). That these rich historic herbaria are only now described exemplifies centuries of neglect as well as an increasing contemporary appreciation for historic herbaria in general (De Vos & Stöcklin, 2023). The Basel herbaria form a case in point. The University of Basel (BAS) is one of the oldest centres for botanical research in Europe (Burckhardt, 1906; Reeds, 1991), and for centuries, it was the only Swiss university with a medical / botanical curriculum, reaching its eminence mostly due to the influence of Caspar Bauhin and his herbarium (1560-1624; Benkert, 2020; Stöcklin & De Vos, 2023; Walter, 2023). However, at the time of Buxtorf, botany in Basel had lost its global importance, and the Bauhin herbarium was

inaccessible (Linnaeus, 1730; Stöcklin & De Vos, 2023). Other Universities, including Leiden, were more prominent (Burckhardt, 1917). Nevertheless, Basel boasted an active scientific community centred around the Societas Physico-medica Helvetica, of which J. L. Buxtorf was a member, and that published the *Acta Helvetica Societas Physico-Mathematico-Anatomico-Botanico-Medica* (Basel, ca. 1751-1777; Häner, 2017). Members of the Society remained floristically (but mostly not systematically) active. It was founded by J. R. Zwinger, J. L. Buxtorf's maternal grandfather, who in turn had inspired both Albrecht von Haller and Abraham Gagnebin, who were among the most prolific Swiss botanical authors and collectors of the time, respectively, to take on the field of botany (Häner, 2017).

The herbarium that we here ascribe to J. L. Buxtorf fits the characteristics of contemporaneous herbaria, as it is assembled from multiple components, including personal collections from the wild, cultivated plants from botanical gardens, and plants exchanged with other collectors (table 1; Flannery, 2023). Moreover, plants representing the same species, but with contrasting acquisition histories, are added together, jointly representing a species (e.g. fig. 1). This illustrates how herbaria were compendia of species knowledge, further evidenced by extensive literature references and descriptions of uses, phenology, and the distribution of plants that go well beyond identifying a single gathering in space and time (Flannery, 2023; figs. 2, 7). Similarly, complex specimens that represent species rather than single collection events are present in the contemporaneous Van Royen Herbarium in Leiden, which is unsurprising, given that Buxtorf studied there at that time. Indeed, Buxtorf's friend Locher (fig. 1) is mentioned as a correspondent of David van Royen (Thijsse *et al.*, 2023; fig. 1).

It appears that the complexity of these historic specimens fuelled their neglect in the early 20th century. When the various herbaria of Basel collectors were merged into a single collection by A. Binz (1870-1863), at least one thousand 16th-18th-century specimens were discarded (even though the labels were retained) because they were «*irrelevant and damaged*» or «*because provenances are missing*» (Binz, 1908), including well over 600 specimens of Caspar Bauhin (Stöcklin & De Vos, 2023) and ca. 500 of the present herbarium. These revisions were commissioned by plant physiologist Professor A. Fischer (1858-1913, suicide), head of the «botanical committee», in the same year as he arrived in Basel (i.e. 1902; Burckhardt, 1906; Binz, 1908; Behrens, 1913) and presumably motivated by a rather single-minded view of herbaria as repositories of plant localities, evidenced by Binz's exclusive focus on floristics (Binz, 1901, 1908). Fortunately, the neglect also implies that its original form has been mostly preserved (except for changing the filing order), as it was never incorporated into other collections or mounted.

The Buxtorf herbarium contains four main components (table 1): (1) the material acquired by himself and for a large part in exchange with his student friends in Leiden (Stockar, Locher, and Scheuchzer) and Basel (Lachenal) (figs 1, 2); (2) the material incorporated after acquiring it from his family, mostly via his father and maternal grandfather from the Zwinger clan (fig. 3); (3) the Abraham Gagnebin material (figs 6, 7); and (4) the beautifully arranged, mounted plants (figs 4, 5, 8). Here, I briefly discuss the acquisition history of these four components, including brief biogeographic notes.

