CHAPTER 4

RESULTS: A NUMERICAL TAXONOMY OF ISLAMIC MEDICAL SYSTEMS AND THEIR ANTECEDANTS

This chapter presents (a) a description of the sample used in this study and (b) the results of testing the general and specific research hypotheses put forward in chapter 3. The description of the sample provides a more detailed picture of the individual sources used in each group. The results section shows the outcome of an application of the principles of a numerical taxonomy approach to the sources under consideration.

Description of the Sample

The sample was divided into two groups; one of modern collections of traditional Middle Eastern (plus India as an out group) prescriptions (or descriptions of medicinal properties) only, the other of pre-modern sources plus two modern sources from the Core of the culture area (for comparative purposes). The descriptions of each source include a brief overview of their geographic and temporal provenience; the total number of recipes or drug plant properties and drug plants present in the source and the number of drug plants and prescriptions or properties which met the selection criteria.

Group I, Modern Sources Only

In this dissertation, the sources in Group I are denoted by the name of the center (city or town) and modern nation state where the data were collected. Since the Ayurvedic Indian text (representing the "out group") is not a primary source but a secondary one reporting drug-plant properties prevalent in a broad cultural area beyond the sphere/periphery of the Middle Eastern culture area, it is simply referred to herein as "India." Language prevalence and literacy rates are included for most of the countries from which the sources were derived. Statistics contemporaneous with the collection dates of all texts were not always available. Therefore, percentages given below may not be entirely accurate. However, the statistics and language information were gathered from reports as close to the collection dates as possible. The demographic and political data is synthesized from *The World Factbook* (1990, 2005), *Country Studies/Area Handbooks* (1988-1998) and *The Ethnologue* (2005).

Aleppo, Syria. This set of prescriptions was obtained sometime around 1988 or 1989 by the academic research team for the "Comparative Study on the Islamic Societies and their Cultural Changes" of the Institute for the Study of the Languages and Cultures of Asia and Africa (ILCAA). The *wasfāt* ('recipes' or 'prescriptions') were provided in Arabic by Mohammad Faez Bawadiqji, an herbalist in Aleppo. Honda et al. (1990) do not provide a translation. Bawadiqji provided seventy-two recipes/prescriptions utilizing seventy-eight plants. Of these, fifty-nine recipes and sixty plants met the selection criteria outlined in the methodology chapter and were used for the analysis of relationships among the members of Group I. Aleppo is a major cultural and commercial center in northern Syria. In 1990, Syria had a literacy rate of 49 percent. Arabic is the official language of Syria, although Armenian, Aramaic, Circassian, and French are also present.

Cairo, Egypt. This set of prescriptions was collected between October 1977 and March 1978 by the academic research team for the "Comparative Study on the Islamic Societies and their Cultural Changes" of the ILCAA. The *wasfāt* were obtained in Arabic from a Cairene herbalist named Surur Muhammad 'abd al-Hadi. Ahmed et al. (1979) provide an English translation. 'Abd al-Hadi's text includes one hundred thirteen recipes using approximately one hundred fifty-three plants. Sixty-six recipes and fifty-four plants from this source were used in the final data analysis for Group I. Cairo is the capital of Egypt and a major urban center. In 1990, the country of Egypt had a 45 percent literacy rate, with Arabic as the primary language and English and French as important secondary languages. At present, literacy is at approximately 57.7 percent. It is likely that the percentage given for 1990 was significantly lower twelve years earlier when 'abd al-Hadi's data were collected.

Gaziantep, Turkey. This set of prescriptions was collected between 1983 and 1984 by the academic research team for the "Comparative Study on the Islamic Societies and their Cultural Changes" of the ILCAA. The recipes were obtained in Turkish from Ilhan Arslanyürek, an *aktar* ("herbalist") in the province of Gaziantep. Başer et al. (1986) include an English translation. Arslanyürek provided three hundred thirty-eight recipes using a total of approximately two hundred twelve plants. Of these, only twenty recipes and forty-six plants met the selection criteria outlined in the previous chapter. Gaziantep is an important industrial and commercial center located in southeastern Anatolia. In 1990, Turkey had 70 percent literacy, with Turkish as the official language and additional literacy in Kurdish and Arabic. At present, literacy is between 70-90 percent.

India. This source is a reference book that was produced by L.D. Kapoor, Ph.D., a retired research scientist from the National Botanical Research Institute, Lucknow, and was initially published in 1989. Kapoor has undertaken research throughout India on various aspects of Ayurvedic medicinal plants and their uses. The text describes some two hundred fifty plants and their pharmacological and therapeutic uses in Ayurveda (traditional Hindu medicine, based on the doctrine of "signatures"). In addition, it provides the plants' Arabic, Bengali, English, German, Hindi, Nepali, Persian, Sanskrit, Tibetan, and Unani (Greco-Arabic) names. Of the two hundred fifty-one plants included in Kapoor's text, seventy were selected for the current project based on their being shared with other, non-out group sources (also see the "Limitations" section in the previous chapter). Ayurvedic pharmacology recognizes four basic categories of properties by which materia medica may be classified. For every plant, each of these categories is represented by one of several characters. By category, the number of attributes which Kapoor notes, and that were relevant to the drug plants selected for this project were *rasa* (6), *guna* (20), *veerya* (8), and *vipak* (3).

Karachi, Pakistan. This set of prescriptions was collected between 1983 and 1984 by the academic research team for the "Comparative Study on the Islamic Societies and their Cultural Changes" of the ILCAA. The recipes were obtained in Urdu from Hakim Mohammad Said, who, in his youth, studied *tibb* (Islamic medicine) in Delhi, India, before relocating to Pakistan sometime around 1948. Ushmangani et al. (1986) provide an English translation. The recipes are from a technical manual composed by Said's uncle that has been circulated widely throughout the subcontinent. The text gives approximately forty-one recipes, using a total of about four hundred forty-five plants. Of these, however, only eighteen recipes and forty plants met the selection criteria outlined in the previous chapter. Karachi is a major port city in southern Pakistan, a Muslim nation that separated from British India in 1947. Literacy was at 26 percent in 1990. In 2005, it stands at approximately 45.7 percent. Urdu and English are the official and majority languages of Pakistan. In 1990, 27 percent of the population also spoke Balochi, Pashtu, Punjabi, Sindhi, or other minority languages.

Marrakech, Morocco. This set of prescriptions was collected in October of 1980 by the academic research team for the "Comparative Study on the Islamic Societies and their Cultural Changes" of the ILCAA. The recipes were obtained in Arabic from Rahhal ben el-Hajj Mohammad, an herbalist resident in Marrakech. Bellakhdar et al. (1982) provide both English and French translations. The Arabic text gives thirty-two recipes utilizing a total of three hundred ten plants. Of these, fifty-two plants and twenty-seven recipes met the selection criteria and were used in the present analysis. In 1990, Morocco had a literacy rate of 28 percent. In 2005, the literacy rate was 51.7 percent.

Sanaa, North Yemen. This set of prescriptions was obtained sometime around 1988 or 1989 by the academic research team for the "Comparative Study on the Islamic Societies and their Cultural Changes" of the ILCAA. The *wasfāt* were provided in Arabic by Ahmed al-Nashiri, the proprietor of the Nashiri Drug Store in Sanaa. Sanaa was the capital of Northern Yemen, which joined with Southern Yemen and became the Republic of Yemen in 1990 (retaining Sanaa as the new capital of the unified state). Honda et al. (1990) do not provide a translation from the Arabic. The text includes fifty-five recipes utilizing a total of approximately fifty-two plants. Of these, forty-two plants and forty-eight recipes were used in the current data analysis. In 1990, literacy in Yemen was estimated at approximately 15 percent. By 2005, it had reached 50.2 percent.

Group II, Pre-Modern and Modern Core Sources

The pre-modern sources are generally referred to by (a) their author, where known; (b) their traditional designation (e.g., "P. Ebers" for the ancient Egyptian Ebers medical papyrus), or (c) their language (e.g., Syriac). Since the Syriac text was divided into two sources, one Greek-based and the other native Syriac, it is described in two separate subsections under the headings Syriac α and Syriac β, respectively. The two modern Core sources (Syria and Egypt) were described under the Group I heading above. However, they both shared different drug plants in common with other Group II sources that were not shared with other sources in Group I. Fifty-three plants from the modern Egyptian source and 58 from the modern Syrian source met the selection requirements for Group II.

al-Kindi. This source is an *Aqrābādhīn* (registry of prescriptions, from Greek γραφιδιον) by Abū Yūsuf Ya'qūb ibn Ishāq al-Kindi (ca. 800-870 A.D.) containing both simple and compound remedies. Al-Kindi is thought to have been born in Kufa (in what is present-day Iraq) and to have studied Greek philosophy, mathematics, and medicine at Basra and Baghdad during the early Abbasid period. Levey (1966) provides an Arabic facsimile and English translation of this manuscript from the Aya Sofia library (number 3603, fols. 91b-139a). Al-Kindi's materia medica includes approximately three hundred nineteen items, the vast majority of which are plants and plant-derived products. The text consists of two hundred twenty-six formulas. A total of one hundred fifteen drug plants and one hundred thirty-seven recipes were selected for further analysis based on the criteria given in the previous chapter.

ibn Wafid. This source is drawn from chapter V of Muwaffaq al-Dīn 'Abd al-'Azīz ibn 'Abd al Jabbār ibn Abī Muhammad al-Sulamī al-Dimashqī's *Expert's Examination for All Physicians*. al-Sulamī (ca. 1155-1208 A.D.) practiced medicine in the *bīmāristān* (hosptital) of Nūr al-Dīn in Damascus. His fifth chapter (on simple drugs) is intended as a test of aspiring physicians' knowledge of the humoral qualities that ibn Wafid al-Lakhmi 'Abd al-Karim of Toledo (d. 1075 A.D.) ascribes to some one hundred fifty-five drug plants. al-Sulamī asks which plants ibn Wafid classifies as "hot and dry in the third degree," "moist and cool in the second degree," etc., and then proceeds to provide the answers for each possible permutation of degree and quality. Leiser and al-Khaledi (al-Sulamī et al. 2004) provide an English translation and footnotes with the Arabic names given in the original manuscript. Of the one hundred fifty-five plants, one hundred two were selected for this analysis.

Pseudo-Avicenna. This source was excerpted from a modern English "handbook" of Avicenna's medicine, written by a *hakim* (i.e., a traditional healer), G.M. Chisti, who studied Greco-Arabic medicine in Afghanistan, Pakistan, and India. His work is closely based on the book *Mizan al-Tibb* (*The Standard of Medicine*), an eighteenth-century commentary on a slightly earlier Persian abbreviation of Avicenna's (980-1037 A.D.) extremely lengthy Arabic classic, the *Qanūn* ("Canon of Medicine"). Chisti provides descriptions of one hundred seventeen drug plants. He gives their Latin and

Arabic names as well as their Avicennan humoral qualities. Sixty-nine of the plants so described were used in the current analysis.

Syriac α. This set of prescriptions is based on the first section of the twelfth-century A.D. Syriac "Book of Medicines" acquired by the British Museum at Mosul in the early years of the first decade of the twentieth century. It was translated into English and published in 1913 by E. A. W. Budge (Keeper of the Egyptian and Assyrian Antiquities of the British Museum). Many of the recipes in this section are attributed to Dioscorides, Galen, and other Greek physicians of note, and they seem to have been translated from Greek into Syriac by a Syrian (probably Nestorian) physician, possibly at Edessa, during the first three or four centuries A.D. This text, therefore, represents the closest we can come to an exemplar of the proximate source of Greek influence on Islamic medicine. It gives us a window on the Syriac perception and practice of Greek medicine through which the Hellenic tradition ultimately was passed on into Arabic. Data for the present research were collected using Budge's English translation of the *Book of Medicines*, as it is recognized as fairly literal and accurate and is the only translation of the text yet produced. Although the translator has been the subject of considerable derision in Egyptological circles, Middle Easternists and medical historians have found little fault with his work on this particular text. Most criticisms of Budge stem from his tenacity in advocating his own orthographic transliteration of the Egyptian hieroglyphic script, which others rejected in favor of a different system.

Budge states that there are nearly one thousand recipes given in this section of the manuscript, although the researcher only counted approximately seven hundred that included multiple identifiable drug plants. Due to the large number of prescriptions, most of which were far lengthier (on average) than those found in any other source considered, a presumably representational sample of one hundred forty-six recipes was selected using a random numbers table. The author of the manuscript identifies around one hundred seventy plants and plant products in a list of "medicines mentioned in the book" (including those drugs used in the prescriptions grouped herein under the rubric Syriac β). One hundred twelve plants in the one hundred forty-six recipes used met the selection criteria outlined in the "Methods" chapter.

Syriac β. The prescriptions making up the source referred to as "Syriac β" are derived from the third part of Budge's English translation of the

Syriac Book of Medicines (see Syriac α for details of the manuscript's provenience). The third part of the Syriac manuscript, from which these recipes are drawn, "The Book of Native Medicines," consists of a record of the local practices of traditional Mesopotamian folk healers, presumably collected by the same physician who composed the first section (Syriac α) of the manuscript. It consists of approximately four hundred prescriptions, one hundred three of which met the selection criteria and were used in the data analysis. Seventy-two drug plants used in these recipes met the selection criteria outlined in the previous chapter.

P. Chassinat. The Chassinat Coptic Medical Papyrus is the lengthiest preserved text of its kind (Chassinat 1921). It consists of a collection of 237 prescriptions dated by paleographic means to sometime between the ninth and tenth centuries A.D. Approximately ninety plants can be equated to Linnean generic taxa with a fair level of certainty. The papyrus utilizes over a dozen Arabic plant names, indicating at least a minimal degree of diffusion of Arabic terminology, if not of cognitive categories. It uses almost twice as many Greek terms as Arabic. One hundred forty-four of the two hundred thirty-seven recipes and sixty of the eighty-nine identifiable plants met the selection criteria for, and were included in, the analysis.

P. Ebers. This source is the longest hieroglyphic medical text (one hundred ten pages) known from ancient Egypt and is dated (based on internal evidence) to ca. 1534 B.C. While its original provenience is uncertain, it is likely that the papyrus came from the tomb of a physician in the Theban necropolis on the west bank of the Nile. An English interpretation of other-language translations (French and German) was produced by Bryan in 1930 and a direct English translation was published by Ebbel in 1937, but the extant English versions are notoriously unreliable (Nunn 1996). The present research utilizes the current "definitive" German translation of von Westendorf (1999), which preserves the hieroglyphic names for materia medica. The text includes eight hundred seventy-seven recipes, three hundred seventy-two of which met the selection criteria for this project. Approximately one hundred forty-two plants are used in the papyrus, although only thirty-nine could be identified with relative certainty (based on authoritative scholarship) as equivalent to plants occurring in other sources of Group II.

Results

The results of the study are presented in three topical divisions corresponding to the three research questions listed in the previous chapter. The first addresses the shape or appearance of Middle Eastern systems (ancient, medieval, and modern) of drug plant prescription taken as individual wholes. The second addresses the interrelationships among sources, implied by the results of a numerical taxonomy of Groups I and II, i.e., the relative similarity evaluations necessary for confirming or disconfirming the hypotheses under consideration. The third division is a brief evaluation of the efficacy and accuracy of the instruments and measures used in this study.

