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

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Abstract

Plant illustrations were compared in three ancient illustrated recensions of the non-illustrated manuscript of Dioscorides titled Περί ύλης ιατρικής (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 Περί ύλης ιατρικής (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 Exarchte 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 preface 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 M6522 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 Cyparissus 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 Mazel 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 Mazel, 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
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 peplus 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

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**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)
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.

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 esthetic reasons. The M652 copyist clearly used the NAP model rather than JAC. We consider this 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.
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.

by the copyist. One conjecture to account for the non-random distribution of images is 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. 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

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 telephioides
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 maratimus 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-

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.

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**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 aethiopis; (C) Antirrhinum orontium; (D) Euphorbia apios; (E) Brassica napus.
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.

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