Umanistica Digitale – ISSN: 2532-8816 – n. 11, 2021
J. Rydberg-Cox – *Modeling the Sources and Topics of Pliny's* Natural History
DOI: http://doi.org/10.6092/issn.2532-8816/12521

Modeling the Sources and Topics of Pliny's *Natural History*

Jeff Rydberg-Cox

University of Missouri, Kansas City, USA
rydbergcoxj@umkc.edu

Abstract

Pliny's *Natural History*, a large-scale encyclopedia containing more than 1.1 million words from the first century CE, provides a snapshot of scientific knowledge in the Roman Empire with sections devoted to topics such as geography, geology, zoology, botany, anthropology, minerology and an important overview of the history of Greek art. While scholars have used the *Natural History* as an *ad hoc* source for investigations about specific aspects of scientific knowledge in the Roman Empire, it is much more difficult to define the broader models that unify the work's disparate parts because of its size and scope. Quantitative and computational text technologies provide a methodology that help us understand the nature of this monumental compendium of scientific knowledge from the Roman Empire and allow us to answer specific questions such as the nature of sources that were used, the interrelations of the topics covered in the text, and the ways that these topics have been adopted or reflected in the publication history of the work. This paper explores the ways that other scholars and editors have tried to make this massive work more manageable, and then talk about the ways that network analysis and other quantitative approaches can help us understand the sources that Pliny used when writing his work.

L'*Historia Naturalis* di Plinio, un'enciclopedia su larga scala del I secolo d.C. contenente più di 1,1 milioni di parole, fornisce un'istantanea della conoscenza scientifica nell'Impero Romano con sezioni dedicate ad argomenti come geografia, geologia, zoologia, botanica, antropologia, mineralogia e un'importante panoramica della storia dell'arte greca. Mentre gli studiosi hanno utilizzato l'*Historia Naturalis* come fonte *ad hoc* per indagini su aspetti specifici della conoscenza scientifica nell'Impero Romano, è molto più difficile definire i modelli più ampi che uniscono le parti disparate dell'opera a causa delle sue dimensioni e portata. Le tecnologie testuali quantitative e computazionali forniscono una metodologia che ci aiuta a comprendere la natura di questo monumentale compendio del sapere scientifico dell'Impero Romano e ci permette di rispondere a domande specifiche come la natura delle fonti utilizzate, le interrelazioni tra gli argomenti trattati nel testo e i modi in cui questi argomenti sono stati adottati o riflessi nella storia di pubblicazione dell'opera. Questo articolo esplora i modi in cui altri studiosi ed editori hanno cercato di rendere più gestibile questo enorme lavoro, quindi parla dei modi in cui l'analisi

di rete e altri approcci quantitativi possono aiutarci a capire le fonti che Plinio ha usato quando ha scritto il suo lavoro.

Introduction

Pliny the Elder's *Natural History*, a large-scale encyclopedia that contains more than 1.1 million words from the first century CE provides a snapshot of scientific knowledge in the Roman Empire with sections devoted to topics such as geography, geology, zoology, botany, anthropology, and an important overview of the history of Greek art.[1] The range of topics in the encyclopedia reflect Pliny's wide-ranging curiosity and include descriptions of *mirabila* that occur naturally or are the products of human ingenuity ([30]: 59). While scholars have used the *Natural History* as an *ad hoc* source for investigations into specific aspects of scientific knowledge in the Roman Empire, it is much more difficult to define the broader mental models that unify the work because of its size and scope.

In the introduction to his abridged edition of the work, J. Newsome enumerates some of the problems that modern readers face when approaching this book. He tells us that the bound book is 4 inches thick, weighs 10 pounds, it runs to some 1,438 pages and includes more than 200,000 facts. Neither the work's encyclopedic nature nor Pliny's writing style lend themselves to linear reading. Newsome writes,

> Pliny interleaves what Cuvier calls 'the dryness of his enumerations' with amusing anecdotes, fables, curiosities, and diatribes against contemporary luxury and indolence; but these are so buried beneath interminable ancient geography, pharmacy, and botany that they cannot be exhumed without much spade work. These enumerations, unfortunately, take up at least a quarter of the work, and the capacity of the modern reader would surely be strained by these barren tracts, these endless lists of place names, national boundaries, and pharmacological properties of unidentifiable herbs. ([31]: xvi)

While the text's massive scope is daunting, it does provide us with an unparalleled glimpse into the ways that Romans understood the natural world and the ways that knowledge was created and disseminated in the early Roman Empire. Trevor Murphy has argued that the litany of facts in Pliny's encyclopedia not only organizes and classifies the world but also reveals the scope of imperial power that allows such a breadth of material to be gathered and presented for public consumption.[2] Murphy argues that the use of written sources is one of the fundamental aspects

1 The research described in this paper was completed during my time as a scholar-in-residence at the Linda Hall Library in Kansas City, Missouri in early 2020. Benjamin Gross, the Vice President for Research and Scholarship at the Linda Hall Library, and members of the library's Works in Progress Seminar provided valuable feedback as the work was taking shape. I am grateful to my colleagues at the library and the members of the Works in Progress Seminar for their insight and their ongoing support of this work.