The Cognitive Structures of Islamic Medical Systems and Their Antecedents

The cognitive "shapes" of Middle Eastern traditions of drug-plant prescription have hitherto been obscured. This state of affairs results from our methodological inability to view the overall structure of these patterns apart from either generalized impressionistic portraits of ethnomedical systems or simplistic reporting of specific (and typically only the most unusual or exceptional) cures. Consequently, descriptions of Islamic ethnomedicine have historically taken a perspective that does not allow for any kind of quantification of similarity across societies. The figures presented in this subsection of the chapter provide a quantifiable mid-range perspective through the visual representation of the distributional similarities of drug plants for the sources considered in this study. They provided the basis for the cross-society comparisons made in reference to Research Hypotheses I and II. Since, for the purposes of this project, no particular hypotheses were made regarding the shape of their expected *individual* structures (only regarding their interrelationships determined through comparison across sources), the immediately following analysis will be limited to a simple graphic presentation of their overall forms. It is hoped that these portraits may spur botanists, pharmacologists and ethnobotanists to investigate the chemical and cultural properties of drug plants that the sources have clustered together. The goal is to determine the specific motivations (both denotative and connotative) underlying their similar use patterns in a given source.

The drug plants appearing in the figures are labeled with their Linnean taxon gloss. For purposes of coding and data entry with SYSTAT 10, some glosses needed to be abbreviated. Thus, for example, "ALLIUM1" is equivalent to *Allium* cepa, "ALLIUM2" is equivalent to *Allium sativa*, "ALLIUM3" is equivalent to *Allium porum,* "CASSIA1" is equivalent to *Cassia acutifolia*, "CASSIA2" is equivalent to *Cassia acutifolia,* etc. In addition, multiple sources consistently present more than one native language name for the same Linnean taxa. When multiple names for the same Linnean taxon are nearly identical across sources, they are coded as two separate entities, indicated by ancillary numbers after the Linnean identification. Thus, for *Anethum graveolens,* we have both "ANETHUMGRAV1" and "ANETHUMGRAV2," glossing *knds* and *krfs*, respectively, in the Egyptian and Moroccan sources. In addition, any gloss ending with the designation -"COMBO" represents an agglomerated taxon where two or three native language names, often unique to a source, are applied to the same Linnean taxa, but are not consistent across sources. Occasionally, details of coding vary slightly (but not meaningfully) from figure to figure. Thus, *Cassia acutifolia* may be coded as "CASSIA1" in one figure and as "CASSIAACUTIF" in another. However, variations in representation are incidental to our concerns here and the Linnean genus designations we are most concerned with are easily recognizable in all of the figures.

As discussed in the previous chapter, the last two "joins" on a cluster tree (in the following figures, the last two nodes to the right of a given tree, excluding the furthest node to the right that joins all member items into that tree) divide the items into three to four groups, or "piles." The "piles" arrived at in this manner are indicated by roman numerals to the left of each figure. Each "pile" is separated from its nearest neighbor(s) by a thin horizontal line. Thus, in Figure 4.1 (representing Aleppo, Syria), we may observe that *Cassia acutifolia*, *Foeniculum vulgare*, *Pimpinella anisum* and *Rosa sp.* occur in the "pile" marked with roman numeral I. In Figure 4.2 (representing the distributional similarity for Cairo, Egypt), we may observe the same plants grouping together in the lower part of the "pile" labeled with a roman numeral III. By agreeing on grouping these four plants together into one of three to four piles, Aleppo and Cairo show a quantifiable modicum of agreement in their overall classification of drug plants.

Group I, Modern Sources Only. The first seven figures that follow (4.1-4.7) present the distributional similarity of all drug plants meeting the selection criteria of chapter 3 for each source in Group I. It should again be noted that extending the analysis of a source to more than a handful

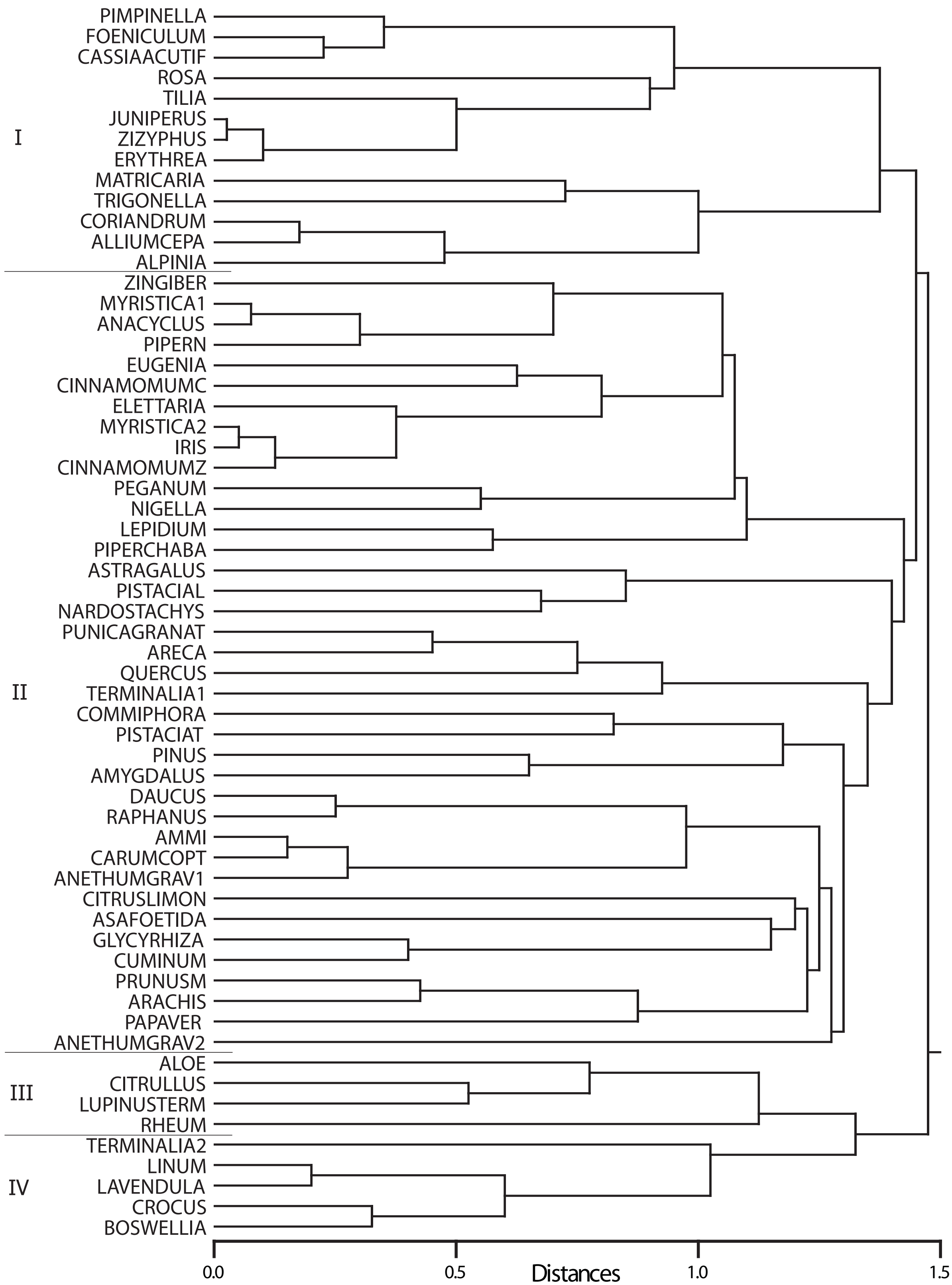

Figure 4.1. Hierarchical clustering tree representing the distributional similarity of drug plants used in prescriptions from Aleppo, Syria.

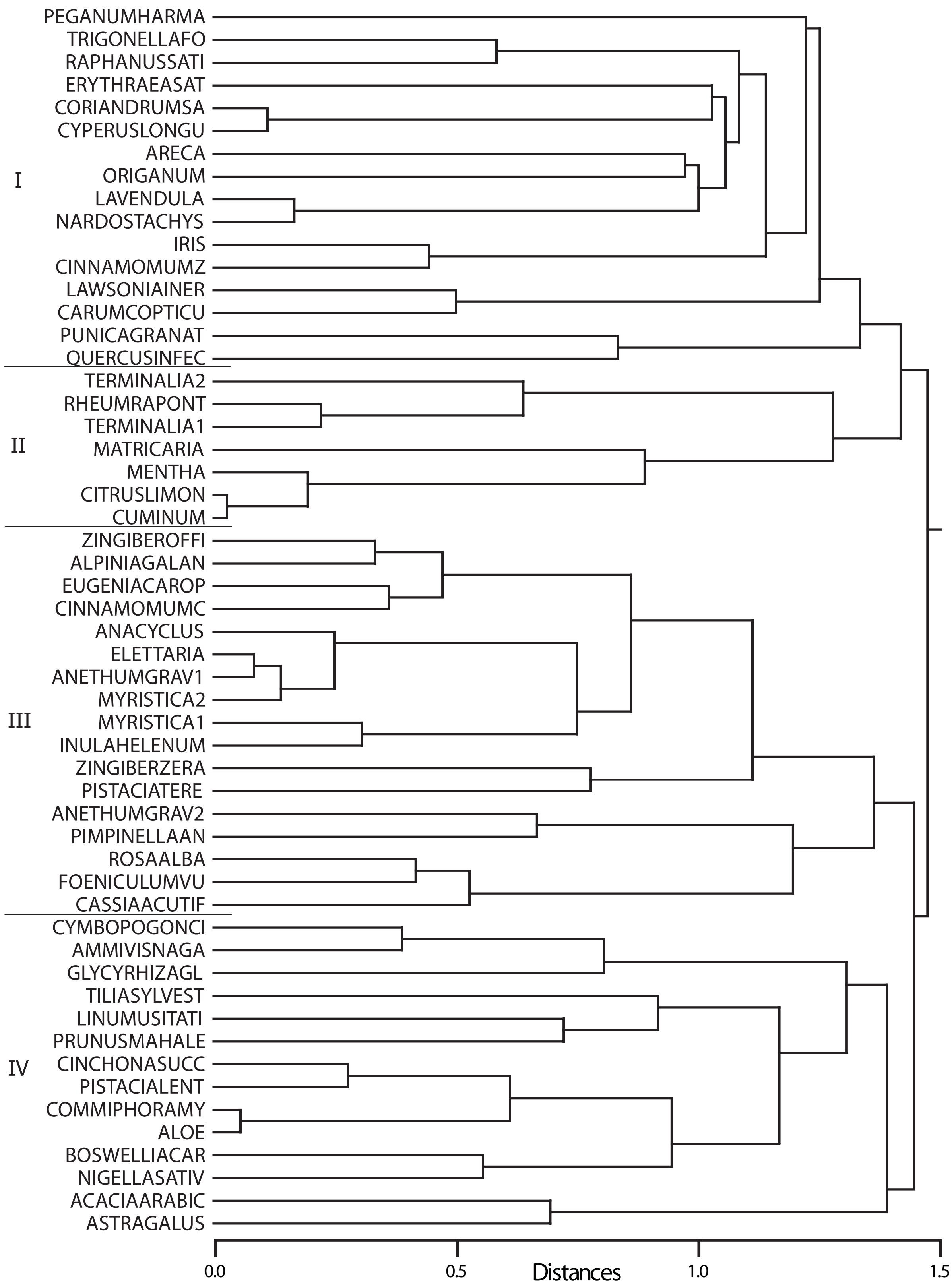

Figure 4.2. Hierarchical clustering tree representing the distributional similarity of drug plants used in prescriptions from Cairo, Egypt.

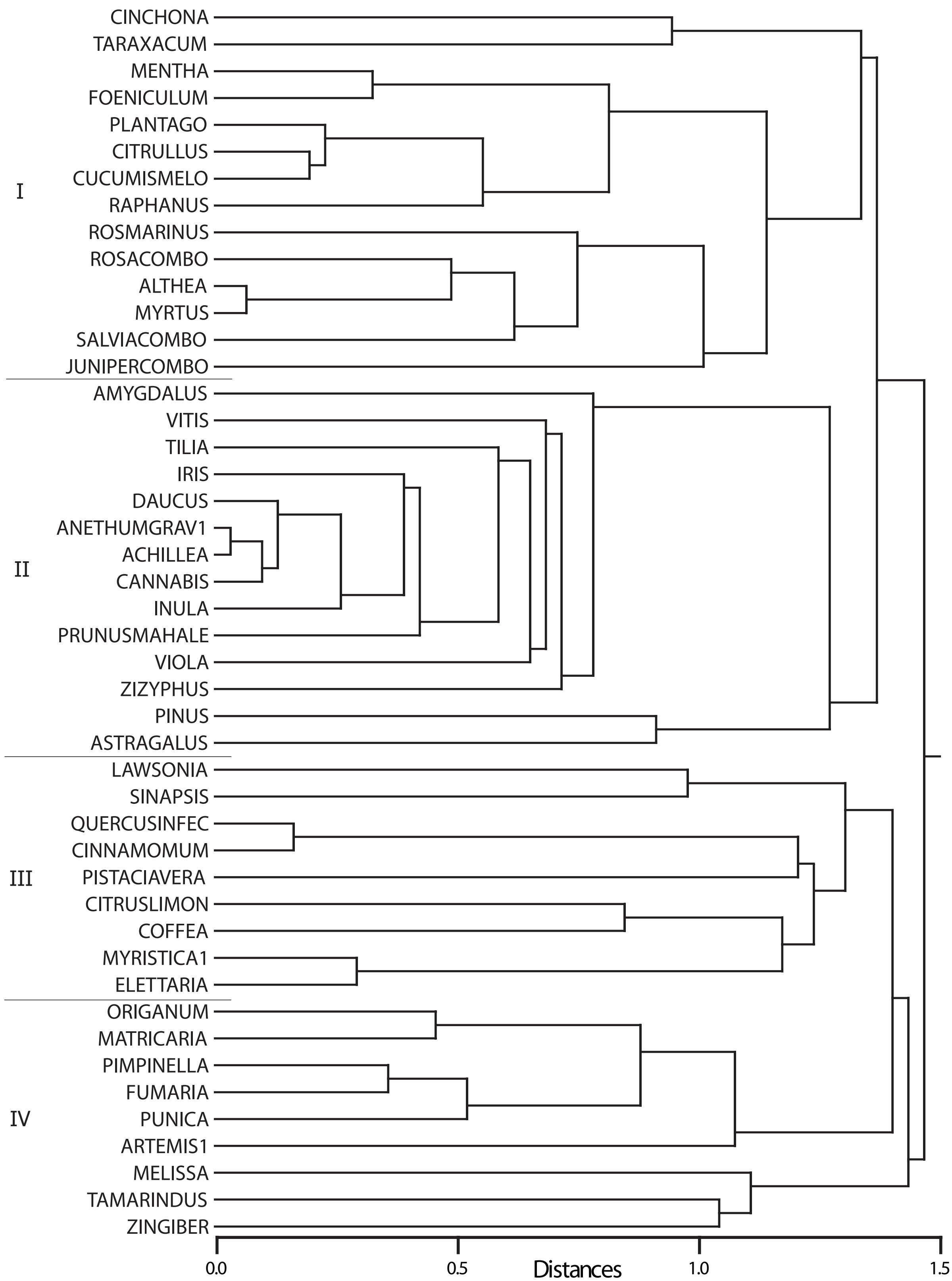

Figure 4.3. Hierarchical clustering tree representing the distributional similarity of drug plants used in prescriptions from Gaziantep, Turkey.

