

Synteny of Images in Three Illustrated Dioscoridean Herbals: *Juliana Anicia Codex*, *Codex Neapolitanus*, and *Morgan 652*

Jules JANICK¹, Anna L. WHIPKEY¹, John STOLARCZYK²

¹Department of Horticulture and Landscape Architecture, West Lafayette IN 47907-2010, USA

²World Carrot Museum, 51 Clayton Hall Road, Cross Hills, Skipton, UK

Abstract

Plant illustrations were compared in three ancient illustrated recensions of the non-illustrated manuscript of Dioscorides titled Περὶ ὕλης ἰατρικῆς (*De Materia Medica* in Latin; *On Medical Matters* in English) written about the year 65: *Juliana Anicia Codex* (*JAC*) or *Codex Vindobonensis* produced in the year 512, *Codex Neapolitanus* (*NAP*) produced in the late 6th or early 7th century, and *Morgan 652* (*M652*) produced between 927 and 985. *M652* contains many illustrations that are similar to those of *JAC*, and it has long been evident that large parts of the *M652* were based on the *JAC* or a precursor. *NAP* also appears to be a source in the creation of *M652* since *M652* contains several images that appear in *NAP* but not *JAC*, and when images are common in all three herbals about 19.3% of the *M652* images are closer to *NAP* than *JAC*. We conclude that *M652* illustrations are based on images from both *JAC* and *NAP*. A database of the three herbals is available online www.hort.purdue.edu/newcrop/herbalimages.

Keywords: art history, *Codex Vindobonensis*, Dioscorides, illustrated herbals

Introduction

In genetics, *synteny* (Greek: on the same ribbon) refers to preservation of the same gene on chromosomes of individuals related by descent. In this paper we use this term to describe the relationship between derivative images found in three ancient illustrated manuscripts based on the non-illustrated Περὶ ὕλης ἰατρικῆς (*De Materia Medica* in Latin, *On Medical Matters* in English) of Pedanios Dioscorides (20-70 CE) written about the year 65. Variant images are referred to as syntenic when they are judged to be based on copying from an original source despite their being altered (mutated as alleles) by the replication process. The objective of this paper is to determine the relationship between these three ancient herbal manuscripts based on an analysis of their images and titles applied thereto.

JAC (also known as the *Codex Vindobonensis*) was produced in Constantinople in 512 and was dedicated as a gift to the Imperial Princess Juliana Anicia by the citizens of Honorata (Collins, 2000; Hummer and Janick, 2010; Janick and Hummer, 2012) and is the first surviving illustrated codex of a portion of the non-illustrated Dioscorides manuscript. It consists of 491 surviving folios of which 12v-387r contain 382 full page contemporary images of the healing plants mentioned by Dioscorides and five other ancient texts on folios 388-491 which are not covered here. There are two 13th century additions: a sketch of mandrake (*Mandragora officinalis*) on folio 289r and a drawing of a leguminous plant labeled Spartos

(*Spartium junceum*) on folio 328r. Neither of these two images is included in the total of 382 plants considered in this paper.

NAP dates to the end of the 6th or early 7th century. Cavallo (1992 p. 12-13) has claimed on the basis of typographic evidence that it was produced in Italy rather than Constantinople, and according to Carlo Bertelli (1992) perhaps in the Exarchate of Ravenna, a center of Byzantine power. However, the provenance of the manuscript is a mystery. The Greek manuscript contains both Greek and Latin scripts: eight Greek hands dated from the 7th to the 16th century and seven Latin hands from the 13th to the 18th century (Cavallo, 2000). The *NAP* was in the possession of Antonio Seripano, an Italian collector of ancient manuscripts in the first decades of the 16th century.

There is high degree of visual resemblance between the illustrations of *JAC* and *NAP* and many of them clearly share several common attributes (Collins, 2000; Orofino, 1992; Janick and Stolarczyk, 2012). There are 25 or 26 missing images in *NAP* accounted for by 11 missing folios at the beginning of the volume and two pages where two images each were torn from the text. Collins (2000) asserts that *NAP* descends from the same archetype as the *JAC* and is not a direct copy of *JAC*.

M652 was produced in Constantinople during the court of Emperor Constantine VII between 927 and 985 (Collins, 2000). It is arranged into eight books and includes other material such as a Mithridatic antidote, a poem on the power of herbs, and most of the non-Dioscoridean

texts found in the *JAC*. Book I on Roots and Herbs (folios 1-199) contains 433 images but prefatory pages and about 50 illustrations are missing (Collins, 2000, p. 61). Singer (1927) has found that in some cases the figures of *JAC* and *M652* are remarkably close. Collins has considered *M652* to be based on the *JAC* or a prototype. Van Buren (1993) notes that over half of the plants in *M652* are practically identical to the naturalistic plants in *JAC*. Brubaker (2002) reports that *JAC*, *NAP*, and *M652* have "pictorial affinities."