2 See [29]. [36] summarizes Murphy's argument as follows: "He presented it not so much to instruct like a textbook, but rather to offer a work of reference, to classify and validate knowledge (be it

of Pliny's monument to Roman Imperial knowledge. In fact, Pliny's working methods and reading habits have long been a source of fascination. Pliny himself talks about consulting some 20,000 esoteric works while his nephew describes him as a voracious reader who would have books read aloud to him in the afternoons, when he ate his meals, and even when he took his baths. He read while being carried through Rome in a litter because he resented the time that walking took away from his studies and he criticized friends who interrupted those who read aloud to him. He also took copious notes. Pliny the Younger writes, "He made extracts of everything he read, and always said that there was no book so bad that some good could not be got out of it."[3]

The first book of the *Natural History* highlights Pliny's relationship with his sources through an extensive table of contents that lists the topics covered in each book of the encyclopedia. This list also includes the names of each of the authors that he consulted for that book and classifies them as either Roman or non-Roman.

Some scholars have perused this list for bits of information about specific authors, used it to help illuminate Pliny's approach to knowledge, or reformatted it as a table of contents for the entire work. In fact, some printed editions such as John Bostock's 1855 translation simply omit Pliny's original list and replace it with their own table of contents (see [32]). John Healey, for example, has separated out the authors into different categories such as encyclopedists, historians, military commanders, provincial governors, specialists on various topics, etc. ([20]). Likewise, Eugenia Lao has argued that Pliny's catalog of sources reflects his understanding of knowledge as a form of intellectual property. She writes, "Pliny, having attached the concept of ownership to knowledge, works with ideas of theft and indebtedness to describe what it means for knowledge to be reproduced without acknowledgment" ([26]). Aude Doody has demonstrated that, "Readers of Pliny have encountered different forms of the summarium over the long history of reading the *Natural History*. … The text of the summarium we use today has changed considerably from the versions that readers of the *Natural History* used right up until the mid-nineteenth century" ([13]: 96).

The list of names in the first book of the *Natural History* is, therefore, a microcosm of the entire encyclopedia that provides a window into Pliny's intellectual world. The list itself is not organized in a way that helps us understand which authors are more or less important. Quantifying these sources and visualizing them within a network allow us to bring order to this monumental compendium of scientific knowledge from the Roman Empire and answer specific questions such as the nature of sources that Pliny consulted, and the interrelations of the topics covered in the text.

familiar, novel or marvelous), and hence above all to celebrate the Roman power which underpinned this authoritative grasp of the world. To Murphy, the Natural History can fairly be compared to an ancient map, as well as to a Roman triumphal procession where newly discovered peoples, lands, plants, animals (or their images) are all paraded for public viewing and instruction."

3 Pliny the Younger, Letters III.5.11; [33]: 175. Pliny's working methods are discussed in [28]: 26, [15]: 51.

Making Sense of the Sources

Quantifying the list of Pliny's sources makes it more comprehensible and give us a sense of the different ways that Pliny used source texts. There are 1,851 names on the complete list and many of them are cited in more than once. When duplicates are eliminated, we find 529 unique individual authors but each of these authors is not equally important in the encyclopedia. Doody has further noted that the names in Pliny are not simply references to individuals who provided source material for the work. The lists of names and citations of sources can serve as markers that structure the text and the fact that an author wrote about a particular topic might also be an interesting fact on its own ([14]: 122). Pliny's use of names in these two ways suggests that they can be studied independently to help form a picture of Pliny's intellectual word. For example, the number of times that each individual is mentioned on the source list helps us begin to form a taxonomy.

