A NUMERICAL TAXONOMIC STUDY ON THE GENUS *SALVIA* L. (LAMIACEAE) IN TURKEY

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ABSTRACT

A NUMERICAL TAXONOMIC STUDY ON THE GENUS *SALVIA* L. (LAMIACEAE) IN TURKEY

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Widely used a medicinal plant, *Salvia* L. is the largest genus in the family Lamiaceae, with over 1700 species found in Asia, Europe, Africa and the Americas. Within this genus, almost 100 species are recognized in Turkey. To date, however, no comprehensive infrageneric treatment of *Salvia* in Turkey exists.

The objective of this study was to propose a more natural infrageneric classification of the genus *Salvia* in Turkey by using the numerical taxonomic approach developed by Sneath and Sokal in 1973. In this study, a total of 43 qualitative and quantitative macromorphological characters were described and measured from 96 taxa. Herbarium specimens collected in the field during the years 2005 to 2009 as part of the taxonomic revision of *Salvia* were used. UPGMA cluster analysis and Principal Coordinates Analysis (PCO) were performed to determine the phenetic relationships among Turkish *Salvia* species. Additionally, a Principal

Components Analysis (PCA) was conducted to distinguish the most useful characters for the infrageneric delimitation of the taxa. All analyses were carried out using the MVSP (version 3.2) computer program.

The results of the cluster analysis and PCO reveal five distinct infrageneric clusters under two major groups. Based on the PCA, 25 vegetative and reproductive morphological characters were found to be diagnostic for the delimitation of *Salvia* into the five infrageneric clusters. Furthermore, the results of this study are not wholly consistent with Bentham’s sections, but instead are more congruent with the findings of recent molecular phylogenetic studies.

Keywords: Morphology, numerical taxonomy, *Salvia*, Turkey

ÖZ

TÜRKİYE’DE BULUNAN *SALVIA* L. (LAMIACEAE) CİNSİ ÜZERİNDE BİR NÜMERİK TAKSONOMİK ÇALIŞMA

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Yaygın olarak kullanılan tıbbı bir bitki olan *Salvia* L. cinsi Lamiaceae familyasındaki en büyük cins olup Asya, Avrupa, Afrika ve Amerika’da bulunmaktadır ve 1700’ü aşkın tür içermektedir. Bu cinse ait 100 kadar tür Türkiye’den bilinmektedir. Günümüze kadar, böylelikle, Türkiye’deki *Salvia* ile ilgili tatmin edici cinsiçi sınıflandırma bulunmamaktadır.

Bu çalışmanın amacı Türkiye’de bulunan *Salvia* cinsine ilişkin daha doğal bir sınıflandırmayı 1973 yılında Sneath ve Sokal tarafından geliştirilmiş numerik taksonomik yöntem kullanılarak ortaya koymaktır. Bu çalışmada toplam 43 kualitatif ve kuantitatif makromolekülar karakter 96 takson üzerinde tanımlanmış ve ölçülmüştür. 2005 – 2009 yılları arasında *Salvia* cinsinin taksonomik revizyonuna yönelik olarak sahadan toplanmış olan herbaryum örnekleri kullanılmıştır. Turkiye’deki *Salvia* türleri arasındaki fenetik ilişkilerin belirlenmesi için UPGMA kümeleme analizi ve Priciple Coordinat Analizi (PCO) kullanılmıştır. Buna ilave olarak, ilgili taksonlara ilişkin olarak cinsiçi sınıflandırmada kullanılabilecek karakterlerin saptanmasına yönelik bir Principle Component Analizi (PCA) yapılmıştır. Tüm analizler MVSP (versiyon 3.2) kompüter proğramı kullanılarak gerçekleştirilmiştir.

Kümeleme analizi ve PCO sonuçları *Salvia*'da iki ana alt grup altında beş farklı cinsiçi kümenin bulunduğunu ortaya koymuştur. PCA tabanınında 25 vegetatif ve reproductif morfolojik karakterin *Salvia*'nın sınıflandırmasında ayırıcı özellik olduğu belirlenmiştir. Buna ilave olarak, bu araştırmanın sonuçları Bentham'ın seksiyonları ile tümüyle örtüşmemektedir, fakat bunun yerine yakın zamanda yapılmış moleküler çalışma sonuçları ile örtüşmektedir.

Anahtar Kelimeler: Morfoloji, numeric taksonomi, *Salvia*, Türkiye

To my mother.

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ABBREVIATIONS

ANK	Ankara University Herbarium
B	The Botanic Garden and Botanical Museum Berlin-Dahlem
BM	The Natural History Museum, London
CBB	Çanakkale Botanical Garden
cm	centimeter
Cum.	cumulative
E	Royal Botanic Garden Edinburgh
ERCIYES	Erciyes University Herbarium
Eur-Sib	Euro-Siberian
FUH	Fırat University Herbarium
G	Geneva Herbarium
GAZI	Gazi University Herbarium
HUB	Hacettepe University Herbarium
Ir-Tur	Irano-Turanian
ISTE	Istanbul University Faculty of Pharmacy Herbarium
ISTF	Istanbul University Herbarium
K	Royal Botanic Gardens, Kew
km	kilometer
KNYA	Selçuk University Herbarium
LE	Herbarium of Vascular Plants of the Komarov Botanical Institute
m	meter
Med	Mediterranean
MO	Missouri Botanical Garden
MVSP	Multi-Variate Statistical Package
OTU	Operational Taxonomic Unit
PCA	Principal Components Analysis
PCO	Principal Coordinates Analysis

s.l.	sensu lato
sect.	section
subg.	subgenus
subsp.	subspecies
UPGMA	Unweighted Pair Group Method with Arithmetic Means
VANF	Yüzüncü Yıl University Herbarium
var.	variety
W	Natural History Museum, Vienna

CHAPTER 1

INTRODUCTION

1.1 The Family Lamiaceae

Lamiaceae – the mint family – is a large family of dicotyledonous angiosperms comprising over 7800 species in about 250 genera (The Plant List, version 1, 2010) with a cosmopolitan distribution all over the world. It is especially widespread in the Mediterranean region, the Old World and the mountains of subtropical regions (Bhattacharyya, 2009). The family was originally described by de Jussieu (1789) in his *Genera Plantarum* under the name of Labiatae (Brands, 1989-present), originating from the word *labium*, after the Latin "gullet" to describe the characteristic 2-lipped feature of its fused petals (Simpson, 2006). Both Lamiaceae and Labiatae are considered valid names, but most botanists now prefer to use the name Lamiaceae when referring to this family (Brands, 1989-present).

The earliest comprehensive taxonomic treatment of Lamiaceae was that of Bentham (1832-1836; 1876), who had based most of his findings on floral architecture. Later, Briquet (1895-1897) made various modifications to Bentham's system, raising some tribes and subtribes to the subspecies level and reclassifying several genera. Successive classifications in floras and textbooks by multiple systematists involve minor modifications and transfers at the super and infrafamilial levels (El-Gazzar and Watson, 1970). A more outstanding dispute was of the family's close relationship with the family Verbenaceae. However, non-molecular and molecular phylogenetic studies in the 1990's have shown that Lamiaceae is polyphyletic, with several clades emerging from within Verbenaceae. In consequence, several genera from Verbenaceae *sensu lato* were transferred to Lamiaceae. Cantino, Harley & Wagstaff (1992) have provided a list of accepted genera of Lamiaceae, including subfamilies, tribes and subtribes. Bentham's treatment of Lamiaceae, notwithstanding, still remains the most widely accepted amongst botanists despite the tremendous increase in the number of genera and species since his time (Kubitzki and Kadereit, 2004).

Lamiaceae is distinguished from other families by being often aromatic with ethereal oils owing to glandular trichomes, with usually tetrangular stems in cross-section, opposite and exstipulate leaves, an inflorescence of a lateral cyme in verticillasters, usually bilabiate flowers having a superior ovary, often deeply 4-lobed, a gynobasic style, and a schizocarp fruit of usually four nutlets (Hedge, 1982a; Simpson, 2006). Due its often high yield of essential oils, Lamiaceae is a popular family throughout the world for its economic importance in the food and pharmaceutical industries (Erdoğan, Everest & Kaplan, 2013). With genera such as *Mentha* L. (mint), *Thymus* L. (thyme), *Ocimum* L. (basil), *Lavandula* L. (lavender), *Salvia* L. (sage) and *Rosmarinus* L. (rosemary), its uses include culinary herbs, medicinal plants, fragrance plants and cultivated ornamentals (Kubitzki and Kadereit, 2004; Bhattacharyya, 2009). Lamiaceae is the third largest family in the Turkish flora, with 574 species in 45 genera, 256 of which are endemic (Pobedimova, 1954; Hedge, 1982b; Martin, Çetin, Kahraman, Celep & Doğan, 2011; Özhatay, Kültür & Gürdal, 2011).

1.2 The Genus *Salvia* L.

Salvia L., vernacularly known as the sage, is by far the largest genus in the family Lamiaceae, with over 1700 known species distributed throughout the world

(The Plant List, version 1, 2010; Kahraman, Doğan & Celep, 2011). Its name derives from the Latin *salvere*, meaning “to save.” This possibly refers to its healing properties, as some of its species have historically been used in traditional medicine. *Salvia officinalis*, the type species of this genus, was used medicinally by societies in ancient Greece, Rome and Egypt. It was believed to increase fertility, heal minor skin injuries, stop bleeding, treat cough, and improve memory function. Western physicians and herbalists such as John Gerard (1545-1607) and Nicholas Culpeper (1616-1654) were also in favor of these beliefs. In modern medicine, volatile compounds and aqueous extracts from some species of *Salvia* are used to treat inflammation of the mouth and throat, excessive sweating, indigestion (Engels, 2010), stomach disorders, and chills. As examples, *S. viridis*, *S. officinalis* and *S. multicaulis* have antioxidant properties, *S. heldreichiana* has antimicrobial activities against the pathogens *Staphylococcus aureus*, *Escherichia coli*, *Sarcina lutea*, *Salmonella typhimurium* and *Pseudomonas aeruginusa* (Erdoğan, Everest & Kaplan, 2013), and *S. sclarea* shows significant anti-inflammatory, and peripheral and analgesic properties (Koçak and Bağcı, 2011). Many species of *Salvia* are also popularly used in the cosmetic, perfume and food industries, and as garden ornaments. The genus exhibits a high diversity of secondary metabolites, including essential oils that give a powerful aroma, hence its broad range of uses throughout history (Engels, 2010).

Salvia is distributed extensively in three regions of the world: Central and Southern Africa, Central Asia, and Eastern Asia (Figure 1). It occurs across a wide range of habitats, from the sea level to altitudes of over 4000 m, and in tropical rainforests, dry bush lands, steppes, temperate forests, forest edges, open meadows and degraded sites (Claßen-Bockhoff, Speck, Tweraser, Wester, Thimm, & Reith, 2004). The oldest fossils of *Salvia* pollen found in sedimentary deposits in Mexico show the genus to be as old as 25 million years, occurring in the lower Miocene epoch. It is assumed that the center of diversity of *Salvia* is the Old World, probably the Mediterranean region, preceding migrations throughout the Miocene to the

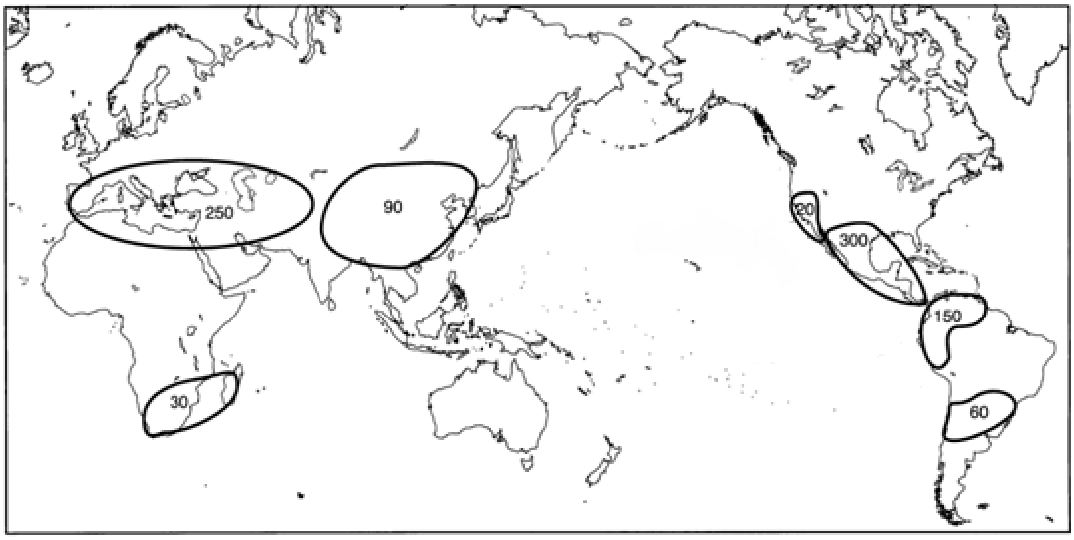

Figure 1. Centers of diversity for the genus *Salvia*, with approximate numbers of species in each region given (Modified from Walker et al., 2004).

Pleistocene via tropical mountains towards South America and South Africa (Kubitzki and Kadereit, 2004, Claßen-Bockhoff et al., 2004).

Salvia displays an impressive diversity in growth forms, secondary metabolites, floral morphology and pollination biology due to marked species radiations throughout its centers of diversity (Walker, Systma, Treutlein & Wink, 2004). Species may either be perennial or annual, and herbaceous or woody. The leaves are always exstipulate, opposite-decussate, and either simple or pinnately compound. The inflorescence consists of cymes borne in the axils of bracts that form false whorls called verticillasters characteristic of the family Lamiaceae (Figure 2). Its flowers are usually hermaphrodite, but occasionally male-sterile. The calyx is composed of five partially fused sepals that form a bilabiate tube, holding the corolla

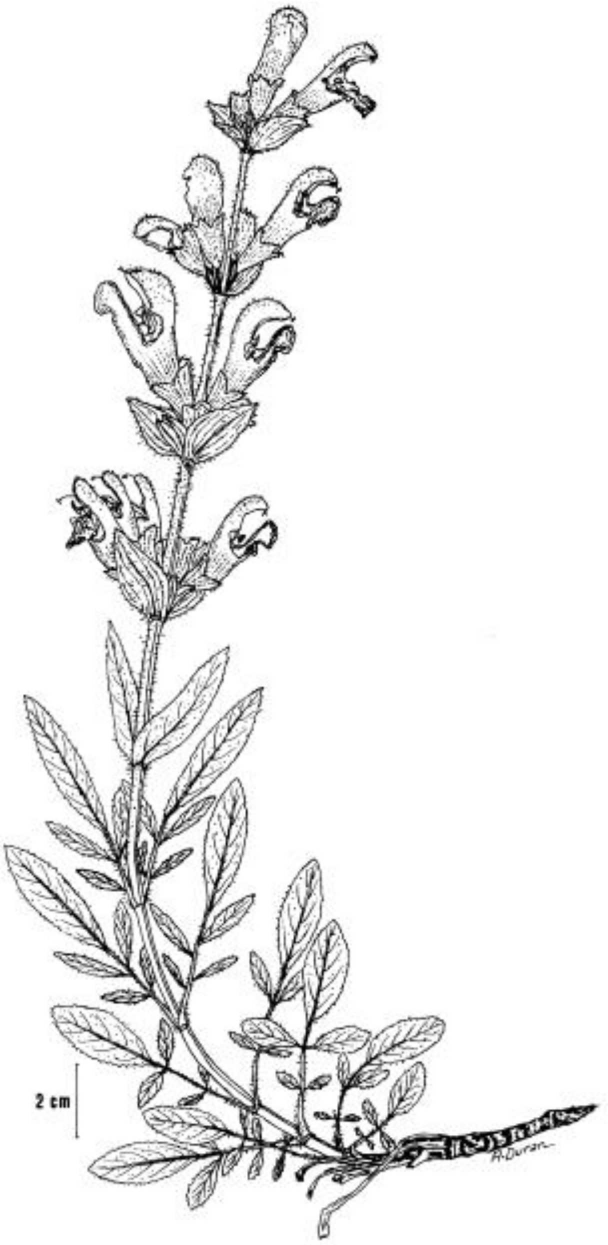

Figure 2. *Salvia anatolica*, a species endemic to East Anatolia, Turkey (Modified from Hamzaoğlu, Duran & Pınar, 2005).

and the ovary onto the pedicel. The apices of the upper and lower lips of the calyx are often toothed. Like the calyx, the corolla is gamopetalous and bilabiate, with a two-lobed upper lip and a three-lobed lower lip. The upper lip may be falcate or erect with regards to the posture of the corolla tube. The proportions of the upper lip, lower lip and corolla tube relative to each other are variable among species. The corolla exhibits a wide spectrum of colors, ranging from white to yellow to blue to purple to pink and sometimes red. Red flowers are existent only in New World species. The corolla tube also possesses morphological traits that vary among species. A ring of hairs, or an annulus, may be present inside the tube to hold the maturing fruits within the flower. The tube may also be swollen in the middle, contain a squamula, or be invaginated near the base. These features all aid in the process of pollination. A style and two stamens are present, largely hidden beneath the upper lip of the corolla. The elongated style ends in a bifid stigma, and rises from between the four ovules attached to the nectar disk. The ovary is superior, 2-carpellate, 4-ovulate and 4-lobed. The fruits are achenes, and referred to as nutlets. Nutlets differ among species in color, from brown to black, shape and the type of mucilage produced upon wetting. During the fruiting stage of the individual, the calyx of some species considerably inflates, with widely diverging lips, until it is broadly influndibuliform. In some species, the upper lip becomes recurved during fruiting or after the corolla abscises. In addition, the calyx also withers to become easily detached, thus playing an important role in seed dispersal by wind. The filaments of the two stamens are histologically fused to the corolla near the throat. Each stamen is weakly attached to an elongated connective leading to an anther at each end. The thecae of the anterior connective arms produce fertile pollen that dehisce longitudinally. On the other hand, the thecae of the posterior connective arms bear sterile pollen and physically block access to the nectar disk (Figure 3) (Hedge, 1982a; Kubitzki and Kadereit, 2004; Glimn-Lacy and Kaufman, 2006; Dufresne, 2015).

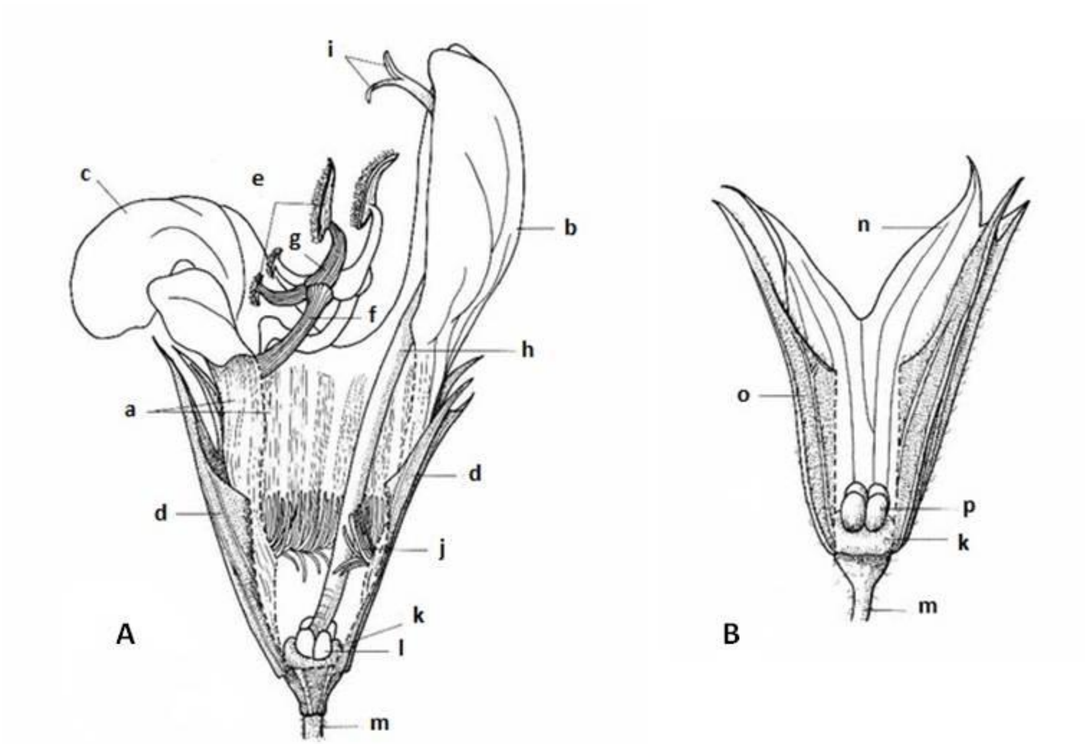

Figure 3. Cross-sections of a *Salvia officinalis* flower (A) and fruiting calyx (B). **a**: corolla tube; **b**: upper lip of the corolla; **c**: lower lip of the corolla; **d**: calyx; **e**: anther thecae; **f**: filament; **g**: staminal connective; **h**: style; **i**: stigma; **j**: annulus; **k**: nectar disk; **l**: ovules; **m**: pedicel; **n**: upper lip of the calyx; **o**: lower lip of the calyx; **p**: nutlets (Modified from Glimn-Lacy and Kaufman, 2006).

In essence, *Salvia* is distinguished from other genera within Lamiaceae by having its two posterior stamens aborted, forming staminodes, and an elongated staminal connective separating the thecae of the two anterior stamens (Hedge, 1982a). It is the elongated and rotating staminal connective that allows the formation of the staminal lever mechanism for animal pollination in this genus. The visiting insect or bird searching for nectar reaches for the throat of the corolla tube and pushes the posterior connective arms backwards. This creates a lever mechanism as the anterior connective arms are consequently pushed forwards. In the process, the anthers of the anterior stamens dust off pollen onto the animal’s head, beak or back.

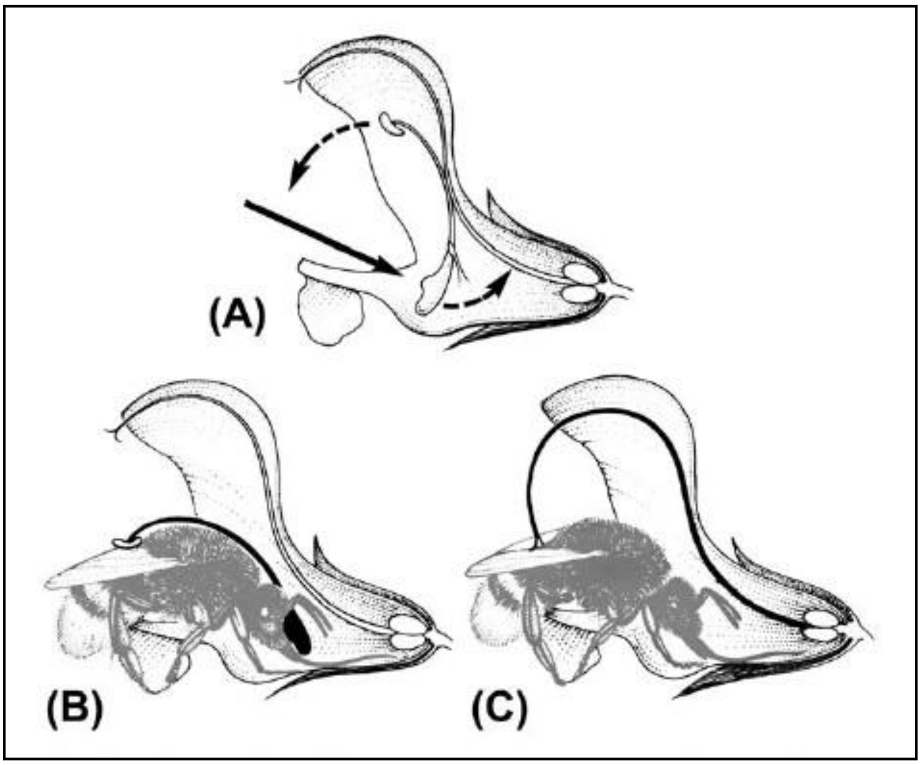

Figure 4. Illustration of pollen transfer by a bee. **(A)** Longitudinal section of a flower showing one of the lever-like stamens and the style in its position at the beginning of anthesis; dashed lines indicate the movement of the plate-like posterior theca and the anterior theca upon contact of the pollinator, indicated by the arrow. **(B)** A bee probing for nectar in a young flower pushes the posterior thecae back, thus triggering pollen deposition onto its back. **(C)** Upon visitation to an older flower in which the style restricts the position of the stamens (not drawn), the bee deposits the carried pollen onto the stigma (Claßen-Bockhoff et al., 2004).

During a subsequent visit to another flower of the same species, the pollinator can then transfer the carried pollen onto the stigma (Figure 4) (Claßen-Bockhoff et al., 2004). Bird-pollinated species are only present in the New World, South Africa and Madagascar. Some species of *Salvia* have deciduous bracts during anthesis or large and colored bracts, or even have a coma of conspicuous bracts at the apex of the inflorescence that do not subtend flowers. The calyces of some species are also brightly colored. These morphological features add significantly to the floral display for pollinator attraction (Hedge, 1974; Will and Claßen-Bockhoff, 2014; Dufresne,2015).

The staminal levers exhibit a wide range of morphology among species of *Salvia* (Claßen-Bockhoff, Wester & Tweraser, 2003; Claßen-Bockhoff et al., 2004). According to Hedge (1982a) in the *Flora of Turkey and the East Aegean Islands*, *Salvia* possesses three different types of stamen morphologies: (1) both anterior and posterior thecae are well-formed and bear fertile pollen, though the posterior thecae are smaller, and the staminal connectives are more or less equal in length to the filaments; (2) the posterior thecae are sterile, forming a flattened dolabriform connivent to each other, and the staminal connectives are clearly longer than the filaments; and (3) the posterior thecae have been completely aborted with a tapering

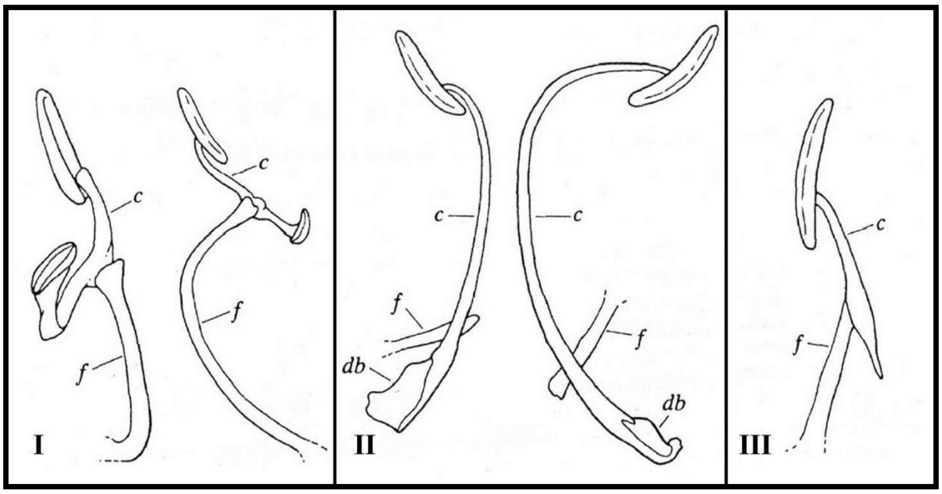

Figure 5. Stamen types as recognized by Hedge in the *Flora of Turkey and the East Aegean Islands*: stamens of type A **(I)**, stamens of type B **(II)**, and stamen of type C **(III)**. **f**: filament; **c**: staminal connective; **db**: dolabriform sterile tissue (Modified from Hedge, 1982a).

connective arm, the staminal connectives longer than the filaments, and the stamens not articulating at the junction of the filament and connective. These different stamen types were given the names of type A, type B, and type C, respectively (Figure 5).

1.3 The Infrageneric Treatment of *Salvia* L.

Etlinger (1777) produced the first botanical monograph of the genus *Salvia* in *Commentatio Botanico-medica de Salvia*, where he recognized 48 species in the world. Bentham (1832-1836; 1848; 1876) then provided the last worldwide monographic revision of the genus. His works in *Labiatarum et species, Prodromus systematics naturalis regni vegetabilis*, and *Genera Plantarum* remain the most comprehensive and most widely accepted despite the tremendous increase in the number of species within the genus since his time (El-Gazzar and Watson, 1970; Walker et al., 2004). His infrageneric treatment of *Salvia* was based heavily on floral morphology, delimiting the genus into 12 sections within 4 subgenera (Bentham, 1832-1836; 1876). After Bentham, several taxonomic treatments followed in publications of various systematists. Most notably, Boissier (1879) in the *Flora Orientalis* made some modifications to Bentham's infrageneric treatment, recognizing and elaborately describing 8 of the 12 sections (Table 1). Briquet (1895) in *Pflanzenfamilien* gave a more recent but not a monographic account of the genus. Stibal revised the Chinese species in 1934 and the Indian species in 1936 (Hedge, 1974). Pobedimova (1954) in the *Flora of the U.S.S.R.* proposed alternative 7 subgenera, 8 sections and 24 consecutive series. El-Gazzar and Watson (1968) conducted a numerical analysis for the revision of *Salvia* using morphological characters. They confirmed the existence of the traditional subgenera and sections, and concluded that *Salvia* can be discretely separated into Old World and New World groups.

Table 1. Infrageneric classifications of *Salvia* by Bentham (1876) and Boissier (1879).

Bentham (1876)		**Boissier (1879)**	
Subgenus *Salvia*	Corolla annulate; posterior anther thecae bearing a sterile cell or rarely fertile pollen, ends subconnected or approximating; species Old World.		
Section *Eusphace* Benth.	Suffruticose or rarely herbaceous; fruiting calyces toothed and scarcely accrescent; corolla upper lip more or less straight-hooded.	Section *Eusphace* Benth.	Corolla tube annulate, upper lip more or less straight; posterior anther thecae bearing fertile pollen; fruiting calyces scarcely or not accrescent.
Section *Hymenosphace* Benth.	Suffruticose or rarely herbaceous; fruiting calyces membranous and broadly accrescent; corolla upper lip straight in Oriental species and falcate-compressed in Southern African species.	Section *Hymenosphace* Benth.	Corolla tube annulate, upper lip more or less straight; posterior anther thecae bearing fertile pollen; fruiting calyces membranous and broadly accrescent, recurved, and obsoletely tridentate.
Section *Drymosphace* Benth.	Herbs often glutinous; fruiting calyces barely toothed; corolla upper lip falcate-compressed.	Section *Drymosphace* Benth.	Corolla annulate, upper lip falcate-compressed; posterior anther thecae bearing fertile pollen; fruiting calyces scarcely or not accrescent.
Subgenus *Sclarea*	Corolla exannulate; posterior anther thecae deflexed, abruptly dilating and bearing a callous; species Old World; herbaceous.		
Section *Horminum* Benth.	Calyx tubular, upper lip truncate, obsoletely toothed; corolla upper lip straight-hooded; annual herbs.	Section *Horminum* Benth.	Corolla exannulate, upper lip straight-hooded; posterior anther thecae deflexed, abruptly dilating and bearing a callous; calyx tubular, upper lip truncate, remotely bidentate, obsoletely tridentate.

Table 1 (cont'd)

Bentham (1876)		**Boissier (1879)**	
Section *Aethiopis* Benth.	Calyx campanulate or tubular, upper lip 3-dentate, teeth erect or barely connivent, median tooth often reduced; corolla upper lip falcate-compressed.	Section *Aethiopis* Benth.	Corolla tube exannulate, upper lip more or less falcate-compressed; posterior anther thecae deflexed, abruptly dilating and bearing a callous; calyx campanulate, upper lip concave-tridentate.
Section *Plethiosphace* Benth.	Calyx oviform, upper lip concave-bisulcate with 3 short connivent teeth; corolla upper lip straight-hooded or falcate-compressed.	Section *Plethiosphace* Benth.	Corolla exannulate, upper lip straight or falcate-compressed; posterior anther thecae deflexed, abruptly dilating and bearing a callous; calyx ovate, upper lip concave-bisulcate, teeth shortly connivent.
Subgenus *Calosphace*	Corolla exannulate, sometimes 2-dentate near the base; posterior anther thecae bearing sterile or rarely fertile pollen, forming a gubernaculum; species New World.		
Section *Calosphace* Benth.	Calyx ovoid-tubular or ovoid-campanulate, upper lip entire or shortly tridentate, middle tooth larger; corolla upper lip straight-hooded; suffruticose.		

Table 1 (cont'd)

Bentham (1876)		**Boissier (1879)**	
Subgenus *Leonia*	Corolla annulate; posterior anther thecae bearing a sterile cell or fertile pollen, or arms tapering; herbs Old World or boreal-American.		
Section *Echinosphace* Benth.	Bracts spinescent; calyx upper lip lip tridentate, lower lip bidentate, teeth spinescent; posterior anther thecae bearing fertile pollen; verticillasters dense; species Californian.		
Section *Pycnosphace* Benth.	Bracts not spinescent; calyx upper lip tridentate, lower lip bidentate, teeth subulate; posterior anther thecae bearing fertile pollen; species Californian and Mexican.		
Section *Heterosphace* Benth.	Bracts deciduous; calyx upper lip truncately 3-dentate; posterior anther thecae bearing fertile pollen; species southern African, boreal-Oriental and boreal-American		
Section *Notiosphace* Benth.	Bracts small or inconspicuous; calyx upper lip entire or minutely 3-dentate, teeth connivent; posterior anther thecae bearing fertile or sterile pollen or arms shortly tapering; species frequently Asian, Mediterranean and subtropical Australian.	Section *Eremosphace* Bge.	Corolla exannulate, upper lip straight; posterior anther thecae distant and bearing fertile pollen; calyx ovate or tubular-campanulate, upper lip tridentate.
Section *Hemisphace* Benth.	Bracts small; calyx upper lip 3-dentate; posterior staminal arms tapering; species Central European, Australian and W. Asian.	Section *Hemisphace* Benth.	Corolla annulate, upper lip falcate; posterior staminal arms shortly tapering.

While Hedge (1972) in the *Flora Europaea* recognized Bentham's sections and moreover changed the name of sect. *Eusphace* Benth. into sect. *Salvia*, he did not later agree on their legitimacy, criticizing these traditional groupings as "outdated" (Hedge, 1982a). In his treatment of *Salvia* in the *Flora Iranica*, Hedge (1982b) quoted, "…my own experience of the genus in Asia and Africa has led me to believe that the only natural supra-specific categories are 'species-groups' – that is, often small, not infrequently monotypic groups of clearly related species. Above this level the categories become increasing artificial." Consequently, Hedge's works on *Salvia* after the *Flora Europaea* (including *Flora Iranica*, *Flora of Turkey and the East Aegean Islands*, and *Flora of Cyprus*) constitute an infrageneric classification system of small, numerous species-groups. Hedge, however, left out the New World species from his inferences (Hedge, 1972).