A comparison of *JAC* and *NAP* images carried out by Janick and Stolarczyk (2012) affirms their close relationship. (Their count of 406 images for *NAP* and 383 images for *JAC* was due to counting the double image of *Cyperus rotundus* in *NAP* (folio 107 Right) as two images and including the 13th century image of Spartos on folio 328r in *JAC*). It was concluded that *NAP* and *JAC* were sister manuscripts from a common source, but the possibility that some illustrations were copied directly from *JAC* was not excluded. Since *NAP* contained more images than *JAC* it was considered an extended version of *JAC*. In this paper, the image analysis between *JAC* and *NAP* is extended to include Book 1 of *M652* (folios 1-199). Since many images of *M652* are known to have derived from *JAC* or an archetype (Collins, 2000; Hummer and Janick; 2010, Janick and Stolarczyk, 2012), our main focus was to determine whether *NAP* had any influence on *M652*, and if so to what extent. Our analyses involve the images and titles only and not the accompanying text.

Methodology

Manuscripts

Facsimile editions of *JAC* (*Der Wiener Dioscorides*, 1998-1999) and *NAP* (*Dioscorides De Materia Medica, Codex Neapolitanus*, 2000) were scanned to create digitized images. Identification of the two-volume *JAC* images (folios 12v-387r) by the facsimile editor Otto Mazal was available in an index called Das Herbarium divided in two volumes that included binomials and families in Latin and common names and some descriptions in German. The *NAP* images have the Greek name as an integral part of most images, and there is an index of Greek names on p. 223-243 in the volume accompanying the facsimile. *M652* was accessed from a digital online version available from The Morgan Library and Museum, New York (<http://www.themorgan.org/home.asp>). There were 8 books, 5 derived from Dioscorides, and three other from other treatises. We restrict our analysis here to Book I (Roots and Herbs, folios 1-199) but it should be noted that folio 13 was missing. An index of the scanned images of *M652* in the form of an Excel spreadsheet was provided by the Morgan Library and Museum listing English common names, binomials, and Greek names (in the Roman alphabet).

Database

We decided to create a database of the images contained in *M652*, *JAC*, and *NAP*, to make the visual, and textual comparison of images a more manageable task. The *M652* images in sequence were combined with binomials, common English and Greek names obtained from the Excel spreadsheet provided by The Morgan Library and Museum. Binomials and Greek names from *JAC* associated with the *JAC* images were based on the index made by Otto Mazal, the facsimile editor. The *NAP* images contained Greek names in red uncial and were also available in an index provided in the accompanying volume of the facsimile. The images from the three herbals based on similar names were placed side by side in columns and linked even if there was no visual connection between the images.

The database created for the three volumes contains the following information: Greek name (Roman alphabet); English common name; binomial; family; and location (herbal, folio number, and location within the page when there is more than one plant image). The database is available at www.hort.purdue.edu/newcrop/herbalimages. We consider this database a work in progress, and we plan to incorporate corrections and additions as they are supplied, as well as providing updated binomials.

Syntenic Analysis of Images

We analyzed 1220 images: *JAC* (382), *NAP* (405), and *M652* (433). An analysis of commonality of images is presented in a Venn diagram (Fig. 1). There were 4 possibilities for each image: when all three herbal manuscripts were considered:

1. Common between two of the herbals taken separately: *JAC* and *NAP* (350), *JAC* and *M652* (289), and *NAP* and *M652* (327).
2. Common exclusively to one of the other two herbals: 68 between *JAC* and *NAP*, 7 between *JAC* and *M652*, and 45 between *M652* and *NAP*.
3. Common to all three herbals (282).
4. Unique to only one herbal: *JAC* (25), *NAP* (10), and *M652* (99).

Synteny Involving Two Herbal Manuscripts

***JAC* and *NAP*.** Commonality of images is based on 382 images for *JAC* and 405 images for *NAP* (Janick and Stolarczyk, 2012). Of the total 787 images, 350 (44.5%) were common to both herbals; 32 images (3.9%) in *JAC* were not in *NAP*, and 55 (6.8%) images in *NAP* were not in *JAC*. Note: These figures can be obtained from the Venn diagram in Fig. 1: the number of images in both *JAC* and *NAP* is 350 (68 in B1 and 282 in A); the number of images only in *JAC* is 32 (25 in C2 and 7 in B2); while the number of images only in *NAP* is 55 (10 in C2 and 45 in