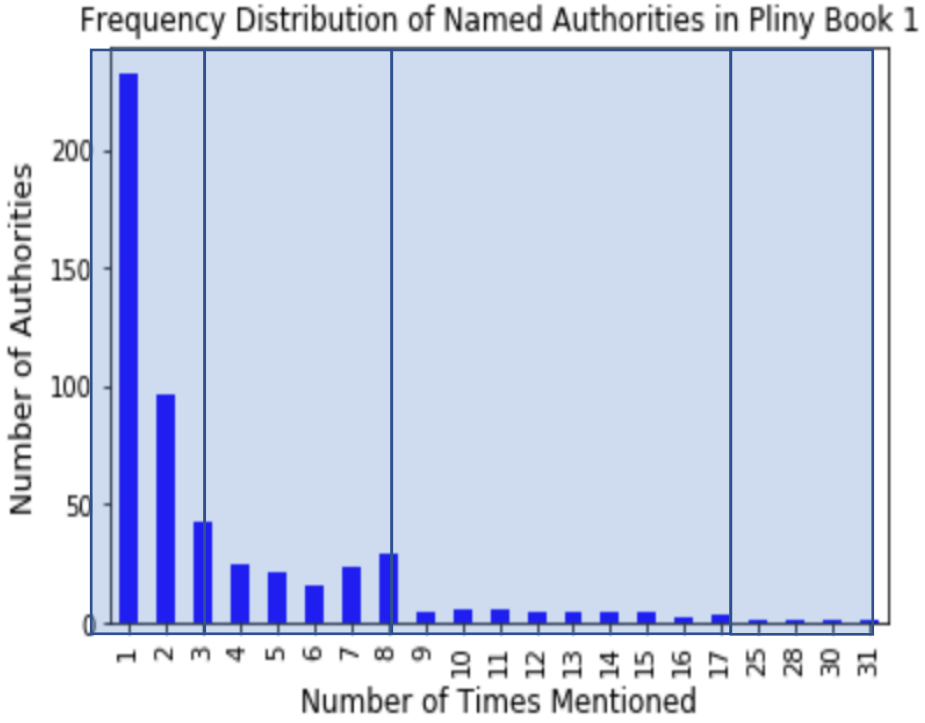

Figure 1: Frequency Distribution of Named Authorities in Pliny Book 1

The clusters of frequency distributions shown Figure 1 suggests that we can group Pliny's sources into four separate categories: specialist sources that he cites in only one, two, or three books, occasional sources that provide information for somewhere between four and eight books, frequent sources who provide information for nine to seventeen books and a group of four

polymaths — Dionysius, Democritus, Theophrastus, and Varro — who are cited in twenty-five, twenty-eight, thirty and thirty one books respectively.

Examining Pliny's classification of his sources as Roman or non-Roman, we find that just over two thirds of his sources are non-Roman, and these authors provide the foundations for the work; three of the four polymaths are non-Roman, twenty-five of the thirty-nine frequent sources are non-Roman, and 86 of the 115 occasional sources are non-Roman. On the other end of the scale, 75% (131 of the 175) of the Roman sources fall into the 'specialist' category that Pliny cites in only one, two or three books. Pliny cites more Roman sources than non-Roman sources in only four books: that one that describes the geography of Italy and Spain, one that describes fish and marine life, one that describes forests and trees, and a fourth that describes gardens. In general, the books with more Roman sources cover topics that have substantial sections about the plants, animals, peoples or environment of Italy and Spain.

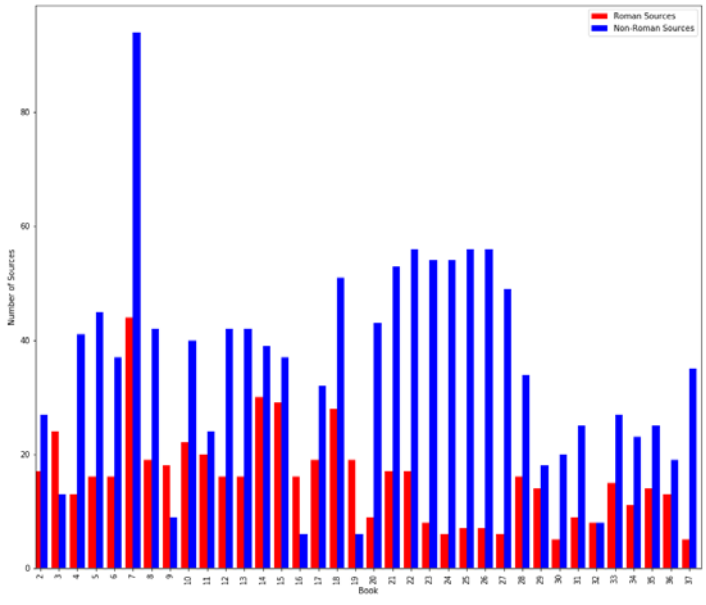

Figure 2: Classification of Pliny's Sources

This portrait of the state of knowledge in Pliny's encyclopedia fits broadly with the picture of knowledge in the ancient Roman world that we have from other sources. The Roman poet Horace writing about 30 years earlier than Pliny has famously written that Greece, although it

had been defeated by the Romans had, "made her savage victor captive, and brought the arts into rustic Latium."[4]

Building A Network of Pliny's Sources and Topics

While quantifying Pliny's sources allows for the classification of the authors that contribute to the encyclopedia and reveals their broad geographic distribution, the aggregate numbers provide an incomplete picture. Envisioning the authors and topics from Pliny's list as a network provides a framework that can allow for the exploration of the different ways that each of them contribute to the overall work, their relationships with each other, and their relative importance for different topics.