Component 1, specimens collected by Johann Ludwig Buxtorf himself

Buxtorf's life bore the imprint of his elite family heritage. He was born in Basel (baptised 19 July 1736) as the son of Johann Buxtorf (1702-1768) and Agnes Zwinger (171?-1781; Stroux, 2011abc). The Buxtorf family was of high societal standing, as his father was a medical professor and became the city's Archiater (chief physician); other family members were influential at the university and in society (including many professors and majors of Basel). Enrolling at the university at the age of 13 (Stud. Phil.), J. L. Buxtorf transferred to study medicine on 2 Dec. 1752 (Stud. Med.), becoming Candidatus Medicinae on 13 October 1756. In the following year, he received many plant specimens annotated with «ex herbarium vivum honoratiss. Parentis 1757», evidence that his father (or mother) also owned an herbarium. J. L. Buxtorf matriculated in Leiden on 22 Sept. 1759, where Locher, Scheuchzer, and Stockar de Neuforn, whom he later acknowledges as «friends», were already studying. In Leiden, especially in 1760, Buxtorf's herbarium grew rapidly, with plants collected not only from the botanical gardens in Leiden, Amsterdam, and Utrecht (129, 8, and 7 mentions, respectively) but also from Dutch and other horticulturalists (table 1; Kuijlen, 1983). He returned to Basel to become a medical doctor in 1763, after which his herbarium stagnated. His focus apparently had become exclusively medicinal, as he lectured on Materia Medica at the University from 1763 to 1794 and from 1799 until his death in 1804 (focusing on obstetrics and medicinal training for countryside vicars; Burckhardt, 1917), but he no longer added lengthy standard labels to his specimens, as virtually none contained a year post-1761. He married Agnes Sonntag (1744-1776) in 1765, Anna Maria Frey (1739-1778) in 1777, and Anna Margaretha Christ (1753-1826) in 1779 and had 10 children, of which ca. 6 reached adulthood. His sister Margaretha (1736-1814) married a brother of Wernhard de Lachenal (1736-1800), an important botanist who held the Chair of Botany and Anatomy at the University of Basel from 1776 to 1800, oversaw the botanical garden, corresponded extensively with and collected for Albrecht von Haller, and owned the Bauhin herbarium from 1772 onward (Stöcklin & De Vos, 2022, 2023). In 1768, J. L. Buxtorf succeeded his deceased father as Archiater (chief physician) of Basel, and he remained in this position until his death (Bubb, 1942). J. L. Buxtorf published a few medical notes in *Acta Helvetica* and *Nova Acta Helvetica*, including posthumously edited manuscripts of others (Buxtorf, 1758, 1772, 1787). However, he produced no major publications or botanical works. Although he applied for the professorship of practical medicine in 1777, Buxtorf never became a faculty member, unlike his father. Thus, as a practicing physician rather than a university professor, he was a user of existing botanical knowledge rather than a producer of new botanical knowledge. His case therefore provides an interesting perspective on how different actors interacted with herbaria in the era in which botany rose to maturity after Linnaeus' (1753) *Species Plantarum*. Buxtorf died on 24 December 1804 at the age of 68. It is unknown whether he bequeathed his assembled herbarium or whether it later became the property of the University of Basel. It was first mentioned by Binz (1908).

Component 2, specimens inherited within the Zwinger and Buxtorf families

A particularly heterogeneous component of the Buxtorf herbarium is material stemming from donations and/or inheritance within Buxtorf's family, in particular via his father Johann Buxtorf (1702-1768) and his maternal grandfather Johann Rudolph Zwinger (1692-1777). Most easily identified are the specimens that are directly referenced on standard labels (e.g. representative citation for J. Buxtorf «ex herb. honor. Parenti.»,

50 cases; for J. R. Zwinger «ex herb. honoratiss. Avi», 6 cases; table 1). However, non-standard labels in handwriting that differ from those of Buxtorf are numerous and contain his annotations, typically by adding later species names (notably Linnean names, e.g. fig. 3). The handwriting and content of these non-standard labels reveal at least about 179 that stem from J. R. Zwinger and another 147 that appear to be in the hand of J. R. Zwinger's brother Johann Jacob (1685-1708) or his father (i.e. J. L. Buxtorf's great grandfather) Theodor Zwinger (1658-1724), the Professor of Botany and Anatomy from 1703 to 1711. Strikingly, these labels reference, in turn, even older components. For instance, multiple specimens indicate «*Smirna*» as a locality (= Smyrna / Izmir, Turkey), sometimes in combination with «*ex herb. Scheuchzer*» or «*miss. a Sher.*», suggesting that they were collected by William Sherard (1659-1728), who lived there from 1711 to 1716 or 1717. Sherard was in close contact with Johann Jakob Scheuchzer (1672-1733) of Zurich, who in turn remained closely connected with Theodor Zwinger after his studies in Basel (Portmann, 1964; Bulinsky, 2020). Clearly, revealing the specifics of these connections requires a more detailed study, but they indicate that J. L. Buxtorf's herbarium is best understood as an integration of four generations of Swiss botanists and their international contacts. Nevertheless, it remains unknown when the material of the Zwinger clan was integrated into Buxtorf's herbarium and via what route it was obtained. It is likely that the bulk of the specimens were incorporated after the main era of assembly, i.e. after ca. 1761, because Buxtorf made annotations but did not replace them with standard labels. Plausible possibilities include that they were bequeathed at the time of death of J. L. Buxtorf's father (J. Buxtorf, 1768) or grandfather (J. R. Zwinger, 1777).