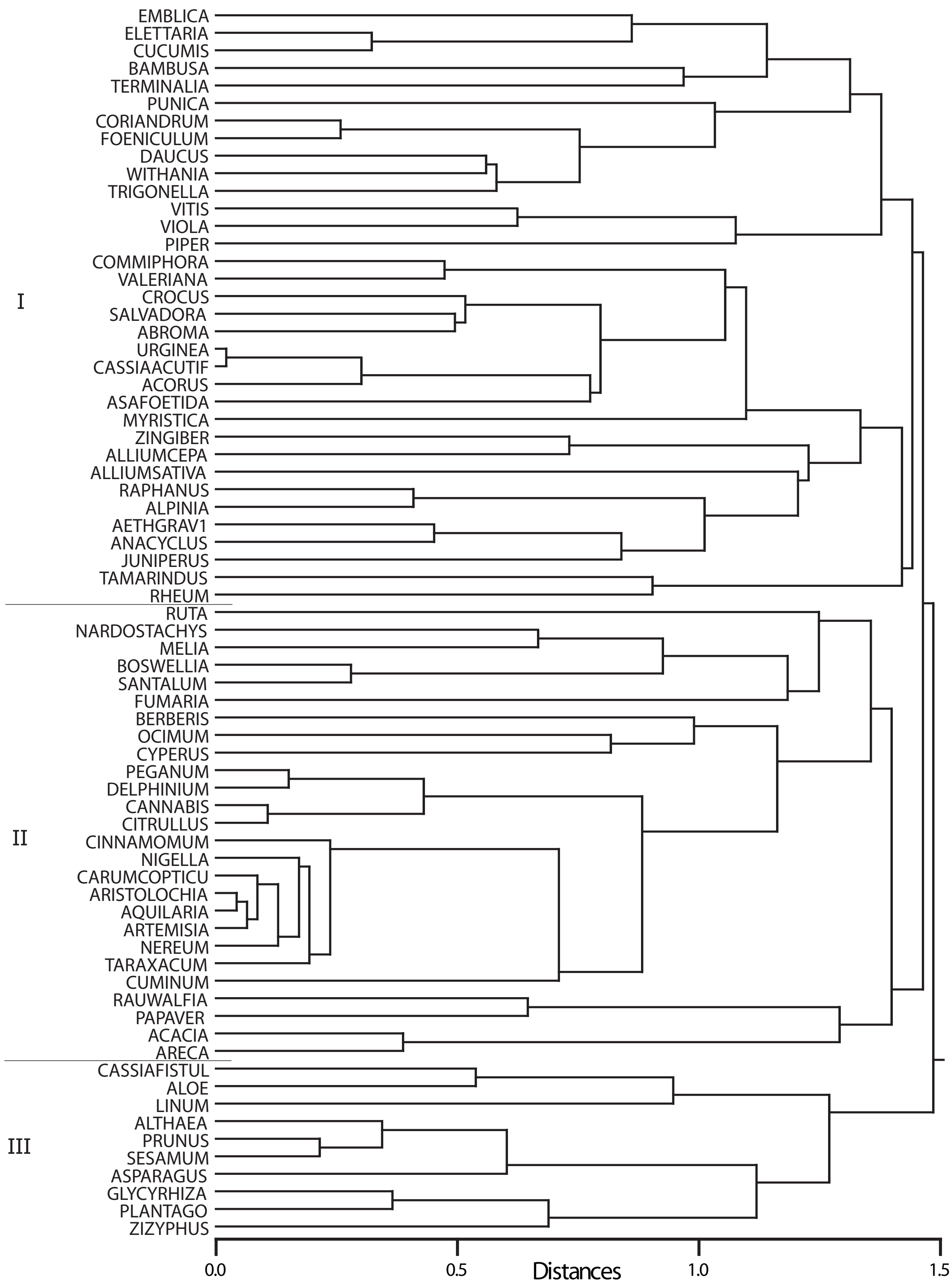

Figure 4.4. Hierarchical clustering tree representing the distributional similarity of drug plants from India, as classified by their Ayurvedic properties.

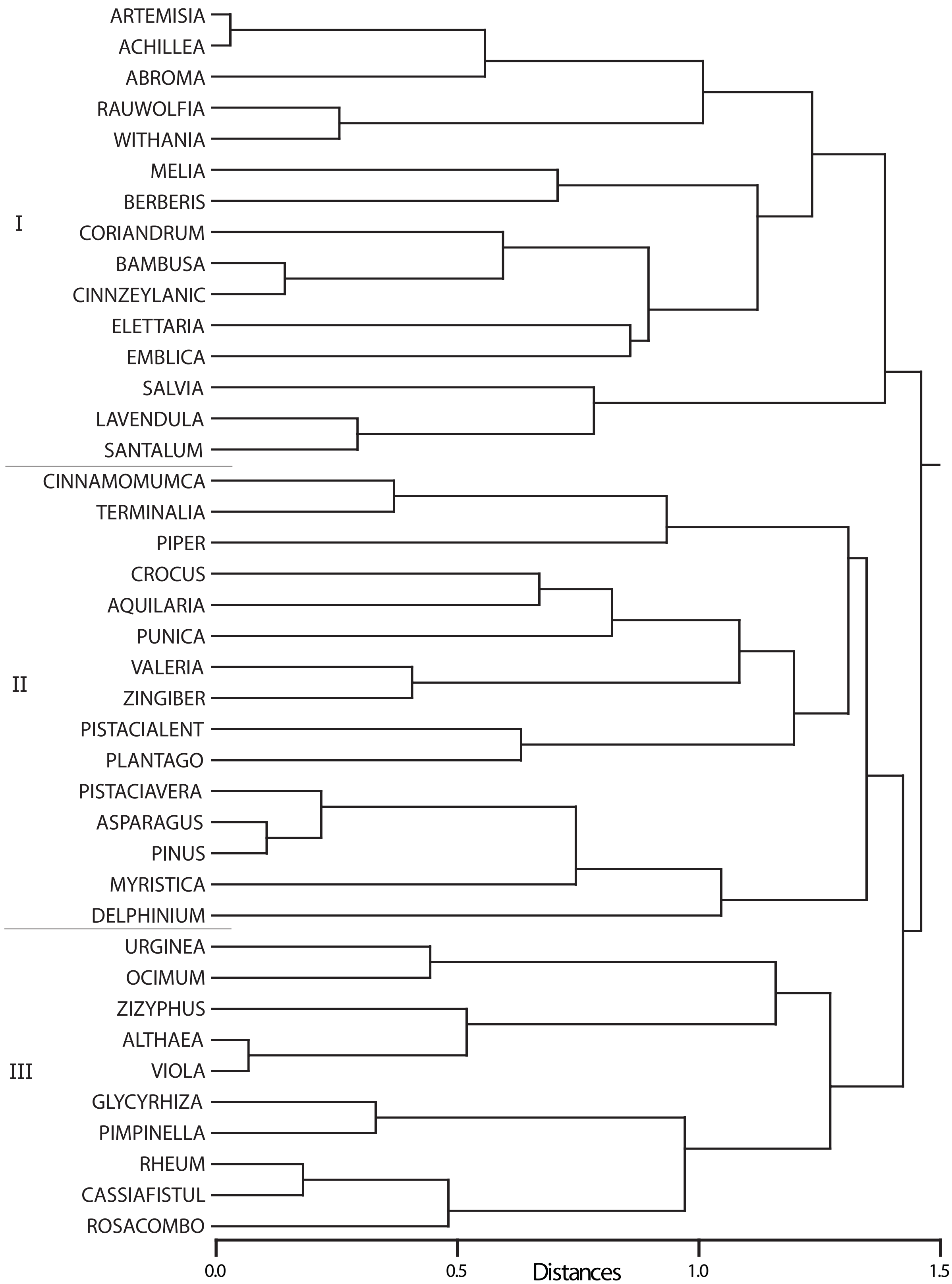

Figure 4.5. Hierarchical clustering tree representing the distributional similarity of drug plants used in prescriptions from Karachi, Pakistan.

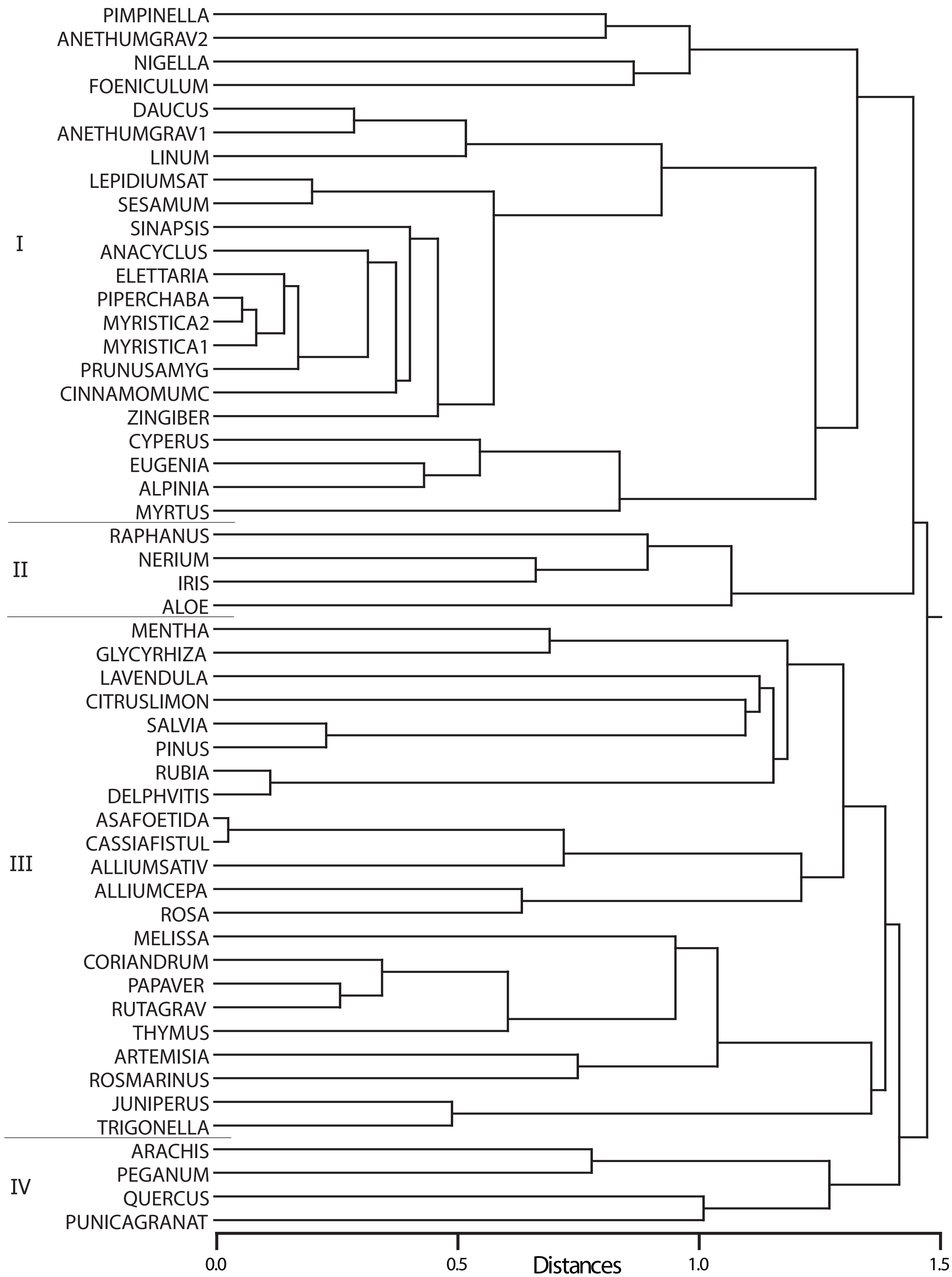

Figure 4.6. Hierarchical clustering tree representing the distributional similarity of drug plants used in prescriptions from Marrakech, Morocco.

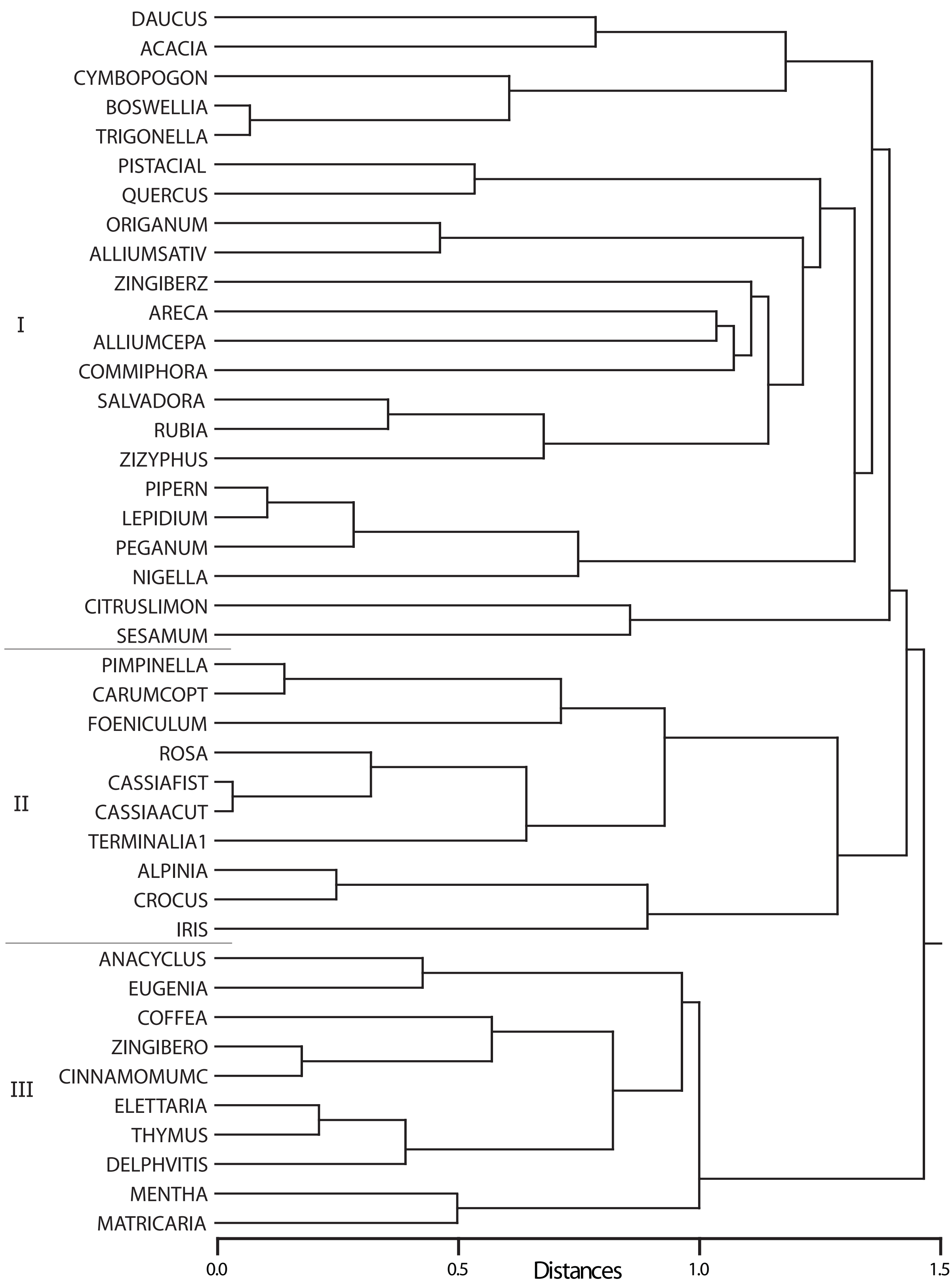

Figure 4.7. Hierarchical clustering tree representing the distributional similarity of drug plants used in prescriptions from Sanaa, Yemen.

of other drug plants not shared with other sources could lead to the production of significantly different hierarchical clustering trees.