To create a network of Pliny's sources and topics, the subject of each book and each author who is mentioned in the source list are nodes in the network. Creating a network from Pliny's list of names requires editorial intervention because the text is not consistent in its mention of names. Sometimes he just gives a name, sometimes he gives a name and a specifier such as the 'medical writer' or 'the poet' and other times he lists the title of the specific works. For example, Pliny cites the poet Ovid as a source for four books in the *Natural History*. In the citations for books eighteen and thirty-one, he is described simply as 'Ovid' while he is described as 'the poet Ovid' in the citations for books twenty-nine and thirty-two. Likewise, Juba II, who Healey describes as "an erudite scholar who carried out a wide range of research and was keen to introduce Greek and Roman culture into his kingdom," ([20]: 44 n. 16) is described as King Juba in books Book 5, 6, 8, 14, 15 and as Juba in books 10, 12, 13, 24, 26. There are other names that need to be disambiguated to distinguish between sources such as the medical writer Attalus and Attalus III, the ruler of Pergamum. The dataset for this study normalizes these variations by eliminating the names of specific works, edits the specifiers for consistency and assigning each author a unique identifier.

The books in Pliny's encyclopedia are also envisioned as nodes. Because each book focuses on a specific topic, these can serve as a high-level overview of the subjects treated by the text. Each book is labeled with a topic heading that has been adapted from John Bostock's 1855 translation. For example, for Book 15, Bostock writes, "The 15th on Fruit Trees." This is normalized as a node label of 'Fruit Trees' for this book. The fact that an author is cited as a source for a specific book creates an edge in the network graph between that author and the book's topic.

A small sample network that connects the four polymaths Democritus, Dionysius, Theophrastus, and Varro to the topics of the first five books of the encyclopedia illustrates this approach. Only Varro and Democritus are mentioned in the source list for the second book, so the network has nodes for these two authors with edges that connect them to the topic, "the World, the Elements and the Heavenly Bodies." The source list for book three mentions Varro and Theophrastus so our network gains nodes for Theophrastus and the topic, "Geography of the Iberian Peninsula and Italy" and an edge that connects them. Continuing to book four that covers the geography

[4] Horace *Epistles* II.155. [21]: 409-410.

of the rest of Europe and book five that describes the geography of Africa and Asia, we find Dionysius and Varro listed as sources. Finally, Varro is the only one of the four most frequent sources who appears in the source list for book 6 that describes the geography of the Black Sea, China, and India. The network visualization of this small dataset allows us to see how each of these four authors contribute to the first part of the work, with Varro offering the most information about geography, Dionysius and Theophrastus contributing to a few books, and Democritus not serving as a source for geographic knowledge.

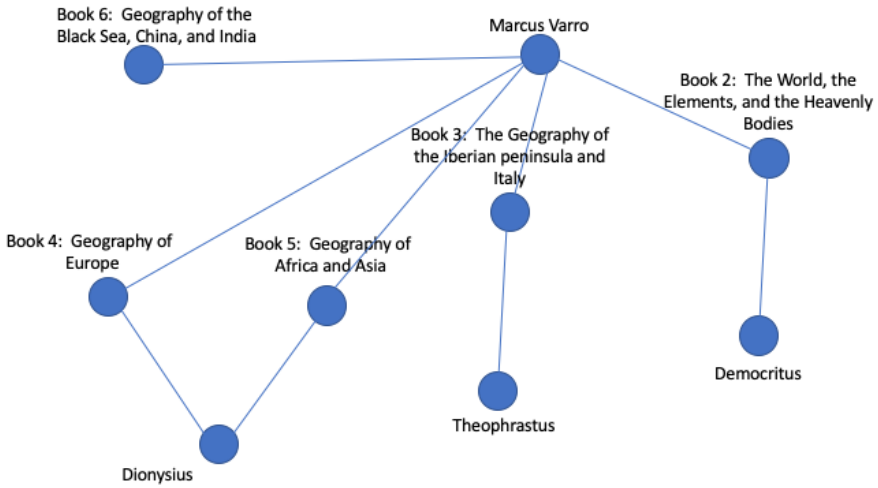

Figure 3: Sample network showing connections between Pliny's four most frequently cited authors and the topics of books 2-6 of the Natural History

The network grows quickly as topics and sources are added. A network that connects Pliny's top four sources to all of the encyclopedia's topics has 39 nodes with 113 edges. A network graph that includes the frequent sources expands to 79 nodes with 591 edges, while adding the occasional sources brings our graph to 194 nodes with 1,287 edges. Finally, a graph that includes all sources has 564 nodes and 1,840 edges.