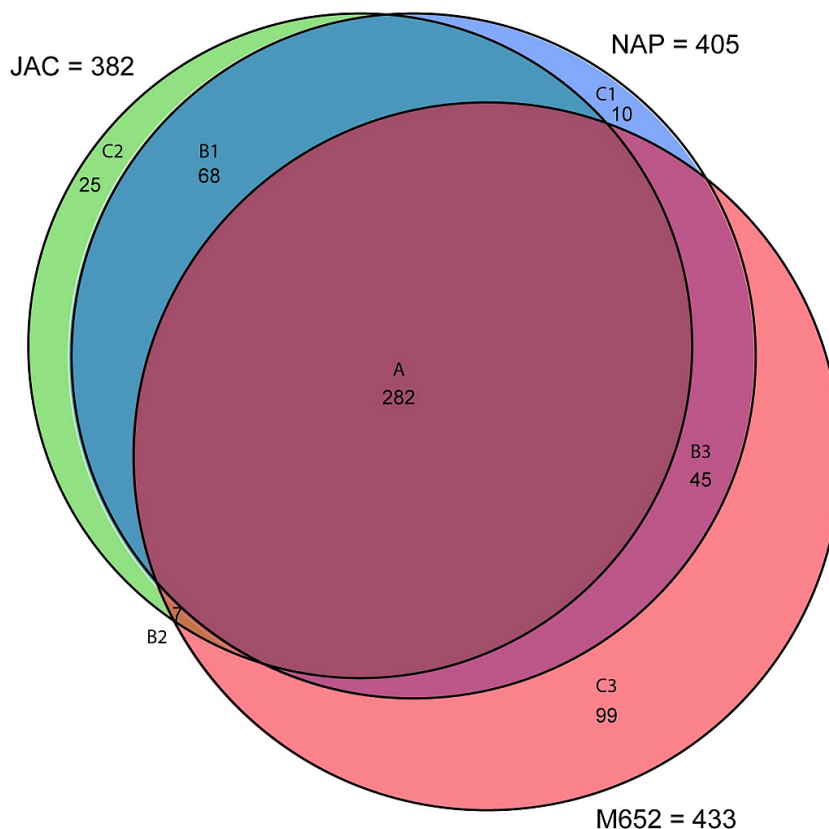


Fig. 1. Proportional Venn diagram of *JAC* (382 images), *NAP* (405 images), and *M652* (433 images): A = image is present in *JAC*, *NAP*, and *M652* (triples); B1 = image is only present in *JAC* and *NAP*; B2 = image is only present in *JAC* and *M652*; B3 = image is only present in *NAP* and *M652*; C1 = *JAC* uniques; C2 = *NAP* uniques; C3 = *M652* uniques. Images in each sector can be obtained from database (www.hort.purdue.edu/newcrop/herbalimages)

B3). The 32 images of *JAC* that were not in *NAP* were explained by the 11 or 12 missing pages of the *NAP* herbal that accounts for 28 images (Lilla, 1992) and 4 from the two torn pages of *NAP* each with two images of *NAP* which are identified in the text as *Euphorbia pepius* and *Marrubium vulgare* (folio 122) and *Sium latifolium* and *Apium graveolens* (folio 161). Of the 55 images in *NAP* not in *JAC*, two can be accounted for by the missing “male and female” mandrake images in *JAC* and the remaining 53 images appear to be images exclusive to *NAP*. The conclusion was that *NAP* was an extended version of *JAC* with additional images from an unknown source, perhaps the prototype of *JAC* made for Theodosius II, the great-grandfather of Juliana Anicia (Collins, 2000). When all three herbals were considered together, 68 images (B1 in Fig. 1) were exclusive to *JAC* and *NAP*.

***JAC* and *M652*.** Of the 815 total images in *JAC* and *M652*, 289 (35.5%) were common, 93 (11.4%) were found only in *JAC*, and 144 (17.7%) were found only in *M652*. When all three herbals were considered together, only 7 images (B2 in Fig. 1) were exclusive to *JAC* and *M652*.

***NAP* and *M652*.** Of the 838 images in *NAP* and *M652*, 327 (39.0%) were common, 78 (9.3%) were found only in *NAP* and 106 (12.6%) were found only in *M652*. When all three herbals were considered, 45 images (B3 in

Fig. 1) were found exclusively between *NAP* and *M652*. If we subtract the 2 missing mandrake images from *JAC*, this still leaves 43 images exclusively in common between *M652* and *NAP*. This is evidence that *NAP* or a prototype must have been one of the sources of *M652*.

Synteny Involving Three Herbal Manuscripts

Of the 1220 images in the three herbals analyzed, 282 (23.1%) were associated with all three. (There are 7 triple common images in later books of *M652* commencing at folio 311v, but these were not considered in this analysis, which concentrated solely on *M652*, Book I.) Differences in the three images, however, range from extreme to minor. An evaluation of synteny, the determination if images were considered derivative from a common source, were first made independently by each author. Of the 282 triple images, 8 involve unrelated images and were considered to be non-syntenic (Fig. 2). Of the remaining 274 syntenic images, 131 (47.8%) were closer to *JAC* (Fig. 3); 53 (19.3%) were closer to *NAP* (Fig. 4); and 90 (32.8%) were difficult to discern because either all images were so similar (Fig. 5) or because while *JAC* and *NAP* images were similar they differed substantially from the image in *M652*. These results