The infrageneric treatment of the New World *Salvia* continued with Epling after Bentham. Epling (1938, 1939) revised Bentham's (1876) subgenus *Calosphace*, in which all species are confined to the New World, and recognized around 470 species based on floral characters and biogeography. However, he did not, like Hedge, recognize Bentham's infrageneric sections, and instead delimited the New World taxa into 91 species groups which he formally described as sections. Soon after, in a series of 10 subsequent publications, Epling expanded both the number of species to over 500 and sections to 102. The only comprehensive treatment of subgenus *Calosphace* since Bentham is Epling's monographic revision to date, although a few numbers of taxonomic revisions and preliminary molecular phylogenetic analyses have been performed to contribute to the understanding of the subgenus (Jenks, Walker & Kim, 2013).

Hedge's 1974 work on *Salvia* in *A revision of Salvia in Africa including Madagascar and the Canary Islands* was based almost entirely on "a considerable number of [herbarium] sheets." After the extensive study on African species and also Asian species from previous works, Hedge noticed the genus' greatly diverse staminal, floral and vegetative morphologies, and postulated that the diversity must be related to its pollination biology, in which at the time was known nothing about. Pollinator-plant interaction studies have shown that populations of *Salvia* possess a large range of flower visitors, from insects to birds. According to Claßen-Bockhoff et al. (2004), it is the staminal lever mechanism that has led to *Salvia*'s adaptive radiation as to its pollinator spectrum, allowing the coexistence of sympatric species that have overlapping phenologies and pollinator species. The significance of the staminal lever mechanism to the reproductive biology of the genus was first described in 1793 by Sprengel, and has since received considerable attention. *Salvia* is one of the few genera of angiosperms to have the unusual staminal lever mechanism, which allows for nototribic pollination to occur. Through field investigations and biomechanical studies, it has been found that the staminal levers are constructed to be easily triggered by flower visitors, and that the process of pollen deposition is dependent on the size and shape of the flower in relation to the pollinator. As a result, the staminal lever mechanism tends to cause reproductive isolation among sympatric populations, as variations in floral architecture can facilitate pollen deposition on specific parts of the pollinators' bodies. Hybridization between two different species is not uncommon in *Salvia*, as the genus lacks any form of genetic incompatibility but instead relies on the degree of polyandry, male sterility, inflorescence size and density, phenology and the length of stay of a pollinator within an individual plant. Therefore, populations of *Salvia* are more versatile to change pollinators according to the temporal and spatial variation in pollinator quality in their environment, consequently contributing to an increase in individual fitness, rate of outcrossing due to pollen partitioning, and evolutionary specialization (Claßen-Bockhoff et al., 2003; 2004).

As the genus *Salvia* is uniquely separated from other members of its tribe Mentheae by having 2 stamens instead of 4 connected by an elongated connective, it has long been assumed that the staminal lever mechanism had evolved only once within the lineage. However, two studies by Walker et al. (2004) and Walker and Systma (2007) on the molecular phylogeny of subfamily Nepetoideae, which has satisfactorily been presented to be a monophyletic group, and tribe Mentheae, respectively, have shown that the staminal lever mechanism had actually evolved three times independently in parallel, so that *Salvia* is a paraphyletic genus. Based on the authors' studies, the "*Salvia* clade" is the least inclusive clade which consists of their examined species of *Salvia* and the genera *Perovskia* Kar., *Rosmarinus* L., *Meriandra* Benth., *Dorystaechas* Boiss. & Heldr. ex Benth. and *Zhumeria* Rech. f. & Wendelbo of tribe Mentheae. Furthermore, the genera *Lepechinia* Willd. and *Melissa* L. are likely sister genera to the "*Salvia* clade." Within the "*Salvia* clade," three major *Salvia* clades have been recognized (Figure 6):

Salvia clade I: Includes all members of subg. *Sclarea* and subg. *Leonia*, and some Old World and New World members of subg. *Salvia*. *Rosmarinus* and *Perovskia* are sister groups to this clade.

Salvia clade II: Includes all members of subg. *Calosphace* and sect. *Audibertia*. Section *Audibertia* was previously treated as a separate genus by Bentham (1876). *Dorystaechas* and *Meriandra* are sister groups to this clade.

Salvia clade III: Includes all members of East Asian species belonging to sect. *Drymosphace*. *Zhumeria* is included within this clade, which implies that *Salvia* clade III could either be monophyletic or a paraphyletic group leading to *Salvia* clade II. The first lineage of *Salvia* consists of West Asian and North African species, while the second lineage consists of Mediterranean and East Asian species.

The authors' results show that the "*Salvia* clade" represents the shared trait of the abortion of two stamens, demonstrating that "staminal morphology is the major defining character in *Salvia*, as well as being integral to the current subgeneric organization of the genus" (Walker et al., 2004; Walker and Systma, 2007). Walker and Systma (2007) further examined the evolution of staminal morphology within

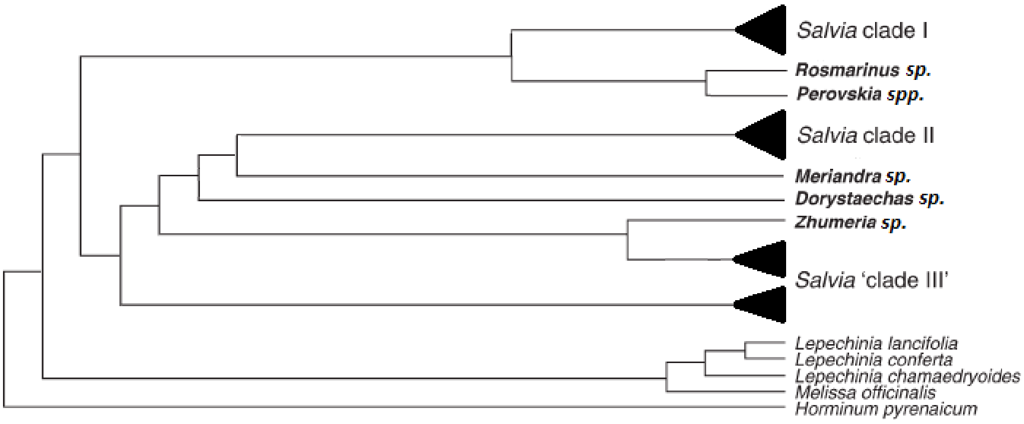

Figure 6. Phylogenetic tree of *Salvia sensu lato* defining the major clades. Strict consensus tree of the combined cpDNA *trnL-F* and nrDNA ITS data. Non-*Salvia* taxa are in bold (Simplified from Walker and Systma, 2007).

tribe Mentheae. Using the results of their molecular phylogenetic analyses, they have identified nine distinct types of staminal structures expressed among species of *Salvia* clades I, II and III (Figure 7): stamens of types A and B are found within *Salvia* clade I; stamens of types E, F, G, H and I are found within the New World group of *Salvia* clade II; and stamens of types M and N are found within *Salvia* clade III. Total abortion of the posterior anther thecae occurs only in stamens of types B, E and N. The authors have also hypothesized that the latter stamen types and stamen of type H are the more evolutionarily advanced types, and that all lineages have derived from the ancestral stamen morphology of type O.

As the field of molecular phylogenetics has progressed tremendously in the past 20 years due to novel techniques and the increasing amount of publicly available phylogenetic data, it is now possible to test complex hypotheses involving phylogenetic relationships, biogeography, range expansions, vicariance and

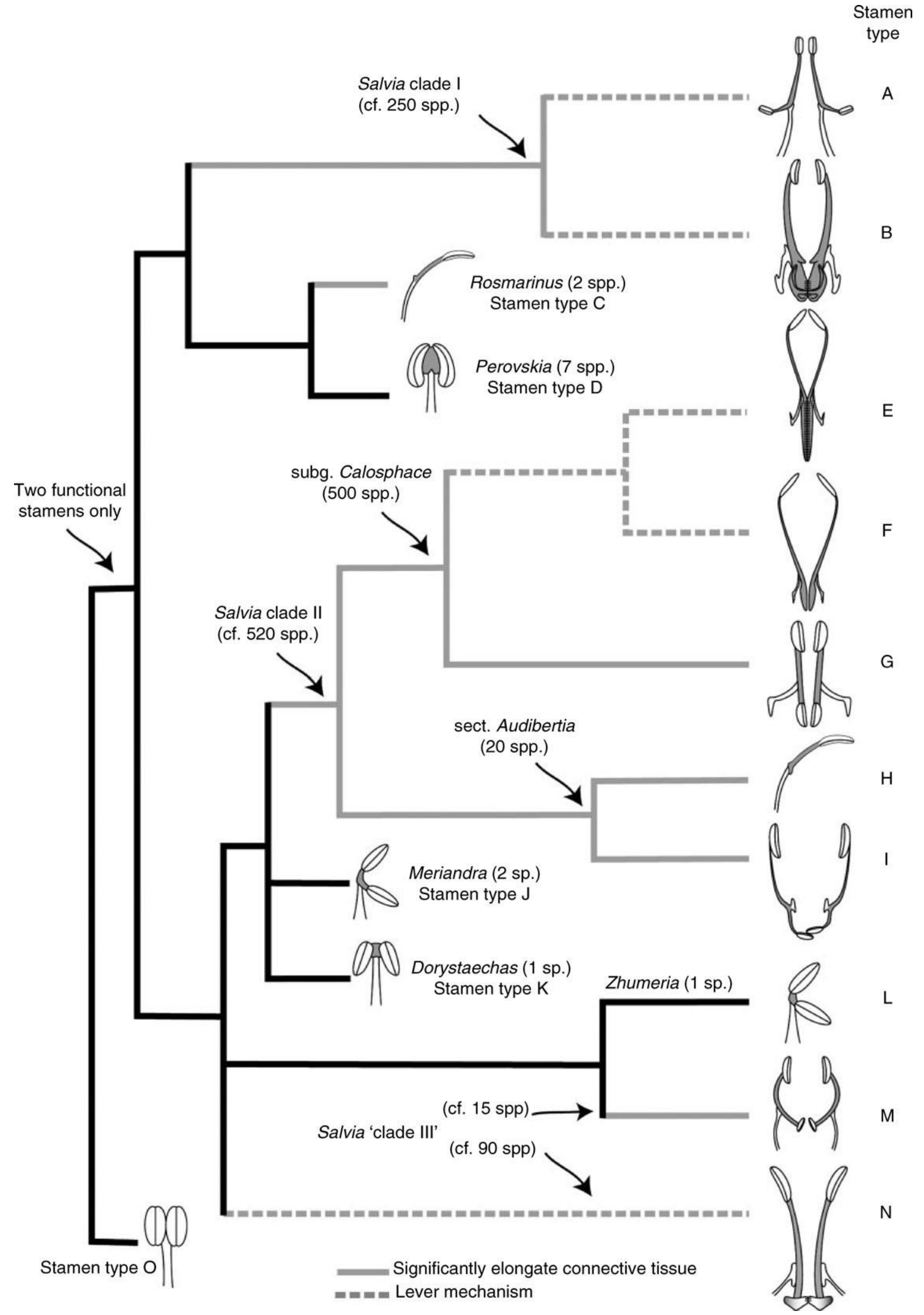

Figure 7. Representations of the stamen types found in tribe Mentheae. Species numbers were hypothesized based on subgeneric groups suggested in numerous literatures (Walker and Systma, 2007).

evolutionary transitions in traits involving groups ranging from closely related species to major lineages (Drew and Systma, 2012). Besides the recent work conducted by Walker et al. (2004) and Walker and Systma (2007), there have been several publications dealing with the molecular phylogeny (Wagstaff, Olmstead & Cantino, 1995; Wagstaff and Olmstead, 1997; Drew and Systma 2011, 2012; Jenks, Walker & Kim, 2013; Will et al., 2013; Will and Claßen-Bockhoff, 2014) and the morphological phylogeny (Wagstaff, 1992; Moon et al., 2008, 2009) of *Salvia* and tribe Mentheae. These studies have all confirmed *Salvia* to be paraphyletic as a well-supported "*Salvia* clade," with the ancestral condition in tribe Mentheae to be that of 4 stamens, and that parallel evolution has played an important part in the evolution of stamen morphology. However, the paramountcy of stamen morphology in the delimitation of the lineages was not agreed upon by Will and Claßen-Bockhoff (2014). With the aim to examine the monophyly and evolutionary origins of African species within tribe Mentheae, the authors have found that stamen morphology is actually quite variable among lineages. Four independent clades were found and described according to shared morphological features:

Clade I: Fruiting calyx expanding or not; stamens of types A, B and C; suffruticose perennials, herbaceous perennials and tall shrubs. Includes African, Circum-Mediterranean, New World, Southwest Asian, East Asian and European *Salvia* spp.

Clade II: Fruiting calyx not expanding; stamen of type B; herbaceous perennials and tall shrubs. Includes New World *Salvia*, *Meriandra* and *Dorystaechas*.

Clade III: Fruiting calyx expanding or not; stamen of type A; suffruticose perennials, dwarf shrubs and tall shrubs. Includes Southwest Asian, East African to the Arabian Peninsula *Salvia* spp. and *Zhumeria*.

Clade IV: Fruiting calyx not expanding; stamens of types A and B; herbaceous perennials. Includes East Asian *Salvia* spp.

Additionally, in a molecular phylogenetic study on tribe Mentheae, Drew and Systma (2012) argued that the evolutionary shift to two stamens within the tribe may not be causative but rather a preadaptation for the staminal lever, and that the multiple independent evolution events to the staminal lever mechanism are much more correlated with the comparatively large species numbers of *Salvia*.

Given the non-monophyly of *Salvia*, the aforementioned recent molecular and morphological studies have conclusively proposed for a subtribal recircumscription of tribe Mentheae by employing phylogenetic nomenclature and including *Rosmarinus* L., *Perovskia* Kar., *Zhumeria* Rech. f. & Wendelbo, *Dorystaechas* Boiss. & Heldr. ex Benth. and *Meriandra* Benth. within *Salvia s.l.*

1.4 *Salvia* L. in Turkey

Turkey lies at 36-42° latitude north, and is surrounded by the Mediterranean Sea, the Aegean Sea and the Black Sea. Bordered by the Taurus Mountains in the south, the Northern Black Sea Mountains in the north, and the Caucasian Mountains in the east, its irregular topography contributes to different climates in different regions on its map. Thus, the coastal areas experience milder climates while the inland Anatolian plateau endures extremes of hot summers and cold winters with limited rainfall (Turkish Meteorological Society, 2006). The World Wildlife Fund recognizes five terrestrial ecoregions in Turkey determined by climate and geology; *viz.* Mediterranean forests, woodland and scrub, temperate coniferous forests, temperate broadleaf and mixed forests, and steppes (World Wildlife Fund, 2015). Turkey, especially the Anatolian region, is one of the major centers of diversity for *Salvia* (Celep, Kahraman & Doğan, 2011). Members of the genus *Salvia* are terrestrial, distributed in all three of the phytogeographic regions of Turkey which are based on floristic differences: Irano-Turanian (represented by Central and East Anatolia), Euro-Siberian (represented by the Euxine province in North Anatolia and along the Black Sea coast), and Mediterranean (represented by the East

Mediterranean provinces of West Anatolia, the Taurus Mountains and the Amanos Mountains) (Figure 8) (Davis, 1965).

The species of *Salvia* are found in a wide diversity of habitats, reaching altitudes of 3500 m from the sea level. Habitats include dry steppes, dry meadows, fallow fields, cultivated fields, roadsides, field edges, *Quercus* and *Pinus* woodlands, broad-leaved and coniferous forests, moist deciduous forests, subalpine meadows, macchies, steep river banks, calcareous slopes, igneous slopes, serpentine slopes, gypsum slopes, screes, and sandy places, among others. Flowering times occur mostly from late-spring to early-summer, but in total range from March to October (Bagherpour, 2010; Celep, 2010; Kahraman, 2011).

The first and last comprehensive treatment of *Salvia* in Turkey was constructed by Hedge (1982a) in Davis' *Flora of Turkey and the East Aegean Islands, vol. 7*. Hedge recognized 87 species plus 1 doubtfully recorded species (*S. compressa,* which was recorded by Boissier in the *Flora Orientalis* but has not been found in Turkey to date). Subsequently, 12 new species – *S. anatolica* (Hamzaoğlu, Duran & Pınar, 2005), *S. aristata* (Behçet and Avlamaz, 2009), *S. aytachii* (Vural and Adıgüzel, 1996), *S. cerino-pruinosa* (Kahraman, Celep, Doğan & Bagherpour, 2010), *S. ekimiana* (Celep and Doğan, 2010), *S. hedgeana* (Dönmez, 2001); *S. macrosiphon* (Kahraman, Celep & Doğan, 2009), *S. marashica* (İlçim, Celep & Doğan, 2009), *S. nydeggeri* (Huber-Morath, A., 1982), *S. pseudeuphratica* (Kahraman et al., 2010), S. *siirtica* (Kahraman, Doğan & Celep, 2011), *S. viscosa* (Celep, Doğan & Duran, 2009) – , 1 new subspecies – *S. brachyantha* subsp. *tankutiana* (Bagherpour, Celep, Kahraman & Doğan, 2011) – and 2 new varieties – *S. cadmica* var. *bozkiriensis* (Celep et al., 2011), *S. sericeo-tomentosa* var. *hatayica* (Celep, Doğan, Bagherpour & Kahraman, 2009) – have been described from Turkey. Currently, the total number of species of *Salvia* in Turkey has reached 98. 53 of these species are endemic to Turkey; hence, the endemism ratio of *Salvia* in Turkey is 54% (Table 2). In addition, Turkey is one of the most important *Salvia*-producing

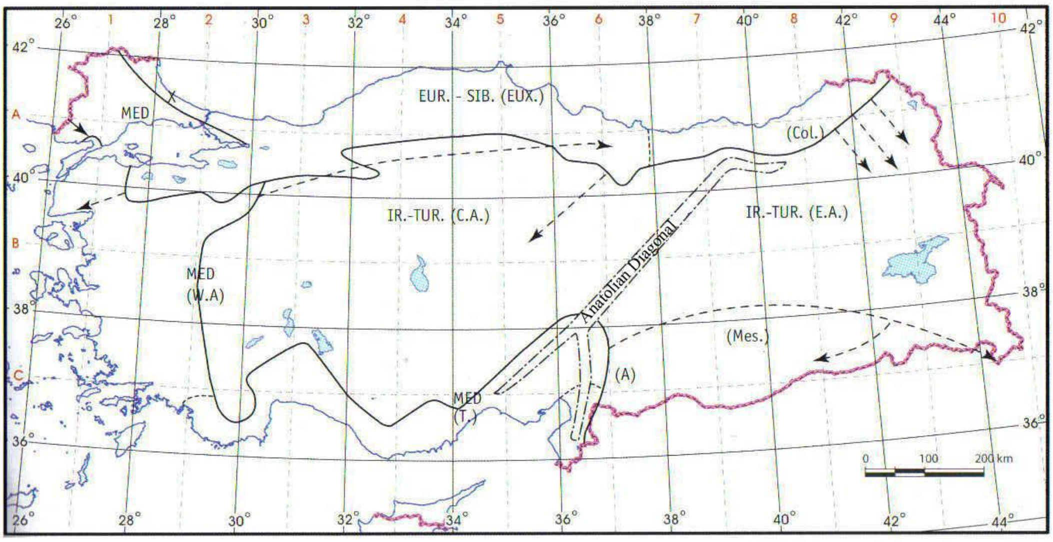

Figure 8. Phytogeographical regions of Turkey. **Eur. Sib. (Eux)**: Euro-Siberian; **Ir.-Tur.:** Irano-Turanian; **Med.:** Mediterranean; **C.A.:** Central Anatolia; **E.A.:** East Anatolia (Davis, 1971).

countries in the world; however, overharvesting of wild populations for economic purposes likely poses a risk to native populations (Engels, 2010). Principal anthropogenic threats to *Salvia* populations also include urbanization, tourism, agriculture, pollution, and road and dam constructions (Celep, Doğan & Kahraman, 2010; Kahraman et al., 2012).

Boissier (1879) in the *Flora Orientalis* recognized 75 species from Turkey and classified them into 7 sections previously recognized and named by Bentham, *viz.* sect. *Eusphace* Benth. (later sect. *Salvia* Hedge), sect. *Hymenosphace* Benth., sect. *Aethiopis* Benth., sect. *Plethiosphace* Benth., sect. *Drymosphace* Benth., sect. *Horminum* Benth., and sect. *Hemisphace* Benth. In the *Flora of Turkey and the East Aegean Islands, vol. 7*, Hedge (1982a) did not acknowledge this sectional classification of Salvia, instead assigning 21 species-groups based on morphology.

Table 2. *Salvia* species found in Turkey, and some of their ecological features. Subspecies are listed where information was available.

Taxon	**Habitat**	**Altitudinal Range (m)**	**Phenology**	**Phytogeographic Element**	**Endemism**
Salvia absconditiflora Greuter & Burdet	Rocky limestone slopes, dry steppes, fallow fields, roadsides	650-2500 m	Apr-Jul	Ir-Tur	Endemic
Salvia adenocaulon P.H.Davis	Calcareous areas	1500-2050 m	Jun-Aug	Med	Endemic
Salvia adenophylla Hedge & Hub.-Mor.	Bushy places	900-1250 m	May-Jun	Med	Endemic
Salvia aethiopis L.	Steppe, igneous and limestone slopes, fallow fields, roadside banks	1-2100 m	May-Aug	Unknown; Multi-	Non-endemic
Salvia albimaculata Hedge & Hub.-Mor.	Screes, open bushes	800-1650 m	May-Jun	Med	Endemic
Salvia amplexicaulis Lam.	Sandy places, field edges, roadsides	50-100 m	May-Jun	Eur-Sib	Non-endemic
Salvia anatolica Hamzaoglu & A.Duran	Calcareous slopes, open *Quercus* scrubs, slightly moist places	1500-1650 m	May-Jun	Ir-Tur	Endemic
Salvia aramiensis Rech.f.	*Pinus brutia* woodland rocky places	150-600 m	Mar-May	Med	Endemic
Salvia argentea L.	Limestone and igneous slopes, rock ledges, with *Pinus*	150-2000 m	Apr-Jun	Med	Non-endemic
Salvia aristata Aucher ex Benth.	Slopes in steppe	1900-2200 m	Jun-Jul	Ir-Tur	Non-endemic
Salvia atropatana Bunge	Rocky slopes in steppe, sloping meadows, fallow fields, roadsides	1245-2560 m	Jun-Jul	Ir-Tur	Non-endemic
Salvia aucheri Benth. subsp. *aucheri*	Limestone slopes, *Quercus* scrub	550-1700 m	Apr-May	Med	Endemic
Salvia aucheri Benth. subsp. *canescens*	Rocky places, *Quercus* and *Pinus* scrub	850-1600 m	Jun	Med	Endemic

Table 2 (cont'd)

Taxon	**Habitat**	**Altitudinal Range (m)**	**Phenology**	**Phytogeographic Element**	**Endemism**
Salvia aytachii M.Vural & N.Adigüzel	Steppe, marly places, gypsum soils	490-900 m	May-Jun	Ir-Tur	Endemic
Salvia ballsiana (Rech.f.) Hedge	Slopes, *Quercus* scrub, non-lime screes	1050-1220 m	May	Ir-Tur	Endemic
Salvia blepharochlaena Hedge & Hub.-Mor.	Calcareous rocks, serpentine slopes	1000-2000 m	May-Jul	Ir-Tur	Endemic
Salvia brachyantha (Bordz.) Pobed. subsp. *brachyantha*	Rocky igneous slopes, steppe, fallow fields, meadows	1050-2800 m	May-Jul	Ir-Tur	Non-endemic
Salvia brachyantha (Bordz.) Pobed. subsp. *tankutiana*	Open *Quercus*, steppe	1400-1700 m	Jun	Ir-Tur	Endemic
Salvia bracteata Banks & Sol.	Igneous and calcareous slopes, with *Quercus brantii*, fallow fields, edge of vineyards, roadsides, waste places	50-2000 m	May-Jul	Ir-Tur	Non-endemic
Salvia cadmica Boiss.	Calcareous rocks, cliffs, screes, among *Quercus* shrubs	1000-2000 m	May-Jun	Ir-Tur	Endemic
Salvia caespitosa Montbret & Aucher ex Benth.	Rocky limestone and igneous slopes, terraces, steppe	1400-2700 m	Jun-Jul	Ir-Tur	Endemic
Salvia candidissima Vahl	Rocky limestone and shale slopes, bushy places, fallow fields, amongst *Pinus*, *Quercus*, *Abies* and *Cedrus*, roadsides	700-2000 m	May-Aug	Ir-Tur	Non-endemic
Salvia cassia Sam. ex Rech.f.	Stony slopes, alluvial gravel	210-650 m	May	Med	Non-endemic
Salvia cedronella Boiss.	Bushy places	900-1250 m	May-Jun	Med	Endemic

Table 2 (cont'd)

Taxon	Habitat	Altitudinal Range (m)	Phenology	Phytogeographic Element	Endemism
Salvia ceratophylla L.	Limestone, igneous and gypsum slopes, corn and fallow fields, waste grounds	300-2250 m	Apr-Jul	Ir-Tur	Non-endemic
Salvia cerino-pruinosa Rech.f.	Road slopes, field sides, marly banks	850-1450 m	May-Jun	Ir-Tur	Endemic
Salvia chionantha Boiss.	*Quercus* scrub, fields	1000-1450 m	May-Jun	Med	Endemic
Salvia chrysophylla Stapf	Limestone slopes, grassy meadows	1300-2300 m	Jul-Aug	Med	Endemic
Salvia cilicica Boiss. & Kotschy	Limestone and granite slopes, in phrygana, among *Pinus*	750-2200 m	Jul-Sept	Med	Endemic
Salvia cyanescens Boiss. & Balansa	Limestone and igneous slopes, shale banks, *Pinus nigra* forest, gravel river beds, fallow fields, vineyards	400-2300 m	Jun-Sept	Ir-Tur	Endemic
Salvia dichroantha Stapf	Steppe, clearings in forest, fallow fields, roadsides	700-2000 m	Jun-Sept	Ir-Tur	Endemic
Salvia divaricata Montbret & Aucher ex Benth.	Limestone slopes, mountain slopes, roadsides	1030-1870 m	Jun-Jul	Ir-Tur	Endemic
Salvia ekimiana F.Celep & Dogan	Open *Pinus sylvestris* forest, alpine steppe	1700-2000 m	Jun	Ir-Tur	Endemic
Salvia eriophora Boiss. & Kotschy	Rocky igneous and limestone slopes	1525-1900 m	May-Jun	Ir-Tur	Endemic
Salvia euphratica Montbret & Aucher ex Benth.	Gypsum areas, calcareous slopes, marly banks, river shingle, roadsides and limestone slopes with *Quercus* scrubs	850-1180 m	Apr-Jun	Ir-Tur	Endemic

Table 2 (cont'd)

Taxon	**Habitat**	**Altitudinal Range (m)**	**Phenology**	**Phytogeographic Element**	**Endemism**
Salvia forskahlei L.	Broad-leaved and coniferous forest, meadows, steep banks	10-1900 m	May-Sept	Eur-Sib	Non-endemic
Salvia freyniana Bornm.	Dry sandy calcareous slopes	900-1200 m	May-Jun	Ir-Tur	Endemic
Salvia frigida Boiss.	*Pinus nigra, Juniperus, Abies* and *Pyrus* woodland, limestone slopes and crevices, meadows	1000-2500 m	May-Jul	Ir-Tur	Non-endemic
Salvia fruticosa Mill.	Macchie or phrygana, among limestone rocks	1-700 m	Mar-May	Med	Non-endemic
Salvia glutinosa L.	Moist places in deciduous (*Fagus, Alnus, Corylus*) forest, scrub, *Picea* forests	780-2360 m	Jul-Oct	Eur-Sib	Non-endemic
Salvia halophila Hedge	Salt steppe	950-1100 m	Jul-Oct	Ir-Tur	Endemic
Salvia haussknechtii Boiss.	Rocky places	2135-2660 m	Jun-Jul (?)	Med	Endemic
Salvia hedgeana Dönmez	Limestone slopes, marly places	1200-1600 m	May-Jun	Ir-Tur	Endemic
Salvia heldreichiana Boiss. ex Benth.	Limestone slopes, with *Pinus nigra* and *Quercus* screes, fieldsides	900-2000 m	Jun-Jul	Med	Endemic
Salvia hydrangea DC. ex Benth.	Rocky limestone and igneous slopes, soil slopes, with *Pinus sylvestris*	1100-2200 m	May-Aug	Ir-Tur	Endemic
Salvia hypargeia Fisch. & Mey.	Dry rocky volcanic, sandy and limestone slopes, mountain steppe, pastures, roadsides	600-2000 m	May-Aug	Ir-Tur	Non-endemic

Table 2 (cont'd)

Taxon	**Habitat**	**Altitudinal Range (m)**	**Phenology**	**Phytogeographic Element**	**Endemism**
Salvia huberi Hedge	Limestone slopes and banks, with *Pinus brutia*, fallow fields	800-2000 m	Jun-Jul	Ir-Tur	Endemic
Salvia indica L.	Rocky limestone slopes, moist places, in *Quercus* scrub	100-1500 m	Apr-May	Ir-Tur	Non-endemic
Salvia kronenburgii Rech.f.	Shale hills, step igneous slopes	1800-2600 m	Jun-Jul	Ir-Tur	Endemic
Salvia kurdica Boiss. & Hohen. ex Benth.	Limestone cliffs	ca. 900 m	May	Ir-Tur	Non-endemic
Salvia limbata C.A.Mey.	Stony slopes, steppe, sandy loam, roadsides, cornfields	1060-2340 m	Jul-Aug	Ir-Tur	Non-endemic
Salvia longipedicellata Hedge	Disturbed steppe, meadows, fallow fields	1480-2110 m	Jun-Aug	Ir-Tur	Endemic
Salvia macrochlamys Boiss. & Kotschy	Rocky mountain slopes	850-1700 m	Apr	Med	Endemic
Salvia macrosiphon Boiss.	Rocky limestone slopes, open slopes, in *Quercus* scrub	900-2400 m	Jun-Aug	Ir-Tur	Non-endemic
Salvia marashica A.İlçim, F.Celep & Dogan	Edges of fields	759 m	May-Jun	Ir-Tur	Non-endemic
Salvia microstegia Boiss. & Balansa	Rocky limestone and igneous slopes, screes, in *Quercus*, *Pinus* woodland, fleldside	970-3350 m	Jun-Aug	Ir-Tur	Non-endemic
Salvia modesta Boiss.	Calcareous and igneus slopes	1700-2200 m	Jun-Aug	Ir-Tur	Endemic
Salvia montbretii Benth.	Calcareous slopes, in *Quercus brantii* scrub, fallow fields, vineyards	700-1150 m	May	Ir-Tur	Non-endemic

Table 2 (cont'd)

Taxon	Habitat	Altitudinal Range (m)	Phenology	Phytogeographic Element	Endemism
Salvia multicaulis Vahl	Rocky limestone and igneous slopes, shale and sandy slopes, screes, fallow fields, in *Quercus* scrub, *Artemisia* steppe	550-2600 m	Apr-Jul	Ir-Tur	Non-endemic
Salvia napifolia Jacq.	Rocky slopes, *Quercus cocciferae* macchie, *Poteridium* phrygana, roadsides	1-1000 m	Apr-Jul	Med	Non-endemic
Salvia nemorosa L.	Rocky slopes in steppe, fallow fields, sloping meadows, waste ground	1000-2830 m	Apr-Sept	Ir-Tur	Non-endemic
Salvia nutans L.	Meadows	89 m	May	Eur-Sib	Non-endemic
Salvia nydeggeri Hub.-Mor.	Screes, bushy places	1000-1465 m	Jun-Jul	Med	Endemic
Salvia odontochlamys Hedge	Sloping meadows, near melting snow	2100-2280 m	Jun-Jul	Ir-Tur	Endemic
Salvia pachystachys Trautv.	Rocky and stony limestone and igneous slopes, screes, subalpine pastures	1200-3200 m	May-Jul	Ir-Tur	Non-endemic
Salvia palaestina Benth.	Limestone and igneous rocky slopes, cliffs, in *Quercus* scrub, vineyards, fallow fields	300-1510 m	May-Jul	Ir-Tur	Non-endemic
Salvia pilifera Montbret & Aucher ex Benth.	Limestone slopes, in *Quercus* scrub, among bushes, macchie	200-2300 m	Apr-May	Ir-Tur	Endemic
Salvia pinnata L.	Cornfields, fallow fields, dry meadows	1-1060 m	Mar-May	Med	Non-endemic

Table 2 (cont’d)

Taxon	Habitat	Altitudinal Range (m)	Phenology	Phytogeographic Element	Endemism
Salvia pisidica Boiss. & Heldr. ex Benth.	*Quercus coccifera* macchie, dry limestone slopes, fieldsides	900-1950 m	May-Jun	Med	Endemic
Salvia poculata Nábelek	Rocky limestone and igneous slopes, sloping meadows, near melting snow	1400-2900 m	May-Jul	Ir-Tur	Non-endemic
Salvia pomifera L.	Rocky slopes, limestone cliffs, macchie	100-800 m	Apr-May	Med	Non-endemic
Salvia potentillifolia Boiss. & Heldr. ex Benth.	Dry rocky slopes, *Quercus coccifera* macchies, under *Pinus brutia*	900-1700 m	Jun-Jul	Med	Endemic
Salvia pseudeuphratica Rech.f.	Calcareous rocks, stony slopes, roadsides	750-900 m	May-Jun	Ir-Tur	Endemic
Salvia quezelii Hedge & Afzal-Rafii	Calcareous rocks	750-1100 m	May-Jun	Med	Endemic
Salvia recognita Fisch. & Mey.	Limestone and igneous slopes and screes in steppe, *Quercus* scrubs	900-2200 m	May-Aug	Ir-Tur	Endemic
Salvia reeseana Hedge & Hub.-Mor.	Igneous and calcareous slopes, fieldsides	700-1400 m	Unknown	Ir-Tur	Endemic
Salvia rosifolia Sm.	Rocky limestone and igneous slopes, loamy hills and in *Quercetum* screes and fieldsides	500-2350 m	May-Aug	Ir-Tur	Endemic
Salvia russellii Benth.	Rocky slopes, grassy meadows amongst *Quercus*, fallow and cultivated fields	100-1600 m	Mar-Jul	Ir-Tur	Non-endemic
Salvia sclarea L.	Rocky igneous slopes, mixed deciduous and coniferous woodland, shale banks, fields, roadsides	1-1200 m	May-Aug	Unknown; Multi	Non-endemic