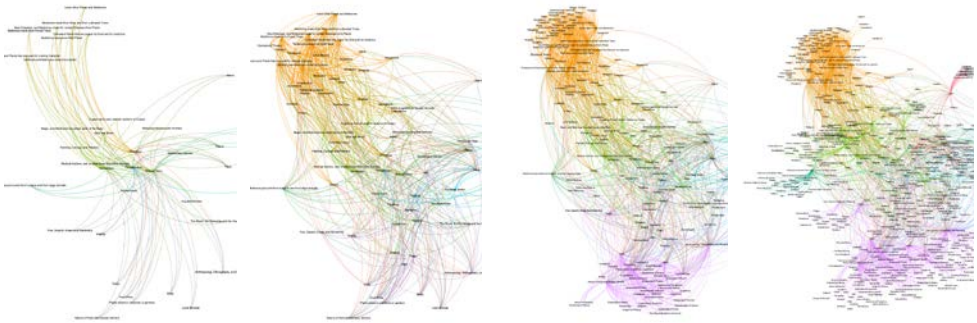

Figure 4: Network Diagrams of Pliny's Sources and Topics with the top four sources, the frequent sources, the occasional sources, and all sources

Network Metrics and Analysis

The resulting network graphs shown above are evocative but difficult to decipher based on visual information. It is possible to drill down into networks such as these and use them to answer specific questions about the relationships between specific actors as Fabian Germedot does in his use of network analysis to explore specific questions about Pliny the Younger's interactions within the social world of the Roman Empire ([18]). Network methods have also been broadly applied to the study of literary texts as a method for distance reading. Recent studies have shown how network methods reveal the ways that fictional worlds such as Shakespeare's plays or the Marvel cinematic universe can reflect the social organization of their real-world counterparts (see, for example, [1]; [35]; [27]; [34]; [4]), how characters interact with each other in literary texts ([6];[7];[8]), and the ways that ideas can spread across space and time in a wide variety of historical contexts ([10];[11];[12];[38];[3];[9]).

This study of Pliny's sources and topics draws most closely on the branches of network analysis that seek to understand relationships among intellectual communities such as the 'Mapping the Republic of Letters' project that has built a network showing who exchanged letters and other forms of communication with whom in the intellectual circles of Europe from the late 15th century into the 18th century.[5] This work has produced visualizations and studies on a range of topics such as Benjamin Franklin's interaction with intellectual circles in Europe, Voltaire's connections to England, and a study of architects who participated in the 'Grand Tour' of Europe in the 18th century.[6]

Building on this previous work, this study of Pliny has focused on quantitative network measures that allow for the broader identification of patterns within these networks. It also seeks to understand connections not just between the individual actors in the network but also the interrelationships between Pliny's sources and the topics that they discuss.[7] Three different network metrics allow us to examine the relationships between sources and topics at a larger scale than is possible for a reader working through the list by hand: **density** that describes the graph's shape and level of connectivity, **modularity** that clusters the graph into communities, and **centrality** that helps identify the central nodes within the graph.[8]

A graph's density measures "the number of direct actual connections divided by the number of possible direct connections in a network" ([24]: 29). A density of zero means that there are no connected nodes within the network and a density of one means that every node is connected ([25]). The density for the network of Pliny's sources is .012, a low ratio that suggests that he consults a wide variety of different sources for each of the topics. This ratio is confirmed by the fact that Pliny cites the vast majority of his sources three or fewer times. If we filter our network

5 http://republicofletters.stanford.edu and [17]; [23]; [16].

6 See [37]; [5]. http://republicofletters.stanford.edu/publications/voltaire/

7 [19]: 562 describe another study that uses networks to connect individuals and topics in the history of biology.

8 For details about calculating these metrics with Python, see [25].

so that it just includes the four polymaths and their topics, the network density is .15 showing that even the four most frequently cited sources have relatively distinct areas of expertise. If each one of Pliny's top four sources were cited for every topic, the density measure for the overall graph would be much higher.