Figures 4.1-4.7 represent classifications based on only those plants shared with other sources in Group I that could be identified as equivalent to Linnean taxa. Since all sources are subjected to the same "imbalance" or "handicap," it seems logical that the comparisons made using these trees should even out any discrepancies due to missing data. The hierarchical clustering trees for all sources in Group I utilized the complete linkage (MAX) method, based on the Pearson coefficient.

Group II, Pre-Modern and Modern Core Sources. Figures 4.8-4.16 include the hierarchical clustering trees representing the distributional similarity for all sources in Group II. The pre-modern sources (all sources in Group II excluding modern Egypt and Syria) utilized a total of fifty-seven drug plants that were not used by more than one modern source. Subsequently, several of the taxonomic trees for Group II (N=3) included over 100 drug plants.

Due to the high number of taxa being grouped in some sources, the most complex of the cluster trees, though legible, may appear somewhat crowded. This situation is regrettable, and technical support staff at SYSTAT confirmed that software limitations preclude any improvements using the current version of the program. It is hoped that future editions may be more accommodating to larger data sets. Other statistical software packages with a hierarchical clustering function are faced with the same difficulty and have not offered any significant improvements over the SYSTAT output.

As with the sources in Group I, Group II data were clustered using the complete linkage (MAX) method. While the majority of trees were based on the Pearson correlation coefficient, the cluster trees for ibn Wafid and Pseudo-Avicenna were based on average Euclidian (dissimilarity) distance (see Chapter 3).

Relationships and Influences among Sources

The application of numerical taxonomy to the sources under consideration produced results that allowed for the testing of this project's two main research hypotheses (based on the upper-level clusters revealed in their individual distributional similarities, see Figures 4.1-4.16, where the clusters are indicated by roman numerals to the left of each figure). General Research Hypothesis 1 posited that there would be a strong correlation between (a) the overall similarity of patterns of drug plant prescription among sources in Group I and (b) their proximity and shared history. The

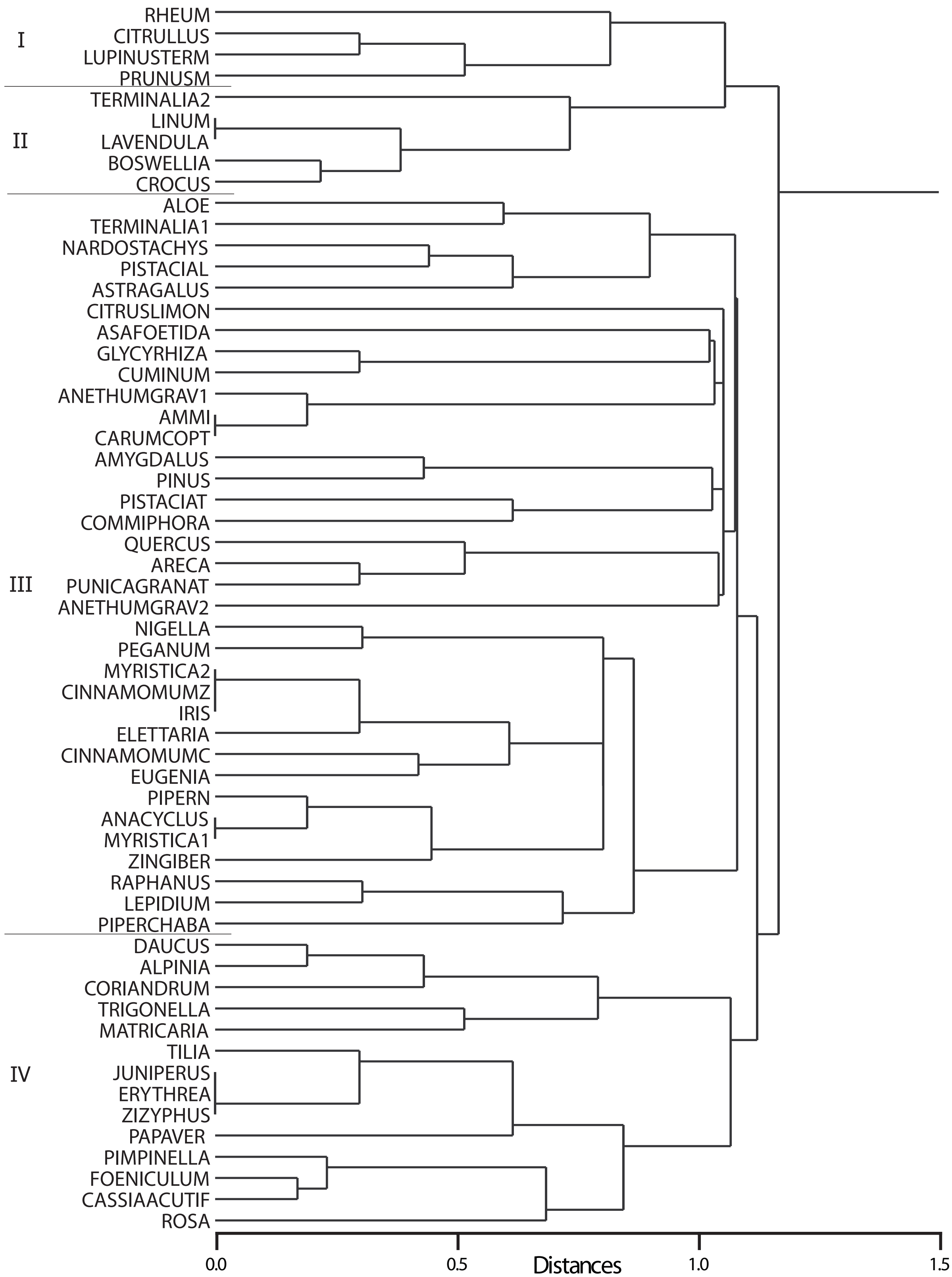

Figure 4.8. Hierarchical clustering tree representing the distributional similarity of drug plants used in prescriptions from Modern Syria.

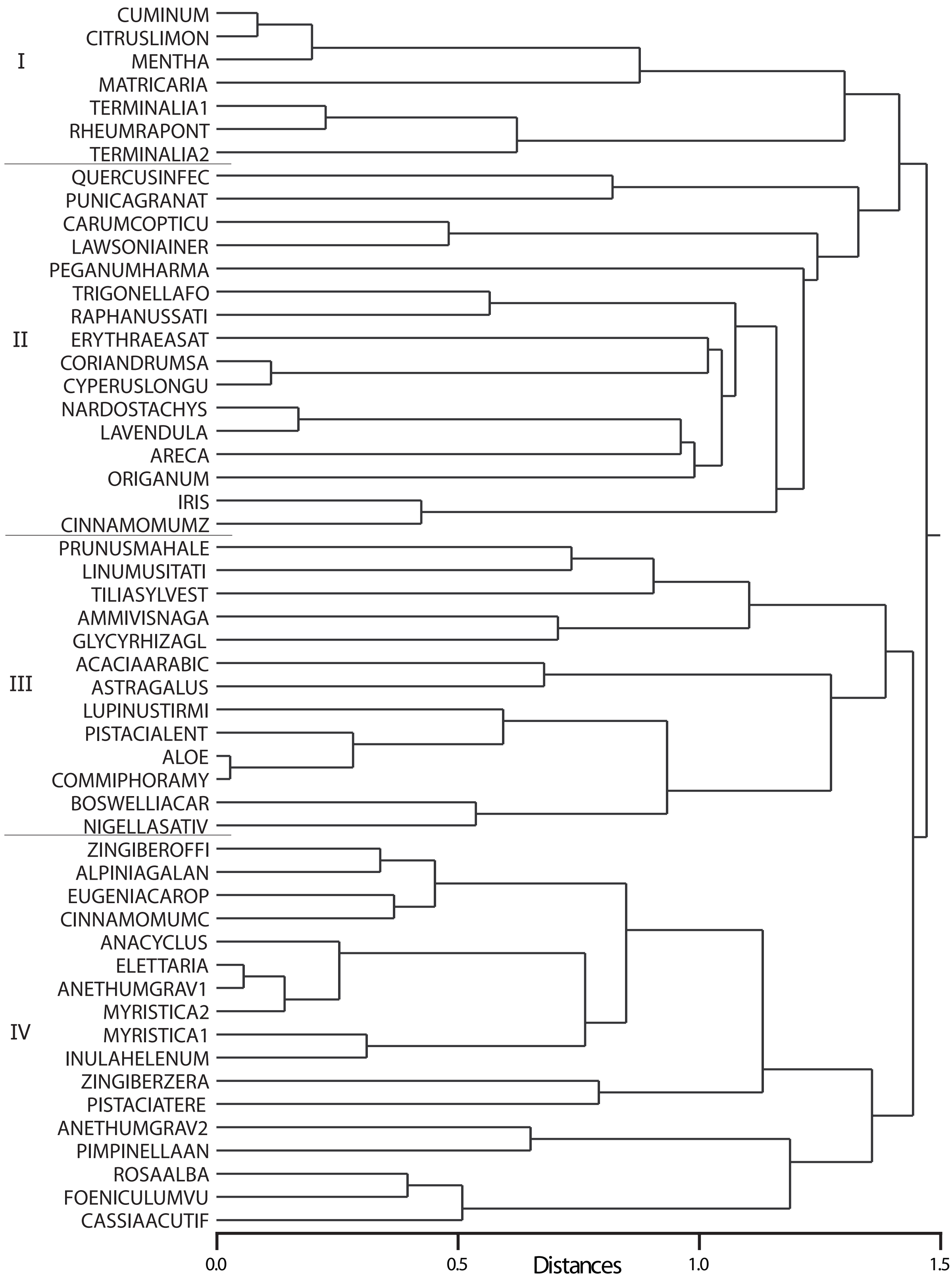

Figure 4.9. Hierarchical clustering tree representing the distributional similarity of drug plants used in prescriptions from Modern Egypt.

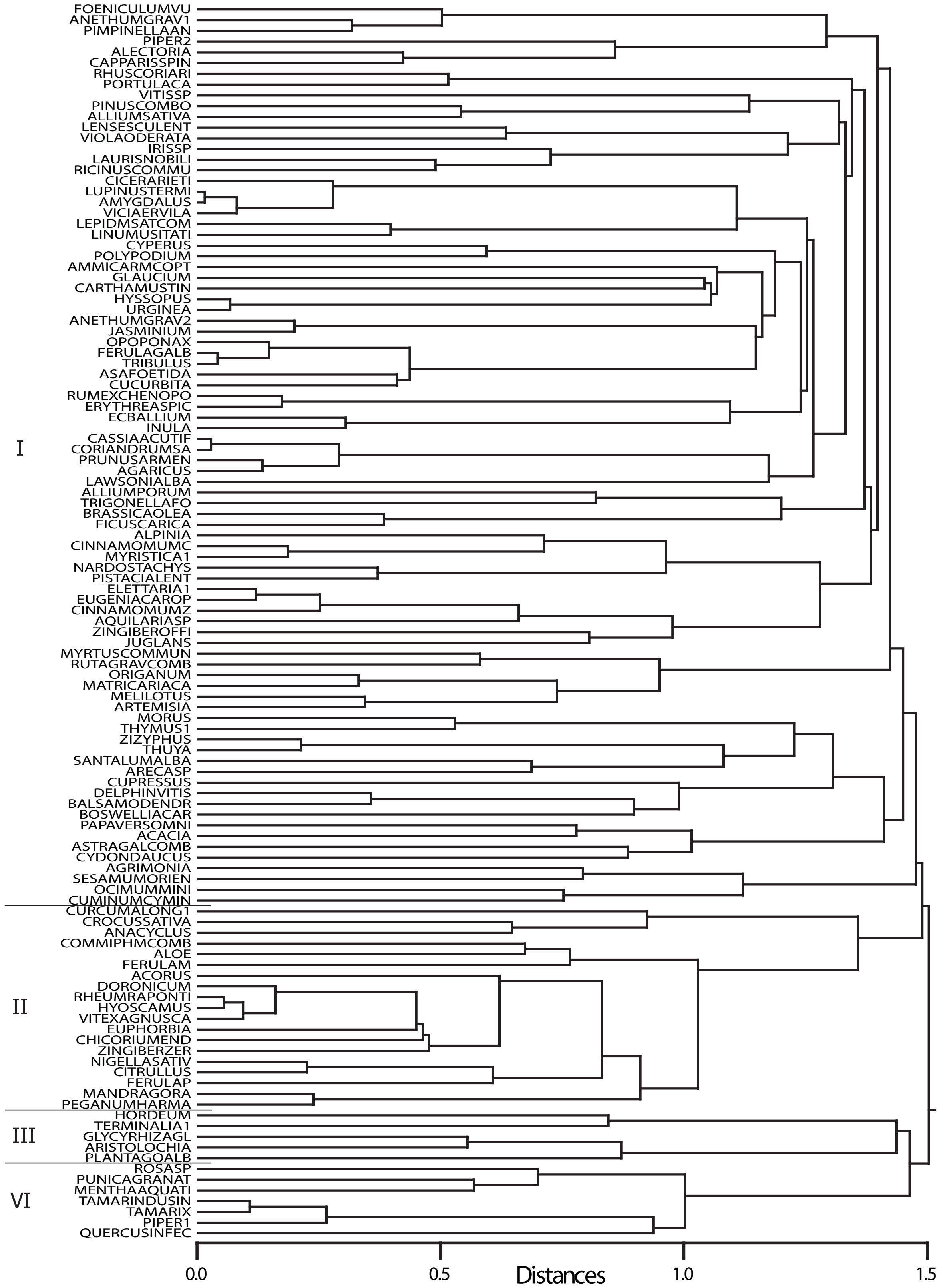

Figure 4.10. Hierarchical clustering tree representing the distributional similarity of drug plants used in prescriptions by al-Kindi.