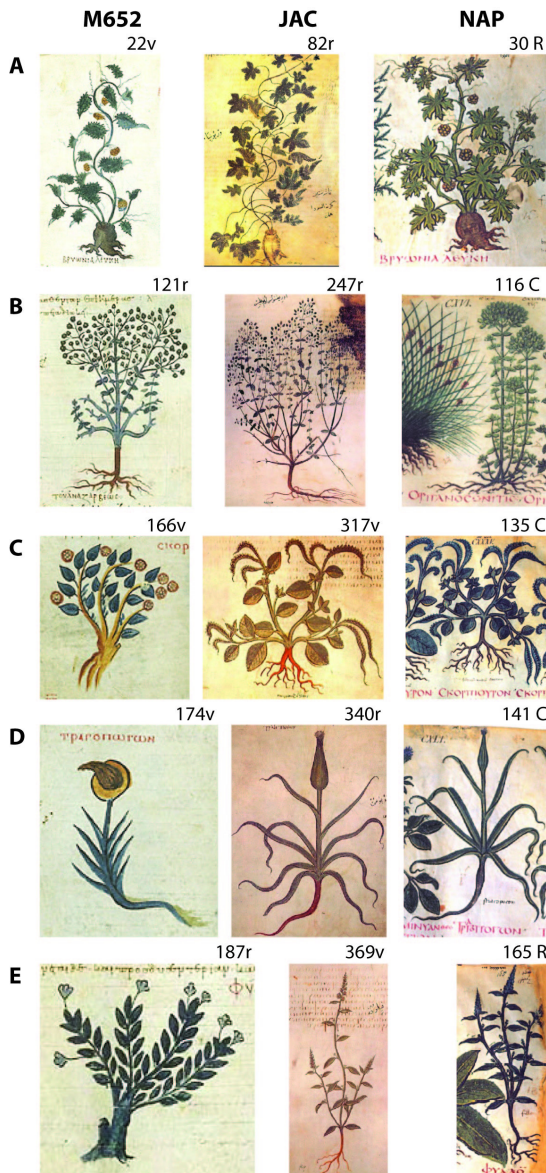


Fig. 2. Five examples of non-syntenic triple images: (A) *Bryonia alba*. JAC image has been identified as *Humulus lupulus* (Renner et al. 2008); M652 and NAP images are considered non-syntenic based on leaf shape; (B) *Origanum vulgare*. NAP image shows a phase difference but M652 and JAC images are considered syntenic. (C) *Heliotropium europaeum*. The crude image in M652 is not syntenic; JAC and NAP images are considered syntenic. (D) *Tragopogon porrifolius*. The crude image in M652 is not syntenic; JAC and NAP images are considered syntenic. (E) *Mercurialis perennis*. The crude image in M652 is not syntenic; JAC and NAP images are considered syntenic

indicate that JAC or a prototype was the major source of M652, but not exclusively.

The most convincing evidence that NAP images were a source of M652 are the images of *Juncus maritimus* (Fig. 4E). The leaves of the JAC image are drawn in a random jumbled pattern while the NAP copyist chose to present the foliage in an artificial ordered pattern, obviously for