Table 2 (cont'd)

Taxon	Habitat	Altitudinal Range (m)	Phenology	Phytogeographic Element	Endemism
Salvia sericeo-tomentosa Rech.f.	Open *Pinus*, macchie	10-1000 m	Apr-May	Med	Endemic
Salvia siirtica Kahraman, Celep & Doğan	Open forests of *Quercus*	1450-1500 m	May-Jun	Ir-Tur	Endemic
Salvia smyrnaea Boiss.	Calcareous rocks, open *Pinus* forest	900-1510 m	May	Med	Endemic
Salvia spinosa L.	Marly steppe, edge of fallow fields, vineyards	300-900 m	May-Jun	Ir-Tur	Non-endemic
Salvia staminea Montbret & Aucher ex Benth.	Limestone and igneous rocky slopes, cliffs, screes, in *Quercus* scrub, alpine meadows	1700-3150 m	May-Aug	Ir-Tur	Non-endemic
Salvia suffruticosa Montbret & Aucher ex Benth.	Banks in steppe, fallow fields, vineyards	300-2000 m	Apr-Jun	Ir-Tur	Non-endemic
Salvia syriaca L.	Steppe, marly banks, fallow, cultivated fields	350-2200 m	Apr-Jun	Ir-Tur	Non-endemic
Salvia tchihatcheffii (Fisch. & Mey.) Boiss.	Steppe, limestone slopes, *Pinus* woodland	400-1200 m	May-Jun	Ir-Tur	Endemic
Salvia tigrina Hedge & Hub.-Mor.	Within macchie, hedges	800 m	May-Jun	Med	Endemic
Salvia tobeyi Hedge	Subalpine meadows, grassy slopes	1700-2100 m	Jun	Eur-Sib	Endemic
Salvia tomentosa Mill.	Often associated with *Pinus brutia*, *P.nigra* and *Quercus pubescens*, in macchie, on limestone or igneous slopes	90-2000 m	Apr-Jun	Med	Non-endemic
Salvia trichoclada Benth.	Rocky limestone slopes, stream, steppe, *Quercus* scrub, grassy places, fallow fields	300-2440 m	May-Jul	Ir-Tur	Non-endemic
Salvia verbenaca L.	Banks, in *Quercus* macchie, deciduous woodland, road- and fieldsides	1-900 m	Mar-May	Med	Non-endemic
Salvia vermifolia Hedge & Hub.-Mor.	Igneous and serpentine slopes	1450 m	Jun-Jul	Ir-Tur	Endemic

Table 2 (cont'd)

Taxon	Habitat	Altitudinal Range (m)	Phenology	Phytogeographic Element	Endemism
Salvia verticillata L. subsp. *amasiaca*	A wide variety of habitats including rocky slopes, *Stipa* steppe, sandy banks, meadows, *Quercus* and *Pinus* woods, fields and roadsides	20-2300 m	May-Sept	Ir-Tur	Non-endemic
Salvia verticillata L. subsp. verticillata	A wide variety of habitats including *Pinus*, *Quercus*, *Fagus* and *Corylus* woods, meadows, gravel beds and roadsides	1-2400 m	Jun-Aug	Eur-Sib	Non-endemic
Salvia virgata Jacq.	Scrub, woodland, meadows, fallow fields, roadsides	1-2300 m	May-Sept	Ir-Tur	Non-endemic
Salvia viridis L.	Rocky slopes, macchie with *Cistus* phrygana, sand-dunes, fields and waste grounds	1-1300 m	Mar-Jul	Med	Non-endemic
Salvia viscosa Jacq.	Open *Laurus nobilis* and *Pinus*	1000 m	Jun-Jul	Ir-Tur	Non-endemic
Salvia wiedemannii Boiss.	Central Anatolian steppe, in *Artemisia*, roadsides, fieldsides	500-1400 m	May-Jul	Ir-Tur	Endemic
Salvia xanthocheila Boiss. ex Benth.	Rocky igneous slopes, steppe	2000-2870 m	May-Jul	Ir-Tur	Non-endemic
Salvia yosgadensis Freyn & Bornm.	*Quercus* scrub, disturbed steppe, fields	800-1635 m	May-Jun	Ir-Tur	Endemic

1.5 Objectives of the Study

Since Bentham's (1832-36, 1848, 1876) proposed subgeneric and sectional delimitation of *Salvia* L., there have been disputes among systematists on the genus' infrageneric boundaries. In the *Flora of Turkey and the East Aegean Islands, vol. 7*, Hedge (1982a) failed to recognize the traditional subgenera and sections within *Salvia*, but instead assigned multiple species-groups. Moreover, molecular and morphological phylogenetic studies since the beginning of the 21st century have confirmed the non-monophyly of the genus. Currently, there is a lack of a comprehensive infrageneric treatment of *Salvia* in the world and in Turkey. Therefore, the objectives of this study are to construct and propose a more natural infrageneric classification of the genus *Salvia* in Turkey by using the numerical taxonomic approach developed by Sneath and Sokal (1973) based on macromorphological characters.

CHAPTER 2

MATERIALS AND METHODS

2.1 Numerical Taxonomy

Numerical taxonomy is a method of classification based on the numerical analysis of the variation in a great number of phenotypic characters among a group of organisms. It ultimately creates a taxonomic structure by calculating the overall similarities between each pair of organisms in the study using the phenetic information provided, and before any comparative analyses can be done between organisms, the information must first be converted into numerical quantities. Since numerical taxonomy is an approach of phenetic classification, it does not make any attempts to reflect evolutionary relationships (Stuessy, 2009).

The method is based on the ideas of Adanson (1763), who proposed that a classification system must be based on a very large range of characters encompassing all features of the organism, and that all of these characters must be given equal importance or weight. Later, in the 1960's and 1970's, when the easy accessibility of computers allowed for the development and wide use of statistical software, numerical taxonomy was purported to be a new field of systematics using statistical and computer techniques to overcome the difficulties and subjectivity of conventional taxonomy (particularly those of lumpers vs. splitters in phyletic classification). Sneath and Sokal in *Principles of Numerical Taxonomy* (1963) and *Numerical Taxonomy: the Principles and Practice of Numerical Classification*

(1973) meticulously and eloquently summarized the general aims and statements of the method, subsequently popularizing it among systematists (Stuessy, 2009). According to Sneath and Sokal (1973), numerical taxonomy “aims to develop methods that are objective, explicit and repeatable, both in the evaluation of taxonomic relationships and in the erection of taxa.” The authors have thus put forward the seven fundamental principles of numerical taxonomy:

1. The greater the content of information in the taxa of a classification and the more characters on which it is based, the better a given classification will be. A character here is defined as a feature of an organism that is divisible into at least two conditions.
2. Every character is of equal weight or importance in creating natural taxa.
3. Overall similarity between any two entities of organisms is a function of their individual similarities in each of the many characters in which they are being compared.
4. Distinct taxa can be recognized because correlations of characters differ in the groups of organisms under study.
5. Phylogenetic inferences can be made from the taxonomic structures of a group of organisms and from character correlations, given certain assumptions about evolutionary pathways and mechanisms.
6. Taxonomy is viewed and practiced as an empirical science.
7. Classifications are based on phenetic similarity.

Because numerical taxonomy is solely based on overall similarities and differences, proponents of the Biological Species Concept will not often regard it as an acceptable method unless some genetic or crossability evidences are incorporated. Despite this aspect, numerical taxonomy has several advantages that have made it a widely-used approach for a taxonomical study. First, it has the power to integrate a very large number of data from a variety of taxonomical evidences, such as morphology, anatomy, physiology, molecular sequences and more. Secondly, the conversion of comparative data into numerical values provides a greater description along the spectrum of taxonomic similarity and difference and a more sensitive taxonomic delimitation. Thirdly, the numerical data can be used in the creation of taxonomic descriptions and keys. Lastly, numerical taxonomy has lead to the reinterpretation of a number of biological concepts and to the rise of new biological and evolutionary questions (Bhattacharyya, 2009).

In practice, the procedure adopted by numerical taxonomy according to Sneath and Sokal (1973) is in the following sequence:

1. Organisms as Operational Taxonomic Units (OTUs) for study are selected.
2. Characters are selected.
3. Character states are described and/or measured.
4. Character states are compared to determine the overall similarities between each pair of OTUs.
5. The taxonomic structure of the group of organisms is determined, and all OTUs are ranked into the categories of the taxonomic hierarchy, informally or formally.
6. Generalizations are made about the taxa (e.g. inferences about their phylogeny, choice of discriminatory characters, and so on.)

As the approach of numerical taxonomy consists of a few more guidelines, each step of its procedure will be successively covered from this point forward in Sections 2.2 to 2.6.

2.2 Selection of Plant Specimens

As a part of the taxonomic revision of the genus *Salvia* in Turkey, in the years 2005 to 2009, extensive field surveys were conducted and specimens of *Salvia* were collected from over 1500 populations in the Mediterranean, Aegean and Anatolian regions of Turkey. The specimens were pressed and dried according to standard plant preservation techniques, and then stored at the Laboratory of Plant

Systematics, Department of Biological Sciences, Middle East Technical University. All plant specimens were cross-checked by their collectors using the identification keys provided in the *Flora of Turkey and the East Aegean Islands* (Hedge, 1982a), *Flora Iranica* (Hedge, 1982b), *Flora of Cyprus* (Hedge, 1985), *Flora Orientalis* (Boissier, 1879), *Flora of Syria, Palestine and Sinai* (Post, 1933), *Flora Europaea* (Hedge, 1972) and *Flora of the U.S.S.R.* (Pobedimova, 1952). Furthermore, the specimens were compared with herbarium specimens at the the herbaria ANK, B, BM, CBB, E, ERCIYES, FUH, G, GAZI, HUB, ISTE, ISTF, K, KNYA, LE, MO, VANF and W (Bagherpour, 2010; Celep, 2010; Kahraman, 2011).

In this study, herbarium specimens at the Laboratory of Plant Systematics were used for the numerical taxonomic analysis. Turkey currently has 98 recognized species of *Salvia*, some of which are classified into subspecies and varieties. Within this number, four species S. *haussknechtii*, *S. kurdica*, *S. reeseana* and *S. tigrina* have been described in the *Flora of Turkey and the East Aegean Islands, vol. 7* (Hedge, 1982a) but are known only from their type localities given in the flora account. These species were not found during the field work of 2005 to 2009 (Bagherpour, 2010; Celep, 2010; Kahraman, 2011). Additionally, *S. hedgeana*, *S. macrosiphon* and *S. brachyantha* subsp. *tankutiana* were not found in the herbarium by the investigator. After a preliminary morphological study of the Turkish *Salvia* species, previously-identified specimens from the herbarium were selected for the numerical taxonomic analysis. Since the objectives of this study are to construct and propose a more natural infrageneric classification of *Salvia* in Turkey, ideally all species should be incorporated. However, for detailed morphological descriptions and measurements to be performed in the laboratory, specimens have to be available. In consequence, *S. haussknechtii*, *S. kurdica*, *S. reeseana*, *S. tigrina*, *S. hedgeana*, *S. macrosiphon* and *S. brachyantha* subsp. *tankutiana* were excluded from the numerical taxonomic analysis.

With regards to the selection of the number of individual specimens per species, it is generally accepted that a sample is adequate if it documents well the variation of its morphological features at the next lower level in the taxonomic hierarchy, whether formally recognized or not (Stuessy, 2009). Some species of Turkish *Salvia* are also closely related in terms of morphology. Therefore, populations and individual specimens were selected in a manner so that their intraspecific morphological and ecological variations were adequately represented given their descriptions in literature and the availability of specimens. Whenever possible, at least 2 populations per taxon and at least 10 individuals per population were selected for analysis in order to establish a representative sample of a population. However, in most cases, populations had 5-6 individuals in the herbarium.

As a result of the preliminary study on the species and the availability of the herbarium specimens, 92 species, 4 subspecies and 4 varieties of the Turkish *Salvia* were investigated in this study. Table 3 in Appendix A gives a list of the taxa used in the numerical taxonomic analysis.

2.3 Character Selection, Description and Measurement

A character is a feature of an organism that is divisible into at least two conditions, and is collectively used in numerical taxonomy as comparative data for analysis. According to Sneath and Sokal (1973), a single character in a numerical taxonomic study should be:

- a unit character, which means that it cannot be subdivided logically;
- unweighted, or given equal importance with the rest of the characters;
- non-correlated (e.g. logically, randomly, evolutionarily, developmentally), and thus not redundant;
- not invariant, otherwise there will be no basis for comparisons;
- selected *a posteriori*, *i.e.* after having studied the organisms, so that bias is eschewed;

- genetically determined and conserved, and not highly susceptible to environmental modifications so that it shows little variance within and between populations of the same species; and
- consistent between the studied specimens and the rest in the wild.

In addition to these, characters can also be selected if they have a high adaptive value or a high evolutionary content (Stuessy, 2009).

In *Numerical Taxonomy: the Principles and Practice of Numerical Classification*, Sneath and Sokal (1973) asserted that it is essential to employ all the characters from all parts and life stages of the individual in order to obtain the ideal or a natural classification. However, each individual may possess hundreds or thousands of characters depending on the judgment of the taxonomist, and it thus becomes an impracticable task to do so. The authors were aware of this impracticability, and have therefore recommended the use of 100 characters instead where possible. The significance and practicality of this number, however, is still dependent on the on the group of organisms under study and on the resources available to the taxonomist. Most taxonomists will usually employ 40 to 60 characters (Stuessy, 2009).

In this study, macromorphological characters were used as the basis of the comparative analysis and for the classification of the taxa within the Turkish *Salvia*. Macromorphological features have always been valuable at all levels of the taxonomic hierarchy, from the variety to the division, and they often best embody genetic and evolutionary relationships. Macromorphological data has been and still is the foundation for most of the classifications, and is the most widely used in identification keys. It has the advantage of being easily observed; hence their variability has been much more appreciated than other types of data (Stuessy, 2009).

Qualitative and quantitative macromorphological characters of plant habit, perennation, stems, leaves, inflorescences, calyx, corolla, gynoecium, androecium and indumenta were described and measured using the unaided eye or a stereo microscope with a 4:8:1 zoom with a magnification of 6.3x – 30x. Nutlets could not be used because of the insufficient number of fruiting specimens in the herbarium.

For all species of *Salvia* in Turkey, a list of 300 characters was initially produced using the concepts and identification terminology provided by Radford et al. (1974), Harris and Harris (2001) and Simpson (2006). Using dried and pressed herbarium specimens for making descriptions and measurements posed a few challenges that needed to be tackled. First, some features such as the corolla, bracts and calyx change color over time when drying so that they appear brownish or yellowish. Also, some features such as plant habit and growth form are often very difficult to discern on pressed specimens. Information was thus obtained from field notes written by the specimens' collectors and from descriptions in flora accounts and other literature. Photographs of individuals in the field were also an indispensable tool for effectively visualizing and finalizing these features. Secondly, membranous structures such as some leaves and calyces often become shriveled and brittle. These structures were soaked in a water bath of 55-60^{o}C for several seconds to a few minutes before they could be worked with. The exception to this was the corolla. Quantitative measurements of corolla length could not be performed on the herbarium specimens because the corollas were much too fragile and difficult to deal with even when softened in the water bath. More importantly, corolla length for *Salvia* is always measured on fresh specimens. Finally, some features of the plant or taxon cannot be known from a few numbers of individuals from a limited number of populations, such as the number of flowers per verticillaster. Therefore, also in order to maintain representative samples for each taxon, documentations from the herbarium specimens had to be cross-checked with and data for these characters had to be obtained from species descriptions given in flora accounts and other literature.

At the end, after multiple revisions of the initially-chosen characters, correlated, overlapping, invariant and highly polymorphic characters were eliminated, and a final of 43 characters were selected.

2.4 Character State Coding

A character state is defined as a condition or an expression of the character to which it was described or measured from. A character may possess two or more character states. For organisms to be compared to obtain estimates of their phenetic similarity, character states must first be coded into numerical values. This practice converts the raw data into a form suitable for computation (Sneath and Sokal, 1973).

In this study, four different approaches were implemented to code characters (there were no missing or incomparable values) with the care to give all characters equal weight:

a) Binary characters or presence-absence characters were coded 0 for negative values and 1 for positive values.
b) Flower number per verticillaster in an inflorescence was the only meristic multistate character. Class intervals were assigned according to information given in literature. 0 was given to the least number of flowers, and 3 was given to the most number of flowers.
c) Continuous multistate characters were ordered and given in units of centimeters with 2 decimal values. The median was used from the ranges given in literature.
d) Qualitative multistate characters were coded starting from 0 to its character state's highest positive integer. These are unordered characters so there are no rules in the choice of numerical values. Generally, numerical values were assigned in a logical manner, with the simplest state being 0.

Table 4 gives a list of the characters and coded character states used in the numerical taxonomic analysis.

Table 4. Characters and character states used in the numerical taxonomic analysis.

Habit	
1.	0 - annual 1 - biennial or perennial
2.	0 - stems herbaceous 1 - stems suffruticose 2 - stems fruticose
3.	0 - dwarf mat-forming subshrubs 1 - dwarf tuft-forming subshrubs 2 - taller subshrubs
Stems	
4.	0 - erect 1 - ascending 2 - procumbent
5.	0 - tetrangular 1 - hexangular above 2 - ± circular
6.	0 - glabrous 1 - hairs straight or wavy, soft and flexible 2 - hairs stiff and sharp 3 - hairs curly, matted and wooly
7.	0 - surface glands absent 1 - surface glands present
Leaves	
8.	0 - simple 1 - pinnately compound
9.	0 - undissected 1 - pinnatifid 2 - pinnatisect
10.	0 - glabrous 1 - hairs straight or wavy, soft and flexible 2 - hairs stiff and sharp 3 - hairs curly, matted and wooly
11.	0 - surface glands absent 1 - surface glands present
12.	0 - leaves mostly basal 1 - leaves ± equally distributed on the stem

Table 4 (cont'd)

13.	0 - cauline leaves sessile
	1 - all leaves petiolate
Inflorescence	
14.	0 - inflorescence erect before anthesis
	1 - inflorescence nodding before anthesis
15.	0 - inflorescence not topped with a coma of bracts
	1 - inflorescence topped with a coma of bracts
16.	0 - inflorescence racemose
	1 - inflorescence paniculate
17.	0 - 1-2 flowers per verticillaster
	1 - 2-8 flowers per verticillaster
	2 - 2-20 flowers per verticillaster
	3 - 20-40 flowers per verticillaster
18.	0 - verticillasters approximating
	1 - verticillasters distant
19.	0 - glabrous
	1 - hairs straight or wavy, soft and flexible
	2 - hairs stiff and sharp
	3 - hairs curly, matted and wooly
20.	0 - surface glands absent
	1 - surface glands present
21.	0 - pedicels erect
	1 - pedicels erecto-patent
	2 - pedicels patent
	3 - pedicels deflexed
Bracts	
22.	0 - bracts absent
	1 - bracts deciduous during anthesis
	2 - bracts green, shorter than or equalling calyces
	3 - bracts green, longer than calyces
	4 - bracts purplish, shorter than or equalling calyces
	5 - bracts purplish, longer than calyces
Bracteoles	
23.	0 - bracteoles absent
	1 - bracteoles present

Table 4 (cont'd)

Calyces

24. 0 - calyx markedly bilabiate
1 - calyx indistinctly bilabiate

25. 0 - corolla tube exerted beyond the calyx
1 - corolla tube included within the calyx

26. 0 - calyces green
1 - calyces purplish
2 - calyces green or purplish

27. 0 - upper lip shorter than lower lip
1 - upper lip equal to lower lip
2 - upper lip longer than lower lip

28. 0 - upper lip of Type Ia
1 - upper lip of Type Ib
2 - upper lip of Type Ic
3 - upper lip of Type IIa
4 - upper lip of Type IIb
5 - upper lip of Type IIc
6 - upper lip of Type III
7 - upper lip of Type IV

29. 0 - upper lip teeth acuminate to acute
1 - upper lip teeth shortly mucronate
2 - upper lip teeth aristate to spinose
3 - upper lip teeth rounded

30. 0 - calyces membranous-reticulate and greatly accrescent in fruit
1 - calyces thick-textured and scarcely or not accrescent in fruit

31. 0 - calyces not recurved in fruit
1 - calyces recurved in fruit

32. 0 - glabrous
1 - hairs straight or wavy, soft and flexible
2 - hairs stiff and sharp
3 - hairs curly, matted and wooly

Corolla

33. 0 - tube not annulate
1 - tube annulate

34. 0 - tube not squamulate
1 - tube squamulate

Table 4 (cont'd)

35. 0 - tube not ventricose
1 - tube ventricose

36. 0 - mouth narrow
1 - mouth wide

37. 0 - upper lip straight-hooded
1 - upper lip falcate-compressed
2 - upper lip stiff and open-hooded
3 - upper lip recurved and hooded

38. 0 - corolla single-colored
1 - lower lip a different color
2 - upper lip a different color
3 - lower and upper lips a different color from the tube

39. 0 - lower lip markings absent
1 - lower lip markings present

40. corolla length (cm)

Androecium

41. 0 - stamens of type A
1 - stamens of type B
2 - stamens of type C
3 - stamens of type M
4 - stamens of type N

42. 0 - stamens included within the upper lip of the corolla
1 - stamens exerted from the upper lip of the corolla

Gynoecium

43. 0 - style included within the upper lip of the corolla
1 - style exerted from the upper lip of the corolla

2.5 Data Matrix Construction

Following a detailed morphological study of the plant specimens and the coding of the character states for each character, the Operational Taxonomic Units or OTUs were finalized and a t x n data matrix was constructed on a Microsoft Excel spreadsheet, where “t” represents the taxa and “n” represents the characters. This data matrix is thus a compilation of the character states for every OTU in the study.

2.6 Hierarchical Cluster Analysis

Cluster analysis comprises a number of different algorithms and methods for grouping similar OTUs into respective clusters (or “phenons”), wherein OTUs with the highest mutual similarity are grouped together. In hierarchical clustering, clusters of OTUs are based on the measured and described character states, starting with each OTU as a separate cluster and then sequentially combining the clusters until eventually only one cluster remains. All OTUs are clustered according to their overall similarity without any reference to symplesiomorphies or synapomorphies in an evolutionary sense. The resulting clusters are arranged in a hierarchical tree-like structure called a phenogram, where the horizontal axis denotes the linkage distance and the vertical axis denotes the OTUs. Related taxa, hence the taxonomic structure can be recognized as a result of the process (Stuessy, 2009).

Before any hierarchical clustering can be performed, however, the first step of a cluster analysis is to calculate the overall similarity by comparing each OTU with every other using a suitable similarity coefficient. A t x t similarity matrix is then constructed with similarities expressed as a numerical value from 0 to 1, where 1 represents identicality and 0 represents no resemblance (Stuessy, 2009).

In this study, the cluster analysis was carried out using MVSP (Multi-Variate Statistical Package) version 3.22 computer software (Kovach, 2014). A similarity matrix was created by employing Gower’s General Similarity Coefficient because it is the most suitable for mixed quantitative and qualitative binary and multistate characters (Gower, 1971; Sneath and Sokal, 1973). Clustering was then done using the average linkage algorithm UPGMA (Unweighted Pair-Group Method with Arithmetic Mean) because averages are weighed by the number of OTUs in each cluster resulting in each distance contributing equally (Stuessy, 2009).

2.7 Gradient Analysis

While a phenogram obtained from a hierarchical cluster analysis shows OTUs of close relationships well, it does not show distant relationships accurately and is generally useful only as a rough guide to taxonomic structure. Therefore, a gradient analysis or an ordination usually complements a numerical taxonomic study (Sneath and Sokal, 1973). Ordination is a group of methods whereby sample units or OTUs are ordered along gradients in multidimensional space. It attempts to calculate multidimensional relations and then compress them onto a reduced number of two or three planes for more effective visualization and comprehension. The taxonomic structure is determined ensemble instead of by successive comparisons of pairs of OTUs (Palmer, n.d.). In this study, a Principal Coordinates Analysis (PCO) using Gower’s General Similarity Coefficient was conducted after the cluster analysis so that the OTUs could be represented in two and three dimensions in space and more distant taxonomic relationships could be evaluated.

In addition to a PCO, a Principal Components Analysis (PCA) of the transposed data matrix was conducted to evaluate the significance of each character used in the study.

MVSP (Multi-Variate Statistical Package) version 3.22 computer software (Kovach, 2014) was used to carry out these gradient analyses.

CHAPTER 3

RESULTS

3.1 Morphological Variation within *Salvia* in Turkey

The macromorphological study of the 100 taxa of Turkish *Salvia* has shown a tremendous diversity in vegetative and reproductive characters, both among species and within individual populations. All observations are based on both literature reviews and laboratory studies on herbarium specimens.

HABIT:

Species are annuals, ephemeral perennials or long-lived perennials. *S. viridis* is the only annual species among the Turkish *Salvia*. The species is widely distributed in Turkey ranging in altitudes from the sea level to 1300 m high. Most species are herbaceous, often with a woody rootstock, (e.g. *S. aethiopis*, *S. divaricata*, *S. forskahlei*, *S. glutinosa*, *S. syriaca* and *S. viridis*) or suffruticose (e.g. *S. anatolica*, *S. euphratica*, *S. pachystachys* and *S. sericeo-tomentosa*). *S. fruticosa* and *S. pomifera* are the only shrubby species. All Turkish species are chamaephytes according to Raunkiær's life-form classification. *S. caespitosa*, *S. pachystachys*, *S. hedgeana*, *S. montbretii* and *S. multicaulis* are dwarf mat-forming plants, forming a distinctive cushion-like appearance. Dwarf tuft-forming plants include species such as *S. absconditiflora*, *S. euphratica*, *S. hydrangea*, *S. quezelii* and *S. tomentosa*. Most species are taller subshrubs such as *S. adenophylla*, *S. aethiopis*, *S. bracteata*, *S. forskahlei* and *S. tomentosa*.

STEM:

The growth direction of the stems of some species is erect (e.g. in *S. longipedicellata*, *S. sclarea*, *S. staminea* and *S. yosgadensis*). Individuals of these species are usually found with solitary and unbranched stems, though possibly with numerous sterile shoots at the base. The stems may also be ascending with numerous branches such as those found in *S. bracteata*, *S. ballsiana*, *S. cerino-pruinosa*, *S. fruticosa*, *S. glutinosa*, *S. palaestina*, *S. russellii* and *S. verticillata*. Other species possess procumbent stems (e.g. *S. caespitosa*, *S. macrochlamys*, *S. nydeggeri*, *S. quezelii* and *S. pisidica*). Any of these growth forms can be associated with the different life-forms exhibited in the Turkish *Salvia* (Figure 9).

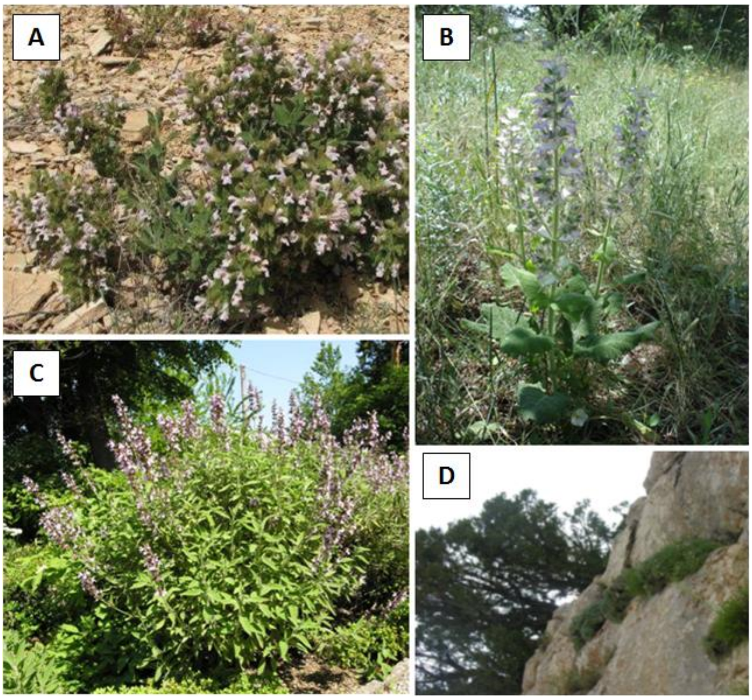

Figure 9. Various plant habits of the Turkish *Salvia*. **A:** *S. euphratica* var. *euphratica*, herbaceous dwarf tufts with ascending stems (Kahraman et al., 2010); **B:** *S. sclarea*, herbs

with solitary and erect stems; **C:** *S. fruticosa*, tall shrubs with many-branched ascending stems (Moro, n.d.); **D:** *S. caespitosa*, suffruticose dwarf mat-forming subshrubs with procumbent stems (Modified from Celep, 2010).

Tetrangular stems are a distinctive trait of the family Lamiaceae, hence the genus *Salvia*. However, some species of *Salvia* possess hexangular stems towards the apex of the individual (*S. aristata*, *S. hedgeana* and *S. staminea*) or more or less circular stems all throughout (*S. ballsiana*, *S. blepharochlaena*, *S. cedronella*, *S. cerino-pruinosa* and *S. pomifera*).

The lengths of stems considerably vary between species and within populations of the same species. Small dwarf mat-forming species such as *S. caespitosa* can be as tall as 5 cm to 40 cm tall, while taller subshrubs such as *S. recognita* can grow up to 180 cm.

LEAVES:

Species possess simple leaves or pinnately compound leaves. Those with simple leaves are either undissected or dissected. Species with undissected leaves include *S. albimaculata*, *S. aucheri*, *S. indica*, *S. limbata* and *S. indica*. Leaf dissection may be reaching more than halfway to the midrib (pinnatisect) as in *S. aristata* and *S. ceratophylla* or less than half of the length to the midrib (pinnatifid) as in *S. argentea*, *S. atropatana*, *S. frigida*, *S. longipedicellata*, *S. microstegia*, *S. montbretii*, *S. verbenaca* and *S. xanthocheila*. In some species, individuals of different populations may possess either dissected or dissected leaves, as seen in *S. atropatana* as one example. South Eastern species of *S. atropatana* exhibit undissected leaves with erose margins in one population, and pinnatifid leaves with crenulate margins in another. Species with pinnately compound leaves always appear undissected with varying numbers of smaller lateral segments. These include *S. caespitosa* with 2-4 pairs of lateral segments, *S. pinnata* with 2-5 pairs of lateral segments, *S. hydrangea* with 2-3 pairs of lateral segments and *S. pilifera* with 1 pair of lateral segments (Figure 10).

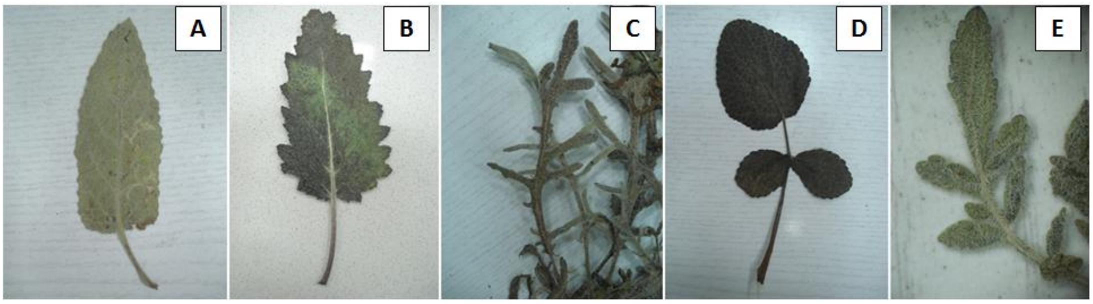

Figure 10. Leaf complexity and dissection in the Turkish *Salvia*. **A:** *S. halophila*, simple and undissected; **B:** *S. argentea*, simple and pinnatifid; **C:** *S. ceratophylla*, simple and pinnatisect; **D:** *S. pilifera*, pinnately compound with 1 pair of lateral segments; **E:** *S. caespitosa*, pinnately compound with 4 pairs of lateral segments.

Margin morphology is highly varied in the Turkish *Salvia*, even within populations of the same species. Margins range from entire to well-defined, such as doubly serrate and erose. Leaf shapes cover elliptic, ovate, obovate and oblong, and length to width ratios range from linear (6:1) to circular (1:1). Leaf apical and basal shapes range from angles of less than 45^{o} to nearly 180^{o} with diverse morphologies. Symmetrical shapes, apical shapes, basal shapes and sizes of mature leaves are also highly varied within populations of the same species and within an individual. For instance, a single individual of *S. ekimiana* found in a population in Yozgat at 1793 m a.s.l. possessed simple, undissected leaves of elliptic to ovate shapes, acute to rounded apices, cuneate bases, and crenulate to serrate margins. Likewise, individuals of a Mediterranean *S. caespitosa* population possessed smaller leaves in average (ca. 3 cm) than those of the two Central Anatolian populations (ca. 5 cm).

Single species may also possess simple leaves or pinnately compound leaves, the latter known to be the evolutionarily advanced state (Nicotra, Leigh, Boyce, Jones, Niklas, Royer, Tsukaya et al., 2011). As examples, single populations of *S. napifolia* and *S. verticillata* exhibited both simple, lyrate leaves and pinnately compound leaves with 1 pair of lateral segments even within the same individual.

Throughout the individual, leaves may be distributed throughout the stems more or less equally or be concentrated at the basal portion of the stems. Examples of species are *S. caespitosa*, *S. fruticosa*, *S. glutinosa*, *S. heldreichiana* and *S. macrochlamys* of the former state, and *S. cilicica*, *S. eriophora*, *S. indica*, *S. limbata* and *S. yosgadensis* of the latter state.

Most Turkish *Salvia* species have petiolate leaves, while seven of them exhibit sessile cauline leaves, *viz. S. amplexicaulis*, *S. atropatana*, *S. cerino-pruinosa*, *S. indica*, *S. russellii*, *S. sclarea* and *S. siirtica*.