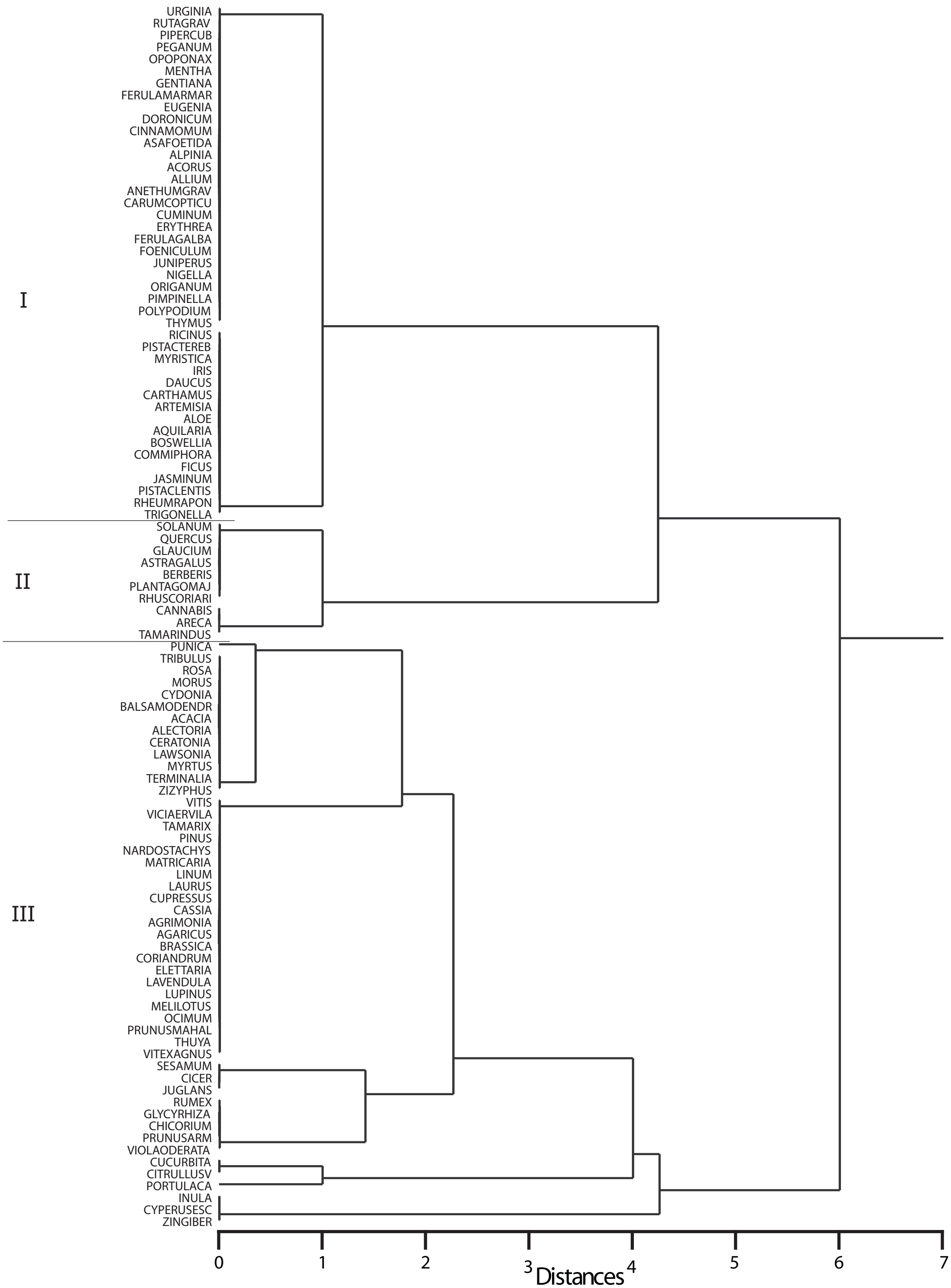

Figure 4.11. Hierarchical clustering tree representing the distributional similarity of drug plants noted by ibn Wafid, as classified by their humoral propoerties.

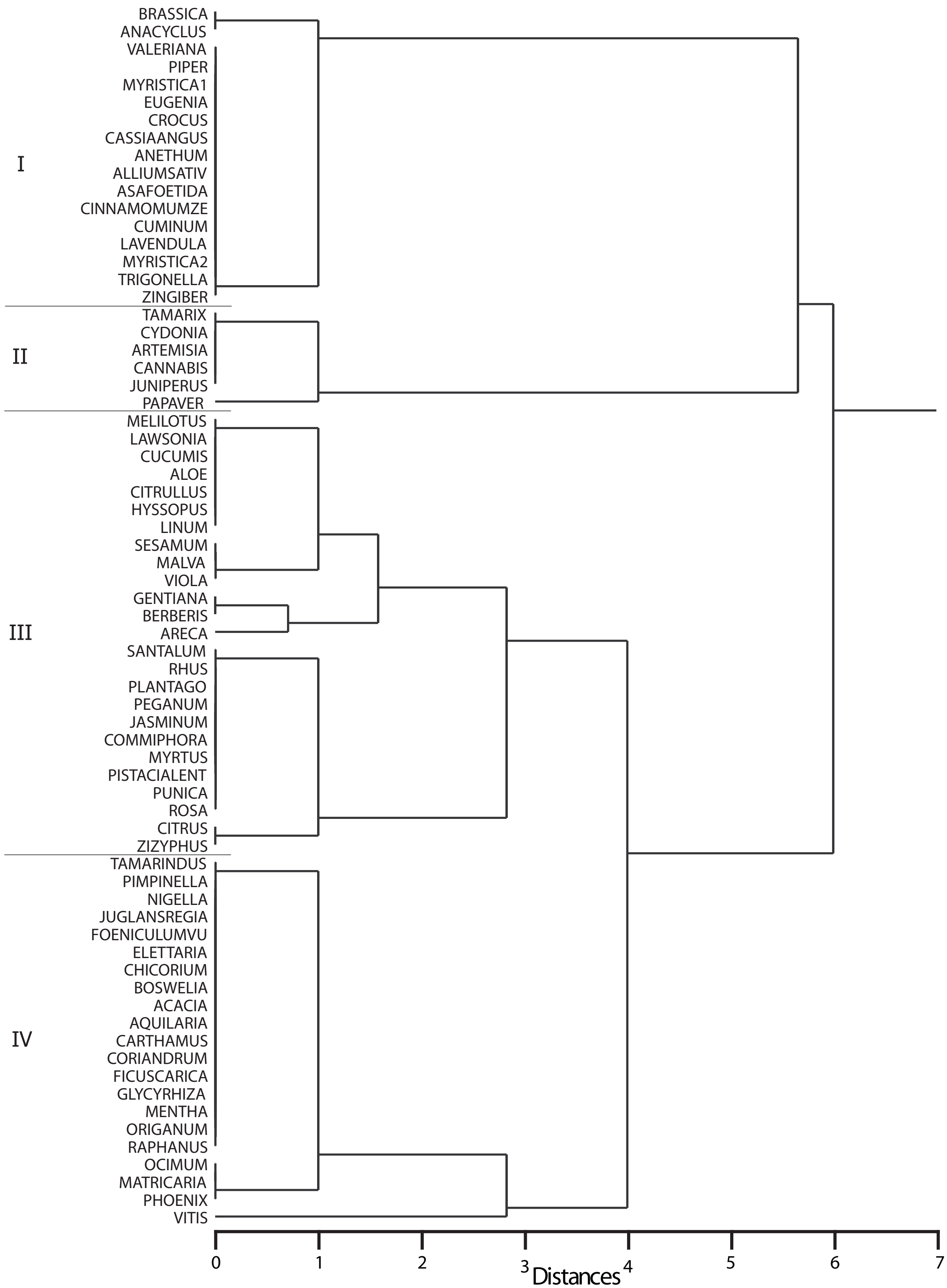

Figure 4.12. Hierarchical clustering tree representing the distributional similarity of drug plants noted by Chisti (Pseudo-Avicenna), as classified by their humoral properties.

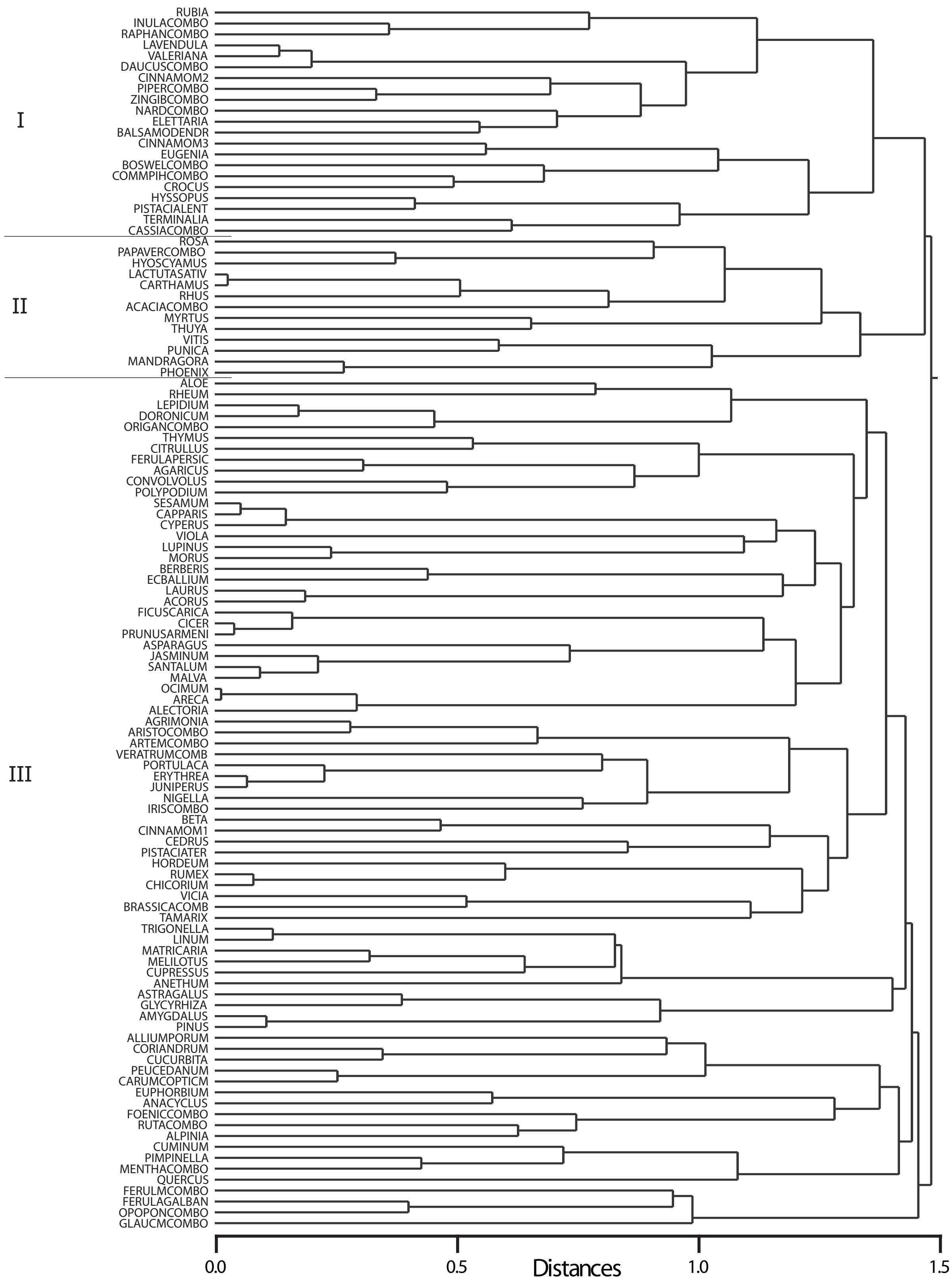

Figure 4.13. Hierarchical clustering tree representing the distributional similarity of drug plants used in c. 400-500 A.D. Greco-Syriac prescriptions (Syriac α).

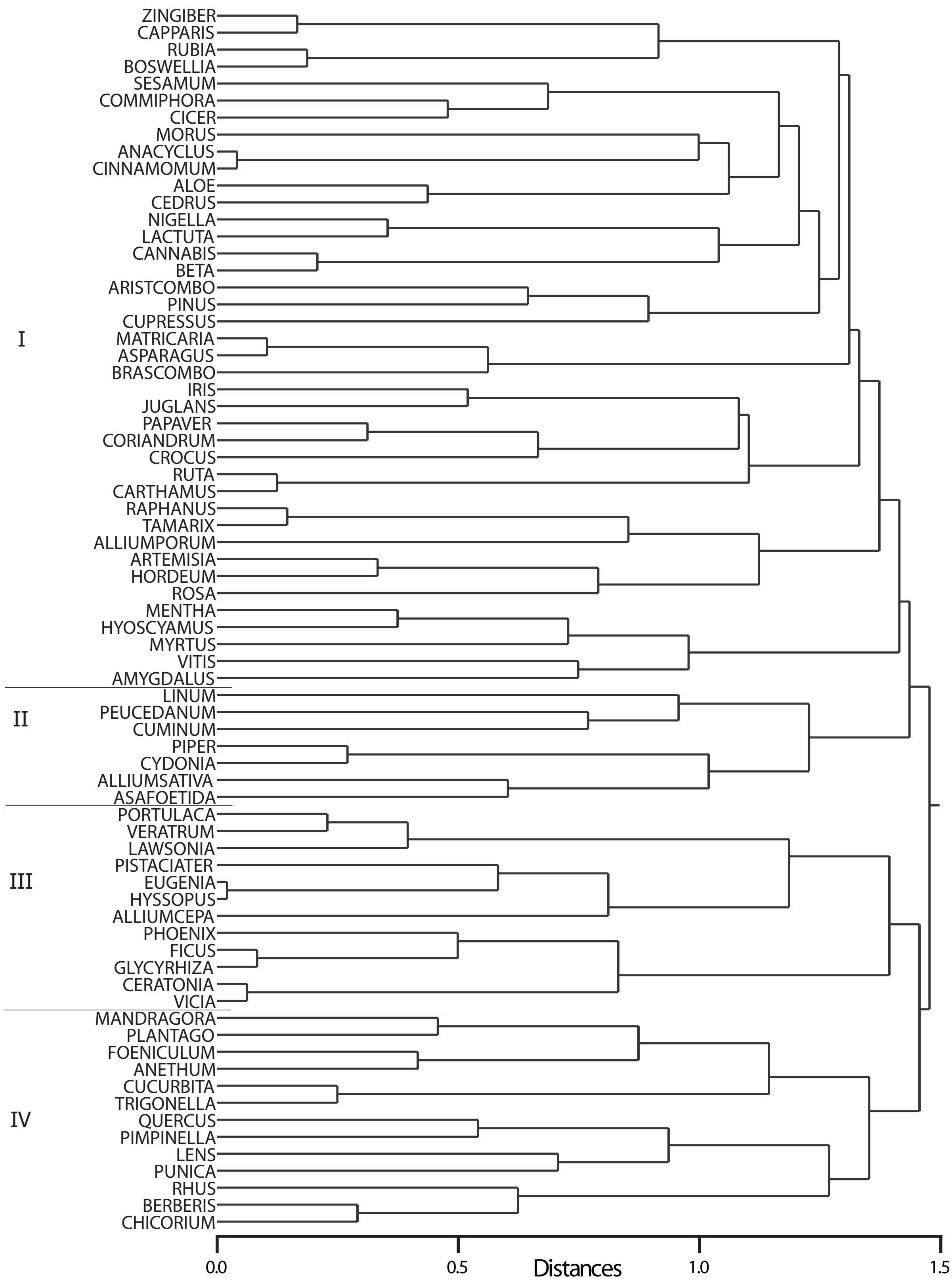

Figure 4.14. Hierarchical clustering tree representing the distributional similarity of drug plants used in c. 200-300 A.D. “native” Syriac prescriptions (Syriac β).