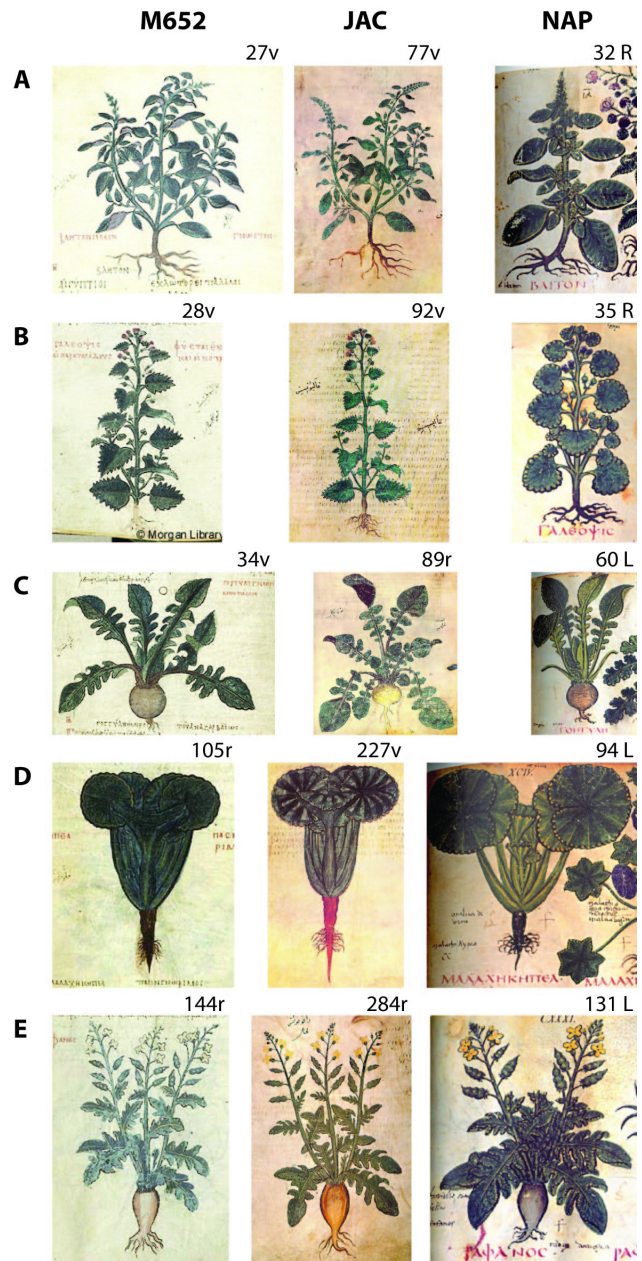


Fig. 3. Five examples of triple images where the M652 image appears closer to JAC than to NAP; thus, JAC is presumed to be the source image: (A) *Amaranthus blitum*, (B) *Scrophularia peregrina*, (C) *Brassica rapa*, (D) *Malva silvestris*, (E) *Raphanus sativus*

esthetic reasons. The M652 copyist clearly used the NAP image as a model rather than JAC. We consider this is the “smoking gun” that ultimately convinces us that NAP must also be a source of M652!

The distribution of triple syntenic images in Book I showing M652 closer to JAC or NAP was not random but tended to appear in clusters (Fig. 6). For example, in one case 10 images in a row resemble NAP. The text of M652 was created in alphabetical order (first letter only) by scribes, and it appears the illustrations were then added

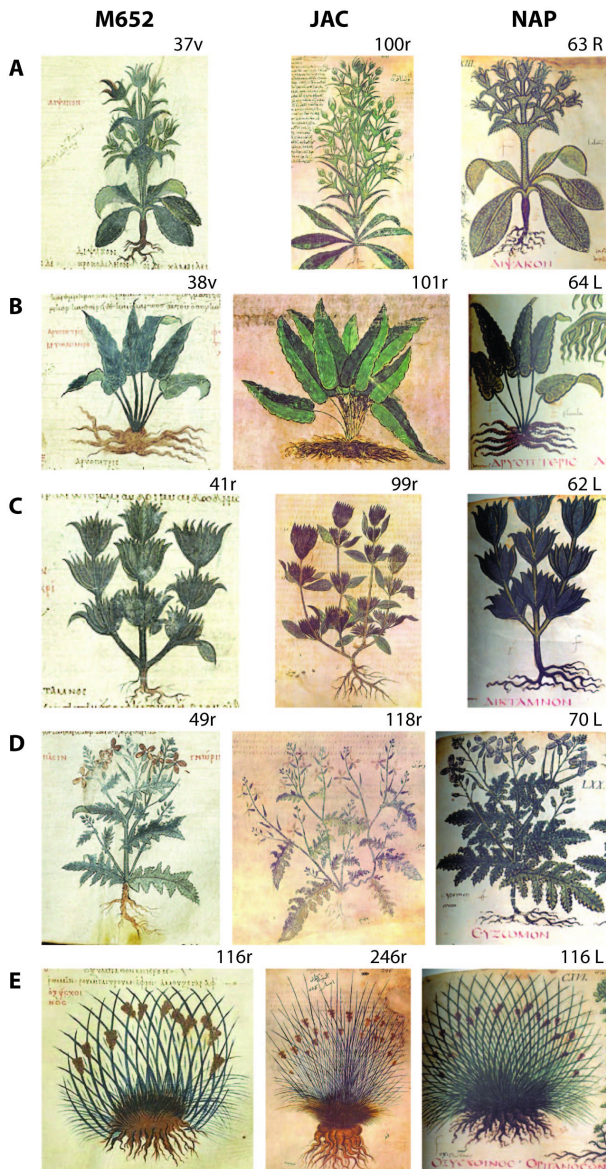


Fig. 4. Five examples of triple images where the *M652* image appears closer to *NAP* than to *JAC*; thus, *NAP* is presumed to be the source image: (A) *Dipsacus fullorum*, (B) *Asplenium onopteris*, (C) *Origanum dictamnus*, (D) *Eruca sativa*, (E) *Juncus maritimus*

by the copyist. One conjecture to account for the non-random distribution of images is that that they were added by a number of independent groups of copyists working on batches of folios, some of which had sole access to the *JAC* and the others to the *NAP* manuscripts. If correct, this confirms that both *JAC* and *NAP* were available at the same time to the workshop of copyists. This is quite logical and makes eminent sense. Basically the workshop shared the burden of copying the two manuscripts (*JAC* and *NAP*) across the studio. It appears that the person commissioning *M652* assumed after a cursory glance, that *JAC* and *NAP* were ostensibly identical.