INFLORESCENCE:

Two unique features of the inflorescence in the Turkish *Salvia* involve a coma of sterile bracts at the apex of the inflorescence and a nodding inflorescence before anthesis (Figure 11). *S. viridis* is the only species among the studied group to possess an inflorescence topped with a coma of purple, white or green bracts that do not subtend flowers. A comparative study by Özdemir, Baran and Aktaş (2009) based on anatomical features has concluded that these morphologically distinct forms are all polymorphic members of *S. viridis*. *S. nutans*, on the other hand, is the only species among the studied group whose inflorescence nods downward before

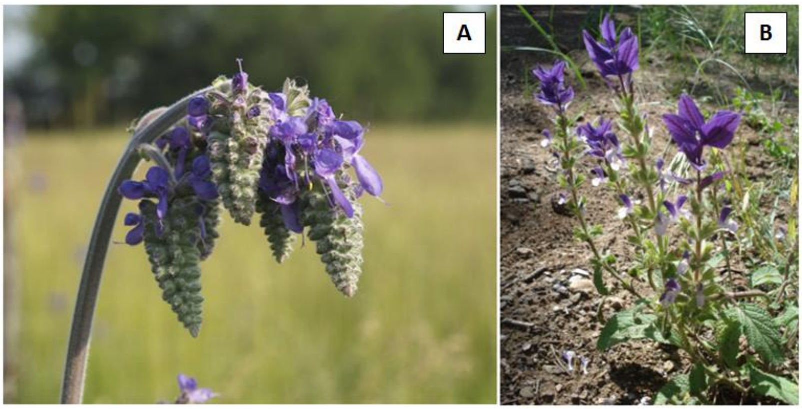

Figure 11. Two unique inflorescence features in the Turkish *Salvia*. **A:** *S. nutans* with a nodding inflorescence (Arpad, n.d.); **B:** *S. viridis* with a coma of purple bracts.

anthesis. These two singular features have made *S. viridis* and *S. nutans* popular ornamental garden plants throughout Europe.

Inflorescences may be branched or paniculate (e.g. in *S. aristata*, *S. chrysophylla*, *S. forskahlei* and *S. verticillata*) or unbranched or racemose (e.g. in *S. huberi*, *S. smyrnaea*, *S. suffruticosa* and *S. vermifolia*). Verticillasters throughout the rachis of the inflorescence may be approximating and appear dense (e.g. in *S. atropatana*, *S. nutans*, *S. pomifera* and *S. wiedemannii*) or be conspicuously distant from each other (e.g. in *S. adenophylla*, *S. ballsiana*, *S. odontochlamys* and *S. suffruticosa*). The number of flowers in a verticillaster also varies among species. Species discretely possess 1-2 flowers, 2-8 flowers, 2-20 flowers or 20-40 flower per verticillaster. Most species possess 2-8 flowers per verticillaster (Figure 12).

Pedicel posture relative to the rachis of the inflorescence is consistent throughout individuals of a species. Pedicels are erect, erecto-patent, patent or deflexed (only in *S. napifolia*, *S. russellii* and *S. verticillata*).

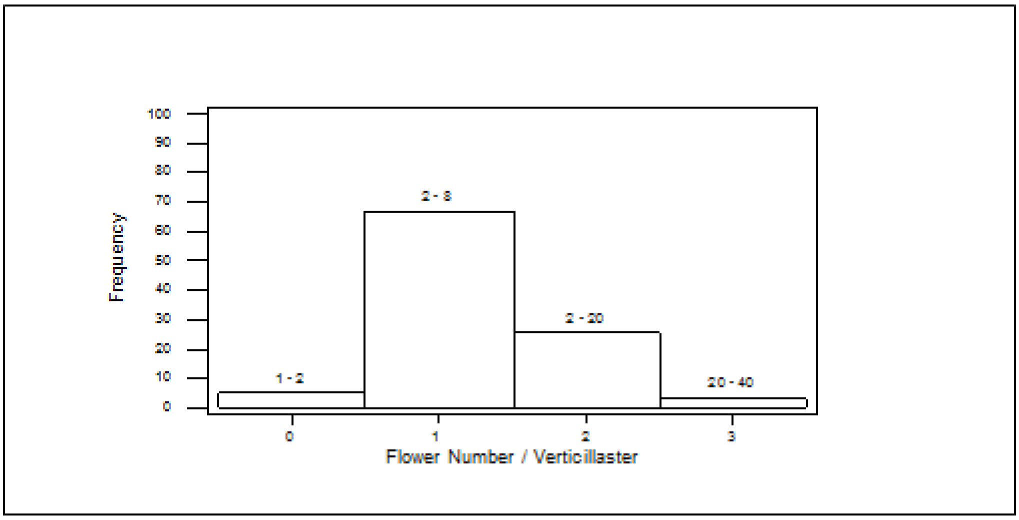

Figure 12. Frequency distribution among the Turkish *Salvia* taxa of the four character states of the number of flowers per verticillaster.

BRACTS AND BRACTEOLES:

With the exception of *S. divaricata*, bracts are present in Turkish *Salvia* species. They may be deciduous before or during anthesis, or persistent throughout most of the plant's seasonal life cycle. Species whose bracts are quickly deciduous are *S. aramiensis*, *S. aucheri*, *S. fruticosa*, *S. limbata*, *S. napifolia*, *S. pinnata*, *S. pomifera*, *S. recognita*, *S. tomentosa* and *S. verticillata*.

Persistent bracts may be smaller than the calyces and hence inconspicuous (e.g. in *S. anatolica*, *S. aristata*, *S brachyantha* subsp. *brachyantha*, *S. cassia*, *S. glutinosa* and *S. nutans*), or considerably larger than the calyces and hence conspicuous (e.g. in *S. amplexicaulis*, *S. bracteata*, *S. brachyantha* subsp. *tankutiana*, *S. sclarea*, *S. trichoclada* and *S. viridis*). Also, persistent bracts may be green (e.g. in *S. aethiopis*, *S. aristata*, *S. cadmica* var. *cadmica*, *S. euphratica* var. *euphratica*, and *S. viridis* possessing a coma of purple bracts), or purplish (e.g. in *S. cadmica* var. *bozkiriensis*, *S. euphratica* var. *leiocalycina*, *S. nutans*, *S. russellii*, *S. sclarea*, and *S. viridis* with a coma of white bracts) (Figure 13).

Figure 13. Bract morphologies in **(A)** *S. aethiopis* with small, green bracts and **(B)** *S. sclarea* with conspicuous, colored bracts.

Bracteoles in inflorescences may be absent (e.g. in *S. aethiopis*, *S. cadmica*, *S. cerino-pruinosa*, *S. divaricata* and *S. staminea*) or present as a pair on the base of the receptacles of flowers or on the base of pedicels where bracts subtend (e.g. in *S. bracteata*, *S. caespitosa*, *S. forskahlei*, *S. pomifera* and *S. viridis*).

CALYX:

The bilabiate calyces of *Salvia* are divided into five partially-fused sepals - three sepals in the upper lip and two sepals in the lower lip. In some species, however, the calyx does not appear distinctly bilabiate but almost actinomorphic. Among the Turkish *Salvia*, these species are *S. aucheri* and *S. fruticosa* (Figure 14). The three-dimensional shape of the calyx in a species may be tubular, campanulate, infundibular or urceolar, or be of intermediate forms of the above.

Within a species, calyces may be green, purplish, or both in different populations. In *S. brachyantha* subsp. *brachyantha*, *S. heldreichiana, S. modesta, S. russellii, S. smyrnaea, S. amplexicaulis, S. eriophora*, *S. nemorosa, S. sclarea, S. trichoclada*, *S. cadmica* var. *bozkiriensis*, *S. euphratica* var. *leiocalycina, S. multicaulis, S. nutans, S. palaestina* and *S. rosifolia,* both bracts and calyces are conspicuously colored.

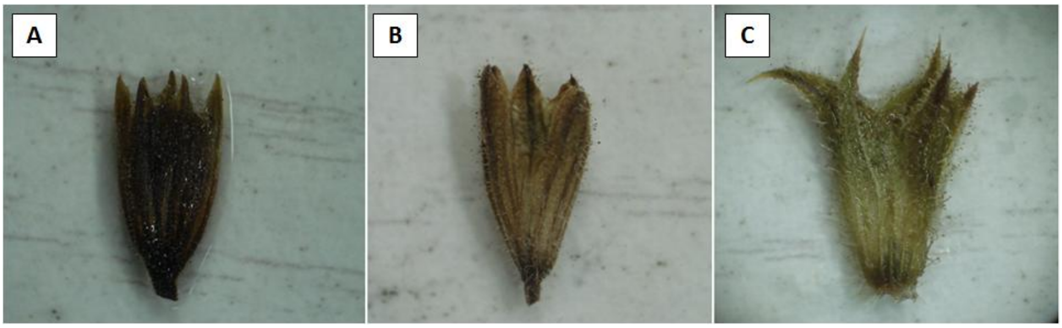

Figure 14. Calyx symmetry in the Turkish *Salvia*. Indistinctly bilabiate calyces in **(A)** *S. aucheri* and **(B)** *S. fruticosa*, and a markedly bilabiate calyx in **(C)** *S. argentea*.

Calyces may be shorter than the tube of the corolla, occurring usually halfway the length of the corolla tube (e.g. in *S. euphratica*, *S. potentillifolia*, *S. quezelii*, *S. rosifolia* and *S. spinosa*), or long enough to enclose the mouth of the corolla (e.g. *S. absconditiflora*, *S. cassia*, *S. cerino-pruinosa*, *S. macrochlamys* and *S. pseudeuphratica*).

The ratio of the length of the upper lip to the lower lip of the calyx differs among species and some formally-recognized taxa. Differences within a species are found between *S. candidissima* subsp. *occidentalis* and subsp. *candidissima*, *S. aucheri* subsp. *canescens* and subsp. *aucheri*, *S. cadmica* var. *cadmica* and var. *bozkiriensis*, and *S. euphratica* var. *euphratica* and var. *leiocalycina*.

The upper lip of the calyx also contains interesting and particular features. Most species possess calyces with tridentate or bisulcate upper lips. Relative to the total length of the calyx, this dentation may either appear marked or obsolete to the investigator. Additionally, the size of the median tooth relative to the lateral teeth of the upper lip may vary. Thus, the median tooth may be significantly larger, significantly smaller or of the same size compared to the lateral teeth. In other species, the upper lip of the calyx does not appear to be bisulcate, but monosulcate that is either dentate or lobed. Both teeth or both lobes are equal in length and width to each other. Contrarily, *S. cerino-pruinosa* is the only species with a truncate upper lip. In consequence, the upper lip of the calyx in the Turkish *Salvia* can be discretely characterized into eight character states: Types Ia, Ib and Ic where the upper lip is distinctly tridentate, in which the size of the median tooth is smaller in Type Ia, equal to the lateral teeth in Type Ib and larger in Type Ic; Types IIa, IIb and IIc where the upper lip is obsoletely tridentate, in which the size of the median tooth is smaller in Type IIa, equal to the lateral teeth in Type IIb and larger in Type IIc; Type III where the upper lip is bidentate or two-lobed; and Type IV where the upper lip is truncate (Figure 15).

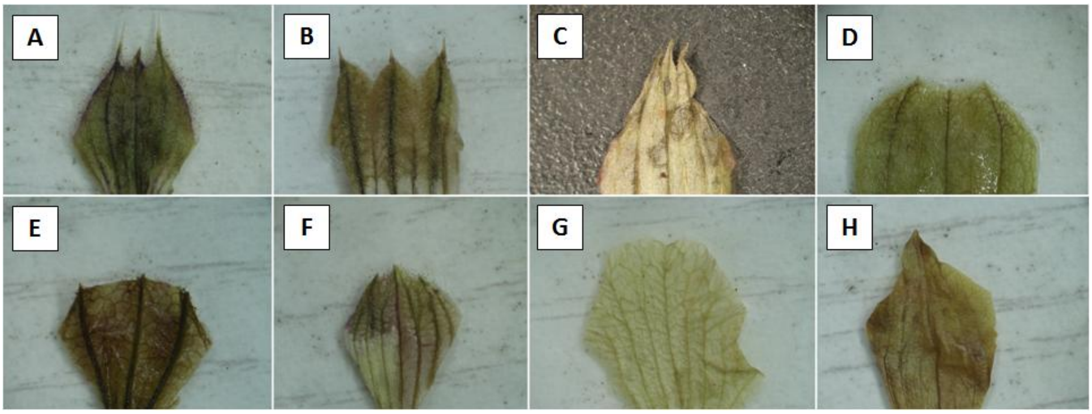

Figure 15. Calyx types in the Turkish *Salvia*. **A:** Type Ia in *S. ceratophylla***; B:** Type Ib in *S. montbretii*; **C:** Type Ic in *S. pilifera*; **D:** Type IIa in *S. quezelii*; **E:** Type IIb in *S. forskahlei*; **F:** Type IIc in *S. caespitosa*; **G:** Type III in *S. absconditiflora*; **H:** Type IV in *S. cerino-pruinosa*.

Further, the apex of the teeth or lobes of the calyx varies between species and some infraspecific taxa. Apical shapes include acute to acuminate (e.g. in *S. albimaculata*, *S. divaricata*, *S. marashica* and *S. pomifera*), and rounded (e.g. in *S. kronenburgii*, *S. euphratica*, *S. pseudeuphratica* and *S. aytachii*). In other cases, the teeth contain apical processes that range from shortly mucronate (e.g. in *S. caespitosa*, *S. napifolia*, *S. pilifera* and *S. viscosa*) to aristate to spinose (e.g. in *S. aristata*, *S. odontochlamys*, *S. spinosa*, *S. xanthocheila* and *S. yosgadensis*).

Three features of fruiting calyces are worth noting as they discretely vary between species. Two of these features, texture and accrescence, are correlated; i.e. fruiting calyces that are membranous-reticulate are always greatly accrescent (e.g. in *S. pomifera*, *S. aytachii*, *S. euphratica* and *S. pseudeuphratica*), and those that are thick-textured are always scarcely or not accrescent (e.g. in *S. viridis*, *S. spinosa*, *S. longipedicellata*, *S. atropatana*, *S. verticillata*, *S. siirtica* and *S. aristata*). Species whose calyces are greatly accrescent during fruiting exhibit either acuminate to acute or rounded calyx upper lip teeth (e.g. *S. pomifera* and *S. euphratica*), while species whose calyces scarcely or do not accresce possess acuminate to acute teeth or teeth with apical processes (e.g. *S. aristata* and *S. spinosa*). Lastly, the upper lip of fruiting calyces of some species recurve backwards (e.g. in *S. pomifera*, *S. aytachii*, *S. euphratica*, *S. pseudeuphratica* and *S. verticillata*), or do not recurve backwards in other species (e.g. in *S. spinosa*, *S. longipedicellata*, *S. aristata*, *S. atropatana* and *S. siirtica*) (Figure 16).

Figure 16. Morphological variations in fruiting calyces. **A:** *S. heldreichiana* with a thick-textured and scarcely accrescent fruiting calyx (left) compared to its flowering calyx (right); **B:** *S. aytachii* with a membranous-reticulate and greatly accrescent fruiting calyx (left) compared to its flowering calyx (right); **C:** *S. siirtica* with a non-recurving fruiting calyx.

COROLLA:

The corolla tube in *Salvia* contains numerous features that have been used throughout its taxonomic history. Initially, the presence or absence of a ring of hairs or annulus inside the tube of the corolla is consistent within a species. For instance, *S. russellii*, *S. viridis* and *S. glutinosa* always posses an annulus inside their corolla tubes, while *S. anatolica*, *S. heldreichiana* and *S. verticillata* do not possess an annulus. Other features of the tube of the corolla also contain important taxonomic information. First, the corolla tube of some species such as *S. aethiopis* and *S. xanthocheila* possesses a squamula, which is a small internal scale. Secondly, if the corolla tube is not squamulate, it may simply dilate gradually

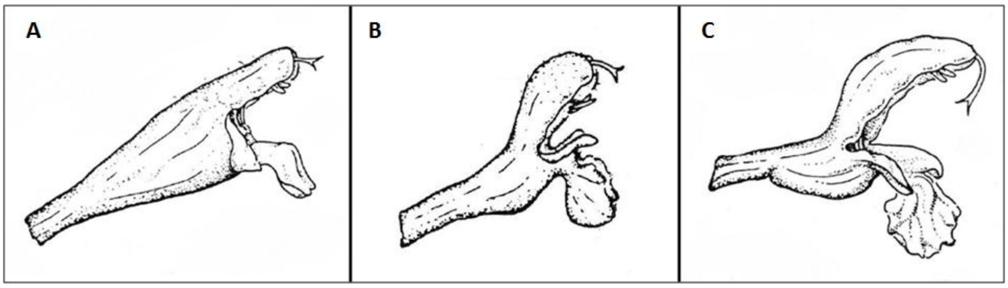

Figure 17. Corolla tube morphology in the Turkish *Salvia*. **A:** *S. caespitosa* with a non-squamulate and non-ventricose corolla tube; **B:** *S. syriaca* with a ventricose corolla tube; **C:** *S. xanthocheila* with a squamulate corolla tube (Modified from Hedge, 1982a).

until the mouth of the corolla (e.g. in *S. glutinosa*, *S. forskahlei* and *S. cerino-pruinosa*), or abruptly dilate in its lower portion like a sac (e.g. *S. aytachii*, *S. viridis* and *S. syriaca*) (Figure 17).

The macromorphology of the upper lip of the corolla has also been used extensively in *Salvia*'s taxonomy. Specifically, the posture of the upper lip relative to the corolla tube remains consistent between individual species. Four distinct upper lip morphologies can be distinguished in the Turkish *Salvia*: one that is erect and hooded (e.g. in *S. aristata*, *S. bracteata* and *S. viridis*), one that is falcate and not hooded (e.g. in *S. glutinosa*, *S. forskahlei* and *S. aethiopis*), one that appears stiff and open with a hood (in *S. russellii*, *S. verticillata* and *S. napifolia*), and one that is recurved backwards and hooded (only in *S. nutans*). In addition, the base of the upper lip and lower lip of the corolla may be constricted or not so that the mouth of the corolla appears narrow or wide, respectively (Figure 18).

The color of the corolla is highly polymorphic within a species. Corollae may be white or range in different shades of yellow, pink, purple and blue. For example, different populations of *S. fruticosa* possess white, pinkish and purplish corollae. *S. vermifolia* is the only species in Turkey whose populations may display red corollae. In lieu of corolla color, corolla variegation provides a more solid

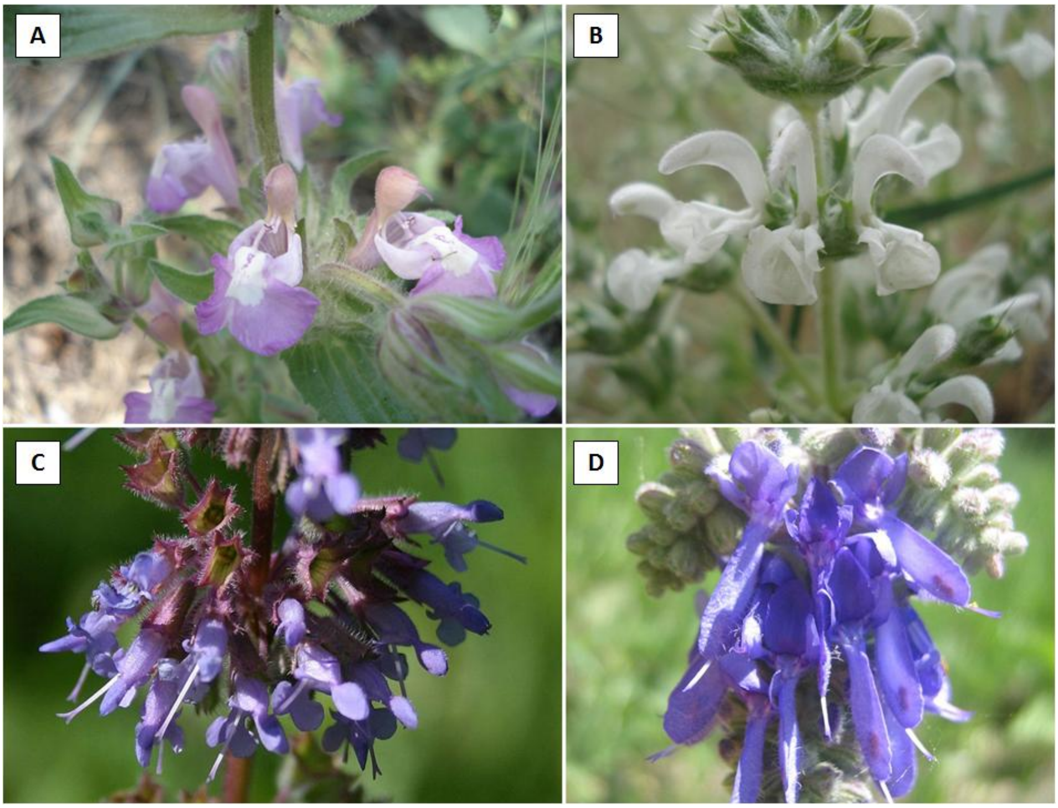

Figure 18. Upper lip postures and mouth types of the corolla in the Turkish *Salvia*. **A:** *S. bracteata* with a straight-hooded upper lip and a wide mouth; **B:** *S. aethiopis* with a falcate-compressed upper lip and a narrow mouth; **C:** *S. verticillata* subsp. *verticillata* with a stiff and open-arched upper lip and a wide mouth (Xaver, 2009); **D:** *S. nutans* with a recurved and hooded upper lip and a narrow mouth (Koswac, 2011).

description. While the corolla may be of a single color in some species as in *S. fruticosa*, the tube, upper lip and lower lip may be of different colors. Therefore, the lower lip may be of a different color (e.g. in *S. sclarea*, *S. argentea* and *S. blepharochlaena*), the upper lip may be of a different color (e.g. in *S. ekimiana*, *S. chrysophylla* and *S. halophila*), or both lower and upper lips may be of a different color than the tube (e.g. in *S. indica* and *S. suffruticosa*). Moreover, the lower lip may contain some distinct markings in some species, such as in *S. bracteata* which has a large white spot amidst the purple in the lower lip of its corolla (see Figure 18).

The total length of the corolla differs between species and ranges from 0.90 cm to 4.00 cm in average. The shortest corollae occur in *S. ekimiana* with lengths from 0.7-1.1 cm, while the longest corollae are found in *S. blepharochlaena* and *S. kronenburgii* with lengths from 2.7-5.0 cm and 3.0-5.0 cm, respectively. The average length of corolla in the Turkish *Salvia* is ca. 2.3 cm. These figures were taken from various published literature, including the theses prepared by Bagherpour (2010), Celep (2010) and Kahraman (2011), since corolla length measurements are always made on fresh specimens.

ANDROECIUM:

According to Hedge (1982a) in the *Flora of Turkey and the East Aegean Islands, vol. 7*, *Salvia* in Turkey possesses three different morphologies of stamens, types A, B and C, as discussed earlier. After the herbarium and literature studies, however, it was found that stamen architecture in *S. glutinosa*, *S. fruticosa* and *S. aristata* are different from the three stamen types proposed by Hedge. Using the stamen classification given by Walker and Systma (2007) (see Figure 7 on page 17), *S. glutinosa* and *S. forskahlei* possess stamens of type N (Figure 19) and *S. aristata* possesses stamens of type M. The stamen of type N is characterized by the posterior anterior thecae producing little or no pollen and flattened by growth, resulting in two fan-shaped thecae that are either entirely fused or connivent and projecting from the mouth of the corolla. In *S. glutinosa* and *S. forskahlei*, the posterior thecae are connivent but separate. The stamen of type M is characterized by expressed and separate posterior anther thecae which do not contribute to a lever mechanism (Walker and Systma, 2007).

The protrusion of the stamens from the upper lip of the corolla may also provide important taxonomic information for *Salvia*. The stamens may either be included (e.g. in *S. aytachii*, *S. ballsiana* and *S. fruticosa*) or exerted from the upper lip of the corolla (e.g. in *S. nemorosa*, *S. staminea* and *S. syriaca*).

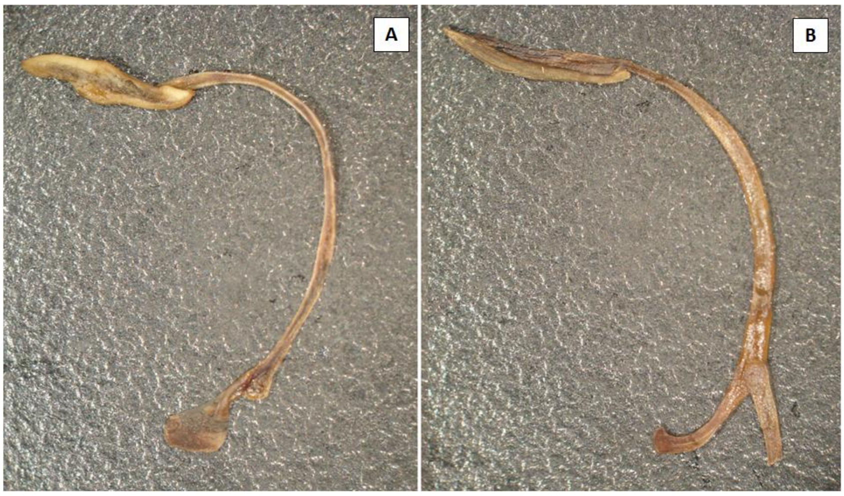

Figure 19. Stamens of type N in **(A)** *S. forskahlei* and **(B)** *S. glutinosa*.

GYNOECIUM:

The protrusion of the style from the upper lip of the corolla may also provide important taxonomic information. In some species (e.g. *S. aethiopis*, *S. pinnata* and *S. tchihatcheffii*) the style is included in the upper lip of the corolla, while in others (e.g. *S. divaricata*, *S. hydrangea* and *S. kronenburgii*) the style is exerted from the upper lip of the corolla.

SURFACE MACROMORPHOLOGY:

The indumenta of cauline stems, leaves, inflorescence rachises and calyces vary considerably between species and some infraspecific taxa within the Turkish *Salvia*, but as a taxonomic character they can be generally and distinctly classified into (1) straight or wavy, soft and flexible, (2) stiff and sharp, and (3) curly, matted and wooly. Cauline stems, leaves, inflorescence rachises and calyces may also be glabrous, without any trichomes or cilia on their surfaces (Figure 20). The indumentum within an individual sometimes differs in different parts of the plant. For instance, in *S. cilicica*, the cauline stems and inflorescence rachis have short,

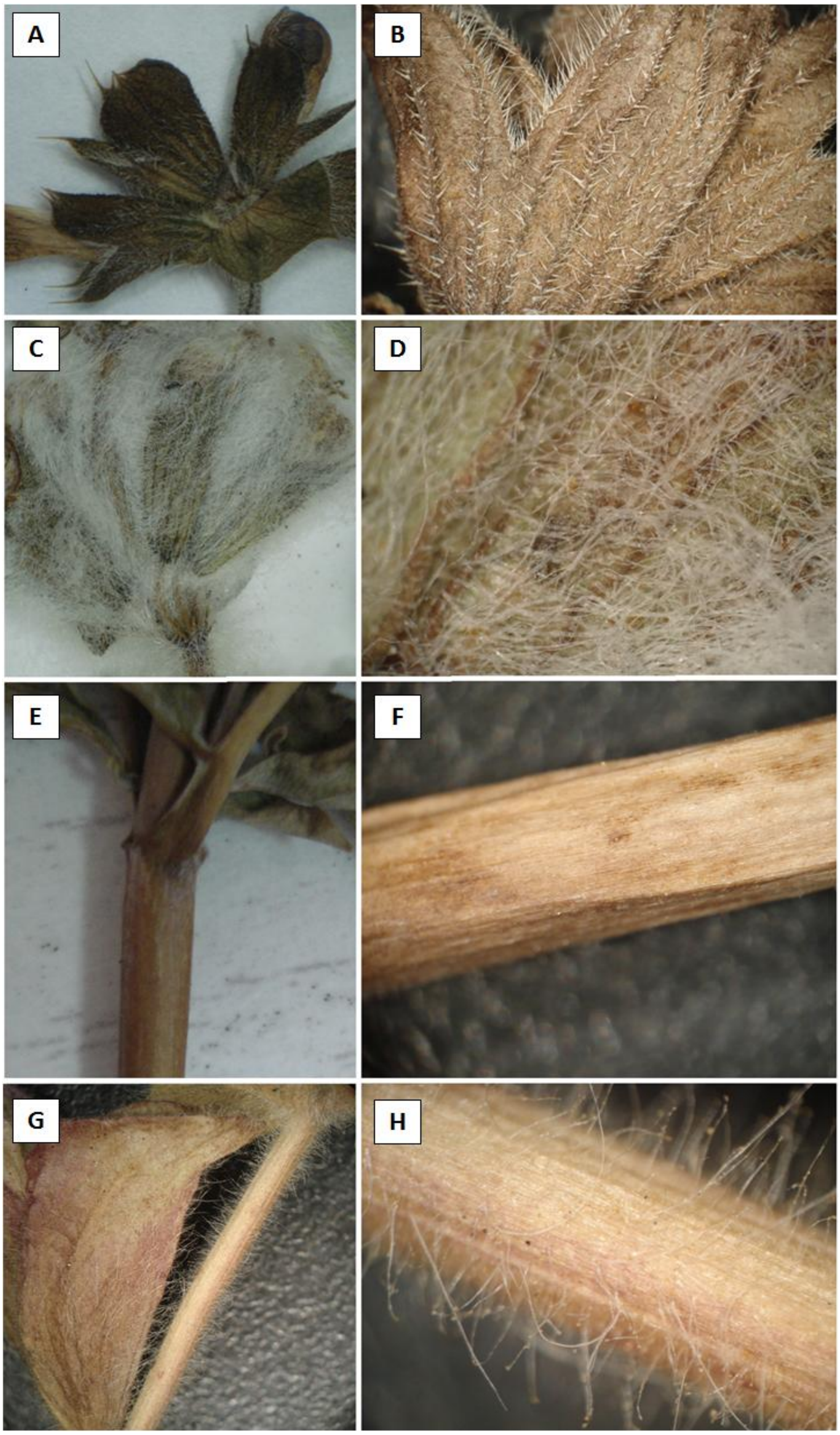

Figure 20. Indumenta types in the Turkish *Salvia*. **A, B:** stiff and sharp hairs on *S. verbenaca* calyces; **C, D:** curly, matted and wooly hairs on a *S. ekimiana* calyces; **E, F:** a glabrous stem in *S. cedronella*; **G, H:** straight, soft and flexible hairs on a *S. cerino-pruinosa* inflorescence rachis.

stiff and sharp hairs (they are hispidulous), both adaxial and abaxial surfaces of the leaves have curly, matted and wooly hairs (they are lanate), and the calyces contain short, straight, soft and flexible hairs (they are puberulent). Although generalized as a character in this numerical taxonomic study, hairs or trichomes present on the surface possess a multitude of other features that differ among species and among infraspecific taxa, such as density, branching presence, number of cells and posture.

Finally, trichomes, when present, may be of three types - eglandular trichomes, peltate glandular trichomes, and capitate glandular trichomes. Glands are distinguished by their sticky and orange to yellow globule-like appearance (Bagherpour, 2010; Celep, 2010; Kahraman, 2011). Moreover, sessile glands, which are not trichomes, may be present on the epidermis of the plant. In most species of the Turkish *Salvia*, glands are present as glandular trichomes and/or sessile glands (Figure 21). In some species, however, glands are absent in the cauline stems, leaves or inflorescence rachises. Glandular trichomes and/or sessile glands are always present on calyces in the Turkish *Salvia*.

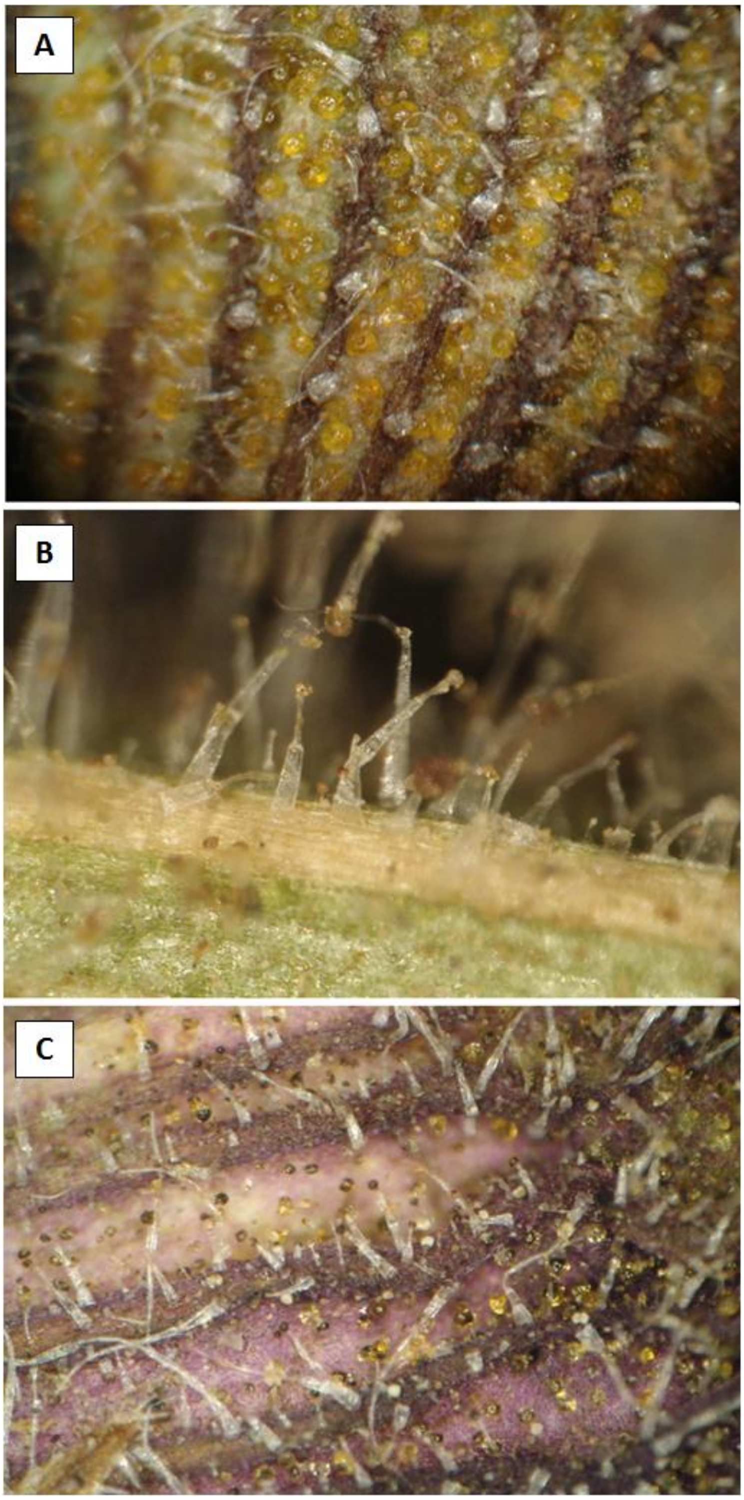

Figure 21. Epidermal glands in the Turkish *Salvia*. **A:** sessile glands and eglandular trichomes on a *S. adenocaulon* calyx; **B:** glandular trichomes on a *S. odontochlamys* inflorescence rachis; **C:** sessile glands and glandular trichomes on a *S. fruticosa* calyx.