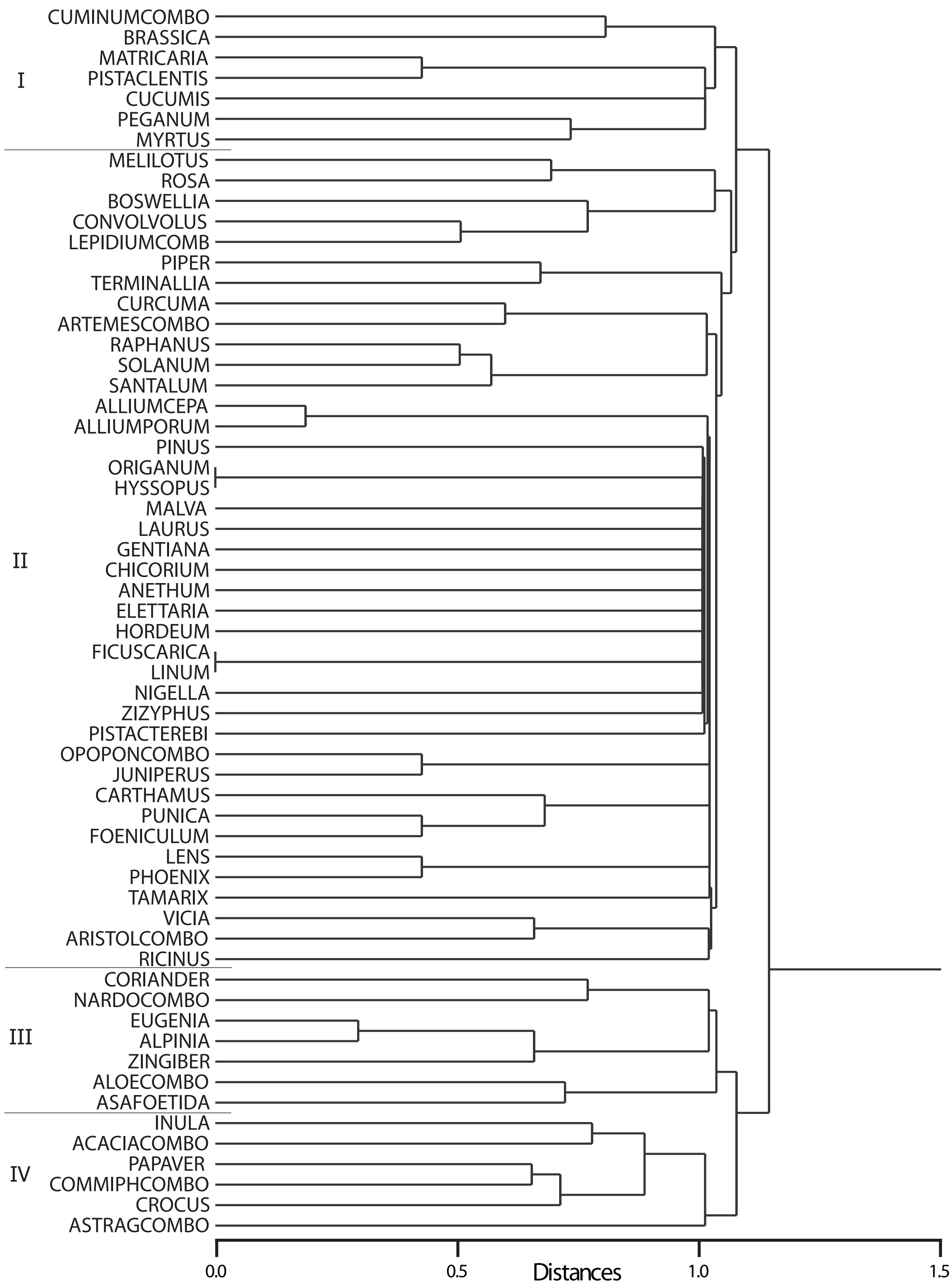

Figure 4.15. Hierarchical clustering tree representing the distributional similarity of drug plants used in c. 800-900 A.D. Coptic prescriptions (P. Chassinat).

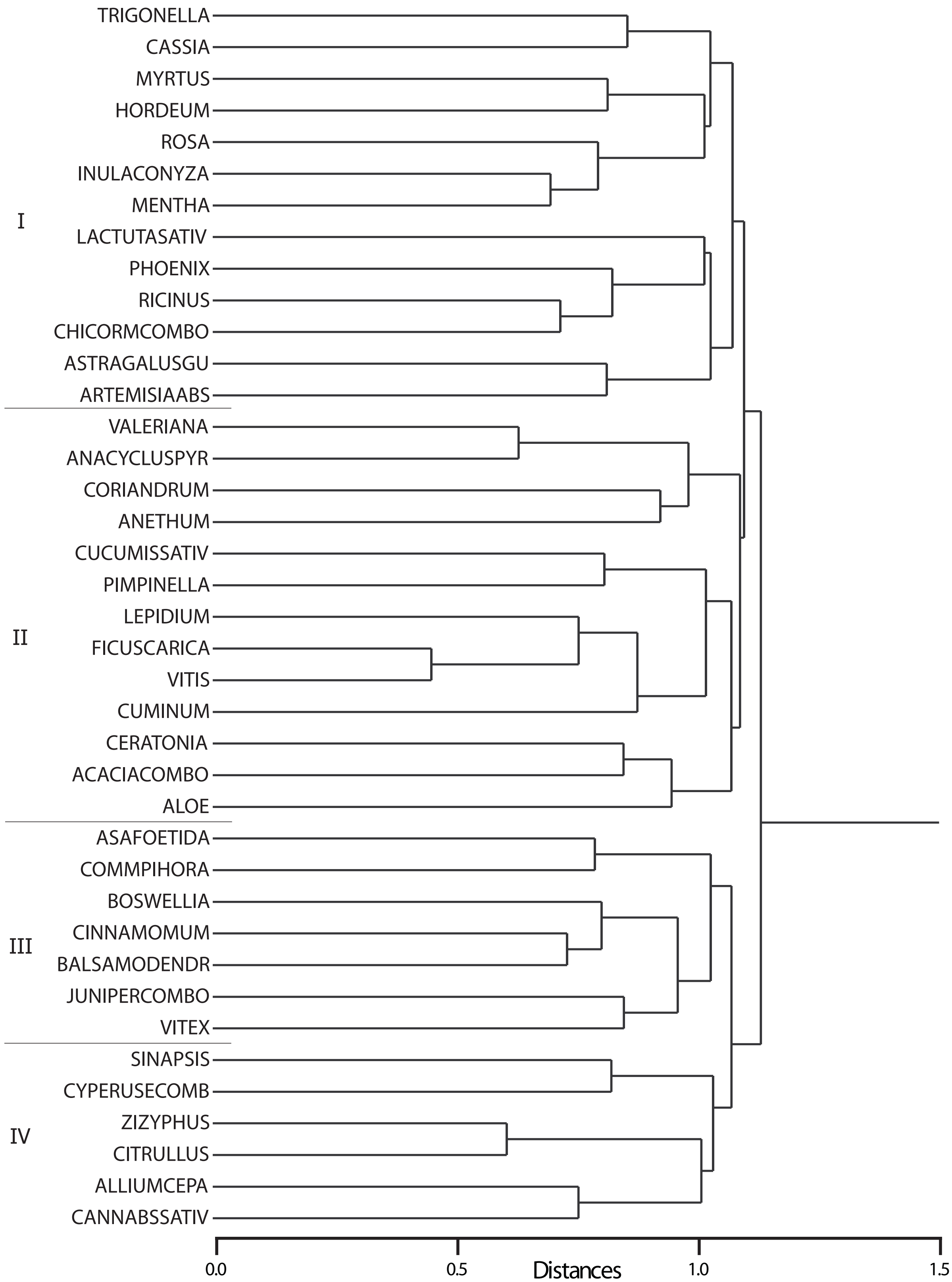

Figure 4.16. Hierarchical clustering tree representing the distributional similarity of drug plants used in c. 1500 B.C. Egyptian prescriptions (P. Ebers).

specific corollary of this hypothesis stated that a distributional similarity-based numerical taxonomy of contemporaneous sources would show sources from the Core region to be most similar to one another and those in more peripheral areas to be most similar to sources in the Core or to their immediate non-Core neighbors. General Research Hypothesis 2 posited that there would be a strong correlation between (a) the overall similarity of patterns of drug plant prescription by sources in Group II and (b) the relative strength of historical (antecedent-successor) relationships among those sources. Its corollary, Specific Research Hypothesis 2, stated that a numerical taxonomy of sources from three or more periods or streams of Middle Eastern medical tradition would show the earliest and latest sources to be more similar to the middle sources than to one another.

Within each group, clusters of sources were identified that compare favorably with the known geographic, cultural, and historical relationships and influences that have shaped Middle Eastern medicine. The clusters and their relation to the facts of the culture area and its development will be discussed below under headings related to each of the two hypotheses. A more descriptive and inferentially historical scheme of interrelationships among sources, based on the rankings and clusters reported in this chapter, will be posited in the concluding chapter.

Group I, modern sources only. Table 1 presents the similarity rankings for Aleppo, Cairo, Gaziantep, India, Karachi, Marrakech, and Sanaa, from the point of view of each source. The rankings are based on the arithmetic mean (A), geometric mean (G), arithmetic mean of the usability quotient (U_A), and geometric mean of the usability quotient (U_G) of overall similarity in patterns of drug-plant prescription among the sources. The measurements given within the table are identical to those used in the data matrices from which the hierarchical clustering trees, multidimensional scaling plots, factor analyses, and k-means clustering results found in figures 4.17-4.20 and table 2 were generated. While the figures in table 1 are technically percentages, they are treated herein as arbitrary units that are relative, i.e., scaled within the bounds of each measure. This is due to the fact that the A and G measures are clearly operating on a different scale from the U measures, although, within each group, the relative rank orderings of sources by the various measures are generally in overall agreement regarding which sources are most similar and dissimilar to one another.

It was found that the hierarchical clustering trees based on A and G were identical. Those based on U_A and U_G were also nearly identical. As a

Table 1

Similarity Rankings of Sources in Group I, in Arbitrary Units

Aleppo, Syria (Al)							
	A	Ca .598	Sa .486	Ma .484	In .417	Ga .358	Ka .347
	G	Ca .594	Ma .478	Sa .467	In .416	Ga .336	Ka .326
	U_A	Ca .721	Ma .609	Sa .586	In .464	Ga .422	Ka .333
	U_G	Ca .720	Ma .608	Sa .577	In .462	Ga .418	Ka .326
Cairo, Egypt (Ca)							
	A	Al .598	Ma .435	Sa .424	In .307	Ga .281	Ka .195
	G	Al .594	Ma .435	Sa .418	In .307	Ga .273	Ka .190
	U_A	Al .721	Sa .571	Ma .547	In .442	Ga .362	Ka .239
	U_G	Al .720	Sa .566	Ma .547	In .439	Ga .361	Ka .236
Gaziantep, Turkey (Ga)							
	A	Al .358	Ca .281	In .239	Ma .238	Ka .166	Sa .112
	G	Al .336	Ca .273	Ma .233	In .230	Ka .166	Sa .112
	U_A	Al .422	Ca .362	In .359	Ma .307	Ka .257	Sa .181
	U_G	Al .418	Ca .361	In .352	Ma .306	Ka .256	Sa .182
India (In)							
	A	Ka .442	Al .417	Ma .356	Sa .315	Ca .307	Ga .239
	G	Ka .426	Al .416	Ma .355	Sa .309	Ca .307	Ga .230
	U_A	Ka .589	Al .464	Sa .476	Ca .442	Ma .435	Ga .359
	U_G	Ka .566	Al .462	Sa .461	Ca .439	Ma .430	Ga .352
Karachi, Pakistan (Ka)							
	A	In .442	Al .347	Ma .314	Sa .238	Ca .195	Ga .166
	G	In .426	Al .326	Ma .307	Sa .238	Ca .190	Ga .166
	U_A	In .589	Al .333	Ma .331	Sa .317	Ga .257	Ca .239
	U_G	In .566	Ma .328	Al .326	Sa .317	Ga .256	Ca .236
Marrakech, Morocco (Ma)							
	A	Al .484	Ca .435	In .356	Sa .344	Ka .314	Ga .238
	G	Al .478	Ca .435	In .355	Sa .341	Ka .307	Ga .233
	U_A	Al .609	Sa .559	Ca .547	In .435	Ka .331	Ga .307
	U_G	Al .608	Sa .556	Ca .547	In .430	Ka .328	Ga .306
Sanaa, Yemen (Sa)							
	A	Al .486	Ca .424	Ma .344	In .315	Ka .238	Ga .112
	G	Al .467	Ca .418	Ma .341	Ka .238	In .309	Ga .112
	U_A	Al .586	Ca .571	Ma .559	In .476	Ka .317	Ga .181
	U_G	Al .577	Ca .566	Ma .556	In .461	Ka .317	Ga .182

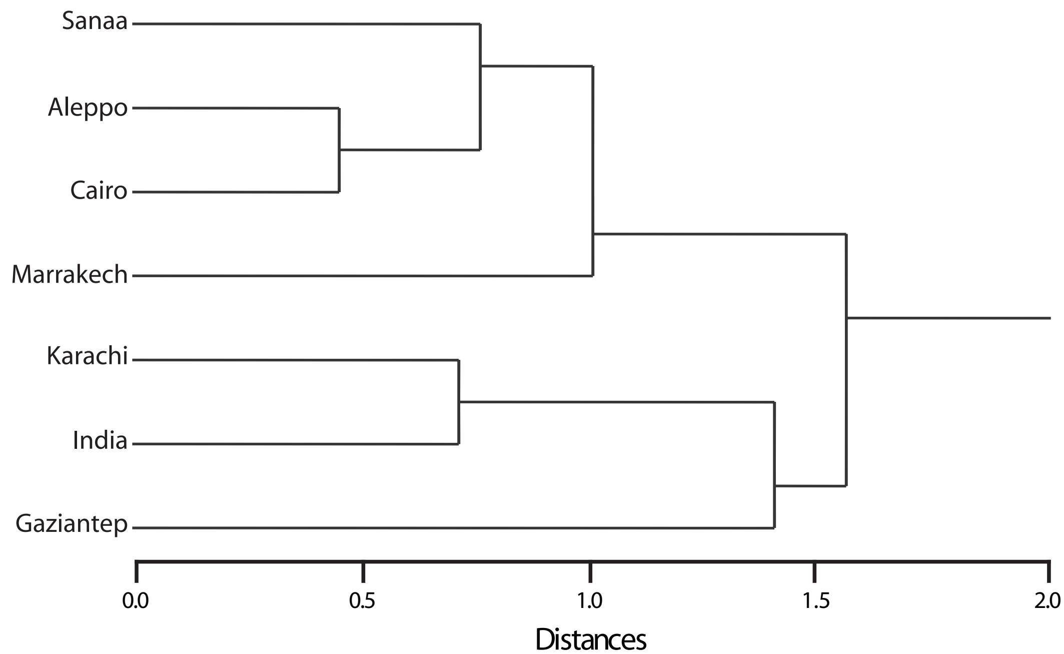

Figure 4.17. Complete Linkage Cluster Analysis of Sources in Group I Pearson Correlation Coefficient of A.