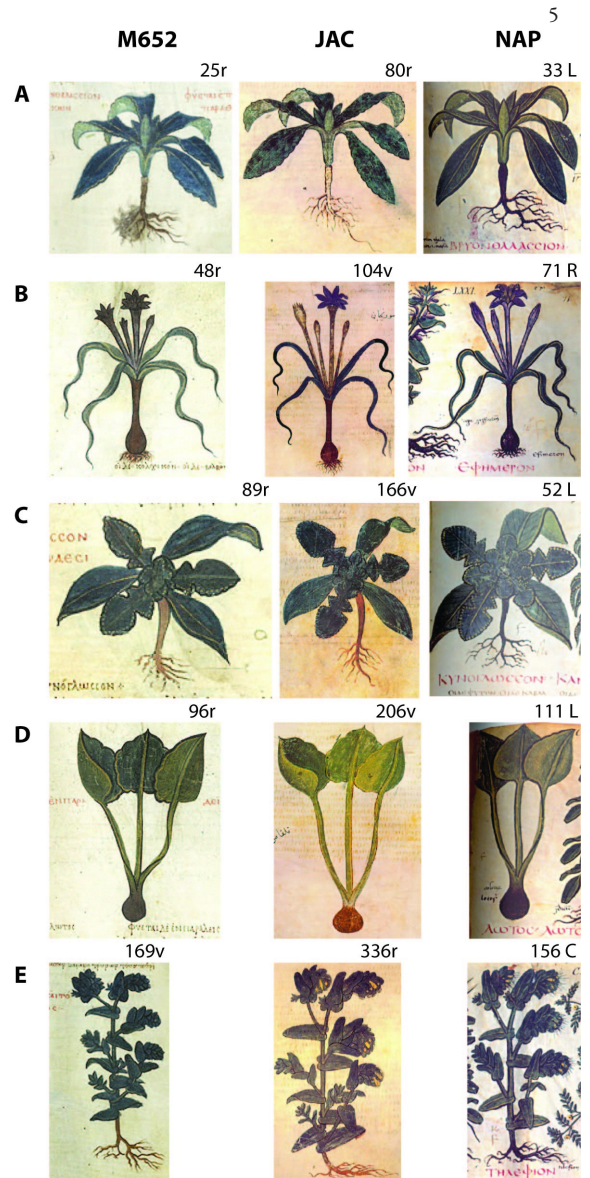


Fig. 5. Five images where it cannot be determined if *JAC* or *NAP* is the source image for *M652*: (A) *Atriplex hortensis*, (B) *Polygonatum multiflorum*, (C) *Cynoglossum columnae*, (D) *Melilotus messinensis*, (E) *Andrachne telephoides*

Images Unique to each Herbal Manuscript

The number of images unique to all herbals was: 25 for *JAC*, 10 for *NAP*, and 99 for *M652*. Of the 25 unique images in *JAC*, 20 began with the letter *alpha* in Greek and can be explained by the 11 missing pages in the beginning of *NAP*, which contain an average of 2.5 images per page. There were only 10 unique images in *NAP*. Of the 99 unique images in *M652*, 94 were crude sketches (Fig. 7), obviously derived from a different source than *JAC* or *NAP*. They appear to be done by different, less talented copyists; and Collins (2000) suggested that some might not have seen the plant. The inclusion of these sketchy drawings confirms that there were other sources for the creation of *M652* than *JAC* or *NAP*.

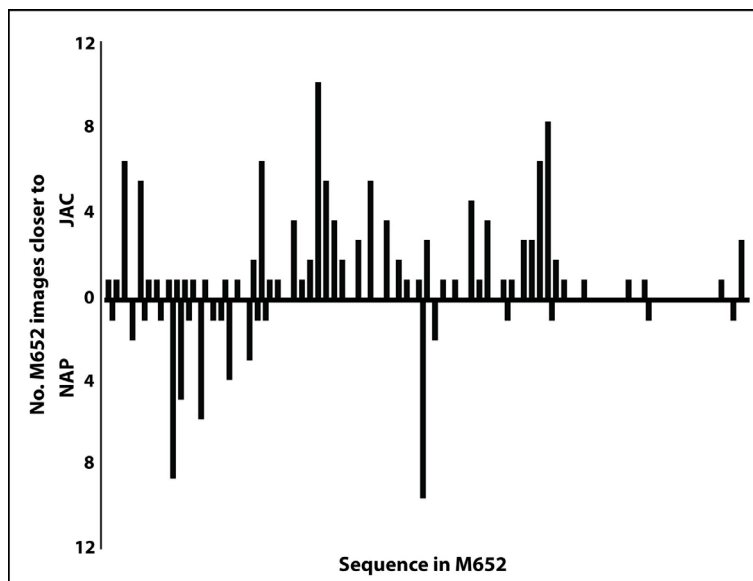


Fig. 6. Sequence of triple syntenic images which are determined to be closer to *JAC* or *NAP* from *M652* folio 2v to folio 199r. The gaps between bars represent images where that determination could not be established