3.2 The Data Matrix

The macromorphological study of the 100 taxa has resulted in a final number of 100 OTUs so that every OTU possessed monomorphic characters. *S. cerino-pruinosa* and *S. caespitosa* were thus subdivided into smaller taxonomic groups. Table 5 in Appendix B shows the data matrix resulting from the numerical taxonomic study based on mixed qualitative and quantitative macromorphological characters. The t x n data matrix is composed of 100 rows (OTUs) and 43 columns (characters).

3.2 The Similarity Matrix

Table 6 in Appendix C shows the t x t similarity matrix using Gower's General Similarity Coefficient calculated by the MVSP version 3.22 computer program. Overall similarities ranged from 0.47 (between *S. cerino-pruinosa B* and *S. aethiopis*) to 0.99 (between *S. cadmica* var. *cadmica* and *S. cadmica* var. *bozkiriensis*).

3.3 The Phenogram

The phenogram constructed in the UPGMA cluster analysis using Gower's General Similarity Coefficient based on 43 characters is given in Figure 22. With a phenon line at 0.75 similarity level, the Turkish *Salvia* can be delimited into five discrete clusters. Table 7 in Appendix D gives a summary for the phenogram, showing the similarities in each pair of nodes. The first cluster in the phenogram, cluster A, consists of only *S. viridis,* befitting the description of Bentham's (1876) sect. *Horminum* of subg. *Sclarea*. The second cluster, cluster B, consists of 43 taxa belonging to 42 species, commonly joined by being perennial, and having markedly bilabiate calyces, thick-textured and scarcely or not accrescent fruiting calyces, annulate corollae, narrow corolla mouths and stamens of type B. The third cluster, cluster C, consists of 4 taxa belonging to 3 species, whose descriptions match that of Bentham’s (1876) sect. *Hemisphace* of subg. *Leonia* and a distinct Southwest Asian clade observed by Will et al. (2013). The fourth cluster, cluster D, consists of 41 taxa belonging to 38 species, and is delimited from the third cluster by not possessing deflexed pedicels, stamens of type C, and stiff and open-arched corolla upper lips. The fifth cluster, cluster E, consists of 9 taxa in 8 species and is distinguished from the other clusters by having two rounded lobes in the upper lip of the calyx. The shared character states of this cluster fit the description of Bentham’s (1876) sect. *Hymenosphace* of subg. *Salvia*.

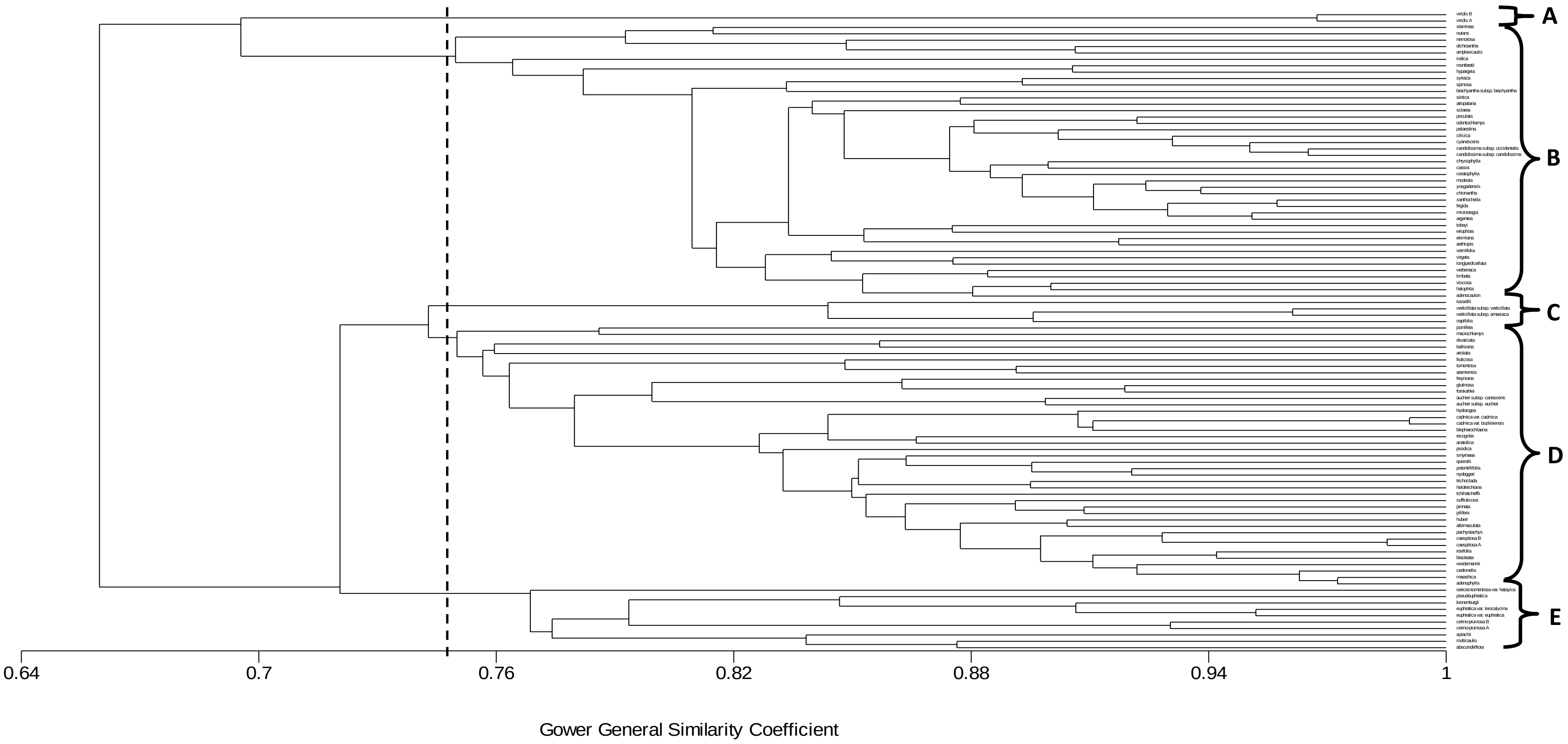

Figure 22. The phenogram constructed in the UPGMA cluster analysis using Gower's General Similarity Coefficient showing the five clusters.

3.4 Principal Coordinates Analysis (PCO)

Table 8 gives the eigenvalues and the percentages of the total variance of each of the axes with an eigenvalue greater than 1 calculated in the PCO using Gower's General Similarity Coefficient. All the vectors with an eigenvalue greater than 1 explained 58% of the total observed variation. The first three axes explained 26.95%, 6.89% and 6.37% of the total variation, respectively.

Table 8. Eigenvalues and percentages of the Principal Coordinates Analysis showing eigenvalues greater than 1.

	Axis 1	**Axis 2**	**Axis 3**	**Axis 4**	**Axis 5**	**Axis 6**	**Axis 7**
Eigenvalues	7.411	1.893	1.751	1.409	1.321	1.165	1.012
Percentage	26.954	6.887	6.370	5.124	4.805	4.238	3.681
Cum. Percentage	26.954	33.840	40.211	45.335	50.140	54.378	58.059

Figures 23 and 24 show the two-dimensional and three-dimensional scatter plots, respectively, constructed in the PCO. Axis 1 is the x-axis, Axis 2 is the y-axis, and Axis 3 is the z-axis. Both scatter plots show that cluster A is clearly separated from cluster B, and clusters A and B are clearly separated from the other clusters, but that there is a rather weak segregation among clusters C, D and E.

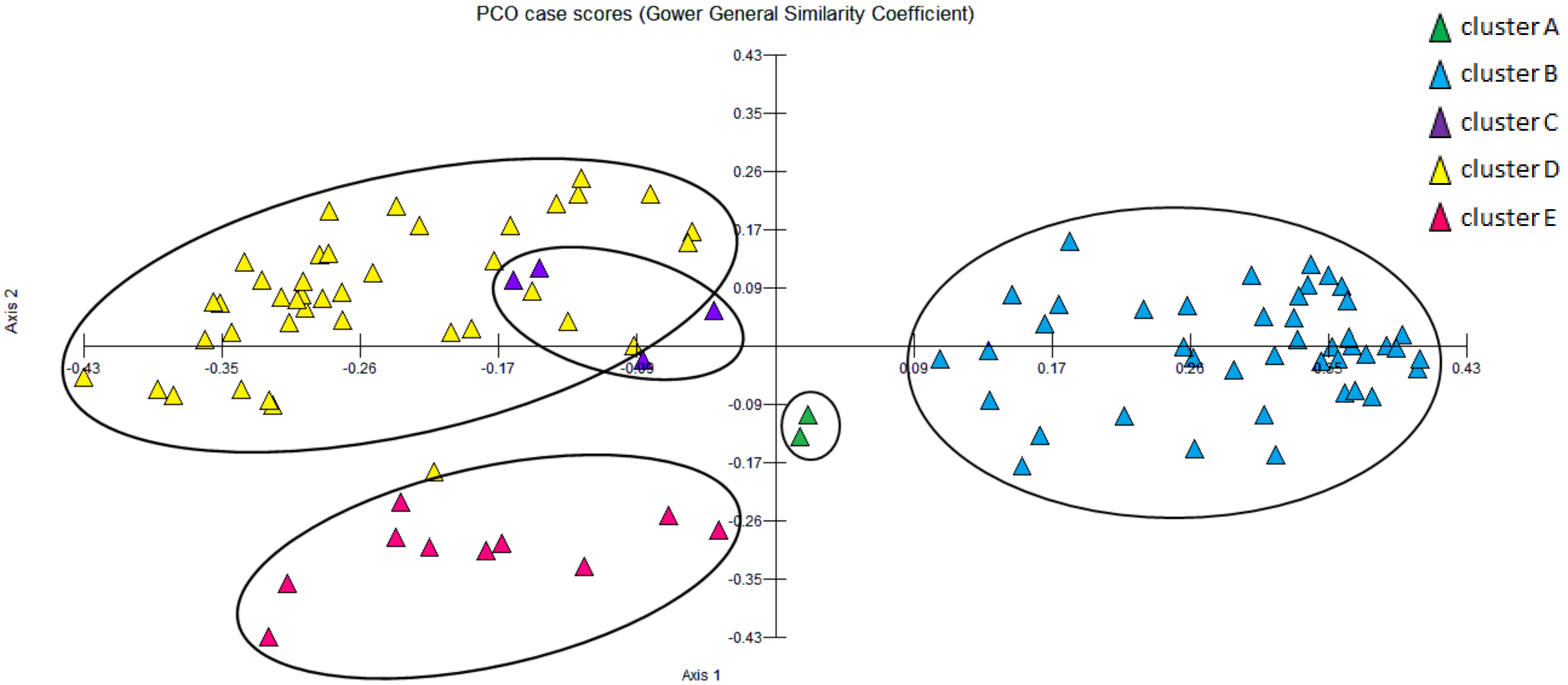

Figure 23. A two-dimensional scatter plot of the first two axes in the PCO using Gower's General Similarity Coefficient. Triangles represent OTUs.

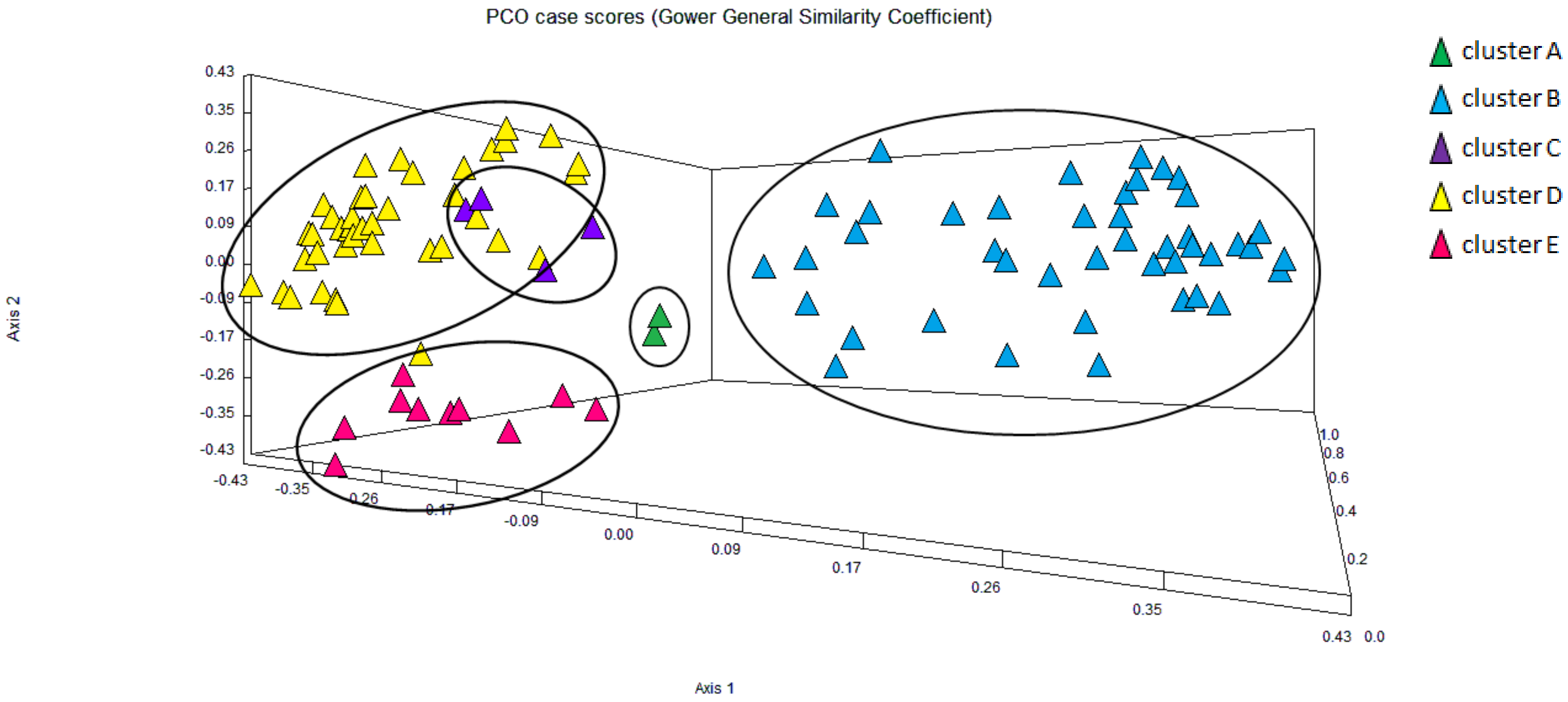

Figure 24. A three-dimensional scatter plot of the first three axes in the PCO using Gower's General Similarity Coefficient. Triangles represent OTUs.

3.5 Principal Components Analysis (PCA)

Table 9 gives the eigenvalues and the percentages of the total variance calculated in the PCA for the characters in the data matrix. All the vectors with an eigenvalue greater than 1 explained 64.6% of the total observed variation. The first three axes explained 31.15%, 13.57% and 7.90% of the total variation, respectively. Table 10 shows the PCA component loadings representing the eigenvectors for each PCA axis.

Table 9. Eigenvalues of the Principal Components Analysis on the characters showing eigenvalues greater than 1.

	Axis 1	**Axis 2**	**Axis 3**	**Axis 4**	**Axis 5**
Eigenvalues	5.350	2.408	1.401	1.242	1.066
Percentage	30.146	13.567	7.896	7.000	6.009
Cum. Percentage	30.146	43.713	51.609	58.609	64.618

Table 10. Component loadings for each PCA axis. Values in bold represent the highest loadings for their respective axes.

CHARACTER	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6	Axis 7	Axis 8	Axis 9
1 - perennation	-0.001	-0.005	-0.035	-0.009	-0.008	0.041	0.046	0.027	-0.014
2 - plant habit	0.067	**-0.149**	**-0.144**	**0.182**	0.083	-0.017	0.078	-0.005	**-0.121**
3 - growth form	-0.088	-0.047	0.056	**-0.169**	-0.005	0.055	-0.075	0.025	**0.224**
4 - stem growth direction	0.078	**-0.132**	-0.004	0.099	-0.032	0.018	-0.046	0.008	**-0.281**
5 - stem cross-sectional shape	0.051	-0.069	0.014	-0.004	0.075	-0.068	**0.177**	-0.063	**0.248**
6 - cauline stem indumentum	**-0.114**	**0.225**	**-0.414**	**0.213**	**-0.237**	0.010	**-0.294**	**-0.101**	-0.090
7 - cauline stem gland presence	-0.029	0.018	-0.075	0.044	**-0.120**	0.053	-0.044	**0.169**	**-0.136**
8 - leaf complexity	0.100	**-0.188**	-0.012	0.071	-0.075	-0.037	0.048	0.081	-0.08
9 - leaf dissection	-0.040	0.048	-0.044	-0.007	0.085	**-0.108**	0.006	**0.112**	0.064
10 - leaf indumentum	**-0.156**	**0.316**	**-0.451**	**0.312**	**0.133**	**0.192**	0.011	**0.256**	0.074
11 - leaf gland presence	0.018	-0.016	-0.004	-0.011	-0.018	-0.035	0.008	-0.014	-0.040
12 - leaf distribution on stem	0.056	-0.063	0.087	0.023	**-0.107**	**-0.223**	-0.052	0.053	**-0.302**
13 - petiole presence	0.001	-0.030	-0.053	-0.005	-0.009	0.022	-0.060	-0.046	0.024
14 - nodding inflorescence	-0.001	0.006	0.017	-0.012	-0.014	0.026	0.003	0.004	-0.004
15 - coma of bracts presence	0.000	0.005	0.034	0.011	0.009	-0.040	-0.041	-0.017	0.017
16 - inflorescence branching	**-0.102**	0.091	-0.040	**-0.164**	-0.008	**0.119**	-0.003	-0.008	**0.118**
17 - flower number per verticillaster	0.029	0.035	-0.092	-0.049	**-0.357**	**-0.189**	**0.125**	**0.158**	-0.027
18 - verticillaster distance	0.025	0.003	-0.034	-0.021	0.041	**-0.107**	-0.011	**0.178**	**0.235**
19 - rachis indumentum	-0.070	**0.125**	**-0.167**	0.093	**-0.318**	**-0.128**	**-0.232**	**-0.115**	-0.009
20 - rachis gland presence	-0.010	-0.003	-0.059	0.040	-0.054	-0.049	**-0.167**	0.084	-0.004
21 - pedicel posture	-0.020	0.030	**-0.104**	**-0.279**	**-0.407**	-0.098	**0.317**	**0.148**	**-0.119**

Table 10 (cont'd)

22 - bracts type	-0.032	**0.169**	**0.652**	**0.472**	**-0.232**	**0.174**	**-0.186**	**0.313**	0.003
23 - bracteole presence	0.080	**-0.156**	0.047	0.022	-0.032	0.040	**-0.183**	**-0.115**	**-0.170**
24 - calyx symmetry	-0.007	-0.024	-0.050	0.012	0.004	0.054	0.009	-0.020	-0.008
25 - calyx length to corolla tube	-0.020	**0.157**	0.069	0.023	0.066	-0.052	0.064	**-0.251**	0.081
26 - calyx color	**0.128**	0.013	0.004	**0.146**	**-0.295**	**0.548**	**0.451**	**-0.137**	**0.207**
27 - calyx lips relative length	0.067	**-0.141**	0.015	**0.234**	**-0.247**	**-0.438**	0.036	-0.071	**0.533**
28 - calyx upper lip type	**0.859**	**0.389**	-0.046	**-0.156**	0.008	0.045	**-0.212**	0.018	0.058
29 - calyx upper lip teeth shape	-0.006	**0.481**	**0.114**	**0.223**	**0.171**	**-0.421**	**0.461**	-0.032	**-0.210**
30 - fruiting calyx accrescence	**-0.102**	-0.036	0.042	-0.083	0.016	0.034	**-0.155**	0.009	-0.090
31 - fruiting calyx recurvature	**0.125**	-0.018	0.054	-0.044	-0.097	-0.013	-0.023	**-0.125**	0.004
32 - calyx indumentum	**-0.101**	0.075	-0.035	0.091	**-0.199**	-0.044	**-0.177**	**-0.203**	**0.232**
33 - corolla tube annulus	**0.123**	**-0.191**	**-0.102**	0.069	**-0.120**	-0.073	0.082	0.088	-0.091
34 - corolla tube squamulate	-0.082	**0.136**	-0.013	**-0.103**	**0.128**	0.047	0.033	-0.004	**0.129**
35 - corolla tube ventricose	-0.082	**0.185**	0.017	0.018	0.058	**0.112**	0.061	-0.055	**-0.113**
36 - corolla mouth width	**0.123**	**-0.190**	**-0.100**	0.071	**-0.117**	-0.078	0.085	0.096	-0.094
37 - corolla upper lip posture	**-0.137**	**0.198**	0.070	**-0.267**	**-0.138**	0.068	0.017	**0.100**	0.035
38 - corolla variegation	-0.049	0.054	0.082	0.015	**0.203**	**-0.196**	**-0.185**	-0.092	**0.123**
39 - corolla lower lip markings	0.036	-0.083	0.002	0.003	-0.013	0.072	-0.033	**0.145**	0.073
40 - corolla length (cm)	**0.142**	**-0.199**	**-0.173**	**0.181**	**0.256**	-0.009	0.036	**0.507**	**0.165**
41 - stamen type	**-0.140**	**0.178**	0.085	**-0.371**	**-0.108**	-0.087	-0.095	**0.433**	0.072
42 - stamen protrusion	-0.015	0.004	0.031	-0.071	-0.023	0.003	0.019	0.016	-0.004
43 - style protrusion	0.001	0.003	0.002	-0.028	0.053	0.008	0.011	0.080	0.041

CHAPTER 4

DISCUSSION

Cluster analysis provides a poor representation of more distant taxonomic relationships, while gradient analysis provides a poor representation of closer taxonomic relationships. Therefore, both methods were used in this numerical taxonomic study to achieve a more robust discrimination of the infrageneric delimitation of the Turkish *Salvia*.

The cluster analysis of the 100 OTUs based on 43 quantitative and qualitative macromorphological characters revealed 5 discrete clusters at Gower's similarity level of 0.75. Initially, all OTUs are segregated into two major clusters at a similarity level of 0.69 based on stamen type, the presence of an annulus within the corolla tube and the width of the corolla mouth.

Super-cluster I: This first major cluster consists of taxa uniquely characterized by stamens of type B, an exannulate corolla and a narrow corolla mouth. Within this cluster are clusters A and B delimited at a similarity level of 0.69.

Cluster A: Cluster A solely consists of *S. viridis*, and is distinguished from cluster B by being annual and having inflorescences topped with a coma of sterile purple, white or green bracts and a straight-hooded corolla upper lip. Character states possessed by this cluster fulfill those of Bentham's (1876) sect. *Horminum* of subg.

Sclarea, also as the calyces are tubular and the plants are herbaceous. So far, *S. viridis* is the only species that was placed within sect. *Horminum* in published accounts. In the molecular phylogenetic studies conducted by Walker et al. (2004) and Walker and Systma (2007), *S. viridis* was found to be included within the large *Salvia* clade I, which includes Old World and New World members of Bentham's (1876) subg. *Leonia*, *Salvia* and *Sclarea* to which genera *Perovskia* and *Rosmarinus* are sister. In the *Flora of Turkey and the East Aegean Islands, vol. 7*, Hedge (1982a) maintained *S. viridis* in a separate and monotypic "species group."

Cluster B: Cluster B is the largest cluster consisting of 43 taxa within 42 species distributed in all three phytogeographic regions of Turkey. Additional shared macromorphological character states among taxa within cluster B are a perennial or biennial life-cycle, present bracts, markedly bilabiate calyces, and fruiting calyces that are thick-textured and scarcely or not accrescent. *S. nutans* is an interesting species because it is the only species within this cluster to possess a nodding inflorescence, recurved corolla upper lips and pinnately compound leaves. Cluster B cannot be delimited according to Bentham's (1876) sectional classification, specifically into sect. *Aethiopis* and/or sect. *Plethiosphace*, because the morphology of the upper lip of the calyx, the shape of the calyx and plant habit are highly varied, with character states distributed in a disarray. Based on the phylogenetic groupings produced by Walker et al. (2004) and Walker and Systma (2007), the taxa within cluster B belong to *Salvia* clade I. The results of the molecular phylogenetic study based on ITS regions by Will et al. (2013) vary slightly from those produced by the former workers. Most species in cluster B were placed in one of the two major Southwest Asian clades, clade B, whose members resemble each other based on a falcate corolla upper lip, stamens of type B and a chromosome number of 2n=22. Other species within cluster B (*S. verbenaca*, *S. amplexicaulis*, *S. adenocaulon*, *S. virgata*, *S. viscosa*, *S. nutans*, *S. montbretii* and *S. hypargeia*), however, were placed into six separate minor clades.

Super-cluster II: This second major cluster is distinguished from super-cluster I by an annulate corolla and a wide corolla mouth characterized by its members. At 0.72 Gower's similarity level, it is divided into two groups, the first group giving rise to clusters C and D and the second group being cluster E.

Cluster C: At 0.75 similarity level, cluster C is distinguished from cluster D by having stamens of type C, a stiff and open-hooded corolla upper lip, and deflexed pedicels. Only 4 taxa belonging to 3 species are included within this cluster, *viz. S. russellii, S. verticillata* and *S. napifolia*. These taxa resemble one another further by being perennial herbs and possessing ascending, tetrangular stems with straight or wavy, soft and flexible hairs, leaves distributed equally throughout the stems, comparatively small flower sizes, large numbers of flowers within a verticillaster, inconspicuous bracts, no bracteoles, short and purplish calyces, thick-textured and scarcely or not fruiting calyces, single-colored corollae, and an exerted style. Phytogeographically, *S. russellii* and *S. verticillata* subsp. *amasiaca* belong to the Irano-Turanian element, *S. verticillata* subsp. *verticillata* belongs to the Euro-Siberian element, and *S. napifolia* belongs to the Mediterranean element. Shared morphological states among the taxa within cluster C befit the description of Bentham's (1876) sect. *Hemisphace* of subg. *Leonia*. Likewise, Hedge (1982a) in the *Flora of Turkey and the East Aegean Islands, vol. 7*, has classified these three species into a distinct "species group." Moreover, Will et al. (2013) has found the three species of this cluster to belong to a separate, Southwest Asian phylogenetic clade. On the contrary, Walker et al. (2004) have found *S. verticillata,* which possesses stamens of type C without a lever mechanism, belonging to *Salvia* clade I. The genus *Rosmarinus* also possesses stamens of type C without a lever mechanism and was strongly supported to be sister to *Salvia* clade I.

Cluster D: Cluster D is the second largest cluster with 41 taxa belonging to 38 species that are distributed in all three phytogeographic regions of Turkey. Most species are characterized by corollae with straight-hooded upper lips and wide mouths, and stamens of type A. The accrescence of fruiting calyces is varied, with most species having thick-textured and scarcely or not accrescent fruiting calyces. *S. pomifera*, *S. hydrangea*, *S. cadmica*, *S. blepharochlaena* and *S. anatolica*, on the other hand, have membranous-reticulate and broadly accrescent fruiting calyces. In the phenogram, *S. hydrangea*, *S. cadmica* and *S. blepharochlaena* were placed close to each other within a single cluster, while *S. pomifera* was placed close to *S. macrochlamys* (further resembling each other by a paniculate inflorescence, erect pedicels, present bracteoles, large calyces, acuminate teeth of calyx upper lips, recurved fruiting calyces, included stamens and exerted styles), and *S. anatolica* was placed close to *S. recognita* (further resembling each other by identical cauline stem surface features, simple and undissected leaves, identical leaf surface features, sessile cauline leaves, 2-8 flowers per verticillaster, distant verticillasters, identical rachis surface features, present bracteoles, calyx upper lips of type Ic, recurving fruiting calyces, identical calyx surface features, included stamens and exerted styles). All of these species characterized by straight-hooded corolla upper lips, wide corolla mouths and stamens of type A were placed into Walker et al. (2004) and Walker and Systma's (2007) *Salvia* clade I, and into Will et al.'s (2013) major Southwest Asian clade A, which is characterized according to the above morphological states plus a chromosome number of 2n=14. Within cluster D, *S. aristata*, *S. glutinosa* and *S. forskahlei* exhibit a few different character states when compared to the rest. *S. aristata* uniquely possesses pinnatisect leaves and stamens of type M. The results of the molecular phylogenetic study by Will et al. (2013) has included *S. aristata* within one minor clade of Southwest Asian, North African and Canary Island species. *S. glutinosa* and *S. forskahlei* differ from the larger group of species in cluster D by having falcate-compressed corolla upper lips and stamens of type N. Bentham's (1876) sectional classification satisfactorily places these two species into sect. *Drymosphace* of subg. *Salvia*. However, according to this cluster analysis these two species cannot be separated from the large cluster D. Will et al. (2013) have found *S. forskahlei* to belong to the major clade A and *S. glutinosa* to belong to a distinct and large Central Asian clade. Contrarily, Walker et al. (2004) and Walker and Systma (2007) have placed

S. aristata, *S. glutinosa* and *S. forskahlei* into *Salvia* clade III, to which taxa exhibiting stamens of types M and N belong. Cluster D cannot be classified according to Bentham's (1876) sectional delimitation even with the exclusion of *S. aristata*, *S. glutinosa* and *S. forskahlei* because criteria for fruiting calyces and calyx upper lip architecture are not met. The type species of *Salvia*, *S. officinalis* L., should belong to cluster D based on its tridentate calyx upper lips, straight-hooded corolla upper lips, wide corolla mouths and stamens of type A.

Cluster E: Taxa within cluster E are separated from clusters C and D by possessing calyces with two, rounded lobes in the upper lip. Shared morphological states also include ascending stems, markedly bilabiate calyces that are often large and conspicuously colored, membranous-reticulate, broadly accrescent and recurving fruiting calyces, straight-hooded corolla upper lips, wide corolla mouths, non-squamulate corolla tubes, and stamens of type A that are included within the upper lip of the corolla. Cluster E comprises 9 taxa belonging to 8 species distributed predominantly in the Irano-Turanian phytogeographic region. *S. sericeo-tomentosa* belongs to the Mediterranean phytogeographic element. The morphologies of the taxa in cluster E befit those described for Bentham's (1876) sect. *Hymenosphace* of subg. *Salvia*. Based on the molecular phylogenetic results by Will et al. (2013), and Walker et al. (2004) and Walker and Systma (2007), members of cluster E belong to the major Southwest Asian clade A and *Salvia* clade I, respectively, although no species were assessed in the latter studies.

Based on the shared morphological states in each of the five clusters, most of the taxa of the Turkish *Salvia*, which were excluded from this study due to reasons aforementioned, can be assigned into their respective clusters: *S. brachyantha* subsp. *tankutiana* and *S. macrosiphon* belong to cluster B, and *S. hedgeana*, *S. reeseana*, *S. tigrina* and *S. kurdica* belong to cluster D. Only one species excluded from this study, *S. haussknechtii*, cannot be assigned into any of the given clusters above because of the insufficient amount of morphological data provided in published literature.

The two-dimensional and three-dimensional scatter plots from the Principal Coordinates Analysis confirm the dissimilarity and separation of cluster A and cluster B, and of super-cluster I and super-cluster II. Along the first axis, cluster A is distinguished from cluster B, and super-cluster I is distinguished from super-cluster II. This is congruent with the results of the cluster analysis. Along the second axis, the segregations between clusters C and D, and D and E are rather weak. Both scatter plots reveal that members of cluster C are very much close to cluster D in space; both subspecies of *S. verticillata* are placed close to *S. potentillifolia* and *S. smyrnaea*, and *S. russellii* is very close to *S. divaricata*. Morphologically, *S. verticillata*, *S. potentillifolia* and *S. smyrnaea* resemble each other based on their plant habits, stem features, leaf features, present petioles, racemose inflorescences, distant verticillasters, rachis indumenta, short calyces, thick-textured fruiting calyces, calyx indumenta, annulate corollae, wide corolla mouths, included stamens and exerted styles, and *S. russellii* resembles *S. divaricata* based on its plant habit, simple and undissected leaves, distant verticillasters, absent bracteoles, short and purplish calyces, thick-textured and recurved fruiting calyces, single-colored and annulate corollae, wide corolla mouths, included stamens and exerted style. The two-dimensional and three-dimensional scatter plots also show that *S. pomifera* of cluster D is included within the space of cluster E. *S. pomifera* is morphologically very similar to the taxa of cluster E with regards to its calyx, corolla and androecium, but it is singled out from cluster E due to its tridentate calyx upper lips. Therefore, both scatter plots did not effectively group members of cluster C, cluster D and cluster E based on overall similarity.

The results of the PCO conclude that cluster A and cluster B are well-defined groups based on overall similarity, and that clusters C, D and E are less dissimilar to each other based on overall similarity. Hence, there is a slightly weak demarcation among the last three clusters. This could be due to the fact that Axis 2 and Axis 3 account for only 6.89% and 6.37% of the total variation of the data, respectively, as opposed to the contribution of 26.95% of the total variation by Axis 1. Furthermore, the first three principal coordinates account for a mere 40.21% of the total observed variation. Therefore, the results of the PCO indicate that the delimitation of the five clusters is not very well defined. This circumstance may suggest that there are no select few characters that are responsible for the delimitation of *Salvia*, but that there is an integration of many vegetative and reproductive characters that contribute to the five clusters.