While the density metric gives the sense that each of Pliny's sources contributes to a distinct set of topics, the modularity calculation places each of the sources into groups based on the topics that they discuss. Walsh describes this as follows: "Modularity is a measure of relative density in your network: a community (called a module or modularity class) has high density relative to other nodes within its module but low density with those outside" ([25]). In the network of Pliny's sources, this measure connects authors and topics into groups. For example, in the small network of Pliny's most frequently cited sources, the modularity calculation places the authors and their topics into three distinct groups with Dionysius being more closely associated with birds, trees and plants, Varro associated most closely with insects, flowering trees, and geography, while Democritus and Theophrastus are associated with the topics that cover anthropology, farmers, plants, vines and painting and painters. In addition to giving us a sense of the topics that are most closely connected to each author, the graph also gives us a sense of the ways that topics are dispersed across the encyclopedia. For example, nine of the thirty-seven books in the encyclopedia cover topics related to health and medicine. These topics are dispersed throughout the modularity classes of our small sample graph and not included in a single cluster. This suggests that even though medicine is a major subject in the encyclopedia, none of the top four writers serve as the single most important source of medical knowledge.

When the modularity calculation is applied to the entire network, it helps a reader make sense of the work by providing a collection of topic clusters for the work. This score divides the encyclopedia into six clusters, 1) a cluster for the four books of geography, 2) one that gathers together the books that cover land animals, trees, vines, and the people who cultivate them, 3) a cluster about trees and medicines derived from humans and large animals, 4) a broad cluster medical knowledge, 5) a cluster that combines medicines derived from magical sources and other animals alongside information about aquatic animals, and 6) one that combines the books on plants, trees, metallurgy and the related book on painters and painting.

While the modularity calculations help give us a better understanding of the ways that Pliny's sources cluster around specific topics in the *Natural History*, the network metrics of centrality help us understand the relative importance of each of these authors within and between the clusters.

Betweenness centrality in network analysis is defined as the relative frequency with which someone traversing the network would pass through a given node. Looking at the network visualization, these are the nodes that fall in the middle of the graph with paths to many if not all of the different topic clusters ([39]: 92-96). The four authors who Pliny cites most frequently not surprisingly also have the highest betweenness score. This metric is particularly useful for differentiating the larger group of thirty-two authors in that Pliny cites frequently and the 115 authors Pliny cites occasionally. The measure of betweenness allows us to divide these authors into two classes, those who Pliny consulted for many different topics in the encyclopedia and others who contribute specialist knowledge within a more limited range of topics. For example, we find both Aristotle and Hippocrates on the list of authors who Pliny cites frequently but

Aristotle's betweenness centrality is much higher than Hippocrates'. This difference reflects the fact that Aristotle is cited for at least one book in all six of the encyclopedia's topic clusters while 10 of the 12 books that cite Hippocrates fall into the clusters that deal with medicines and healing. The betweenness calculation can help us understand the contributions of authors who are less broadly known such as Iollas, a Hellenistic author who wrote on botany and pharmacology, and Mucianus who wrote a large compendium about the wonders of the natural world. Pliny cites both of these authors for seventeen books in the encyclopedia but the difference in their centrality score points us to the qualitative differences in their contributions; Pliny cites Mucianus in books that fall into all six of the encyclopedia's topic clusters while the majority of the citations of Iollas appear in one of the medical clusters.[9]

Conclusion

Doody has noted that, "the possibility of using the text as a mine of information has changed alongside the development of technologies of retrieval, indices, page numbers and chapter numbers."[10] Modeling the sources and topics of the Natural History using network methodologies continues this practice of using new text-technologies to make sense of Pliny's massive work. These quantitative measures allow us to form a nuanced model of Pliny's sources and topics and begin to make sense of massive list that appears at the beginning of his book. We find that Pliny relies on non-Roman sources far more than he does on Roman sources and that most of the sources he read were specialist authors who contributed to just one or two topics while at the other end of the scale we find four authors who contributed far more to the encyclopedia than any of Pliny's other sources. While these four authors were all cited frequently, analyzing their contributions using network methodologies reveals the different ways in which each author contributed to the work with Dionysius being more closely associated with birds, trees and plants, Varro associated most closely with insects, flowering trees, and geography, while Democritus and Theophrastus are associated with the topics that cover anthropology, the nature of farmers, plants, vines and painting and painters. The network graph also allows us to see how concepts in the encyclopedia are related to each other with the topics of the thirty-six individual books falling into six separate clusters that deal with 1) geography, 2) plants, animals, and the people who cultivate them, 3-4) two clusters on different types of medical knowledge, 5) a cluster that joins information about aquatic animals with medicines derived from magical sources and other animals, and 6) one that encompasses plants, metallurgy, and the related segment on painters and painting. Finally, this approach provides a better understanding of the much longer list of sources that Pliny cites frequently throughout the encyclopedia, showing that they generally are cited in distinct areas of expertise and allowing us to distinguish the authors that are important within topic clusters like Hippocrates from those authors that are cited more generally throughout the work like Aristotle. One of the benefits of doing this sort of work using Pliny's encyclopedia is its ability to help validate the results of these quantitative methods. Since

9 For Mucianus, see [2] and [20]: 51–52. For Iollas, see [22]: 133.

10 [13]: 97.

the algorithm identifies the medical author Hippocrates as one of the most important contributors to the cluster on medical knowledge and the agricultural writer Collumella in the cluster related to agricultural knowledge, we can infer that findings about other authors about whom less is known are also useful. It also suggests that we can trust these methods if we apply them to other areas of study in literature or the history of science where we might not necessarily have a source that allows us to directly validate our results.