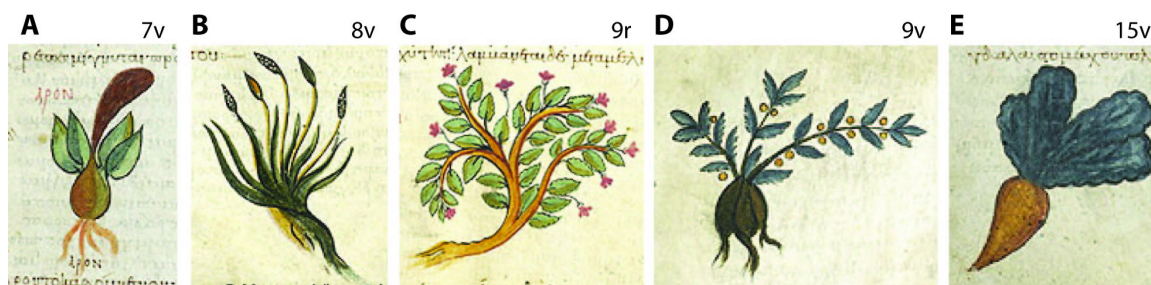


Fig. 7. Examples of crude sketchy illustrations in *M652*: (A) *Colocasia antiquorum*; (B) *Salvia aethiopsis*; (C) *Antirrhinum orontium*; (D) *Euphorbia apios*; (E) *Brassica napus*

The Origins of *JAC*, *NAP*, and *M652*

Speculation on the origins of *JAC*, *NAP*, and *M652* is based on analysis of their images. *JAC* produced in 512 in Constantinople has been considered to be based on a lost archetype or trove of drawings (*THEO*) created for Theodosius II, great-grandfather of Juliana Anicia (Collins, 2007). *THEO* was probably more encyclopedic than *JAC* and may have obtained multiple versions of each plant depicting various stages (Janick and Stolarczyk, 2012). This explains examples of stage differences found between some images of *JAC* and *NAP*.

NAP dated to the late sixth or early seventh century has been demonstrated to be an extended version of *JAC* and thought to be derived from *THEO* (Collins 2000). Although it is considered a sister manuscript, it cannot be excluded that some drawings contained in *NAP* were copied directly from *JAC*. Thus, the workshop producing *NAP* must have had the archetype *THEO* and possibly *JAC* at their disposal. Therefore, the simplest explanation for the origin of *NAP* was that the manuscript was produced in Constantinople rather than in Italy (Ravenna) suggested by Cavallo (1992) on the basis of typographical evidence.

M652 was produced in Constantinople in the 10th century and the analysis of the illustrations presented above clearly indicates that images found in both *JAC* and *NAP* formed the major source for Book I. The relationship of *M652* with *JAC* has been commented on by Van Buren (1973) and Collins (2000). The specific involvement of *NAP* as a source of *M652* is based on three types of evidence: (1) the presence of 45 images of *NAP* in *M652* not found in *JAC*. Excluding the two images of mandrake that can be explained by lost pages in *JAC* still leaves 43 images of *NAP* found in *M652* not found in *JAC*. This is strong evidence that *NAP* was a source of *M652*. (2) In a direct comparison of the 274 “syntenic” images common to all three herbals, 52 (19.3%) of them appear closer to *NAP* than *JAC* (see especially *Juncus maritimus* Fig. 4E). We consider this convincing evidence for the involvement of *NAP*. (3) The non-random distribution of *JAC* and *NAP* image matches with *M652* suggests that the source *JAC* and *NAP* manuscripts were divided between two (or more) copyists who probably worked independently illustrating batches of folios prepared by scribes. This implies that both *JAC* and *NAP* were available to the artists involved in the production of *M652*. Furthermore, it provides evidence that *NAP* must have been present in Con-

stantinople and strongly implies that it was also produced in that location.

Was a unique volume of *NAP* available to the artists in the workshop producing *M652*, or were copies or the archetype *THEO*, now lost, involved? This cannot be answered, but the simplest explanation—the hypothesis with the fewest assumptions (Occam's razor)—is that *NAP* was directly available to the workshop that produced *M652*. Since *M652* contains images that relate to both the *JAC* and *NAP* we assumed that the workshop producing this manuscript must have had both herbals at their disposal. We acknowledge that this casts doubt on the supposition of Lilla and Cavallo (1992) that *M652* originated in Ravenna rather than being a product of Constantinople.