In addition to the cluster analysis and PCO of the t x n data matrix, a Principal Components Analysis was conducted to evaluate the significance of each of the selected 43 characters in the delimitation of *Salvia*. The PCA revealed that different sets of characters show high loadings on the first three axes. On the first axis, cauline stem indumentum, leaf indumentum, inflorescence branching, calyx color and upper lip type, fruiting calyx accrescence and recurvature, calyx indumentum, corolla annulus presence, corolla mouth width, corolla upper lip posture, corolla length, and stamen type had high loadings. On the second axis, plant habit, stem growth direction, stem indumentum, leaf indumentum, rachis indumentum, bracts type, bracteole presence, calyx length, calyx upper lip to lower lip length, calyx upper lip type and teeth shape, corolla annulus presence, corolla tube features, corolla mouth width, corolla upper lip posture, corolla length, and stamen type had high loadings. On the third axis, plant habit, stem indumentum, leaf indumentum, rachis indumentum, pedicel posture, bracts type, calyx upper lip teeth shape, corolla annulus presence, corolla mouth width, and corolla length had high loadings.

In published literature since Bentham's (1832-1836; 1833; 1876) monographic accounts, different systematists have used different sets of characters to delimit *Salvia* into infrageneric categories. As stated earlier, Bentham (1876) and Boissier (1879) have used plant habit, fruiting calyx accrescence, bract features, corolla features and staminal architecture for the sectional delimitation of *Salvia*. Hedge (1974; 1982a; 1982b; 1985) has used a variety of vegetative and reproductive morphological characters to classify species into numerous "species groups." Later, molecular phylogenetic studies by Walker et al. (2004) and Walker and Systma

(2007) have stressed the importance of stamen type to tackle the non-monophyletic nature of *Salvia*. The molecular phylogenetic study of 318 Old World and New World Salvia taxa by Will et al. (2013) has also stressed the importance of stamen type, but has moreover supported corolla architecture as a major delimiting factor. Similarly, Will and Claßen-Bockhoff (2014) have shown that stamen type is not the sole character that delimits evolutionary lineages, but that stamen type is much more variable. Furthermore, Epling's criteria for classifying the New World *Salvia* are "the number of flowers in a glomerule, the persistence or ephemeral nature of the floral bracts, the number of veins in the upper lip of the calyx, the proportions of upper and lower corolla lips, the presence or absence of secretory appendages within the corolla tube, the entire or invaginated nature of the corolla tube, the inclusion or extrusion of the stamens from the upper lip, the attachment of the stamens with reference to the throat of the corolla, the nature of the staminal connectives, particularly in its sterile portion, the proportions and shape of the style braches and hairiness or smoothness of the style itself" (Epling, 1938; 1939).

Based on the PCA results in this study, 25 out of the employed 43 vegetative and reproductive characters appeared diagnostic in distinguishing the five clusters of *Salvia* in Turkey as they accounted for the largest proportion of the total observed variation in the data: plant habit, stem growth direction, stem indumentum, leaf complexity, leaf indumentum, inflorescence branching, rachis indumentum, pedicel posture, bracts type, bracteole presence, calyx length relative to the corolla tube, calyx color, calyx upper lip to lower lip length ratio, calyx upper lip type, calyx upper lip teeth apical shape, fruiting accrescence, fruiting calyx recurvature, calyx indumentum, corolla annulus presence, corolla squamula presence, corolla ventricosity, corolla mouth width, corolla upper posture, corolla length, and stamen type.

The demarcation of the five clusters found in this study is generally congruent with the findings of recent molecular phylogenetic studies on *Salvia* and tribe Mentheae. According to Walker et al. (2004) and Walker and Systma (2007), specific pollination mechanisms have been the driving forces of the genus' evolution so that stamen architecture can be used as the basis for the determination of monophyletic lineages. The results of the cluster analysis and PCO in this study have revealed segregation among taxa possessing stamens of types B, A and C, although the PCO has shown little support for the grouping of taxa with stamens of type C. The previous authors have shown stamens of type B to be the derived state of stamens of type A, and stamens of type N to be the derived state of stamens of type M. However, taxa possessing stamens of types M and N (*S. aristata*, *S. forskahlei* and *S. glutinosa*) were not found as distinct clusters in this study. These results are also not entirely congruent with those of Will et al. (2013). Several reasons can be proposed for the incongruence of the data between this numerical taxonomic study based on morphological characters and the molecular phylogenetic studies by Walker et al. (2004), Walker and Systma (2007) and Will et al. (2013). First, as explained earlier, in this study stamen type has not been shown to be the sole delimiting criterion for infrageneric groups. Instead, several vegetative and reproductive characters have been shown to be diagnostic in the infrageneric delimitation of *Salvia* in Turkey. Consequently, the results of this study give more support to the findings of Will and Claßen-Bockhoff (2014) in the molecular phylogenetic study on African *Salvia* in that stamen type is more variable than was initially thought. Second, it is likely that variations in gene sequences as revealed in the molecular phylogenetic studies may be proceeding at a different rate compared to the divergence of morphological traits. Thus, taxonomically useful discontinuities among taxa, specifically within and among clusters C, D and E, were not pronounced in this study. Furthermore, some taxa may have created difficulties in the delimitation of distinct clusters due to possible continuous variation exhibited by closely-related taxa. Third, parallel evolution within cluster C, cluster D and cluster E might account for the high overall similarities observed among taxa within these clusters. Fourth, 43 macromorphological characters of the stem, plant habit, leaves, inflorescence, bracts, bracteoles, flowering and fruiting calyces, corollae, androecium, gynoecium and indumenta that were used in this study may have limited the discriminatory power of infrageneric groups. The use of more characters from different life-stages and ecology of the plant would perhaps have increased the possibility of a demarcation among taxa, since it has been shown in this study that both vegetative and reproductive characters are taxonomically important. Finally, although this study has aimed to deal with *Salvia* taxa found in Turkey, a satisfactory delimitation of the genus *Salvia* must provide for all known species in the world in order to give a true account of infrageneric groups.

CHAPTER 5

CONCLUSIONS

The genus *Salvia* L. in Turkey can be delimited into five clusters based on a variety of vegetative and reproductive morphological characters:

Cluster A: Annual herbs. Inflorescence topped with a coma of sterile bracts. Fruiting calyces thick-textured and scarcely or not accrescent. Corolla exannulate; upper lip straight-hooded; mouth narrow. Stamens of type B.
Species: *S. viridis*

Cluster B: Biennial or perennial herbaceous or suffruticose plants. Fruiting calyces thick-textured and scarcely or not accrescent; recurved or not. Corolla exannulate; tube squamulate or not; upper lip falcate-compressed or recurved-hooded; mouth narrow. Stamens of type B.
Species: *S. adenocaulon*, *S. aethiopis*, *S. amplexicaulis*, *S. argentea*, *S. atropatana*, *S. brachyantha*, *S. candidissima*, *S. cassia*, *S. ceratophylla*, *S. chionantha*, *S. chrysophylla*, *S. cilicica, S. cyanescens, S. dichroantha, S. ekimiana, S. eriophora*, *S. frigida*, *S. halophila*, *S. hypargeia*, *S. indica*, *S. limbata*, *S. longipedicellata*, *S. macrosiphon, S. microstegia, S. modesta*, *S. montbretii*, *S. nemorosa*, *S. nutans*, *S. odontochlamys*, *S. palaestina*, *S. poculata*, *S. sclarea*, *S. siirtica*, *S. spinosa*, *S. staminea*, *S. syriaca*, *S. tobeyi*, *S. verbenaca*, *S. vermifolia*, *S. virgata*, *S. viscosa*, *S. xanthocheila*, *S. yosgadensis*.

Cluster C: Perennial herbs. Stems ascending. Inflorescences many-flowered, 8-20 or 20-40 flowers per verticillaster. Pedicels deflexed. Bracts inconspicuous; bracteoles absent. Calyces purplish; shorter than the corolla tube. Fruiting calyces thick-textured and scarcely or not accrescent; recurved or not. Corolla annulate; upper lip stiff and open-hooded; mouth wide. Stamens of type C.
Species: *S. napifolia*, *S. russellii*, *S. verticillata*.

Cluster D: Perennial herbaceous, suffruticose or fruticose plants. Calyces usually tridentate, truncate in *S. pinnata*; upper lip teeth acute to acuminate or with apical processes. Fruiting calyces thick-textured and scarcely or not accrescent, or membranous-reticulate and broadly accrescent; recurved or not. Corolla annulate; upper lip straight-hooded, falcate-compressed in *S. glutinosa* and *S. forskahlei*; mouth wide. Stamens of type A, M or N.
Species: *S. adenophylla*, *S. albimaculata*, *S. anatolica*, *S. aramiensis*, *S. aristata*, *S. aucheri*, *S. ballsiana*, *S. blepharochlaena*, *S. bracteata*, *S. cadmica*, *S. caespitosa*, *S. cedronella*, *S. divaricata*, *S. forskahlei*, *S. freyniana*, *S. fruticosa*, *S. glutinosa*, *S. heldreichiana*, *S. huberi*, *S. hydrangea*, *S. macrochlamys*, *S. marashica*, *S. nydeggeri*, *S. pachystachys*, *S. pilifera*, *S. pinnata*, *S. pisidica*, *S. pomifera*, *S. potentillifolia*, *S. quezelii*, *S. recognita*, *S. rosifolia*, *S. smyrnaea*, *S. suffruticosa*, *S. tchihatcheffii*, *S. tomentosa*, *S. trichoclada*, *S. wiedemannii*. Possibly *S. hedgeana*, *S. kurdica*, *S. reeseana* and *S. tigrina*.

Cluster E: Perennial herbaceous or suffruticose plants. Stems ascending. Bracts inconspicuous. Calyces often purplish and longer than the corolla tube. Fruiting calyces membranous-reticulate and broadly accrescent; recurved. Corolla annulate; upper lip straight-hooded; mouth wide. Stamens of type A; included within the upper lip of the calyx.
Species: *S. absconditiflora*, *S. aytachii*, *S. cerino-pruinosa*, *S. euphratica*, *S. kronenburgii*, *S. multicaulis*, *S. pseudeuphratica*, *S. sericeo-tomentosa*.

Unknown: *S. haussknechtii*.

With the exceptions of cluster A and cluster C, these clusters comprising the Turkish *Salvia* cannot be classified according to Bentham's (1876) sectional delimitation. This shows that Bentham's classification is highly artificial. Instead, the infrageneric groupings resulting from this study show more congruence with the findings of molecular phylogenetic studies with regards to shared morphological characters.

The numerical taxonomic analysis based on detailed vegetative and reproductive morphological characters was useful in classifying the 100 *Salvia* taxa found in Turkey. This study has been the first comprehensive phenetic treatment of the Turkish *Salvia* since Bentham's (1832-1833; 1848; 1876) sectional delimitation of the genus and since the publication of the *Flora of Turkey and the East Aegean Islands, vol. 7* in 1982. Because recent molecular phylogenetic studies, such as those by Walker et al. (2004), Walker and Systma (2007), Drew and Systma (2011; 2012) and Will and Claßen-Bockhoff (2014), have revealed *Salvia* to be a paraphyletic genus with the genera *Perovskia* Kar., *Rosmarinus* L., *Meriandra* Benth., *Dorystaechas* Boiss. & Heldr. ex Benth. and *Zhumeria* Rech. f. & Wendelbo being sister lineages, future studies may be carried out by incorporating worldwide *Salvia* species and the genera listed above. Additionally, characters not employed in this study, such as nutlet characteristics, pollen characteristics, ecological data and molecular data, could be added into future phenetic studies. Finally, phylogenetic studies using morphological, ecological and distributional data may be performed and then compared with those using morphological data for a more integrated approach to taxonomy.

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APPENDIX A

TAXA USED IN THE STUDY

Table 3. List of taxa used in the numerical taxonomic analysis.

Taxon	Voucher	Locality
S. absconditiflora	FC1429, SB416, SB417	C3 Konya: Şarkı Kırkağaç to Beyşehir, c. 10 km before Beyşehir, 1139 m, 04 May 008, 37°45’887”N 31°40’401”E B3 Eskişehir: Above Seyitgazi district, 1010 m, 10 May 2008, 39°26’331”N 30°41’920”E B3 Eskişehir: 20 km past Alpu towards Mihalıççık eski near Osmanlı mezarı, 849 m, 39°49’102”N 31°09’677”E
S. adenocaulon	FC1002, FC1251	C4 Karaman: Karaman to Ermenek, around Karaman Bey Pass, 1920 m, 26 Jul 2005, 36°49’713”N 32°56’630”E C4 Ermenek: Sarıveliler, above Civandere village, 1694 m, 21 Jun 2007, 36°41’918”N 32°31’046”E
S. adenophylla	FC1500, FC1467	C2 Denizli: Denizli to Burdur from Yesilova road, junction of Pınarbaşı village, around stream slopes, 937-950 m, 9 Jun 2008, 37°30’463”N 29°27’727”E C2 Denizli/Burdur: Acıpayam to Gölhisar, before ca. 2 km from Çamköy, close to stream and main road, 970 m, 08 Jun 2008, 37°16’297”N 29°32’855”E
S. aethiopis	AK1323, SB274, SB243	B9 Ağrı: Ağrı to Horasan, near Tahir village, 2110 m, 15 Jul 2006, 39°50’12”N 42°24’34”E B5 Yozgat: To Şefahatli near Bozoksatı sign, 1227 m, 04 Jun 2006, 39°39’739”N 34°44’259”E B4 Ankara: Ankara to Kırşehir, 5 km to Keskin, 1060 m, 01 Jun 2006, 39°42’495”N 33°34’496”E
S. albimaculata	FC1249	C4 Karaman: Ermenek to Mut, about 300-500 m, 1273 m, 36°37’149”N 32°55’327”E
S. amplexicaulis	K4475	A1 Çanakkale: Gelibolu, Kavak-Şarköy road, roadside, 15 m, 28 May 2006
S. anatolica	AK1526, AK1174	B7 Sivas: Kemaliye to Divriği, 1544 m, 02 Jun 2008, 39°31’286”N 38°09’536”E B7 Sivas: Divriği to Kemaliye, 22 km from Divriği to Maltepe, 1560 m, 06 Jun 2006, 39°31’210”N 38°09’370”E
S. aramiensis	FC1400, FC1401	C6 Hatay: Arsuz, Hacı Ahmetli to Karagöz village, 448 m, 02 May 2008, 36°22’171”N 35°57’564”E C6 Arsuz: Arsuz to Samandağ, after 4-5 km from Işık village, 164 m, 02 May 2008, 36°19’591”N 35°48’408”E

Table 3 (cont’d)

Taxon	Voucher	Locality
S. argentea	FC1315, FC1494, FC1434	B1 Antalya: Elmalı, Elmalı to Finike, above Avlan Lake, Ördibek Yaylası, 1573 m, 07 Jul 2007, 36°29’501”N 29°55’831”E C2 Muğla: Köycegiz, Sandras Dağ, above Yeşil Köy, 1660 m, 10 Jun 2008, 37°02’702”N 28°47’433”E C2 Konya: Seydişehir to Akseki, before 38 km from Akseki, 1658 m, 06 Jun 2008, 37°12’444”N 31°55’115”E
S. aristata	DA358	B10 Van: Başkale district, Mor Mountain, Çaldıran village, south slopes of Mustepe Hill, steppe, 2000-2200 m, 16 Jun 2007
S. atropatana	AK1548, AK1570	C9 Şırnak: Şırnak and Hakkari, Yemişli village, 1245 m, 06 Jun 2008 C10 Hakkari: Between Hakkari and Van, 1839 m, 07 Jun 2008
S. aucheri subsp. *aucheri*	FC1359, FC980	C5 Niğde-Adana: Çiftehan, Bolkar Dagları, Çiftehan to Alihoca village about 1-2 km from the main road, 1020-1200 m, 30 Jul 2008, 37°30’665”N 34°44’304”E C5 Adana: Pozantı, around Gülek Bogazı, open shrubs and calcareous rocks, 1130-1140 m, 24 Jul 2005, 37°17’250”N 34°47’072”E
S. aucheri subsp. *canescens*	FC1245, FC994, FC999	C4 Karaman: Mut to Ermenek, 39 km before Ermenek, slopes, 872 m, 21 Jun 2007, 36°34’171”N 33°10’196”E C4 Karaman: Mut to Ermenek, 25 km before Ermenek, Çamlıca village to Damlaçal, roadsides, 1200 m, 25 Jul 2008, 36°37’846”N 33°01’761”E C4 Karaman: Ermenek, Mut to Ermenek, 1.5-2 km before Ermenek, 1300-1400 m, 26 Jul 2005, 36°37’715”N 32°54’609”E
S. aytachii	FC903, SB412	A3 Ankara: ~10 km West of Beypazarı, Çairhanede, 623 m, 04 Jun 2005, 40°06’705”N 31°45’943”E B3 Ankara: 21 km past Polatlı towards Sivrihisar, ~42 km to about 200 m N. side of road, 751 m, 10 May 2008, 39°34’541”N 31°55’304”E
S. ballsiana	AK1505	B7 Adıyaman: East of Adıyaman, Gerger, above Kaşyazı village, near Dokuzdere, 1050-1160 m, 18 May 2008, 38°03’277”N 39°04′695″E
S. blepharochlaena	FC1134, SB447, SB321	C4 Karaman: Karaman to Mut, c. 1.2 km, 1112 m, 01 Jul 2006, 37°08’205”N 33°13’618”E B5 Ürgüp: Karlık to Yeşilöz, on the hills to the right, 1304 m, 29 May 2008, 38°33’195”N 34°59’481”E B6 Pınarbaşı: 2 km south of A. Beycayır, 1032 m, 08 Jun 2006, 38°38’800”N 36°26’605”E

Table 3 (cont’d)

Taxon	Voucher	Locality
S. brachyantha subsp. *brachyantha*	AK1448	B9 Van: Van to Başkale, Güzeldere, 2791 m, 11 May 2007
S. bracteata	AK1499,	B6 Malatya: Darende to Malatya, 1260 m, 17 May 2008, 38^{o}22′116″N 37^{o}57′105″E
	FC899,	A4 Ankara: Ayaş road around Ayaş beli, 1052 m, 04 Jun 2005, 40^{o}01’371”N 32^{o}20’482”E
	SB386	C6 Gaziantep: Karkmış, 2 km to Nazip, 490 m, 21 Apr 2007, 36^{o}58’205”N 37^{o}4’307”E
S. cadmica var. *bozkiriensis*	FC1207,	C4 Konya: Bozkır, Bozkır to Akseki, Around Dere Village, 1150 m, on limestone rocks, 11 May 2007, 37^{o}10’034”N 32^{o}09’489”E
	FC1210	C3 Sarkıkaragaç to Akşehir: Sultan Mountain, above Bağkonak village, 1250 m, on limestone rocks, 38^{o}13’197”N 31^{o}17’375”E
S. cadmica var. *cadmica*	FC1209	C3 Sarkıkaragaç to Akşehir: Sultan Mountain, above Bağkonak village, 1250 m, on limestone rocks, 38^{o}13’197”N 31^{o}17’375”E
S. caespitosa	AK1248,	B6 Sivas: around Yağdonduran Pass, 1650-1850 m, 08 Jul 2006
	AK1587,	B7 Sivas: Arapkir to Divriği, Sarıçiçek village, 1772 m, 25 Jul 2008
	FC1070,	B6 Kayseri: Sarız, Yeşilkent (Yalak), Binboğa Dağ, above Dayoluk village, Afan Yaylası, 2172 m, 10 Jun 2006, 38^{o}21’082”N 36^{o}30’905”E
	FC1154,	C3 Antalya: Merkez, above Feslikan Yaylası, Karçukuru mevkii, 1929-1950 m, 03 Jul 2006, 36^{o}48’693”N 30^{o}23’098”E
	FC1520,	C3 Antalya: Kemer, top of Tahtalı Mountain, 2200-2300 m, 09 Jun 2008, 36^{o}32’338”N 30^{o}26’347”E
	SB431	B6 Pınarbaşı: East of Şirvan Dağı, Keklikpınar village hills, 1609 m, 11 Jun 2008, 38^{o}42’824”N 36^{o}24’624”E
S. candidissima subsp. *candidissima*	FC938,	A4 Çankırı: Eldivan towards TV tower station on the mountain, 673 m, 05 Jul 2005, 40^{o}31’260”N 33^{o}29’600”E
	SB508	B4 Ankara: Ankara Hills above Kalecik, 4 km to Gülkoy, 18 Jul 2008, 40^{o}05’067”N 33^{o}22’060”E
S. candidissima subsp. *occidentalis*	FC1326,	C2 Antalya: Elmalı, Cedar Research Forest, 1690 m, 07 Jul 2007, 36^{o}35’800”N 30^{o}02’077”E
	SB532	B5 Nevşehir: 5 km to Karalık-Yeşilöz turn off, 1304 m, 22 Jul 2008, 38^{o}37’435”N 34^{o}57’575”N

Table 3 (cont’d)

Taxon	Voucher	Locality
S. cassia	FC1411	C6 Hatay: Kırıkhan, Merkez, Cevizyokuşu, 200-210 m, 03 May 2008, 36^{o}29’753”N 36^{o}20’710”E
S. cedronella	FC1470,	C2 Denizli-Burdur: SW Anatolia, Acıpayam to Gölhisar, before ca. 2 km from Çamköy, close to stream and main road, 970 m, 08 Jun 2008, 37^{o}16’297”N 29^{o}32’855”E
	FC1499,	C2 Denizli: Denizli to Burdur from Yeşilova road, junction of Pınarbaşı village, around stream slopes, 937-950 m, 09 Jun 2008, 37^{o}30’463”N 29^{o}27’727”E
	FC1363	B3 Afyon: Dinar to Dazkırı, about 8 km, open *Pinus* forest, 978 m, 22 Jun 2007, 38^{o}02’383”N 30^{o}04’609”E
S. ceratophylla	AK1500,	B6 Malatya: Darende to Malatya, 1260 m, 17 May 2008, 38^{o}22′116″N 37^{o}57′105″E
	SB261	B6 Sivas: Zara to Divriği, 4-5 km to Divriği, 1285 m, 02 Jun 2006, 37^{o}50’392”N 44^{o}07’156”E
S. cerino-pruinosa	AK1530	B7 Elazığ: 20 km from Elazığ to Pertek, 850-915 m, 03 Jun 2008
S. chionantha	FC1464,	C2 Burdur: Tefenni to Çavdır, about 4-6 km, fields, 1166 m, 08 Jun 2007, 37^{o}15’406”N 29^{o}45’288”E
	FC1485	C3 Antalya: Elmalı, around Avlan Lake, road of Çıglıkkara forest (Kofu Dağları), 1055 m, 09 Jun 2008, 36^{o}34’737”N 29^{o}55’211”E
S. chrysophylla	FC1327,	C2 Antalya: Elmalı, Elmalı to Kaş, Göyre town, Akdağlar, above Uçansu, 2119-2300 m, 07 Jul 2007, 36^{o}34’432”N 29^{o}36’432”E
	FC1330	C2 Muğla: Elmalı to Fethiye, Seki, Eren Mt., 07 Jul 2007, 1800-1850 m, 36^{o}44’890”N 29^{o}36’477”E
S. cilicica	FC1199,	C5 Adana: Pozantı, Pozantı to Akçatekir, about 3-4 km, 858-945 m, 24 Jul 2005, 37^{o}23’287”N 34^{o}51’027”E
	FC1358,	C5 Niğde: Çiftehan, Çiftehan to Ulukısla, Alihoca-Madenköy road, ca. 1-2 km from main road, 1020-1200 m, 30 Jul 2007, 37^{o}30’665”N 34^{o}44’304”E
	FC979	C5 Adana: Pozantı, Pozantı to Akçatekir, about 3-4 km, 858-945 m, 24 Jul 2005, 37^{o}23’287”N 34^{o}51’027”E
S. cyanescens	FC1140,	C4 Karaman: Ermenek, 5 km before Karamanbey pass, 1657 m, 01 Jul 2006, 36^{o}52’652”N 32^{o}56’513”E
	FC863,	B5 Yozgat: Akdağmadeni to Yıldızeli roadside, 1323 m, 12 Jul 2005, 39^{o}49’217”N 36^{o}19’432”E
	FC932	B4 Ankara: Elmadağ on the road to Kırıkkale, 1084 m, 05 Jul 2005, 39^{o}55’346”N 33^{o}15’826”E

Table 3 (cont’d)

Taxon	Voucher	Locality
S. dichroantha	FC1340, FC960	C2 Antalya-Muğla: Elmalı to Fethiye, Eren Mountain, 1800-1850 m, 07 Jul 2007, 36°44’890”N 29°36’477”E B4 Konya: Cihanbeyli roadside, 884 m, 38°38’117”N 32°55’858”E
S. divaricata	AK1270, AK1260	B7 Erzincan: Çiğdemli Mountain, Hayatlar hill, 1775 m, 09 Jul 2006, 39°35′34″N 38°44′26″E B7 Sivas: 26 km from Divriği to Kemaliye, 1535 m, 09 Jul 2006, 39°31′14″N 38°09′40″E
S. ekimiana	FC1214	B5 Yozgat: Above Akbağmadeni, Aktaş region, 1793 m, *Pinus sylvestris* forest and alpine steppe, 16 Jun 2007, 39°35’157”N 35°50’014”E
S. eriophora	AK1495, AK1363	B6 Kayseri/Sivas: near Güneşli village, 1878 m, 17 May 2008, 38°52′054″N 36°51′744″E B6 Kayseri/Sivas: Pınarbaşı to Gürün, 45-50 km to Gürün, 1870 m, 18 May 2007
S. euphratica var. *euphratica*	AK1098, AK1226a, AK1510b	B6 Malatya: 1-1.5 km from Darende to Malatya, 1000-1030 m, 16 May 2006 B6 Sivas: Gürün to Gökpınar, after 9 km from Gürün, 1525 m B6 Sivas: Gürün to Kangal, 1455 m, 01 Jun 2008
S. euphratica var. *leiocalycina*	AK1226b, AK1511a	B6 Sivas: Gürün to Gökpınar, after 9 km from Gürün, 1525 m B6 Sivas: 9 km from Gürün to Gökpınar, 1544 m, 01 Jun 2008
S. forskahlei	K5471, K5631, K6210	A4 Samsun: Bafra-Balık Lake road, Üçpınar village, roadside, 59 m, 15 Jun 2007 A7 Trabson: Maçka, around the Sümestra monastery, *Picea orientalis* forest, 1343 m, 10 Jul 2007 A9 Artvin: Ardanuç-Arevet (Torbalı) road, near Ekşiler village, 520 m, 25 Jun 2008
S. freyniana	SB277	B5 Yozgat: South of Yozgat, Yozgat to Boğazlıyan, near Yenipazar, Kaşkışla village, hill side, around the graveyard, 1100-1200 m, 04 Jun 2006, 39°30’553”N 35°06’970”E
S. frigida	FC1446, FC1509	C3 Isparta: Aksu, Akpınar Da. summit, 1940 m, 07 Jun 2008, 37°49’670”N 31°03’471”E B2 Kütahya: Saphane, Akdağ, around the summit, Gökçukur Yaylası, 1690-1750 m, 11 Jun 2008, 39°04’252”N 29°14’880”E

Table 3 (cont’d)

Taxon	Voucher	Locality
S. fruticosa	FC1048,	C1 Muğla: Milas, Milas to Akbük, above Kazıklı village, 184-200 m, 04 May 2006, 37^{o}22’382”N 27^{o}29’597”E
	FC1373	C2 Muğla: Marmaris, İçmeler to Turunç, about 1 km, 34 m, 26 Apr 2008, 36^{o}47’721”N 28^{o}13’145”E
S. glutinosa	AK1606	A9 Ardahan: Posof to Derindere, 1660 m, 28 Jul 2008, 41^{o}28’597’’N 42^{o}46’655’’E
S. halophila	FC962,	B4 Konya: Cihanbeyli, Gölyazı Kuşabaşı, 910 m, 23 Jul 2005, 38^{o}32’244”N 33^{o}23’323”E
	SB534	B4 Konya: Sultanhanı to Aksaray, 44 km to Aksaray, 6 km to new salt factory “Balküpü tuz factory”, 1000 m, 23 Jul 2008, 38^{o}15’197”N 33^{o}34’712”E
S. heldreichiana	FC1108,	C5 Adana: Pozantı, Gülek, Kandilsırtı pass, 1370 m, 14 Jun 2006, 37^{o}17’176”N 34^{o}44’231”E
	FC995,	C4 Karaman: Ermenek, above Çamlıca village, Damlaçal, 1755 m, 25 Jul 2005, 36^{o}39’846”N 33^{o}01’053”E
	FC1531	B4 Ankara: Elmadağ ilçesi, Elmadağ to Kırıkkale, main road, about 2-3 km from Elmadağ, slopes, 1100-1200 m, 05 Jul 2005, 39^{o}55’354”N 33^{o}15’816”E
S. huberi	AK1474	A8 Erzurum: 41 km from Erzurum to Tortum, 2121 m, 14 Jul 2006, 40^{o}13′341″N 41^{o}28′545″E
S. hydrangea	AK1468,	A9 Kars: 1 km from Kağızman to Kars, 1315 m, 13 Jul 2007, 40^{o}09′332″N 43^{o}06′692″E
	AK1317	B9 Iğdır: foots of Ağrı Mountain, 1318 m, 14 Jul 2006, 39^{o}47′17″N 44^{o}07′41″E
S. hypargeia	AK1173,	B7 Sivas: Divriği to Kemaliye, near Demirdağ bridge, 1017 m, 06 Jun 2008, 39^{o}25′29″N 38^{o}06′27″E
	AK1215,	B6 Malatya: 64 km from Darende to Malatya, near Develi village, 1326 m, 07 Jun 2006, 38^{o}22′59″N 37^{o}55′25″E
	FC955	A3 Kızılcahamam: Çamlıdere to Peçenek roadside, 1124 m, 07 Jul, 40^{o}26’627”N 32^{o}24’992”E
S. indica	AK1539,	C9 Siirt: Eruh to Şırnak, near Yanılmazlar village, 1195 m, 05 Jun 2008, 37^{o}42′269″N 42^{o}15′804″E
	FC1419	C6 Kahramanmaraş: Çağlayancerit, above Erince village, 1281 m, 03 May 2008, 37^{o}44’279”N 37^{o}24’221”E
S. kronenburgii	AK1326a,	B9 Van: Between Van and Gürpınar, 2125 m, 16 Jul 2006, 38^{o}24’15”N 43^{o}23’10”E
	AK1575	B9 Van: 5 km from Köşebaşı village to Van, 1975 m, 08 Jun 2008

Table 3 (cont’d)

Taxon	Voucher	Locality
S. limbata	AK1293, AK1329	B8 Erzurum: Ilıca to Erzurum, ca. 5 km to Erzurum, 1817 m, 10 07 2006, 38°55′00″N 41°12′42″E B9 Van: Van to Gürpınar, 2220 m, 16 Jul 2006, 38°22′31″N 43°23′30″E
S. longipedicellata	AK1459, SB528	B9 Ağrı: 60 km from Ağrı to Horasan, 2081 m, 12 Jul 2007 B6 Sivas: Zara-Kangal to Külekli, c. 3 km, 1484 m, 20 Jul 2008, 39°21’624”N 37°39’978”E
S. macrochlamys	AK1540, AK1440	C8 Siirt: Eruh to Şırnak, 8 km to Şırnak near Yanılmazlar village, 1195 m, 05 Jun 2008, 37°42′269″N 42°15′804″E B9 Van: Bahçesaray-Van road, 1-2 km to junction of Gevaş-Çatak road, around Yapılı (Derniş) village, 2150 m, 09 Jul 2007, 38°07′622″N 43°05′997″E
S. marashica	FC1020	C6 Kahramanmaraş: Ahır Da., Sarıçukur to Maksutlu village, 871 m, 27 Apr 2006, 37°39’140”N 36°50’538”E
S. microstegia	FC1067, FC1133, FC965	B5 Kayseri: Bakırdag to Saimbeyli, around Gezbeli pass, above Hanyeri village, 1880 m, 09 Jun 2006, 38°12’700”N 36°00’304”E C4 Karaman: above Kazımkarabekir, Hacıbaba Tepesi, 1519 m, 01 Jul 2006, 37°09’882”N 32°57’969”E B5 Niğde: Melendiz Dağı to Tepeköy, 2228 m, 23 Jul 2005, 38°06’298”N 34°36’624”E
S. modesta	FC1065, FC1072	B5 Kayseri/Adana: Bakırdağ to Saimbeyli, Gezbeli pass, 1970 m, 09 Jun 2006, 38°12’225”N 35°59’650”E B5 Kayseri: Sarız, Yeşilkent (Yalak), Binboğa Da., above Dayoluk village, Afan Plateau, 2172 m, 10 Jun 2006, 38°21’065 N 36°30’649”E
S. montbretii	AK1379, AK1375	C8 Batman: Gercüş, 1003 m, 23 May 2007 C8 Mardin: Mardin to Midyat, 933 m, 23 May 2007, 37°20′46″N 40°49′28″E
S. multicaulis	AK1000, AK1122, FC1066	B6 Kahramanmaraş: Karaelbiatan to Elbisatan, 1162 m, 27 Apr 2006, 38°12′24″N 37°09′42″E B7 Elazığ: Malatya to Elazığ, 30 km after from Kale, 1256 m, 17 May 2006, 38°28′47″N 39°02′23″E B5 Kayseri: Bakırdağ to Saimbeyli, around Gezbeli pass, 1900 m, 09 Jun 2006, 38°12’225”N 35°59’650”E

Table 3 (cont’d)