Component 3, specimens collected by Abraham Gagnebin

Abraham Gagnebin was a well-known Swiss naturalist and prolific collector from the Jura (Renan, 1707 - La Ferrière, 1800, Switzerland; see Thurmann [1851] and Wolf [1860] for biographies, de Beer [1953], Jacquat [2017, 2018], Baldi [2012], Chèvre *et al.* [2017] for collections and correspondence, Häner [2017] for Gagnebin in the context of Basel's natural history collections). He was a Medical Doctor at La Ferrière, the ancient Diocese of Basel, and studied in Basel, and like Buxtorf, was a member of the Societas Physico-Medicae Basiliensis. Gagnebin is best known as an important correspondent of Albrecht von Haller and as a prolific collector, who together with his brother Daniel (1709-1781), amassed an enormous natural history collection that was famous during his life (Häner, 2017). His collections remain incompletely known, as they were dissolved between 1795 and 1826; Wolf (1860) alleged that a notebook ended up in the possession of Schleicher (Johann Christoph, 1768-1834), which may represent a (partial) inventory of these dispersed collections. Of thousands of alleged plant specimens belonging to Gagnebin, only several hundred remain (mostly at NEU, Chèvre *et al.*, 2017, but at least some survive in TO, Torino; Jacquat, 2017, 2018); thus, the finding of 19 mounted and 226 unmounted specimens in BAS is significant.

Gagnebin started collecting in Switzerland with Professors of Botany and Anatomy at the University of Basel, Theodor Zwinger (1658-1724), and with his son Johann Rudolf Zwinger (1692-1777) from 1721 onward. After 1728, he was stationed in Strasbourg for three years, where he collected plants with «Doctors of the University» while being the surgeon of a Swiss regiment. In this role, he travelled throughout France until 1735, the year he returned to Switzerland, married, and

moved to La Ferrière. In 1739, he collected in the Jura with Haller, d'Ivernois, and Scholl (Letter of Gagnebin to Albrecht von Haller, 15 December 1741; cited in DE BEER, 1953). In the period during which Buxtorf's herbarium was assembled, Gagnebin continued intensive correspondence with Haller (addressing to him at least 118 letters between 1739 and 1773; BOSCHUNG *et al.*, 2002), sending him hundreds of specimens and observations (DE BEER, 1953). However, Haller complained to Gessner that Gagnebin required too high a price for a later collecting trip (120 imperials, letter to Johann Gessner, 30 July 1759). In 1761-1763, Gagnebin travelled throughout the Alps for «Mylord of Coventry» (presumably George William Coventry, 6th Earl of Coventry; 1722-1809), as ordered by Robert Colebrooke (1718-1784; British minister to the Helvetic cantons 1762-1764) (Letter from Gagnebin to Haller, 25 November 1766), during which he collected material with the intention of selling it (announced in *Journal Helvétique*, 1760). Gagnebin appointed persons of contact throughout Europe; for Basel, the appointed contact person was Johann Rudolf Zwinger (1692-1777, maternal grandfather of J. L. Buxtorf). Strikingly, many of the Gagnebin specimens in the Buxtorf herbarium mention locations seen in the 1730s, even though the plants appear to have been collected in the 1760s (fig. 7). This suggests that the Gagnebin specimens originated from later rather than earlier trips as they bear names from HALLER (1742), and the most common year is 1760. Gagnebin published several minor botanical notes. Of particular interest is his paper on *Campanula latifolia* in the *Acta Helvetica* (GAGNEBIN, 1760), where Gagnebin describes the species, provides new localities, and presents synonyms. Curiously, the article was supposed to be much longer and contain an illustration, as an editor's footnote explained, but the illustration was refused, and the paper was much abbreviated in its printed form. The specimen from which that unpublished illustration was generated is present in the Buxtorf herbarium (fig. 6).