How was *M652* produced? This problem has been considered by the late Anne Van Buren (1973). She notes that the Morgan herbal is heavily indebted to *JAC* with 245 out of 448 plants practically identical to the naturalistic plants in the Vienna codex. She considers 41 more plants that would correspond to missing images from the Vienna manuscript. She further notes a set of paintings derived from a different herbal text for 58 plants that occur in the *NAP*. Finally there is a group of 104 rudimentary images not included in the Vienna codex. Her analysis agrees with our conclusion that *M652* is a compilation of at least three different herbals: *JAC*, *NAP*, and an unidentified herbal. It appears that the producers of *M652* preferred the naturalistic drawings of *JAC* and *NAP* as their sources but then added many plants which were not available in *JAC* or *NAP* from another source or sources. These plants were added in bunches as the volume was being prepared but the present binding of *M652* has probably not preserved the original sequence of preparation.

Acknowledgments

We thank Whitney Huang for creation of the Venn diagram, Audra Franz for assistance with the database, and Lawrence Mykytiuk for editorial assistance. We thank the Lillian Goldman Foundation for financial support.

References

- Bertelli C (1992). A proposal concerning the client of the Neapolitan Dioscurides, 125-131 p. In: Bertelli C, Lilla S, Orofino G, (commentarium). Dioscurides Neapolitanus. Biblioteca Nazionale di Napoli Codex ex Vindobonensis Graecus. Commentarium. Salerno Ediotrice, Roma.
- Brubaker L (2002). The Vienna Diokorides and Anicia Juliana, 189-214 p. In: Littlewood A, Maguire H, and Wolschke-Bulmahn J (Eds.). Byzantine Garden culture. Dumbarton Oaks Research Library and Collection, Washington, D.C.
- Cavallo G (1992). Introduction, 9-13 p. In: Bertelli C, Lilla S, Orofino G, (commentarium). Dioscurides Neapolitanus. Biblioteca Nazionale di Napoli Codex ex Vindobonensis Graecus. Commentarium. Salerno Ediotrice, Roma.
- Cavallo G (2000). The Naples codex: A codicological description and history of the manuscript. In: Dioscurides *De material Medica, Codex Neapolitanus Graecus I of the National Library of Naples*, 69-77 p. Alimos, ΜΙΑΗΤΟΣ.
- Collins M (2000). Medieval herbals: The illustrative traditions. The British Library, London.
- Der Wiener Dioscorides (1998-1999). 2 vol. (commentary by Otto Mazal), Graz: Akademische Druck-u Verlagsanstalt.
- Dioscurides De materia Medica, Codex Neapolitanus Graecus I of the National Library of Naples. (facsimile). (2000? undated) 3 volumes. Alimos, ΜΙΑΗΤΟΣ.
- Hummer KE, Janick J (2010). *Rubus* iconography: Antiquity to the present. Acta Horticulturae 759:89-105.
- Janick J, Hummer KE (2012). The 1500th anniversary (512-2012) of the Juliana Anicia Codex: An illustrated Dioscoridean recension. Chronica Horticulturae 52(3):9-15.
- Janick J, Stolarczyk J (2012). Ancient Greek illustrated Dioscoridean Herbals: Origins and Impact of the Juliana Anicia Codex and the Codex Neapolitanus. Not Bot Horti Agrobo 40(1):9-17 (www.notulaeobotanicae.ro (1842-4309)).
- Lilla S (1992). A study of the manuscript, 49-82 p. In: Bertelli C, Lilla S, Orofino G, (commentarium). Dioscurides Neapolitanus. Biblioteca Nazionale di Napoli Codex ex Vindobonensis Graecus. Commentarium. Salerno Ediotrice, Roma.
- Orofino G (1992). The miniatures, 99-113 p. In: Bertelli C, Lilla S, Orofino G, (commentarium). Dioscurides Neapolitanus. Biblioteca Nazionale di Napoli Codex ex Vindobonensis Graecus. Commentarium. Salerno Ediotrice, Roma.
- Renner SS, Scarborough J, Schaefer H, Paris HS, Janick J (2008). Dioscorides' *bruonia melaina* is *Bryonia alba*, not *Tamus communis* and an illustration labelled *bruonia melaina* in the *Codex Vindobonensis* is *Humulus lupulus* not *Bryonia dioica*. p. 273-280. In: Pitrat M (Ed.). Cucurbitaceae 2008, IXth Meeting on Genetics and Breeding of Cucurbitaceae, INRA, Avignon.
- Singer C (1927). The herbal in antiquity and its transmission to later ages. J. Hellenistic Studies 47:1-52.
- The Dioscurides of the Biblioteca Nazionale of Naples: The miniatures: In: Commentarium. Dioscurides Neapolitanus: Biblioteca Nazionale de Napoli Codex ex Vindobonensis Graecus I. Salerno: Editrice Roma.
- Van Buren A (1973). De material medica of Dioscurides, 66-69 p. In: Vikan G (Ed.). Illuminated Greek manuscripts from American collection: An exhibition in honor of Kurt Weitsmann. The Art Museum of Princeton University, Princeton, New Jersey.
- Wellman M (1906-1914). Pedanii Dioscuridis Anazarbei De materia medica libri quinque. Three volumes, reprinted 1958. Weidmann, Berlin.