Taxon	Voucher	Locality
S. napifolia	FC1632, FC1646	C4 Mersin: Fındıkpınar, around Cemilli village, 470 m, 01 Jun 2009, 36^{o}48’091”N 34^{o}27’214”E C6 Hatay: Antakya, Samandağ to Yayladağ, above Gözene village, 287 m, 02 Jun 2009, 36^{o}03’317”N 36^{o}00’960”E
S. nemorosa	AK1456, SB473, AK1308	B9 Ağrı: Between Tutak and Hamur, 2 km to Hamur, 1610 m, 12 Jul 2007, 39^{o}36’392”N 42^{o}57’767”E B5 Kayseri: Kayseri to Tomarza, 1 km to Tomarza, 1407 m, 10 Jun 2008, 38^{o}28’540”N 35^{o}48’496”E A9 Kars: near Selim, 2012 m, 12 Jul 2006, 40^{o}17’40”N 42^{o}39’21”E
S. nutans	K4492	A1 Kırklareli: Lüleburgaz-Çorlu, Kepirtepe, 1 km before Yenibedir village, 89 m, 28 May 2006
S. nydeggeri	FC1164, FC1491	C2 Antalya/Muğla: Elmalı to Fethiye, before Seki, around Zorlar village, 1465 m, 22 Jun 2007, 36^{o}48’661”N 29^{o}41’439”E C2 Antalya: Elmalı to Fethiye, after Eskihisar village, slopes, 1163-1263 m, 22 Jun 2007, 36^{o}48’474”N 29^{o}47’586”E
S. odontochlamys	B6859, AK1579H	B9 Bitlis: Above Doğanlı village, Kalem Dağı, 1900 m, 08 Jun 2003 B9 Bitlis: Kambos Mt., above Hürmüs, 2280 m, 09 Jun 2008, 38^{o}19’408”N 41^{o}58’079”E
S. pachystachys	AK1233	B6 Kayseri: 3 km from Sarız to Pınarbaşı, 1700-1800 m, 08 Jun 2006, 38^{o}30′01″N 36^{o}29′53″E
S. palaestina	AK1063, AK1124, AK1383	C6 Şanlıurfa: Near Birecik, 447 m, 29 Apr 2006, 37^{o}00′994″N 37^{o}53′259″E B7 Malatya: Malatya to Adıyaman, 903 m, 17 May 2006, 38^{o}19′41″N 38^{o}12′33″E C8 Diyarbakır: Mardin to Diyarbakır, near Çınar, 619 m, 24 May 2007, 37^{o}49′58″N 40^{o}15′06″E
S. pilifera	AK1506, FC1017	B7 Adıyaman: East of Adıyaman, Gerger, above Kaşyazı Village, 1084 m, 18 May 2008, 38^{o}03’277”N 39^{o}04’879”E B6 Kahramanmaraş: Ahır Dağı, Merkez to Sarıçukur village about 2 km, 764 m, 27 Apr 2006, 37^{o}37’207”N 36^{o}49’920”E
S. pinnata	FC1370, FC1021	C2 Denizli: Tavas to Kale, between Hırka to Kale village, 950 m, 26 Apr 2008, 37^{o}28’094”N 28^{o}53’989”E C6 Kahramanmaraş: Merkez, road of Kılavuzlu village, 528 m, 27 Apr 2006, 37^{o}37’430”N 36^{o}48’440”E

Table 3 (cont’d)

Taxon	Voucher	Locality
S. pisidica	FC1381, FC1456, FC1461	C3 Antalya: Elmalı, Finike to Elmalı, before Elmalı about 1-2 km, rocky slopes, 1027 m, 28 Apr 2008, 36°42’674”N 29°55’035”E B3 Afyon: Dazkırı to Dinar, before about 8-10 km from Dinar, 1026 m, 05 Jul 2006, 38°02’240”N 30°03’320”E C3 Burdur: Burdur to Çavdır, above Hacılar village, 950 m, 08 Jun 2008, 37°33’470”N 30°04’483”E
S. poculata	AK1431, AK1457	B9 Van: Soğuksu to Bahçesaray, 20 km to Bahçesaray, 2218 m, 09 Jul 2007 B9 Ağrı: Tutak to Hamur, 1610 m, 12 Jul 2007, 39°36′392″N 42°57′767″E
S. pomifera	FC1050	C1 Aydın: Kuşadası, Davutlar, Milli Park, 10-25 m, 04 May 2006, 37°42’648”N 27°12’671”E
S. potentillifolia	FC1488, FC1490	C3 Antalya: Elmalı, around Avlan Lake (Kofu Da.) to Çığlıkara forest, 1080 m, 09 Jun 2008 C3 Antalya: Elmalı to Fethiye, after Pirhasan village ca. 500 m, 1070 m, 09 Jun 2008
S. pseudeuphratica	AK1384, AK1200	B7 Elazığ: 1.5-2 km from Keban to Elazığ, 750-800 m, 24 May 2007 B7 Elazığ: 5 km from Keban to Elazığ, 850-900 m, 07 Jun 2006
S. quezelii	FC1626	C4 Mersin: Anamur to Ermenek, about 37-39 km, 1023 m, 31 May 2009, 36°13’060”N 32°53’970”E
S. recognita	FC949, SB378, SB470	A4 Ankara: Kalecik to Akyurt, pass the rail road on the right side on the bank of the river, 1052 m, 07 Jul 2005, 40°08’724”N 33°21’351”E B5 Kayseri: Erciyes Mountain 2-3 km after the ski center on the left side of the road, 1833 m, 22 Jul 2006, 38°27’985”N 35°31’101”E B5 Kayseri: Ali Mountain, 1600 m, 10 Jun 2008, 38°40’437”N 35°33’451”E
S. rosifolia	AK1471	A9: 28 km from Kağızman to Kars, 1834 m, 13 Jul 2007, 40°16′875″N 42°57′084″E
S. russellii	AK1451, SB258, SB271	B9 Van: Van to Gürpınar, 2230 m, 11 Jul 2007 A4: Eldivan to Ankara 4 km to Şabansı, 1199 m, 01 Jun 2006, 40°28’847”N 33°18’851”E B5 Yozgat: From Ankara 35 km to Yozgat, roadside, 923 m, 04 Jun 2006, 39°39’361”N 34°32’344”E

Table 3 (cont’d)

Taxon	Voucher	Locality
S. sclarea	AK1194, FC919, FC1161, SB453	B7 Erzincan: Kemaliye, 950-1100 m, 06 Jun 2006, 39^{o}14′35″N 38^{o}29′36″E B4 Ankara: Çiğdem Mah., 22 Jun 2005 C3 Antalya: Elmalı, Elmalı to Fethiye, around Eskihisar village, 1122 m, 03 Jul 2006, 36^{o}49’607”N 29^{o}47’371”E C2 Uşak: 7 km to Sivaslı, 797 m, 30 May 2008, 38^{o}32’534”N 29^{o}37’713”E
S. sericeo-tomentosa var. *hatayica*	FC1402, FC1232	C6 Hatay: Samandağ to Arsuz, among *Quercus coccifera* shrubs, 20-50 m, 02 May 2008, 36^{o}15’684”N 35^{o}48’706”E C6 Hatay: Samandağ to Arsuz, among *Quercus coccifera* shrubs, 20-50 m, 19 Jun 2007, 36^{o}12’734”N 35^{o}51’218”E
S. siirtica	FC1661	C9 Siirt: North of Siirt, Aydınlar, Çatılı region, 1473 m, open *Quercus* forest, 03 Jun 2009, 38^{o}1’23.9988’’N 42^{o}16’0.9984’’E
S. smyrnaea	FC1053	B1 İzmir: Kemalpaşa, Nif Dağı, around the summit, 1450-1510 m, 04 May 2006, 38^{o}23’225”N 27^{o}21’350”E
S. spinosa	AK1382	C8 Diyarbakır: Mardin to Diyarbakır, 46 km to Diyarbakır, 759 m, 24 May 2007, 37^{o}39′16″N 40^{o}28′21″E
S. staminea	AK1277, AK1310, AK1460	B7 Erzincan: Sipikör Mountain, 2270 m, 10 Jul 2006, 39^{o}52’39’’N 39^{o}33’36’’E A9 Kars: Susuz to Ardahan, 31 km to Ardahan, 2012 m, 13 Jul 2006, 40^{o}58’17’’N 42^{o}53’50’’E B9 Ağrı: Ağrı to Horasan, near Tahir village, 2081 m, 12 Jul 2007, 39^{o}50’13’’N 42^{o}25’275’’E
S. suffruticosa	AK1527, SB429	B6 Malatya: Kangal to Hekimhan, near Hasançelebi village, 02 Jun 2008 B6 Sivas: Divriği to Kangal, 1 km to Kayaburun Köy at Mürsel cross road, 1183 m, 17 May 2008, 39^{o}17’465”N 38^{o}01’875”E
S. syriaca	AK1127, SB440, SB244, AK1347	B6 Malatya: Malatya to Adıyaman, ca. 4 km to Doğanşehir, 1279 m, 17 May 2006, 38^{o}05′04″N 37^{o}54′32″E B5 Aksaray: Aksaray, 30 km to Nevşehir roadside, 1260 m, 29 May 2008, 38^{o}31’686”N 34^{o}24’826”E B4 Ankara: Ankara to Kırşehir, 5 km to Keskin, 1060 m, 39^{o}42’495”N 33^{o}34’496”E C6 Gaziantep: Sof Mountain, 1075 m, 20 May 2007, 37^{o}09′44″N 37^{o}12′44″E

Table 3 (cont’d)

Taxon	Voucher	Locality
S. tchihatcheffii	FC1425, FC897	B4 Ankara: Behind the Department of Biological Sciences at O.D.T.Ü., 900 m, 39^{o}53’747”N 32^{o}46’727”E B4 Ankara: Behind the Department of Biological Sciences at O.D.T.Ü., 900 m, 39^{o}53’747”N 32^{o}46’727”E
S. tobeyi	SB539	B4 Ankara: Elmadağ, above Yeşildere, 1400-1700 m, 20 May 2010, 40^{o}01’537”N 33^{o}16’944”E
S. tomentosa	FC986, SB455, FC1167, FC1150, SB502	C5 İçel: Çamlıyayla, around Namrun Castle, 1300-1350 m, 24 Jul 2005, 37^{o}09’933”N 34^{o}36’029”E B1 Izmir: Kemal Paşa Mountain, 490 m, 02 Jun 2008, 38^{o}25’061”N 27^{o}24’015”E C2 Denizli: 15 km before Kızılbucak, above Geyre, Baba Da., 1314 m, 05 Jul 2006, 37^{o}43’287”N 28^{o}49’910”E C3 Antalya: Akseki, Murtiçi, Çukurbağ village c. 5 km, 655 m, 02 Jul 2006, 36^{o}52’531”N 31^{o}49’343”E A4 Ankara: Eldivan Mountain near the fire department, 1081 m, 17 Jul 2008, 40^{o}29’738”N 33^{o}30’371”E
S. trichoclada	AK1422, AK1532, AK1541	B8 Bingöl: Elazığ-Bingöl road, near Bingöl, 08 Jul 2007, 38^{o}54’243”N 40^{o}27’522”E B7 Elazığ: Yaylım Mountain, near Şemik village, 1335 m, 03 Jun 2008, 38^{o}29′671″N 39^{o}35′031″E C9 Siirt: Eruh to Şırnak, near Yanılmazlar village, 1195 m, 05 Jun 2008, 37^{o}42′269″N 42^{o}15′804″E
S. verbenaca	FC1372, FC1027, FC1029, FC952	C1 Muğla: Akyaka town, 28 m, 27 Apr 2008, 37^{o}03’271”N 28^{o}19’203”E C6 Hatay: İskenderun, Belen, around Soğukoluk village, 30 Apr 2006, 837 m, 36^{o}29’270”N 36^{o}09’309”E C5 İçel: Silifke, above Cennet-Cehennem Mağaraları, 01 May 2006, 266 m, 36^{o}27’458”N 34^{o}05’619”E A4 Ankara: Çamlıdere to Peçenek roadside, 1124 m, 07 Jul 2005, 40^{o}26’627”N 32^{o}24’990”E
S. vermifolia	SB521	B6 Sivas: Ulaş Kurtlukaya to Boğazdere, left side of the road, 1495 m, 20 Jul 2008, 39^{o}23’142”N 36^{o}55’898”E

Table 3 (cont’d)

Taxon	Voucher	Locality
S. verticillata subsp. *amasiaca*	AK1169,	B7 Sivas: Dumlucadağ, 1500-1575 m, 06 Jun 2006
	AK1217,	B6 Malatya: Malatya to Darende, near Yukarı Ulupınar village, 1410 m, 07 Jun 2006
	FC984	C5 İçel: Çamlıyayla, Fakılar village, Papazın Bahçesi, 400-1000 m, 24 Jul 2005, 37^{o}11’332”N 34^{o}38’640”E
S. verticillata subsp. *verticillata*	AK1551,	C9 Şırnak: Şırnak to Hakkari, near Yemişli village, 1245 m, 06 Jun 2008
	AK1559	A9 Erzurum: Şenkaya, Allahuekber Mountain, 2643 m, 27 Jul 2008
S. virgata	AK1218,	B6 Malatya: Malatya to Darende, 1410 m, 07 Jun 2006
	SB467,	B5 Kırşehir: Kırşehir, 40 km to Kayseri, 1150 m, 38^{o}53’558”N 35^{o}06’893”E
	SB520,	B6: Sivas to Ulaş roadside, 1373 m, 20 Jul 2008, 39^{o}27’489”N 37^{o}01’047”E
	SB239	B3 Ankara: From Nallıhan, 47 km to Beypazarı, 652 m, 31 May 2006, 40^{o}08’677”N 31^{o}28’713”E
S. viridis	AK1038,	C7 Adıyaman: Besni to Şanlıurfa, 625 m, 28 Jun 2006, 37^{o}31′645″N 38^{o}13′121″E
	AK1536,	C9 Siirt: 26 km from Siirt to Pervari, 807 m, 05 Jun 2008, 38^{o}02′017″N 42^{o}03′462″E
	FC1024	C6 Hatay: Erzin to İskenderun, 12 m, 36^{o}37’550”N 35^{o}57’445”E
S. viscosa	FC1647	C6 Hatay: Samandağ to Yayladağ, road of Aydınbahçe village, about 2-3 km, 557 m, 02 Jun 09, 36^{o}00’572”N 36^{o}01’137”E
S. wiedemannii	FC1361,	B3 Eskişehir: Sivrihisar to Emirdağ, around Camili village (main road), 885 m, 26 Apr 2008, 39^{o}11’387”N 31^{o}18’137”E
	SB216,	A4 Ankara: Ankara to Polatlı, 20 km past Ümıtköy, 500 m to Başkent Organize Sanayi, 822 m, 31 May 2006, 39^{o}45’699”N 32^{o}27’646”E
	SB413	A4 Ankara: 21 km past Polatlı, 751 m, 10 May 2008, 39^{o}34’541”N 31^{o}55’304”E

Table 3 (cont’d)

Taxon	Voucher	Locality
S. xanthocheila	AK1340, AK1475	B9 Van: Van to Başkale, 2870 m, 17 Jul 2006, 38°10′55″N 43°54′39″E B8 Erzurum: Around Palandöken, 2417 m, 14 Jul 2007, 39°51′077″N 41°17′020″E
S. yosgadensis	SB441, SB449, SB266	B5 Nevşehir: 12 km to Gölşehir on the historic location, 938 m, 29 May 2008, 38°44’155”N 34°40’299”E A4 Ankara: 29 km past Polatlı to Sivrihisar, 880 m, 30 May 2008, 39°33’845”N 31°48’664”E B5 Yozgat: Roadside to Yozgat Büyükyaptı Köyü, 884 m, 04 Jun 2006, 39°56’67”N 33°54’914”E

APPENDIX B

THE DATA MATRIX

Table 5. The t x n data matrix constructed for the numerical taxonomic analysis.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
absconditiflora	1	0	1	1	0	1	1	0	0	1	1	0	1	0	0	0	2	0	1	1	2	2	1	0	1	2	0	6	3	0	1	1	1	0	1	1	0	0	0	1.65	0	0	1
adenocaulon	1	0	2	0	0	1	1	0	0	1	1	1	1	0	0	1	1	1	1	1	1	2	0	0	0	1	0	3	0	1	1	1	0	0	1	0	1	0	0	1.35	1	0	1
adenophylla	1	1	2	1	0	1	1	1	0	1	1	1	1	0	0	0	1	1	1	1	1	2	1	0	0	0	1	3	0	1	1	1	1	0	0	1	0	0	0	2.60	0	0	1
aethiopis	1	0	2	0	0	3	1	0	0	3	1	0	1	0	0	1	2	1	3	1	1	2	0	0	1	2	1	0	2	1	0	3	0	1	1	0	1	0	0	1.60	1	0	0
albimaculata	1	1	2	1	0	1	1	1	0	1	1	0	1	0	0	0	1	1	1	1	0	2	1	0	0	1	2	0	0	1	1	1	1	0	0	1	0	0	1	3.30	0	1	1
amplexicaulis	1	0	2	1	0	1	1	0	0	1	1	1	0	0	0	1	1	0	1	0	1	5	1	0	1	1	1	3	2	1	1	1	0	0	1	0	1	0	0	1.00	1	0	1
anatolica	1	1	2	0	0	0	0	1	0	1	1	0	1	0	0	0	1	1	1	1	0	2	1	0	0	0	2	5	0	0	1	1	1	0	0	1	0	0	0	3.85	0	0	1
aramiensis	1	1	2	1	0	3	1	0	0	3	1	0	1	0	0	1	2	0	1	1	1	1	1	0	0	1	2	0	0	1	0	1	1	0	1	1	0	0	0	2.70	0	0	1
argentea	1	1	2	1	0	1	1	0	1	3	1	0	1	0	0	1	1	1	1	1	1	2	0	0	0	0	1	0	2	1	0	1	0	1	1	0	1	1	0	2.40	1	0	1
aristata	1	1	2	0	1	1	1	0	2	1	1	1	1	0	0	1	1	1	1	1	1	2	0	0	0	0	2	0	2	1	0	1	1	0	0	1	0	0	0	3.10	3	0	1
atropatana	1	1	2	1	0	1	1	0	1	3	1	0	0	0	0	1	1	0	1	1	0	3	0	0	0	0	0	0	2	1	0	1	0	1	1	0	1	1	0	2.15	1	0	1
aucheri subsp. *aucheri*	1	1	2	1	0	0	0	1	0	3	1	0	1	0	0	1	0	1	0	0	1	1	1	1	0	2	1	1	0	1	0	1	1	0	0	1	0	0	1	3.00	0	0	1
aucheri subsp. *canescens*	1	1	2	1	0	3	1	0	0	3	1	0	1	0	0	1	0	1	0	1	1	1	1	1	0	2	1	1	0	1	0	1	1	0	0	1	0	0	1	1.90	0	0	1
aytachii	1	1	1	1	0	1	0	0	0	1	1	0	1	0	0	0	1	1	0	0	2	2	1	0	0	2	2	6	3	0	1	1	1	0	1	1	0	0	0	2.30	0	0	1
ballsiana	1	1	2	1	2	0	0	1	0	1	1	0	1	0	0	1	2	1	0	0	1	2	0	0	0	0	1	0	0	1	1	1	1	0	0	1	0	1	0	3.05	0	0	1
blepharochlaena	1	1	2	1	2	1	1	1	0	1	1	0	1	0	0	0	1	1	1	1	1	2	1	0	0	2	2	5	0	0	1	1	1	0	0	1	0	1	1	3.85	0	0	1
brachyantha subsp. *brachyantha*	1	0	2	1	0	1	0	0	0	1	1	0	1	0	0	1	1	1	1	0	1	4	0	0	1	1	1	0	2	1	0	3	0	1	1	0	1	0	0	1.00	1	0	1
bracteata	1	0	2	1	0	1	1	1	0	1	1	1	1	0	0	1	2	1	1	1	0	3	1	0	0	1	2	5	1	1	1	1	1	0	0	1	0	0	0	2.75	0	0	1
cadmica var. *bozkiriensis*	1	0	2	1	0	1	1	1	0	1	1	0	1	0	0	0	2	1	1	1	1	4	0	0	0	2	2	5	0	0	1	1	1	0	0	1	0	0	1	2.90	0	0	1
cadmica var. *cadmica*	1	0	2	1	0	1	1	1	0	1	1	0	1	0	0	0	2	1	1	1	1	2	0	0	0	2	2	5	0	0	1	1	1	0	0	1	0	0	1	2.90	0	0	1
caespitosa A	1	1	0	2	0	1	1	1	0	1	1	1	1	0	0	0	1	1	1	1	0	2	1	0	0	1	1	5	1	1	1	1	1	0	0	1	0	0	0	2.90	0	0	1
caespitosa B	1	1	0	2	0	1	1	1	0	1	1	1	1	0	0	0	1	1	1	1	0	2	1	0	0	1	0	4	1	1	1	1	1	0	0	1	0	0	0	2.90	0	0	1
candidissima subsp. *candidissima*	1	0	2	1	0	1	1	0	0	3	1	0	1	0	0	1	1	1	1	1	0	2	0	0	0	2	0	3	2	1	0	1	0	1	1	0	1	1	0	2.60	1	0	1
candidissima subsp. *occidentalis*	1	0	2	1	0	1	1	0	0	3	1	0	1	0	0	1	1	1	1	1	0	2	0	0	0	0	0	3	2	1	0	1	0	1	1	0	1	0	0	2.60	1	0	1
cassia	1	0	2	0	0	1	1	0	0	3	1	0	1	0	0	1	1	1	1	1	1	2	0	0	1	0	0	3	2	1	1	1	0	1	1	0	1	1	0	2.50	1	1	1
cedronella	1	1	2	1	2	1	1	1	0	1	1	1	1	0	0	0	1	1	1	1	1	2	1	0	0	0	2	3	0	1	1	1	1	0	0	1	0	0	0	2.60	0	0	1
ceratophylla	1	0	2	0	0	3	1	0	2	3	1	0	1	0	0	1	1	1	1	1	1	2	0	0	1	0	2	0	2	1	1	1	0	1	1	0	1	0	0	2.25	1	0	1

Table 5 (cont'd)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
cerino-pruinosa A	1	1	1	1	2	1	1	1	0	1	1	1	0	0	0	0	1	1	1	1	0	2	0	0	1	2	2	7	3	0	1	1	1	0	0	1	0	0	0	3.00	0	0	1
cerino-pruinosa B	1	1	1	1	2	0	0	1	0	1	1	1	0	0	0	0	1	1	0	0	0	2	0	0	1	2	2	7	3	0	1	0	1	0	0	1	0	0	0	3.00	0	0	1
chionantha	1	0	2	0	0	1	1	0	0	3	1	0	1	0	0	1	2	1	1	1	1	2	0	0	1	0	1	0	2	1	0	1	0	1	1	0	1	1	0	3.10	1	0	1
chrysophylla	1	0	2	0	0	1	1	0	0	1	1	1	1	0	0	1	1	1	1	1	1	2	0	0	1	0	0	3	2	1	0	1	0	1	1	0	1	2	0	2.00	1	0	1
cilicica	1	0	2	1	0	2	1	0	0	3	1	0	1	0	0	1	1	1	2	1	1	2	0	0	0	0	0	3	2	1	1	1	0	1	1	0	1	1	0	1.95	1	0	1
cyanescens	1	0	2	1	0	1	1	0	0	3	1	0	1	0	0	1	1	1	1	1	0	2	0	0	0	2	0	3	1	1	1	1	0	1	1	0	1	0	0	2.45	1	0	1
dichroantha	1	0	2	1	0	1	0	0	0	1	1	1	1	0	0	1	1	0	1	0	0	2	1	0	1	2	0	3	2	1	1	1	0	0	1	0	1	0	0	1.30	1	0	1
divaricata	1	0	2	0	0	1	0	0	0	1	1	0	1	0	0	1	1	1	0	0	1	0	0	0	0	1	0	4	0	1	1	1	1	0	0	1	0	0	0	3.00	0	0	1
ekimiana	1	0	2	0	0	3	1	0	0	3	1	0	1	0	0	1	2	1	3	1	0	2	0	0	1	1	2	0	2	1	0	3	0	1	1	0	1	2	0	0.90	1	0	1
eriophora	1	0	2	0	0	3	1	0	0	3	1	0	1	0	0	1	1	0	3	1	0	5	0	0	0	1	1	0	2	1	0	3	0	0	1	0	1	0	0	1.05	1	0	1
euphratica var. *euphratica*	1	1	1	1	0	1	1	1	0	3	1	1	1	0	0	0	2	1	1	1	1	2	0	0	0	2	1	6	3	0	1	1	1	0	1	1	0	0	0	3.00	0	0	1
euphratica var. *leiocalycina*	1	1	1	1	0	1	1	1	0	3	1	1	1	0	0	0	2	1	0	0	1	4	0	0	0	2	1	6	3	0	1	0	1	0	1	1	0	0	0	3.00	0	0	1
forskahlei	1	0	2	1	0	1	1	0	0	1	1	0	1	0	0	1	2	1	1	1	1	2	1	0	0	1	0	4	1	1	0	1	1	0	0	1	1	0	1	2.50	4	1	1
freyniana	1	1	2	1	0	1	1	1	0	1	1	0	1	0	0	1	2	1	1	1	0	2	1	0	0	1	1	5	0	1	0	1	1	0	0	1	0	0	1	1.40	0	0	1
frigida	1	1	2	0	0	1	1	0	1	3	1	0	1	0	0	1	1	1	1	1	1	2	0	0	1	0	1	3	2	1	0	1	0	1	1	0	1	0	0	1.15	1	0	1
fruticosa	1	2	2	1	0	3	1	1	0	3	1	1	1	0	0	1	2	0	3	1	1	1	1	1	0	1	1	1	0	1	0	1	1	0	1	1	0	0	0	2.10	0	0	0
glutinosa	1	0	2	1	0	1	1	0	0	1	1	1	1	0	0	1	1	1	1	1	1	2	1	0	0	0	0	4	0	1	0	1	1	0	0	1	1	0	1	3.50	4	0	1
halophila	1	0	2	1	0	1	1	0	0	1	1	0	1	0	0	1	1	1	1	1	1	2	1	0	0	0	1	3	0	1	1	1	0	0	1	0	1	2	0	1.35	1	0	1
heldreichiana	1	1	2	1	0	1	1	1	0	1	1	1	1	0	0	0	1	0	1	1	1	4	1	0	0	1	2	1	0	1	1	1	1	0	1	1	0	0	1	3.00	0	0	1
huberi	1	1	2	1	0	1	1	1	0	1	1	0	1	0	0	0	1	1	1	1	1	2	1	0	0	2	0	2	0	1	1	1	1	0	0	1	0	0	0	3.30	0	0	1
hydrangea	1	1	1	1	0	1	1	1	0	1	1	1	1	0	0	0	2	1	1	1	1	2	1	0	0	1	2	5	0	0	1	1	1	0	0	1	0	0	1	4.00	0	0	1
hypargeia	1	0	1	1	0	3	1	0	0	3	0	0	1	0	0	0	1	1	1	1	0	3	0	0	0	0	1	0	1	1	0	3	0	0	1	0	1	0	0	2.50	1	0	1
indica	1	0	2	1	0	1	0	0	0	1	0	0	0	0	0	1	1	1	1	0	1	2	0	0	0	0	0	3	2	1	0	1	0	1	1	0	1	2	1	2.85	1	0	1
kronenburgii	1	1	1	1	0	3	1	1	0	3	1	1	1	0	0	0	2	1	1	1	1	2	0	0	1	0	1	6	3	0	1	0	1	0	1	1	0	0	0	4.00	0	0	1
limbata	1	0	2	1	0	2	0	0	0	1	1	0	1	0	0	1	1	1	2	1	1	1	0	0	0	0	1	4	1	1	1	2	0	1	1	0	1	0	0	1.95	1	0	1
longipedicellata	1	0	2	0	0	3	0	0	1	3	1	0	1	0	0	1	1	1	1	1	1	2	1	0	1	0	0	6	2	1	0	1	0	1	1	0	1	0	0	2.25	1	0	1
macrochlamys	1	0	2	2	0	1	1	0	0	1	1	1	1	0	0	1	0	0	1	1	0	3	1	0	1	0	1	1	0	1	1	1	1	0	0	1	0	1	0	2.90	0	0	1
marashica	1	1	2	1	0	1	1	1	0	1	1	1	1	0	0	0	2	1	1	1	1	2	1	0	0	0	2	5	0	1	1	1	1	0	0	1	0	0	0	2.40	0	0	1

Table 5 (cont'd)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
microstegia	1	1	2	0	0	3	1	0	1	3	1	0	1	0	0	1	1	1	1	1	1	2	0	0	0	0	1	3	2	1	0	1	0	1	1	0	1	0	0	2.35	1	0	1
modesta	1	1	2	1	0	1	1	0	0	3	1	0	1	0	0	1	1	1	1	1	1	4	0	0	1	1	1	0	2	1	0	1	0	1	1	0	1	1	0	0.95	1	0	1
montbretii	1	0	0	0	0	3	0	0	1	3	0	0	1	0	0	0	1	1	1	1	0	3	0	0	1	0	1	1	2	1	0	3	0	0	1	0	1	0	0	2.25	1	0	1
multicaulis	1	0	0	1	0	1	1	0	0	1	1	0	1	0	0	0	2	1	1	1	1	4	1	0	1	2	2	6	3	0	1	1	1	0	1	1	0	0	1	1.90	0	0	0
napifolia	1	0	2	1	0	1	1	1	0	1	1	1	1	0	0	1	2	1	2	1	3	1	0	0	0	1	2	3	1	1	1	1	1	1	1	1	2	0	0	1.30	2	1	1
nemorosa	1	0	2	1	0	1	0	0	0	1	1	1	1	0	0	1	1	0	1	1	1	5	1	0	0	1	2	3	2	1	1	1	0	0	1	0	1	0	0	1.15	1	1	0
nutans	1	0	2	0	0	1	1	1	0	1	1	0	1	1	0	1	1	0	1	1	2	4	1	0	1	2	0	3	1	1	1	1	0	0	1	0	3	0	0	1.20	1	0	1
nydeggeri	1	1	2	2	0	1	1	1	0	1	1	1	1	0	0	0	1	1	1	1	1	2	1	0	0	0	1	0	2	1	0	1	1	0	0	1	0	0	1	2.85	0	0	1
odontochlamys	1	0	2	0	0	1	1	0	0	3	0	0	1	0	0	1	1	1	1	1	1	3	0	0	0	2	1	0	2	1	0	1	0	1	1	0	1	0	0	1.70	1	0	1
pachystachys	1	1	0	1	0	1	0	1	0	1	1	1	1	0	0	0	1	1	1	1	0	3	1	0	0	2	2	5	1	1	1	1	1	0	0	1	0	0	0	3.10	0	0	1
palaestina	1	0	2	1	0	2	1	0	0	3	1	0	1	0	0	1	1	1	1	1	1	4	0	0	0	2	1	1	2	1	0	1	0	0	1	0	1	0	0	2.75	1	0	1
pilifera	1	0	2	1	0	0	0	1	0	1	1	1	1	0	0	0	2	1	1	1	1	3	1	0	0	2	2	2	1	1	0	1	1	0	0	1	0	0	0	2.75	0	0	1
pinnata	1	0	2	1	0	1	1	1	0	1	1	1	1	0	0	0	1	1	1	1	1	1	1	0	0	1	2	4	1	1	0	1	1	0	0	1	0	0	0	2.50	0	0	0
pisidica	1	1	2	2	0	1	0	1	0	1	1	0	1	0	0	0	1	0	1	1	1	2	1	0	0	1	0	0	1	1	1	1	1	0	1	1	0	0	0	2.15	0	0	1
poculata	1	0	2	1	0	1	1	0	0	1	0	0	1	0	0	1	1	1	1	1	1	3	0	0	1	2	1	3	0	1	0	1	0	1	1	0	1	0	0	1.40	1	0	1
pomifera	1	2	2	1	2	0	0	0	0	1	1	0	1	0	0	1	1	0	0	1	0	1	1	0	1	2	2	3	0	0	1	1	1	0	0	1	0	0	0	2.85	0	0	1
potentillifolia	1	1	2	1	0	1	1	1	0	1	1	1	1	0	0	0	1	1	1	1	0	2	1	0	0	0	1	0	2	1	0	1	1	0	1	1	0	1	0	2.60	0	0	1
pseudeuphratica	1	1	1	1	0	3	1	0	0	3	1	1	1	0	0	1	2	0	3	1	1	2	0	0	1	1	1	6	3	0	1	1	1	0	1	1	0	0	0	1.75	0	0	1
quezelii	1	1	1	2	0	1	1	1	0	1	1	1	1	0	0	0	0	1	1	1	2	2	1	0	0	1	1	3	0	1	0	1	1	0	1	1	0	0	1	2.95	0	0	1
recognita	1	0	2	1	0	0	0	1	0	1	1	0	1	0	0	1	1	1	1	1	2	1	1	0	0	0	2	3	1	1	1	1	1	0	0	1	0	0	1	3.00	0	0	1
rosifolia	1	1	2	1	0	1	1	1	0	1	1	1	1	0	0	1	2	1	1	1	1	4	1	0	0	2	1	5	0	1	1	1	1	0	0	1	0	0	0	2.35	0	0	1
russellii	1	0	2	1	0	2	1	0	0	2	1	1	0	0	0	0	3	1	2	1	3	4	0	0	0	1	1	3	2	1	1	2	1	0	0	1	2	0	0	0.95	2	0	1
sclarea	1	0	2	0	0	1	1	0	0	3	1	1	0	0	0	1	1	1	2	1	1	5	0	0	1	1	1	0	2	1	0	2	0	1	1	0	1	1	0	2.50	1	0	1
sericeo-tomentosa	1	1	2	1	0	3	1	0	0	3	1	0	1	0	0	1	1	1	3	1	2	2	0	0	1	2	2	6	3	0	1	3	1	0	0	1	0	1	0	2.85	0	0	1
siirtica	1	0	2	0	0	1	1	0	0	1	1	1	0	0	0	1	2	0	1	1	2	2	0	0	0	0	0	0	1	1	0	1	0	1	1	0	1	0	0	1.90	1	0	1
smyrnaea	1	1	2	1	0	1	1	1	0	1	1	0	1	0	0	0	1	1	1	1	1	4	0	0	0	1	2	1	1	1	0	1	1	0	1	1	0	0	0	3.15	0	0	1
spinosa	1	0	2	0	0	1	1	0	0	1	1	1	1	0	0	1	1	1	1	1	1	3	0	0	0	0	1	0	2	1	0	1	0	0	0	0	1	0	0	2.25	1	1	1
staminea	1	0	2	0	1	1	1	0	0	0	1	0	1	0	0	1	1	0	1	0	2	2	0	0	1	2	0	3	1	1	1	1	0	1	1	0	1	0	0	1.40	1	1	1