References

[1] Alberich, R., J. Miro-Julia, and F. Rossello. 2002. "Marvel Universe Looks Almost like a Real Social Network." *ArXiv:Cond-Mat/0202174*. At http://arxiv.org/abs/cond-mat/0202174, accessed February 2, 2018.

[2] Ash, Rhiannon. 2007. "The Wonderful World of Mucianus." *Bulletin of the Institute of Classical Studies. Supplement* no. 100: 1–17.

[3] Bode, Katherine. 2017. "Fictional Systems: Mass-Digitization, Network Analysis, and Nineteenth-Century Australian Newspapers." *Victorian Periodicals Review* 50, no. 1 Johns Hopkins University Press: 100–138.

[4] Carron, Pádraig Mac, and Ralph Kenna. 2012. "Universal Properties of Mythological Networks." *EPL (Europhysics Letters)* 99, no. 2: 28002.

[5] Ceserani, Giovanna, Giorgio Caviglia, Nicole Coleman, Thea De Armond, Sarah Murray, and Molly Taylor-Poleskey. 2017. "British Travelers in Eighteenth-Century Italy: The Grand Tour and the Profession of Architecture." *The American Historical Review* 122, no. 2: 425–50.

[6] Chaturvedi, Snigdha, Shashank Srivastava, Hal Daume III, and Chris Dyer. 2015. "Modeling Dynamic Relationships between Characters in Literary Novels." *ArXiv Preprint ArXiv:1511.09376*.

[7] Chaturvedi, Snigdha, Shashank Srivastava, Hal Daumé III, and Chris Dyer. 2016. "Modeling Evolving Relationships Between Characters in Literary Novels." *AAAI*.

[8] Chen, Bikun, and Yuefen Wang. 2016. "Character Interaction Network Analysis of Chinese Literary Work: A Preliminary Study." *Proceedings of the 79th ASIS&T Annual Meeting: Creating Knowledge, Enhancing Lives Through Information & Technology* ASIST '16 Silver Springs, MD, USA: American Society for Information Science. At http://dl.acm.org/citation.cfm?id=3017447.3017535, accessed February 13, 2017.

[9] Cline, Diane Harris. 2020. "Athens as a Small World." *Journal of Historical Network Research* Journal of Historical Network Research: 36-56 Pages.

[10] Collar, Anna. 2009. "Network Theory and Religious Innovation." In Irad Malkin, C Constantakopoulou, and K Panagopoulou, eds. *Greek and Roman Networks in the Mediterranean* Abingdon: Routledge.

[11] Collar, Anna.. 2011. "Military Networks and the Cult of Jupiter Dolichenus." In E Winter, ed. *Von Kummuh Nach Telouch: Historische Und Archäologische Untersuchungen in Kommagene.Dolichener Und Kommagenische Forschungen IV* Bonn. At http://www.academia.edu/230734/Military_networks_and_the_cult_of_Jupiter_Dolichenus, accessed May 10, 2017.