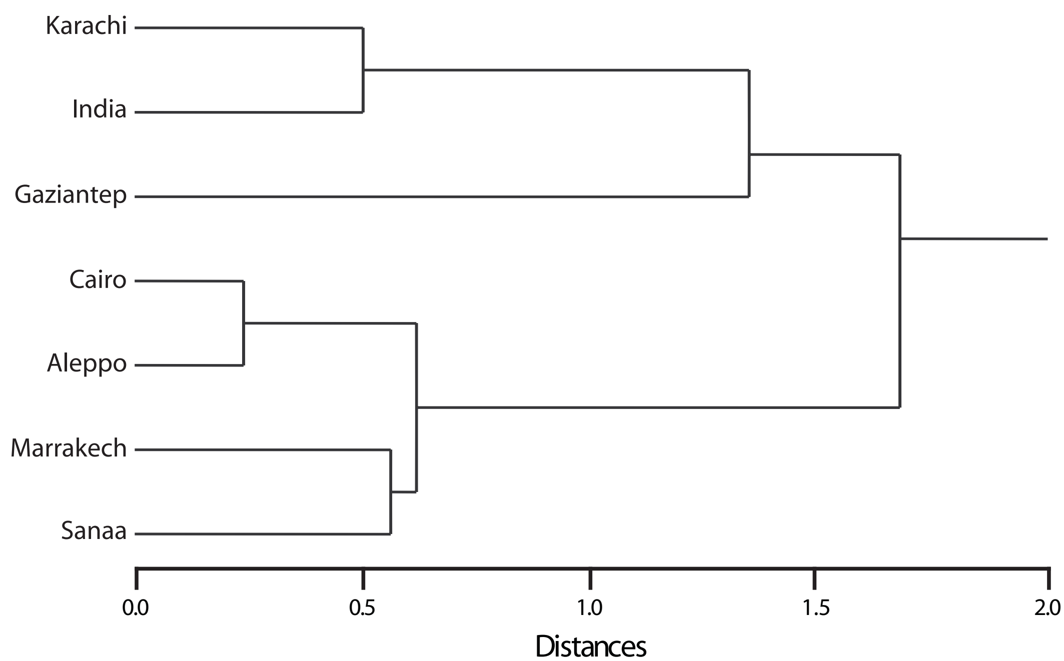

Figure 4.18. Complete Linkage Cluster Analysis of Sources in Group I Pearson Correlation Coefficient of U_A

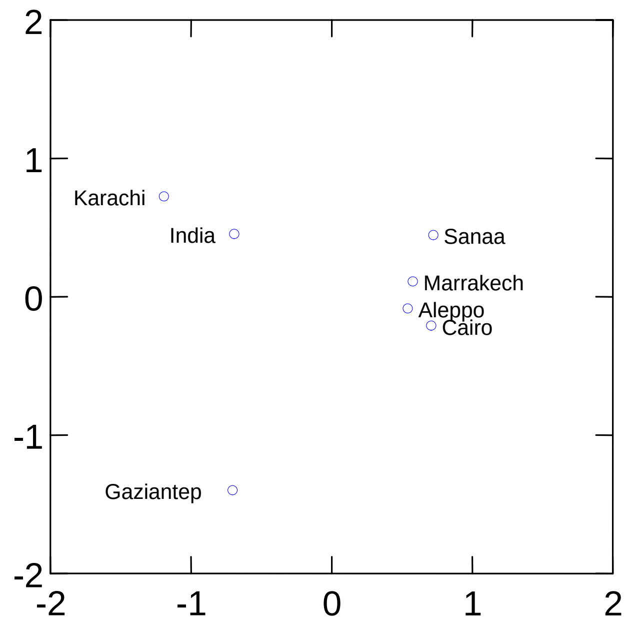

Figure 4.19. Two-Dimensional MDS Solution for Sources in Group I, U_A

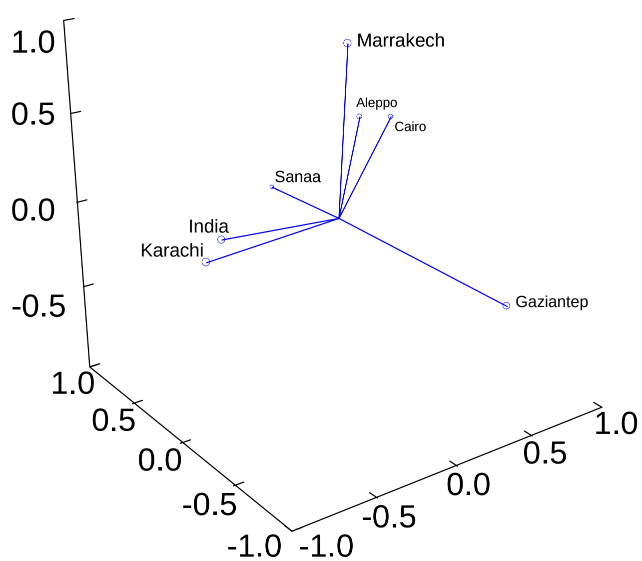

Figure 4.20. Plot of Principal Components of Similarity Data, A

Table 2
K-Means Clustering Results for Sources in Group I (A)

Cluster	K=2	K=3	K=4	K=5
Cluster 1	Gaziantep Karachi India	Karachi India	Karachi India	Karachi India
Cluster 2	Aleppo Cairo Marrakech Sanaa	Aleppo Cairo Marrakech Sanaa	Aleppo Cairo	Aleppo Cairo
Cluster 3	--	Gaziantep	Gaziantep	Gaziantep
Cluster 4	--	--	Marrakech Sanaa	Marrakech
Cluster 5	--	--	--	Sanaa

result, only the trees based on A and U_A will be shown below. Multidimensional scaling plots and factor analyses were somewhat more variable, but not significantly so in terms of the actual clusters they suggest. Therefore, the figures presented below will be limited to those based on the measures that produced the clearest portrayal of tendencies evident in the majority of outputs generated using each instrument.

As shown in the hierarchical clustering trees of figures 4.17 and 4.18, Aleppo, Cairo, Marrakech, and Sanaa are one clear cluster. Within this cluster, Aleppo-Cairo is a definite subcluster. Due to a contrast between the two figures (and the measures in table 1), it is unclear whether or not Sanaa or Marrakech is more closely related to Aleppo-Cairo, or if Marrakech and Sanaa are simply equidistantly “orbiting” around the subcluster. Karachi-India is another clear cluster. Gaziantep is only weakly linked to the Karachi-India cluster in figures 4.17 and 4.18 (at a Euclidian distance only slightly below 1.5). In table 1 it is always one of the two most weakly related sources to any other source (including India and Pakistan). In addition, a clustering tree using a single linkage (MIN) algorithm (rather than complete linkage) showed the India-Pakistan cluster linking to the Aleppo-Cairo-Marrakech-Sanaa cluster *before* Gaziantep (which was the last to join). These facts suggest that Gaziantep should be seen as acting as its own group (an isolate) according to the results of the numerical taxonomy. Multidimensional scaling (MDS), factor analysis and K-means clustering results lend further support to all of the above contentions (see especially table 2, K=3-5).

From a holistic point of view, the overall shape of the clusters seen in figures 4.17-4.20 and table 2 accords rather well with the culture area morphology described in the previous chapter. The reader should recall that Aleppo and Cairo are representatives of the Proximal Core, Marrakech and Sanaa of the Proximal Domain and Distal Core/Proximal Domain, respectively, and Karachi (in the so-called "Double-Periphery Zone") is well within the orbit of the Inner Asian sphere (represented by the out group, India, which Pakistan borders). In addition, Gaziantep, Turkey, is part of the Distal Sphere of the culture area. The results of numerical taxonomy place Aleppo and Cairo at the center of a cluster (its Core). They are orbited by Marrakech and Sanaa (representing the Proximal Domain). India (a member of the Inner Asian Domain/Sphere) and Karachi (in the double periphery between Inner Asia and the Islamic Middle East, but geographically nearer to, and possibly within, the Inner Asian sphere) are in another cluster. Turkey (belonging to the Middle Eastern Sphere) is placed as an isolate.

From a more particularistic point of view, Aleppo and Cairo (members of the Proximal Core) both rank each other as most similar to themselves; Gaziantep, Marrakech, and Sanaa (members of the Sphere and Proximal Domain) each rank Aleppo and Cairo as most similar to themselves, and both Karachi and India rank Aleppo as the most similar to themselves after the other member of their own cluster. Thus, the numerical taxonomy shows sources in the Core (i.e., Aleppo and Cairo) to be more similar to one another than to sources on the periphery. Peripheral sources (i.e., Gaziantep, Karachi, India, Marrakech, Sanaa) are more similar to sources in the Core or to their immediate neighbors (e.g., India-Pakistan). These results support Specific Hypothesis 1 in all details.

Group II, pre-modern and modern Core sources. Table 3 presents the similarity rankings of Modern Syria (Aleppo), Modern Egypt (Cairo), al-Kindi, Ibn Wafid, Pseudo-Avicenna, Syriac α, Syriac β, P. Chassinat, and P. Ebers, from the point of view of each source. The rankings are based only on the arithmetic mean of the usability function (U_A) and geometric mean of the usability function (U_G) of overall similarity in patterns of drug-plant prescription among the sources in Group II. As with the measures given in table 1, the measures given in table 3 are identical to those used in the data matrices from which the hierarchical clustering trees, multidimensional scaling plots, factor analyses, and k-means clustering results found in figures 4.21-4.24 and table 4 were generated. Again, as with the results for Group I, the units in table 3 are technically percentages, but are treated as arbitrary (following Yablokov 1986).

It was found that the factor analysis plots and K-means clustering results based on U_A and U_G were identical to one another. As a result, only the factor analysis plot and K-means solutions based on U_A will be shown below. Hierarchical clustering trees and multidimensional scaling plots were somewhat more variable, but not significantly so in terms of the requirements necessary for confirming or rejecting the relevant hypotheses.

The similarity rankings in table 4, hierarchical clustering trees in figures 4.21 and 4.22, and MDS and factor analysis plots in figures 4.23-4.25 suggest two main clusters for Group II: (a) Egypt-Syria and (b) a cluster centered on al-Kindi and Ibn Wafid (the two most strongly related sources in the sample) extending to include Pseudo-Avicenna and Syriac α. Contrastingly, Syriac β, P. Chassinat, and P. Ebers do not cluster well with other sources. In terms of higher-level groupings, it is unclear from the figures whether Egypt-Syria is closer to the al-Kindi-Ibn Wafid-Syriac α cluster, or whether Syriac β, P. Chassinat and P. Ebers are. However, by averaging the similarity scores of Egypt and Syria in relation to al-Kindi, Ibn Wafid, and Syriac α (U_A .545 and U_G .524) and likewise averaging the similarity scores of Syriac β, P.Chassinat and P. Ebers in relation to the al-Kindi-Ibn Wafid-Syriac α cluster (U_A .519 and U_G .495), it becomes apparent that Egypt-Syria is slightly closer to the al-Kindi-Ibn Wafid-Syriac α cluster.

On the whole, these patterns are in concord with what is known about the major historical relationships of descent and influence among the sources. Al-Kindi, ibn Wafid, and Avicenna are broadly contemporaneous

Table 3

Similarity Rankings of Sources in Group II, in Arbitrary Units

Modern Syria (Sy)									
	U_A	Eg .703	Ki .557	Wa .553	Sα .523	Av .507	Ch .440	Sβ .389	Eb .214
	U_G	Eg .703	Wa .533	Ki .526	Av .505	Sα .496	Ch .440	Sβ .386	Eb .210
Modern Egypt (Eg)									
	U_A	Sy .703	Sα .625	Wa .616	Ki .550	Av .433	Ch .373	Sβ .343	Eb .222
	U_G	Sy .703	Sα .584	Wa .584	Ki .512	Av .429	Ch .372	Sβ .339	Eb .219
Al-Kindi (Ki)									
	U_A	Wa .822	Sα .775	Av .625	Sβ .587	Sy .557	Eg .550	Eb .480	Ch .443
	U_G	Wa .821	Sα .775	Av .606	Sβ .571	Sy .526	Eg .512	Ch .421	Eb .418
Ibn Wafid (Wa)									
	U_A	Ki .822	Sα .777	Av .728	Ch .635	Eg .616	Sβ .556	Sy .553	Eb .513
	U_G	Ki .821	Sα .776	Av .715	Ch .613	Eg .584	Sβ .548	Sy .533	Eb .459
Pseudo-Avicenna (Av)									
	U_A	Wa .728	Ki .625	Sα .608	Sβ .553	Sy .507	Ch .451	Eg .433	Eb .381
	U_G	Wa .715	Ki .606	Sα .591	Sβ .553	Sy .505	Ch .450	Eg .429	Eb .366
Syriac α (Sα)									
	U_A	Wa .777	Ki .775	Sβ .672	Eg .625	Eb .625	Av .608	Ch .549	Sy .523
	U_G	Wa .776	Ki .775	Sβ .657	Av .591	Eg .584	Ch .524	Sy .496	Eb .363
Syriac β (Sβ)									
	U_A	Sα .672	Ki .587	Wa .556	Av .553	Ch .504	Eb .414	Sy .389	Eg .343
	U_G	Sα .657	Ki .571	Av .553	Wa .548	Ch .502	Eb .396	Sy .386	Eg .339
P. Chassinat (Ch)									
	U_A	Wa .635	Sα .549	Sβ .504	Av .451	Ki .443	Sy .440	Eg .373	Eb .373
	U_G	Wa .613	Sα .524	Sβ .502	Av .450	Sy .440	Ki .421	Eg .372	Eb .351
P. Ebers (Eb)									
	U_A	Wa .513	Ki .480	Sα .414	Sβ .414	Av .381	Ch .359	Eg .222	Sy .214
	U_G	Wa .459	Ki .418	Sβ .396	Av .366	Sα .363	Ch .351	Eg .219	Sy .210

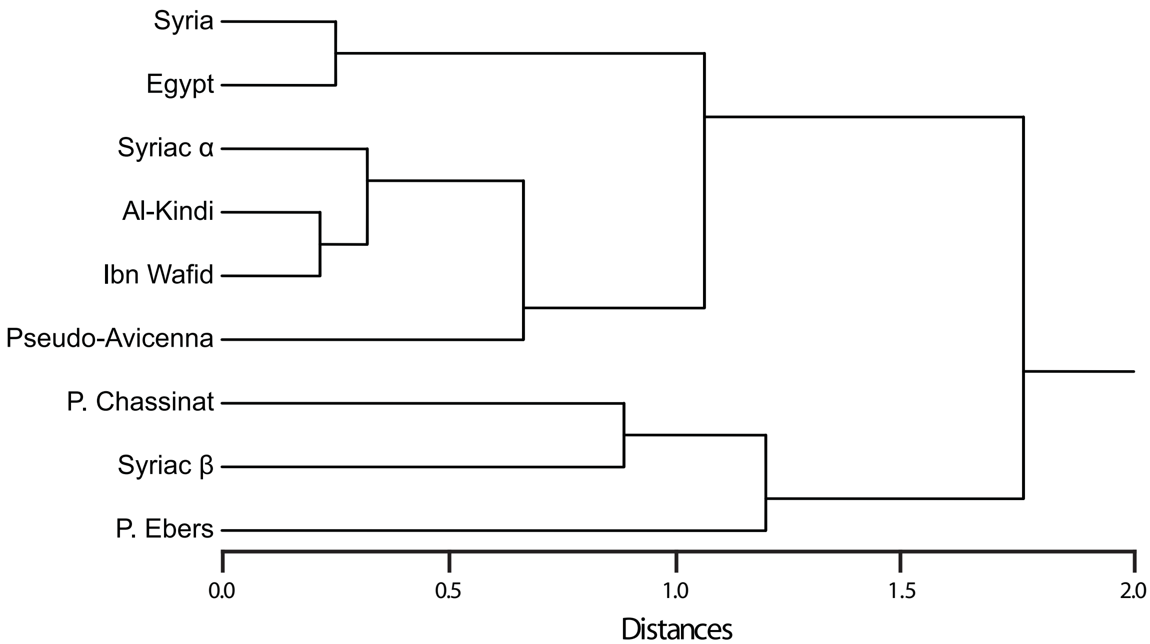

Figure 4.21. Complete Linkage Cluster Analysis of Sources in Group I Pearson Correlation Coefficient of U_A