How Gagnebin's specimens ended up in Buxtorf's herbarium remains unknown. Although Gagnebin and J. R. Zwinger corresponded and J. R. Zwinger donated specimens to Buxtorf, the pattern of specimen annotations by Buxtorf on donated material argues against their transfer via Zwinger. Specifically, annotations by Buxtorf are often absent on Gagnebin specimens (but see fig. 7), and rarely mentioned on standard labels (only 6 cases). The material received from the Zwinger clan is frequently heavily annotated (fig. 3). This suggests that Gagnebin's collections were added late in Buxtorf's life, possibly later than the Zwinger material, and thus possibly via a different route. Without known correspondence between Gagnebin and Buxtorf, the origin of Gagnebin's material in Buxtorf's collection remains unclear, although a link with J. R. Zwinger is most likely.

Component 4, arranged and mounted specimens

The arranged and mounted specimens are of singular beauty and represent exceptional craftmanship (fig. 5), but their creator (and possibly commissioner) remains unknown. In style, they are reminiscent of those of Felix Platter (1536-1614; DAUWALDER, 2013), and illustrations of the 16th and 17th century appear to convey an idealised image of a species, arising from the deliberately neat but unnatural arrangement of individual plant parts. For instance, specimens may have internodes of an unnaturally even length and contain flowers and fruits simultaneously (e.g. *Solanum lycopersicum*, fig. 4), have a leaf shape adjusted by cutting (e.g. *Orchis* spp.), or have roots glued to the plants (e.g. *Maianthemum bifolium*). Several exotics include a small decorative vase (e.g. *Oryza sativa*). Often, individual plant parts were dried separately, then individually arranged and glued without error (fig. 5). Because the age of the paper could be confidently dated

to Basel in the 1730s (specifically, paper mill Heusler, fig. 8), the specimens must have been collected and mounted around the 1730s or 1740s; thus, well before the time Buxtorf amassed most of his specimens. This dating is consistent with the exclusive use of pre-Linnaean botanical names, although Linnean binomials are added as revisions in the hand of J. L. Buxtorf (fig. 5). Since paper from Basel mills was sold widely in this era (pers. comm. Martin KLUGE), the geographic provenance needs not be Basel itself, although the presence of German common names (fig. 4) places them in a German-speaking place. It is unlikely that they stem from the Gagnebin family either because those specimens are annotated in French on distinctly different papers (compare figs 5 and 6). The specimens may have been prepared as a model for botanical illustrations, although this remains speculative.

CONCLUSION

The Buxtorf herbarium has diverse origins and spans four generations of botanists, unveiling a complex scientific interaction network of 18th-century plant exchange. It documents vertical transfer within scientific family dynasties and contemporary horizontal transfer within networks of friends and colleagues, coupled with an important intermediate role of botanical gardens and commercial plant collections as hubs from which specimens of local and exotic plants were sourced. Clearly, it is an invaluable resource for natural scientific and historical research, in stark contrast to BINZ's (1908) dismissive judgment and discarding of hundreds of Buxtorf's specimens. The herbarium's value is multifaceted. On the one hand, now that the herbarium can be placed in time, the biological material has significantly gained scientific value. The plants in this herbarium originate mostly from pre-Industrial Revolution periods (which started circa 1760–1780), thus growing under atmospheric conditions radically distinct from those of today, with significantly lower aerosol concentrations and over 30% reduced CO_2 levels. The associated isotopic signatures offer an opportunity to understand how environmental changes affect plant physiology (KAHMEN *et al.*, 2023). The specimens likewise contain recoverable amounts of ancient DNA (a whole tomato genome was sequenced from the plant in fig. 4; unpublished manuscript); thus, these plants are important sources of material for retrospective genetic analyses, such as for crop domestication and phylogeography. Finally, the labels provide essential information on historic species' distributions. For instance, *Teucrium scordium* (fig. 2), nowadays an increasingly rare weed, was noted to be « frequent » in throughout Switzerland; for *Saxifraga hirculus*, now mostly restricted to a single Swiss population and in great decline throughout central Europe, a Gagnebin specimen from 1746 lists many localities as having an abundance of this species. However, the herbarium is also of great interest for the history of science, as its rather unique, intermediate stage of curation allows researchers to infer the acquisition history of most of the material, and it provides direct evidence regarding how different actors interacted with objects, and what label revisions were deemed most urgent (first and foremost, the addition of Linnean binomial names). Moreover, the herbarium documents how physician J. L. Buxtorf, as a user rather than a scientific producer of botanical knowledge, interacted with herbaria. The destructive revisions of BINZ (1908) of the Basel herbaria serve as a humbling reminder that the true and multifaceted value of historic herbarium specimens may be deceivingly hard to gauge, as herbaria preserves research opportunities for both the present *and* future.

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