[12] Collar, Anna.. 2014. *Religious Networks in the Roman Empire: The Spread of New Ideas*. New York: Cambridge University Press.
[13] Doody, Aude. 2010. *Pliny's Encyclopedia: The Reception of the Natural History*. Cambridge, UK ; New York: Cambridge University Press.
[14] Doody, Aude. 2011. "The Science And Aesthetics Of Names In The Natural History." In Roy Gibson and Ruth Morello, eds. *Pliny the Elder: Themes and Contexts* BRILL. At https://brill.com/view/book/edcoll/9789004210073/Bej.9789004202344.i-248_008.xml, accessed January 14, 2021.
[15] Dunn, Daisy. 2019. *The Shadow of Vesuvius: A Life of Pliny*. London ; New York: Liveright Publishing.
[16] Edmondson, Chloe, and Dan Edelstein, eds. 2019. *Networks of Enlightenment: Digital Approaches to the Republic of Letters*. Oxford University Studies in the Enlightenment 2019:06 Liverpool: Liverpool University Press on behalf of Voltaire Foundation.
[17] Fumaroli, Marc, and Lara Vergnaud. 2018. *The Republic of Letters*. New Haven: Yale University Press.
[18] Germerodt, Fabian. 2020. "Networking in the Early Roman Empire: Pliny the Younger." *Journal of Historical Network Research* Journal of Historical Network Research: 252-270 Pages.
[19] Gibson, Abraham, and Cindy Ermus. 2019. "The History of Science and the Science of History: Computational Methods, Algorithms, and the Future of the Field." *Isis* 110, no. 3: 555–66.
[20] Healy, John F. 1999. *Pliny the Elder on Science and Technology*. Oxford ; New York: Oxford University Press.
[21] Horatius Flaccus, Quintus. 2005. *Satires, Epistles and Ars Poetica*. Translated by Henry Rushton Fairclough Reprinted The Loeb Classical Library 194 Cambridge, Mass.: Harvard Univ. Press.
[22] Hornblower, Simon, Antony Spawforth, and Esther Eidinow, eds. 2014. *The Oxford Companion to Classical Civilization*. Second edition New York, NY: Oxford University Press.
[23] Hotson, Howard, and Thomas Wallnig. 2019. "Reassembling the Republic of Letters in the Digital Age." At http://www.univerlag.uni-goettingen.de/handle/3/isbn-978-3-86395-403-1, accessed December 8, 2019.
[24] Kadushin, Charles. 2012. *Understanding Social Networks: Theories, Concepts, and Findings*. 1 edition Oxford University Press.
[25] Ladd, John R., Jessica Otis, Christopher N. Warren, and Scott Weingart. 2017. "Exploring and Analyzing Network Data with Python." *Programming Historian*. At https://programminghistorian.org/en/lessons/exploring-and-analyzing-network-data-with-python, accessed October 14, 2020.
[26] Lao, Eugenia. 2011. "Luxury And The Creation Of A Good Consumer." In Roy Gibson and Ruth Morello, eds. *Pliny the Elder: Themes and Contexts* BRILL. At https://brill.com/view/book/edcoll/9789004210073/Bej.9789004202344.i-248_004.xml, accessed October 28, 2020.
[27] Matthews, P., and L. Barrett. 2005. "Small-Screen Social Groups: Soap Operas and Social Networks." *Journal of Cultural and Evolutionary Psychology* 3, no. 1: 75–86.

[28] McHam, Sarah Blake. 2013. *Pliny and the Artistic Culture of the Italian Renaissance: The Legacy of the Natural History*. New Haven: Yale University Press.

[29] Murphy, Trevor Morgan. 2004. *Pliny the Elder's Natural History: The Empire in the Encyclopedia*. Oxford ; New York: Oxford University Press.

[30] Naas, Valérie. 2011. "Imperialism, Mirabilia, And Knowledge: Some Paradoxes In The Naturalis Historia." In Roy Gibson and Ruth Morello, eds. *Pliny the Elder: Themes and Contexts* Brill. At https://brill.com/view/book/edcoll/9789004210073/Bej.9789004202344.i-248_005.xml, accessed October 28, 2020.

[31] Newsome, J., ed. 1964. "Introduction." *Pliny's Natural History: A Selection From Philemon Holland's Translation.* Oxford: Clarendon Press.

[32] Pliny the Elder. 1855. *The Natural History*. Translated by John Bostock and H.T. Riley London: Taylor and Francis.

[33] Pliny the Younger. 1969. *Letters, Volume I: Books 1-7.* Translated by Betty Radice Loeb Classical Library 55 Harvard University Press.

[34] Stiller, J., and M. Hudson. 2005. "Weak Links and Scene Cliques within the Small World of Shakespeare." *Journal of Cultural and Evolutionary Psychology* 3, no. 1: 57–73.

[35] Stiller, J., D. Nettle, and R. I. M. Dunbar. 2003. "The Small World of Shakespeare's Plays." *Human Nature* 14, no. 4: 397–408.

[36] Talbert, Richard. 2012. "Review of Pliny the Elder's Natural History: The Empire in the Encyclopedia by Trevor Murphy, 2004." *Bryn Mawr Classical Review* 2004.12.23. At https://bmcr.brynmawr.edu/2004/2004.12.23/.

[37] Winterer, Caroline. 2012. "Where Is America in the Republic of Letters?" *Modern Intellectual History* 9, no. 3: 597–623.

[38] Xu, Shaobin, David Smith, Abigail Mullen, and Ryan Cordell. 2014. "Detecting and Evaluating Local Text Reuse in Social Networks." *Proceedings of the Joint Workshop on Social Dynamics and Personal Attributes in Social Media* Baltimore, Maryland: Association for Computational Linguistics. At http://aclweb.org/anthology/W14-2707, accessed September 2, 2021.

[39] Zinoviev, Dmitry. 2018. *Complex Network Analysis in Python: Recognize - Construct - Visualize - Analyze - Interpret*. 1 edition Raleigh, North Carolina: Pragmatic Bookshelf.