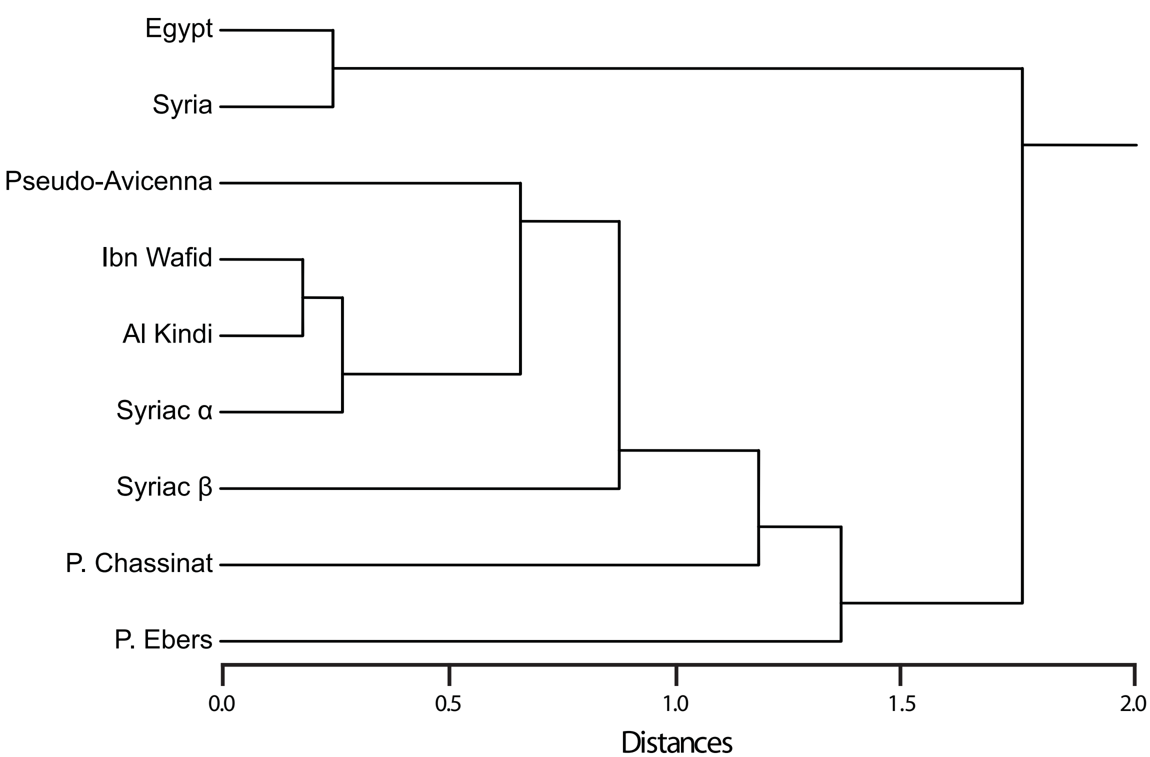

Figure 4.22. Complete Linkage Cluster Analysis of Sources in Group I Pearson Correlation Coefficient of U_G

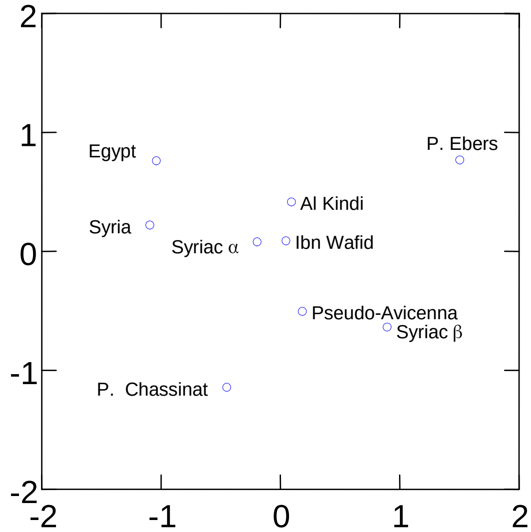

Figure 4.23. Two-Dimensional MDS Solution for Sources in Group II, U_A

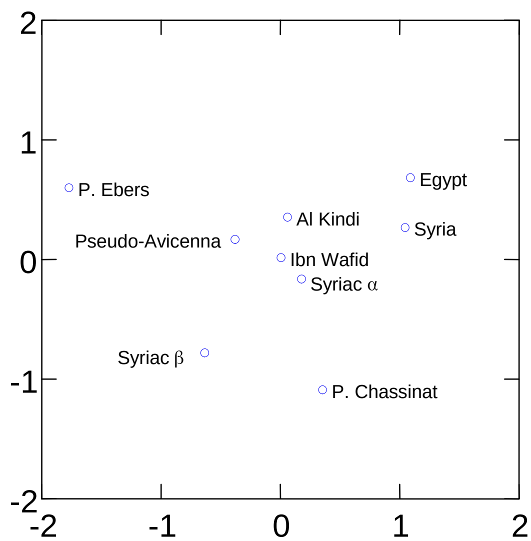

Figure 4.24. Two-Dimensional MDS Solution for Sources in Group II, U_G

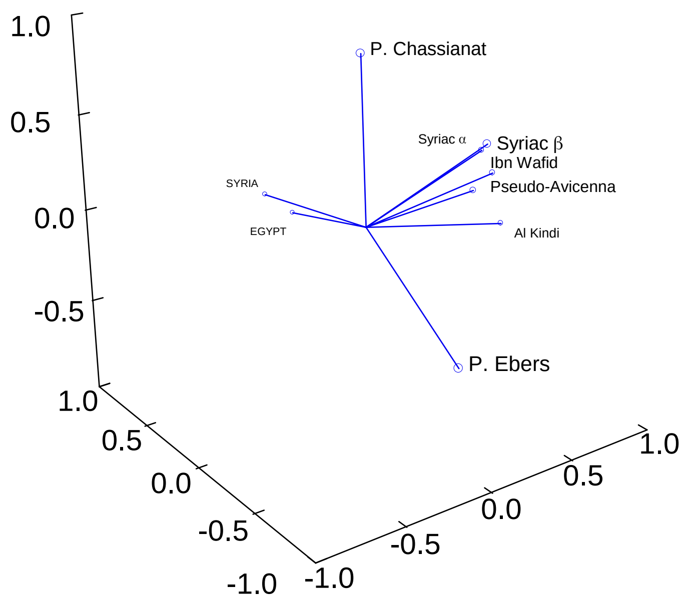

Figure 4.25. Plot of Principal Components of Similarity Data, U_A

Table 4

K-Means Clustering Results for Sources in Group II ($U_{A/G}$)

Cluster	K=2	K=3	K=4	K=5	K=6	K=7	K=8
Cluster 1	Syria Egypt Al-Kindi Ibn Wafid P-Avicenna Syriac α	Syria Egypt Al-Kindi Ibn Wafid Syriac α	Al-Kindi Ibn Wafid P-Avicenna Syriac α	Al-Kindi Ibn Wafid Syriac α	Al-Kindi Ibn Wafid Syriac α	Al-Kindi Ibn Wafid Syriac α	Al-Kindi Ibn Wafid
Cluster 2	Syriac β P. Chassinat P. Ebers	P-Avicenna Syriac β P. Chassinat	Syriac β P. Chassinat	P. Chassinat	P. Chassinat	P. Chassinat	P. Chassinat
Cluster 3		P. Ebers	P. Ebers	P. Ebers	P. Ebers	P. Ebers	P. Ebers
Cluster 4			Egypt Syria	Egypt Syria	Egypt Syria	Syria	Syria
Cluster 5				P-Avicenna Syriac β	Syriac β	Syriac β	Syriac β

Table 4 - Continued

K-Means Clustering Results for Sources in Group II ($U_{A/G}$)

Cluster	K=2	K=3	K=4	K=5	K=6	K=7	K=8
Cluster 6					P-Avicenna	P-Avicenna	P-Avicenna
Cluster 7						Egypt	Egypt
Cluster 8							Syriac α

("medieval," i.e., c. 500-1500) representatives of Greek humoral medicine in an Islamic framework and thus should be expected to cluster together. Given the sources under investigation, Syriac α ought to cluster with them as a near antecedent (it will be recalled that the Syriac tradition of Alexandrian medicine is the conduit through which Galenic theory and practice came to the Muslim world). Egypt and Syria are contemporaries to one another and should therefore cluster together as well.

"Native," non-Galenic traditions (Syriac β, P. Chassinat, and P. Ebers) likely have deep historical roots in their own territories. Even though two of them (Syriac β and P. Chassinat) come from time depths where contact with Greeks and some intellectual cross-pollination may have been possible (see chapter 1), the general scholarly consensus is that they over-ridingly represent local non-Greek systems. The modern sources (Egypt and Syria) are more similar to the medieval cluster than they are to these "local"/"native" pre-Greek systems. Similarly, Syriac β, P. Chassinat, and P. Ebers are more similar to Al-Kindi, ibn Wafid, and Avicenna than they are to modern Egypt or Syria.

For Group II, a particularistic perspective does not provide many more enlightening insights than a holistic one, as it does for Group I. However, some observations of import may still be made. After Al-Kindi and ibn Wafid, Syriac α is most similar to Syriac β. Syriac β is most similar to Syriac α. This special kinship between Syriac α (Alexandrian medicine as practiced by a third-fourth century Syrian) and Syriac β (traditional Mesopotamian cures from the same period) is what we would predict of two sources from the same temporal and geographic provenience, even if they claim to adhere to different ethnomedical traditions (much like the modern, near-neighbors Karachi, Pakistan, and India in Group I).

Pseudo-Avicenna, a modern summary of a nineteenth-century commentary of an abridgement of a medieval work, though most similar to the "true" medieval Islamic medical texts, is still the most peripheral member of its cluster. This is what should be expected in a situation where translation and abridgement (without significant modification) prevail.

Finally, P. Ebers, our most ancient text (at a remove of at least 1,834 years from its nearest chronological neighbors, Syriac α and Syriac β) is the most consistently dissimilar source in relation to all others in the sample.

It is only ever ranked higher than the least similar source by the two Syriac sources, which are the nearest to it in time.

In placing (a) the medieval sources together in a cluster, (b) the Alexandrian Galenic source along with them, and (c) the cluster of modern sources descended from the medieval Islamic tradition nearest to the medieval cluster, a numerical taxonomy of the sources in Group II shows similar interrelationships to those that are known from the historical record of Islamic pharmacological practice. These results support the second pair of general and specific research hypotheses in all respects.

The Efficacy of Various Instruments and Measures

The third research question under consideration focused on discovering what instruments and measures might best facilitate the application of numerical taxonomy procedures to G2 cognitive categories. Each of the measurements and instruments used in the course of this investigation will be briefly discussed below.

Instruments. The four instruments used in this study are agglomerative hierarchical clustering, multidimensional scaling, factor analysis and K-means clustering. They each have their individual pros and cons. Taken as a whole, however, they serve as checks on one another, alleviating the most extreme misinterpretations that would likely arise if procedures were limited to a single-instrument approach.

Hierarchical clustering procedures produced results visually similar to those with which historical linguists and evolutionary biologists are most familiar (i.e., *the Stammbaum*). The trees made the strongest clusters readily apparent with only a cursory inspection. Occasionally, however, the necessity of clustering all entities with one or more other entities can mislead a naïve researcher into assuming relationships where there are none (as in the case of clustering Gaziantep with India and Karachi in Group I in Figs. 4.17 and 4.18, or the discrepancy between the Group II trees for U_A and U_G in Figs. 4.21 and 4.22). Double checking results based on complete linkage (MAX) clustering by using a single linkage (MIN) algorithm alleviated some of this problem.

Multidimensional scaling (MDS) does not force items into clearly demarcated clusters and thereby circumvents the major pitfall of hierarchical clustering. Rather, it allows entities to gravitate toward one another without necessitating the drawing of hard and fast boundary lines between groups or of making connecting lines like the nodes of a tree. In addition, MDS seems to provide a fairly accurate representation of the numerical interrelationships of sources considered in this project. For the two groups under consideration, the "stress" (how well actual similarities fit the distances in an MDS plot) was between .11 and .12 for the MDS plots shown in Figures 4.19, 4.23 and 4.24, a relatively "good" result (see Wilkinson et al. 1996:667). In addition, the Shepard diagrams for the plots produced multi-step outputs where the variance of the residuals was equal to or larger than the variance of the fitted curve, also a good result (see Wilkinson et al. 1996:668). One drawback to MDS is that it can occasionally place fairly dissimilar items into proximities that are visually suggestive of relationships not actually present. For example, in Figure 4.23, Syriac β and Pseudo-Avicenna appear to be as similar to one another as modern Syria and Egypt are to each other, a patently false conclusion in the face of the numerical evidence in table 3.

Factor analysis generates factor plots that seem to accentuate and disambiguate the similarities and dissimilarities evident in MDS clusters. The added dimensionality of a multi-factor plot, like the one found in figure 4.25, precludes some of the misinterpretation that could result from MDS solutions like the ones shown in Figures 4.23 and 4.24. However, also like MDS (but unlike hierarchical clustering), factor analysis does not allow for the recognition of higher levels of grouping. Nevertheless, the factor analysis results fit the data at hand reasonably well. The three factors of figures 4.20 and 4.25 accounted for approximately 71 percent and 76 percent of the total variation present, respectively.

For the present sample, K-means clustering analyses with K set between three and five seemed to produce the most revealing clusters. By running multiple cluster analyses with K set at different levels, it was possible to test the clusterings suggested by the other instruments and confirm or disconfirm them. Unlike MDS and factor analysis, a multiply-iterated K-means clustering procedure *does* allow higher level grouping. However, it also shares a disadvantage with hierarchical clustering: it *must* join all variables into however many groups the program has been instructed to make, sometimes lumping dissimilar items together for want of anything else to do with them.

In the final analysis, none of the instruments is superior in all respects to the others. Taken together, they are highly complementary, with each providing a corrective to the excesses or short fallings of the others.

Measures. Like the instruments, the various measures served to constrain and complement one another. Both the arithmetic and the geometric means seem to provide roughly the same overall results. Any disagreements between them (such as the discrepant rankings of the relationships prevailing between Gaziantep and Marrakech, Karachi and Sanaa, and Gaziantep and India in Table 1) are rather minor issues of sub-ranking within a series of rankings that, relative to the rankings of other pairs, is generally established as a continuous “run” of interrelationships by both measures. Both A and G offer a fairly “fine-grained” measurement because they are based on numerous implicationally ordered characters. The U measures (not based on implicationally ordered characters but on the “usability” of variables as discovered through paired comparison of sources) are inherently less nuanced than either the A or G measure, but still provide results that generally comparable to them. In addition, they provide a distinct advantage over the standard A and G measures in their ability to measure similarity across a larger pool of sources while demanding what is only a minimally more labor intensive process with the addition of each additional source

Summary

This chapter consisted primarily of a description of each source in the sample, the results of testing the research hypotheses, and an evaluation of the instruments and measures used to achieve the results. The results confirmed both the general and specific research hypotheses, demonstrating that a multi-instrumental, multi-measure numerical taxonomy approach accurately groups cognitive dialects of Islamic medicine and representatives of its antecedents into clusters that would be expected given the known facts of history and geography in the region.

In the final chapter, we will review the study as a whole, as well as how the results of the present chapter relate to the purposes of the project and to the studies reviewed in Chapters 1 and 2. In addition, statements the findings of the project will be made and implications drawn regarding both the study of Middle Eastern ethnomedicine and future prospects for the development of cognitive dialectometry as a method. Finally, suggestions for further research using the techniques of cognitive dialectometry will be proposed.