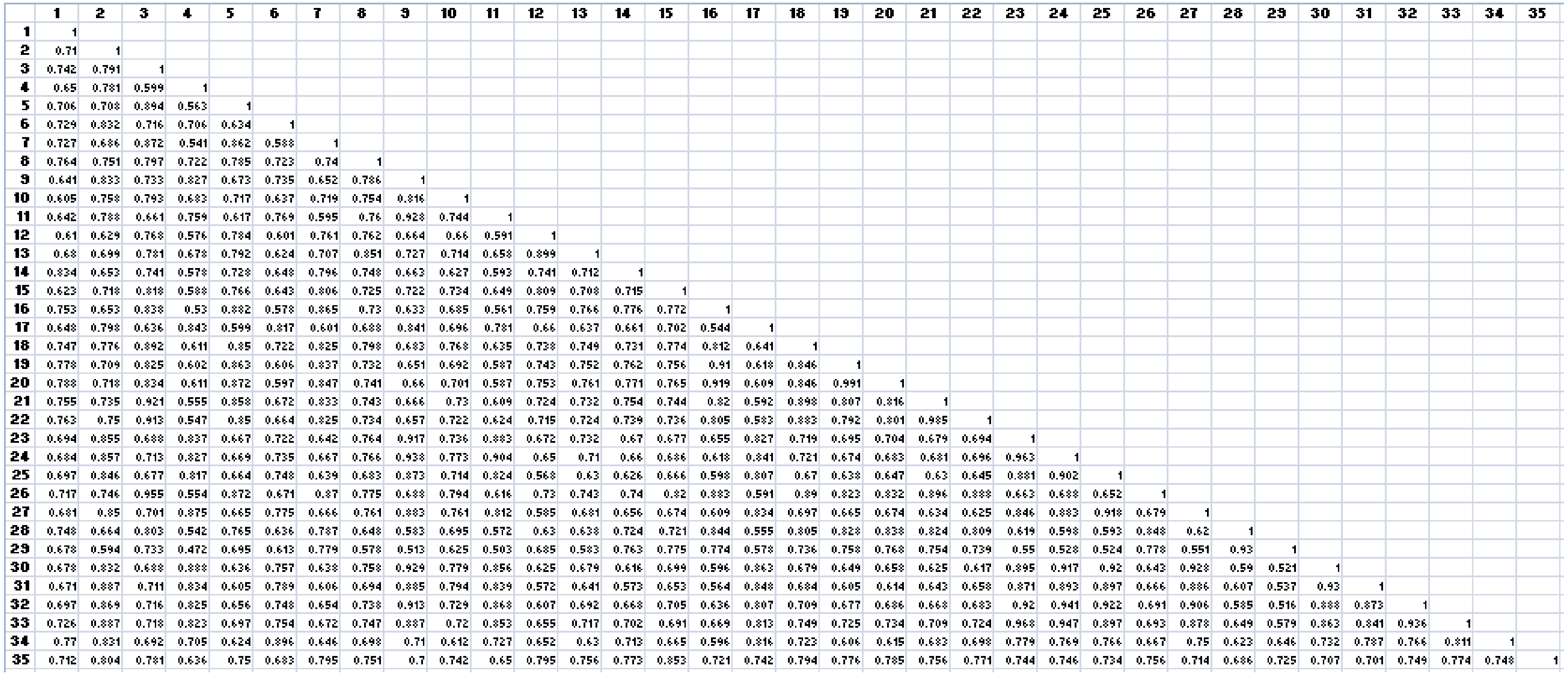
Table 5 (cont'd)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
suffruticosa	1	1	2	1	0	0	0	1	0	1	1	1	1	0	0	0	1	1	1	1	0	2	1	0	0	0	2	4	2	1	0	1	1	0	0	1	0	2	0	2.35	0	0	1
syriaca	1	0	2	0	0	1	0	0	0	1	1	1	1	0	0	1	1	1	1	0	1	2	0	0	1	0	1	0	2	1	0	1	0	0	1	0	1	0	0	1.00	1	1	1
tchihatcheffii	1	1	2	1	0	1	1	1	0	0	1	1	1	0	0	0	1	0	1	1	0	2	1	0	0	0	1	1	0	1	1	2	1	0	0	1	0	0	0	1.25	0	0	0
tobeyi	1	0	1	1	0	3	1	0	0	3	1	0	1	0	0	1	1	0	1	1	1	2	0	0	1	0	1	0	2	1	0	1	0	0	1	0	1	1	0	1.35	1	0	1
tomentosa	1	1	1	1	0	3	1	0	0	3	1	1	1	0	0	1	2	1	3	1	2	1	1	0	0	1	2	1	0	1	0	1	1	0	0	1	0	0	0	2.80	0	0	1
trichoclada	1	1	2	1	0	1	0	1	0	1	1	1	1	0	0	1	1	1	1	1	0	5	1	0	0	1	2	5	1	1	1	1	1	0	1	1	0	0	1	3.25	0	0	1
verbenaca	1	0	2	1	0	1	0	0	1	1	1	0	1	0	0	1	2	1	1	1	2	2	1	0	0	0	2	4	2	1	1	2	0	0	1	0	1	0	0	2.30	1	0	1
vermifolia	1	0	2	1	0	1	0	0	0	3	1	0	1	0	0	0	0	1	1	1	0	2	0	0	1	0	1	4	1	1	1	1	0	1	1	0	1	1	0	1.95	1	0	1
verticillata subsp. *amasiaca*	1	0	2	1	0	2	1	1	0	2	1	1	1	0	0	1	3	1	2	1	3	1	0	0	0	1	2	1	0	1	1	2	1	0	0	1	2	0	0	1.20	2	0	1
verticillata subsp. *verticillata*	1	0	2	1	0	1	1	1	0	1	1	1	1	0	0	1	3	1	1	1	3	1	0	0	0	1	2	1	1	1	1	1	1	0	0	1	2	0	0	1.20	2	0	1
virgata	1	0	2	0	0	1	0	0	0	1	1	1	1	0	0	1	1	1	1	1	1	2	1	0	1	1	1	4	2	1	1	1	0	1	1	0	1	0	0	1.50	1	0	1
viridis A	0	0	2	1	0	1	1	0	0	1	1	1	1	0	1	0	1	1	1	1	0	5	1	0	1	0	2	3	2	1	1	1	0	0	0	0	0	2	0	1.40	1	0	1
viridis B	0	0	2	1	0	1	0	0	0	1	1	1	1	0	1	0	1	1	1	1	0	3	1	0	1	0	2	3	2	1	1	1	0	0	0	0	0	2	0	1.40	1	0	1
viscosa	1	0	2	1	0	3	1	0	0	3	1	0	1	0	0	1	1	1	1	1	1	2	1	0	0	1	1	3	1	1	1	1	0	0	1	0	1	0	0	1.75	1	1	1
wiedemannii	1	1	2	1	0	1	1	1	0	2	1	1	1	0	0	0	1	0	1	1	1	2	1	0	0	1	1	5	1	1	1	1	1	0	0	1	0	0	0	1.85	0	0	1
xanthocheila	1	1	2	0	0	1	1	0	1	3	1	0	1	0	0	1	1	0	1	1	1	2	0	0	1	0	0	3	2	1	0	1	0	1	1	0	1	0	0	2.20	1	0	1
yosgadensis	1	0	2	0	0	1	1	0	0	1	1	0	1	0	0	1	1	1	1	1	1	2	0	0	1	0	2	0	2	1	0	1	0	1	1	0	1	0	0	1.05	1	0	1

APPENDIX C

THE SIMILARITY MATRIX

Table 6. The t x t similarity matrix.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	1																																		
2	0.71	1																																	
3	0.742	0.791	1																																
4	0.65	0.781	0.599	1																															
5	0.706	0.708	0.894	0.563	1																														
6	0.729	0.832	0.716	0.706	0.634	1																													
7	0.727	0.686	0.872	0.541	0.862	0.588	1																												
8	0.764	0.751	0.797	0.722	0.785	0.723	0.74	1																											
9	0.641	0.833	0.733	0.827	0.673	0.735	0.652	0.786	1																										
10	0.605	0.758	0.793	0.683	0.717	0.637	0.719	0.754	0.816	1																									
11	0.642	0.788	0.661	0.759	0.617	0.769	0.595	0.76	0.928	0.744	1																								
12	0.61	0.629	0.768	0.576	0.784	0.601	0.761	0.762	0.664	0.66	0.591	1																							
13	0.68	0.699	0.781	0.678	0.792	0.624	0.707	0.851	0.727	0.714	0.658	0.899	1																						
14	0.834	0.653	0.741	0.578	0.728	0.648	0.796	0.748	0.663	0.627	0.593	0.741	0.712	1																					
15	0.623	0.718	0.818	0.588	0.766	0.643	0.806	0.725	0.722	0.734	0.649	0.809	0.708	0.715	1																				
16	0.753	0.653	0.838	0.53	0.882	0.578	0.865	0.73	0.633	0.685	0.561	0.759	0.766	0.776	0.772	1																			
17	0.648	0.798	0.636	0.843	0.599	0.817	0.601	0.688	0.841	0.696	0.781	0.66	0.637	0.661	0.702	0.544	1																		
18	0.747	0.776	0.892	0.611	0.85	0.722	0.825	0.798	0.683	0.768	0.635	0.738	0.749	0.731	0.774	0.812	0.641	1																	
19	0.778	0.709	0.825	0.602	0.863	0.606	0.837	0.732	0.651	0.692	0.587	0.743	0.752	0.762	0.756	0.91	0.618	0.846	1																
20	0.788	0.718	0.834	0.611	0.872	0.597	0.847	0.741	0.66	0.701	0.587	0.753	0.761	0.771	0.765	0.919	0.609	0.846	0.991	1															
21	0.755	0.735	0.921	0.555	0.858	0.672	0.833	0.743	0.666	0.73	0.609	0.724	0.732	0.754	0.744	0.82	0.592	0.898	0.807	0.816	1														
22	0.763	0.75	0.913	0.547	0.85	0.664	0.825	0.734	0.657	0.722	0.624	0.715	0.724	0.739	0.736	0.805	0.583	0.883	0.792	0.801	0.985	1													
23	0.694	0.855	0.688	0.837	0.667	0.722	0.642	0.764	0.917	0.736	0.883	0.672	0.732	0.67	0.677	0.655	0.827	0.719	0.695	0.704	0.679	0.694	1												
24	0.684	0.857	0.713	0.827	0.669	0.735	0.667	0.766	0.938	0.773	0.904	0.65	0.71	0.66	0.686	0.618	0.841	0.721	0.674	0.683	0.681	0.696	0.963	1											
25	0.697	0.846	0.677	0.817	0.664	0.748	0.639	0.683	0.873	0.714	0.824	0.568	0.63	0.626	0.666	0.598	0.807	0.67	0.638	0.647	0.63	0.645	0.881	0.902	1										
26	0.717	0.746	0.955	0.554	0.872	0.671	0.87	0.775	0.688	0.794	0.616	0.73	0.743	0.74	0.82	0.883	0.591	0.89	0.823	0.832	0.896	0.888	0.663	0.688	0.652	1									
27	0.681	0.85	0.701	0.875	0.665	0.775	0.666	0.761	0.883	0.761	0.812	0.585	0.681	0.656	0.674	0.609	0.834	0.697	0.665	0.674	0.634	0.625	0.846	0.883	0.918	0.679	1								
28	0.748	0.664	0.803	0.542	0.765	0.636	0.787	0.648	0.583	0.695	0.572	0.63	0.638	0.724	0.721	0.844	0.555	0.805	0.828	0.838	0.824	0.809	0.619	0.598	0.593	0.848	0.62	1							
29	0.678	0.594	0.733	0.472	0.695	0.613	0.779	0.578	0.513	0.625	0.503	0.685	0.583	0.763	0.775	0.774	0.578	0.736	0.758	0.768	0.754	0.739	0.55	0.528	0.524	0.778	0.551	0.93	1						
30	0.678	0.832	0.688	0.888	0.636	0.757	0.638	0.758	0.929	0.779	0.856	0.625	0.679	0.616	0.699	0.596	0.863	0.679	0.649	0.658	0.625	0.617	0.895	0.917	0.92	0.643	0.928	0.59	0.521	1					
31	0.671	0.887	0.711	0.834	0.605	0.789	0.606	0.694	0.885	0.794	0.839	0.572	0.641	0.573	0.653	0.564	0.848	0.684	0.605	0.614	0.643	0.658	0.871	0.893	0.897	0.666	0.886	0.607	0.537	0.93	1				
32	0.697	0.869	0.716	0.825	0.656	0.748	0.654	0.738	0.913	0.729	0.868	0.607	0.692	0.668	0.705	0.636	0.807	0.709	0.677	0.686	0.668	0.683	0.92	0.941	0.922	0.691	0.906	0.585	0.516	0.888	0.873	1			
33	0.726	0.887	0.718	0.823	0.697	0.754	0.672	0.747	0.887	0.72	0.853	0.655	0.717	0.702	0.691	0.669	0.813	0.749	0.725	0.734	0.709	0.724	0.968	0.947	0.897	0.693	0.878	0.649	0.579	0.863	0.841	0.936	1		
34	0.77	0.831	0.692	0.705	0.624	0.896	0.646	0.698	0.71	0.612	0.727	0.652	0.63	0.713	0.665	0.596	0.816	0.723	0.606	0.615	0.683	0.698	0.779	0.769	0.766	0.667	0.75	0.623	0.646	0.732	0.787	0.766	0.811	1	
35	0.712	0.804	0.781	0.636	0.75	0.683	0.795	0.751	0.7	0.742	0.65	0.795	0.756	0.773	0.853	0.721	0.742	0.794	0.776	0.785	0.756	0.771	0.744	0.746	0.734	0.756	0.714	0.686	0.725	0.707	0.701	0.749	0.774	0.748	1

Table 6 (cont'd)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
36	0.622	0.78	0.594	0.925	0.596	0.71	0.574	0.74	0.838	0.701	0.784	0.548	0.649	0.572	0.598	0.541	0.847	0.644	0.597	0.606	0.565	0.557	0.84	0.838	0.827	0.572	0.893	0.552	0.482	0.898	0.86	0.835	0.81	0.696	0.63
37	0.652	0.825	0.639	0.862	0.618	0.783	0.597	0.793	0.821	0.676	0.824	0.593	0.695	0.594	0.613	0.547	0.817	0.66	0.622	0.613	0.611	0.602	0.823	0.837	0.764	0.594	0.822	0.528	0.458	0.82	0.781	0.818	0.809	0.742	0.676
38	0.828	0.74	0.832	0.633	0.756	0.642	0.777	0.739	0.705	0.701	0.632	0.683	0.69	0.834	0.719	0.803	0.607	0.823	0.85	0.859	0.849	0.834	0.714	0.705	0.669	0.807	0.673	0.851	0.781	0.681	0.659	0.708	0.744	0.66	0.715
39	0.78	0.691	0.784	0.585	0.707	0.659	0.729	0.691	0.657	0.653	0.594	0.697	0.657	0.848	0.733	0.755	0.625	0.784	0.82	0.811	0.801	0.786	0.666	0.657	0.621	0.759	0.625	0.803	0.81	0.633	0.611	0.659	0.696	0.658	0.729
40	0.727	0.749	0.767	0.654	0.824	0.663	0.706	0.789	0.726	0.746	0.677	0.751	0.812	0.664	0.709	0.748	0.675	0.805	0.773	0.782	0.749	0.764	0.769	0.771	0.737	0.742	0.671	0.62	0.55	0.719	0.704	0.729	0.754	0.681	0.783
41	0.719	0.743	0.864	0.657	0.89	0.668	0.812	0.839	0.74	0.75	0.687	0.848	0.872	0.693	0.791	0.832	0.681	0.87	0.834	0.843	0.837	0.829	0.743	0.745	0.649	0.833	0.663	0.719	0.65	0.707	0.677	0.696	0.729	0.672	0.774
42	0.672	0.826	0.687	0.863	0.627	0.754	0.648	0.739	0.938	0.793	0.869	0.624	0.694	0.638	0.66	0.591	0.859	0.656	0.624	0.633	0.639	0.631	0.875	0.912	0.901	0.662	0.908	0.603	0.533	0.937	0.898	0.878	0.86	0.747	0.696
43	0.663	0.69	0.775	0.692	0.692	0.662	0.654	0.86	0.674	0.661	0.652	0.745	0.797	0.621	0.655	0.643	0.581	0.759	0.645	0.654	0.726	0.718	0.655	0.657	0.577	0.737	0.628	0.608	0.538	0.642	0.633	0.652	0.641	0.644	0.641
44	0.695	0.79	0.833	0.622	0.784	0.692	0.738	0.771	0.732	0.807	0.683	0.753	0.807	0.647	0.72	0.758	0.658	0.823	0.758	0.767	0.785	0.8	0.753	0.779	0.697	0.808	0.677	0.668	0.599	0.718	0.756	0.735	0.737	0.711	0.785
45	0.74	0.893	0.8	0.744	0.741	0.818	0.739	0.783	0.858	0.698	0.789	0.668	0.738	0.706	0.743	0.721	0.784	0.782	0.715	0.724	0.741	0.733	0.853	0.863	0.844	0.776	0.836	0.624	0.554	0.833	0.834	0.891	0.87	0.814	0.764
46	0.757	0.752	0.891	0.56	0.884	0.743	0.799	0.829	0.671	0.713	0.654	0.742	0.749	0.732	0.716	0.835	0.615	0.848	0.839	0.829	0.847	0.839	0.655	0.657	0.622	0.876	0.662	0.754	0.684	0.632	0.648	0.66	0.685	0.706	0.708
47	0.802	0.767	0.93	0.622	0.904	0.67	0.872	0.798	0.709	0.73	0.66	0.804	0.811	0.778	0.802	0.885	0.635	0.86	0.865	0.875	0.892	0.907	0.747	0.726	0.69	0.898	0.677	0.799	0.729	0.672	0.664	0.729	0.777	0.705	0.823
48	0.768	0.698	0.884	0.522	0.881	0.623	0.864	0.744	0.617	0.707	0.544	0.734	0.741	0.775	0.724	0.914	0.543	0.873	0.901	0.91	0.889	0.874	0.615	0.617	0.581	0.882	0.608	0.842	0.773	0.595	0.594	0.619	0.645	0.618	0.72
49	0.657	0.791	0.716	0.789	0.672	0.691	0.65	0.753	0.838	0.671	0.79	0.6	0.692	0.656	0.642	0.6	0.781	0.667	0.666	0.666	0.687	0.679	0.83	0.855	0.759	0.671	0.813	0.604	0.534	0.814	0.769	0.813	0.814	0.672	0.659
50	0.551	0.746	0.602	0.671	0.593	0.695	0.591	0.633	0.797	0.643	0.794	0.66	0.623	0.596	0.688	0.573	0.8	0.586	0.614	0.623	0.547	0.562	0.818	0.828	0.761	0.578	0.726	0.522	0.546	0.779	0.79	0.799	0.786	0.713	0.732
51	0.779	0.703	0.819	0.627	0.723	0.628	0.776	0.734	0.668	0.666	0.596	0.623	0.661	0.74	0.706	0.756	0.594	0.775	0.79	0.799	0.801	0.786	0.643	0.668	0.679	0.794	0.714	0.837	0.783	0.693	0.669	0.686	0.673	0.623	0.679
52	0.667	0.844	0.714	0.803	0.654	0.734	0.699	0.721	0.86	0.716	0.792	0.637	0.676	0.684	0.733	0.625	0.855	0.713	0.681	0.69	0.673	0.665	0.855	0.881	0.846	0.689	0.869	0.59	0.567	0.836	0.821	0.924	0.888	0.776	0.786
53	0.689	0.772	0.646	0.82	0.587	0.72	0.654	0.73	0.851	0.706	0.804	0.63	0.68	0.664	0.619	0.564	0.826	0.659	0.574	0.583	0.612	0.62	0.834	0.871	0.86	0.621	0.875	0.536	0.512	0.873	0.854	0.848	0.82	0.785	0.709
54	0.762	0.758	0.85	0.612	0.764	0.785	0.749	0.788	0.692	0.741	0.691	0.691	0.747	0.645	0.735	0.715	0.658	0.845	0.718	0.718	0.821	0.813	0.692	0.702	0.712	0.812	0.714	0.727	0.657	0.721	0.739	0.704	0.706	0.773	0.758
55	0.757	0.757	0.963	0.58	0.88	0.682	0.878	0.798	0.699	0.779	0.626	0.737	0.754	0.763	0.796	0.857	0.601	0.926	0.859	0.868	0.917	0.902	0.67	0.695	0.661	0.961	0.69	0.822	0.752	0.666	0.676	0.701	0.702	0.677	0.77
56	0.632	0.827	0.703	0.853	0.644	0.706	0.665	0.787	0.955	0.81	0.883	0.641	0.735	0.654	0.677	0.608	0.812	0.673	0.641	0.65	0.656	0.648	0.892	0.928	0.871	0.678	0.908	0.573	0.503	0.907	0.863	0.904	0.877	0.701	0.713
57	0.679	0.829	0.69	0.866	0.653	0.801	0.608	0.766	0.933	0.75	0.874	0.644	0.714	0.645	0.678	0.613	0.907	0.672	0.649	0.64	0.646	0.637	0.897	0.895	0.876	0.645	0.888	0.609	0.539	0.932	0.894	0.876	0.867	0.753	0.679
58	0.633	0.726	0.623	0.782	0.579	0.66	0.634	0.66	0.782	0.637	0.736	0.561	0.61	0.631	0.596	0.515	0.797	0.581	0.58	0.58	0.624	0.616	0.744	0.781	0.754	0.585	0.806	0.565	0.541	0.803	0.761	0.742	0.729	0.695	0.643
59	0.876	0.649	0.708	0.658	0.741	0.662	0.716	0.706	0.607	0.594	0.547	0.622	0.692	0.807	0.588	0.789	0.628	0.745	0.832	0.823	0.743	0.728	0.636	0.627	0.639	0.706	0.67	0.737	0.667	0.644	0.613	0.639	0.668	0.662	0.654
60	0.673	0.783	0.761	0.677	0.748	0.675	0.676	0.722	0.721	0.751	0.653	0.614	0.638	0.646	0.703	0.665	0.687	0.815	0.737	0.746	0.736	0.728	0.739	0.741	0.754	0.759	0.738	0.677	0.607	0.712	0.728	0.77	0.772	0.67	0.71
61	0.682	0.812	0.696	0.686	0.683	0.838	0.658	0.725	0.715	0.64	0.702	0.587	0.611	0.671	0.623	0.601	0.748	0.744	0.629	0.619	0.672	0.663	0.721	0.735	0.747	0.694	0.731	0.565	0.542	0.69	0.722	0.747	0.753	0.849	0.682
62	0.772	0.794	0.678	0.714	0.641	0.809	0.639	0.684	0.697	0.575	0.707	0.592	0.616	0.622	0.604	0.629	0.729	0.703	0.657	0.648	0.653	0.668	0.75	0.74	0.776	0.653	0.76	0.594	0.524	0.742	0.75	0.753	0.782	0.831	0.664
63	0.694	0.719	0.928	0.597	0.873	0.668	0.804	0.773	0.731	0.795	0.659	0.793	0.803	0.693	0.75	0.817	0.634	0.834	0.803	0.812	0.888	0.88	0.674	0.711	0.629	0.884	0.652	0.735	0.666	0.69	0.709	0.667	0.658	0.643	0.713
64	0.661	0.853	0.673	0.871	0.636	0.741	0.615	0.749	0.901	0.756	0.842	0.65	0.72	0.651	0.646	0.604	0.847	0.678	0.669	0.669	0.629	0.62	0.911	0.901	0.844	0.628	0.871	0.569	0.499	0.9	0.861	0.867	0.896	0.73	0.709
65	0.743	0.688	0.874	0.543	0.838	0.646	0.859	0.719	0.63	0.721	0.583	0.748	0.709	0.812	0.746	0.823	0.612	0.884	0.816	0.816	0.93	0.915	0.655	0.646	0.595	0.873	0.622	0.825	0.802	0.593	0.608	0.633	0.685	0.717	0.757
66	0.712	0.855	0.711	0.841	0.677	0.775	0.652	0.804	0.89	0.727	0.826	0.697	0.77	0.711	0.686	0.671	0.834	0.745	0.746	0.736	0.696	0.687	0.922	0.913	0.83	0.686	0.85	0.636	0.566	0.87	0.821	0.884	0.906	0.775	0.753
67	0.726	0.711	0.873	0.616	0.816	0.657	0.846	0.78	0.664	0.75	0.601	0.805	0.754	0.756	0.771	0.797	0.669	0.886	0.831	0.831	0.845	0.836	0.702	0.681	0.599	0.865	0.632	0.762	0.754	0.66	0.665	0.637	0.686	0.706	0.762
68	0.732	0.706	0.867	0.63	0.807	0.654	0.782	0.766	0.671	0.752	0.599	0.721	0.735	0.731	0.685	0.785	0.62	0.886	0.794	0.804	0.856	0.841	0.679	0.693	0.612	0.865	0.639	0.763	0.693	0.648	0.672	0.65	0.664	0.649	0.73
69	0.81	0.754	0.863	0.597	0.827	0.714	0.828	0.823	0.704	0.667	0.705	0.747	0.721	0.783	0.774	0.771	0.68	0.789	0.757	0.767	0.842	0.857	0.702	0.704	0.67	0.818	0.674	0.689	0.666	0.656	0.662	0.713	0.734	0.759	0.783
70	0.704	0.834	0.672	0.848	0.636	0.768	0.611	0.725	0.854	0.709	0.794	0.633	0.703	0.624	0.645	0.623	0.874	0.686	0.689	0.689	0.636	0.628	0.895	0.874	0.84	0.647	0.847	0.635	0.565	0.876	0.861	0.84	0.881	0.778	0.705
71	0.746	0.612	0.704	0.583	0.711	0.63	0.794	0.791	0.623	0.687	0.613	0.756	0.75	0.737	0.744	0.776	0.642	0.727	0.715	0.725	0.688	0.68	0.66	0.639	0.588	0.749	0.615	0.756	0.764	0.629	0.601	0.58	0.644	0.71	0.743
72	0.738	0.764	0.926	0.642	0.836	0.712	0.814	0.816	0.791	0.789	0.734	0.741	0.754	0.738	0.76	0.78	0.678	0.845	0.751	0.76	0.875	0.866	0.75	0.771	0.689	0.882	0.697	0.745	0.675	0.746	0.769	0.727	0.718	0.703	0.707
73	0.844	0.733	0.72	0.711	0.637	0.728	0.658	0.796	0.688	0.675	0.666	0.588	0.689	0.75	0.647	0.661	0.647	0.748	0.709	0.719	0.732	0.717	0.672	0.685	0.698	0.695	0.736	0.749	0.679	0.702	0.695	0.729	0.704	0.723	0.69
74	0.738	0.728	0.867	0.583	0.836	0.653	0.765	0.782	0.693	0.712	0.621	0.779	0.787	0.737	0.691	0.801	0.619	0.804	0.786	0.795	0.883	0.874	0.691	0.693	0.611	0.842	0.615	0.742	0.672	0.654	0.671	0.649	0.675	0.648	0.696
75	0.704	0.706	0.845	0.572	0.861	0.642	0.875	0.769	0.682	0.725	0.61	0.836	0.782	0.75	0.824	0.825	0.655	0.863	0.833	0.843	0.802	0.794	0.68	0.706	0.67	0.843	0.697	0.697	0.689	0.667	0.637	0.708	0.71	0.684	0.823
76	0.759	0.782	0.918	0.629	0.835	0.726	0.81	0.8	0.7	0.757	0.638	0.786	0.803	0.743	0.798	0.836	0.646	0.937	0.856	0.847	0.895	0.881	0.719	0.697	0.663	0.893	0.669	0.801	0.731	0.668	0.679	0.704	0.751	0.726	0.795
77	0.7	0.753	0.776	0.654	0.694	0.725	0.669	0.686	0.668	0.709	0.655	0.586	0.672	0.662	0.672	0.658	0.66	0.771	0.748	0.739	0.752	0.744	0.674	0.688	0.653	0.752	0.676	0.716	0.646	0.658	0.663	0.731	0.706	0.651	0.717
78	0.621	0.816	0.648	0.841	0.565	0.816	0.563	0.677	0.844	0.731	0.827	0.562	0.623	0.573	0.59	0.545	0.835	0.673	0.604	0.595	0.624	0.615	0.852	0.85	0.854	0.623	0.842	0.634	0.564	0.89	0.891	0.839	0.821	0.737	0.658
79	0.774	0.67	0.716	0.734	0.707	0.618	0.728	0.755	0.697	0.699	0.625	0.657	0.744	0.774	0.693	0.77	0.662	0.748	0.787	0.796	0.709	0.694	0.707	0.681	0.708	0.714	0.75	0.765	0.696	0.702	0.651	0.731	0.721	0.637	0.736

Table 6 (cont’d)

	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
36	1																																										
37	0.88	1																																									
38	0.604	0.634	1																																								
39	0.556	0.605	0.952	1																																							
40	0.649	0.679	0.676	0.628	1																																						
41	0.67	0.7	0.749	0.7	0.871	1																																					
42	0.864	0.816	0.678	0.63	0.7	0.722	1																																				
43	0.64	0.716	0.723	0.674	0.682	0.785	0.639	1																																			
44	0.616	0.662	0.698	0.649	0.921	0.85	0.706	0.707	1																																		
45	0.773	0.788	0.699	0.651	0.779	0.789	0.832	0.683	0.796	1																																	
46	0.578	0.665	0.806	0.777	0.735	0.832	0.631	0.789	0.783	0.745	1																																
47	0.594	0.639	0.828	0.78	0.803	0.877	0.676	0.735	0.81	0.79	0.857	1																															
48	0.54	0.546	0.864	0.816	0.763	0.846	0.59	0.704	0.803	0.704	0.881	0.861	1																														
49	0.799	0.854	0.699	0.66	0.686	0.69	0.791	0.639	0.692	0.8	0.663	0.692	0.623	1																													
50	0.696	0.664	0.551	0.55	0.696	0.666	0.755	0.524	0.719	0.783	0.597	0.619	0.556	0.741	1																												
51	0.622	0.605	0.905	0.873	0.628	0.712	0.688	0.717	0.692	0.686	0.769	0.773	0.842	0.705	0.538	1																											
52	0.798	0.797	0.677	0.629	0.71	0.694	0.841	0.636	0.716	0.873	0.658	0.703	0.624	0.803	0.805	0.668	1																										
53	0.815	0.767	0.611	0.563	0.712	0.668	0.897	0.627	0.718	0.801	0.591	0.659	0.563	0.758	0.761	0.652	0.841	1																									
54	0.638	0.677	0.694	0.655	0.74	0.783	0.683	0.725	0.81	0.789	0.809	0.791	0.745	0.66	0.595	0.727	0.687	0.666	1																								
55	0.598	0.605	0.844	0.795	0.773	0.859	0.672	0.763	0.822	0.786	0.884	0.906	0.918	0.68	0.585	0.83	0.706	0.645	0.819	1																							
56	0.847	0.846	0.695	0.647	0.716	0.724	0.952	0.683	0.723	0.834	0.648	0.693	0.607	0.839	0.771	0.689	0.867	0.896	0.653	0.689	1																						
57	0.886	0.84	0.685	0.655	0.706	0.735	0.937	0.658	0.689	0.83	0.669	0.689	0.597	0.803	0.753	0.671	0.824	0.833	0.704	0.655	0.889	1																					
58	0.792	0.8	0.625	0.586	0.6	0.608	0.814	0.557	0.606	0.718	0.577	0.606	0.537	0.908	0.701	0.666	0.767	0.828	0.621	0.595	0.814	0.773	1																				
59	0.607	0.585	0.793	0.764	0.716	0.728	0.634	0.629	0.683	0.701	0.764	0.744	0.803	0.632	0.539	0.745	0.632	0.631	0.69	0.745	0.598	0.659	0.631	1																			
60	0.699	0.659	0.756	0.708	0.754	0.741	0.711	0.706	0.722	0.743	0.752	0.727	0.726	0.633	0.619	0.708	0.777	0.633	0.687	0.785	0.712	0.718	0.551	0.642	1																		
61	0.664	0.761	0.641	0.612	0.709	0.661	0.707	0.694	0.692	0.818	0.752	0.662	0.646	0.67	0.648	0.581	0.78	0.72	0.725	0.705	0.706	0.732	0.646	0.685	0.744	1																	
62	0.692	0.756	0.646	0.617	0.668	0.689	0.758	0.63	0.65	0.8	0.71	0.737	0.605	0.652	0.606	0.61	0.715	0.748	0.707	0.663	0.711	0.759	0.651	0.667	0.687	0.762	1																
63	0.592	0.637	0.788	0.74	0.8	0.886	0.685	0.75	0.858	0.729	0.87	0.862	0.862	0.702	0.628	0.751	0.654	0.644	0.806	0.891	0.701	0.688	0.621	0.706	0.7	0.647	0.629	1															
64	0.842	0.85	0.691	0.652	0.712	0.713	0.888	0.641	0.695	0.816	0.643	0.696	0.58	0.856	0.791	0.608	0.83	0.816	0.649	0.638	0.895	0.901	0.803	0.633	0.718	0.721	0.749	0.671	1														
65	0.553	0.585	0.839	0.8	0.703	0.79	0.604	0.679	0.741	0.695	0.834	0.871	0.868	0.649	0.547	0.757	0.673	0.623	0.76	0.893	0.621	0.62	0.645	0.764	0.713	0.716	0.651	0.83	0.626	1													
66	0.812	0.876	0.758	0.728	0.776	0.751	0.863	0.694	0.762	0.861	0.699	0.749	0.647	0.862	0.758	0.69	0.854	0.821	0.695	0.7	0.895	0.888	0.788	0.696	0.716	0.775	0.78	0.711	0.908	0.693	1												
67	0.61	0.626	0.795	0.756	0.774	0.836	0.631	0.74	0.791	0.71	0.829	0.865	0.835	0.679	0.608	0.723	0.682	0.66	0.765	0.888	0.648	0.653	0.64	0.724	0.744	0.72	0.655	0.862	0.683	0.9	0.737	1											
68	0.602	0.624	0.804	0.756	0.766	0.815	0.644	0.776	0.796	0.712	0.811	0.833	0.83	0.665	0.559	0.732	0.653	0.647	0.747	0.887	0.661	0.651	0.591	0.767	0.739	0.723	0.635	0.865	0.657	0.844	0.72	0.881	1										
69	0.591	0.683	0.777	0.729	0.736	0.804	0.661	0.761	0.719	0.763	0.871	0.886	0.77	0.685	0.628	0.728	0.734	0.689	0.783	0.828	0.675	0.687	0.642	0.705	0.712	0.74	0.745	0.826	0.67	0.819	0.702	0.818	0.766	1									
70	0.823	0.784	0.664	0.625	0.72	0.73	0.889	0.624	0.715	0.84	0.649	0.708	0.599	0.821	0.81	0.651	0.838	0.812	0.701	0.658	0.845	0.904	0.785	0.675	0.73	0.721	0.773	0.647	0.93	0.622	0.881	0.684	0.653	0.658	1								
71	0.593	0.615	0.653	0.621	0.701	0.76	0.643	0.682	0.7	0.664	0.699	0.744	0.705	0.575	0.563	0.64	0.633	0.649	0.767	0.71	0.614	0.65	0.582	0.688	0.587	0.653	0.635	0.683	0.61	0.734	0.67	0.772	0.693	0.73	0.676	1							
72	0.667	0.697	0.828	0.78	0.751	0.853	0.729	0.794	0.806	0.789	0.864	0.856	0.81	0.762	0.637	0.792	0.698	0.689	0.808	0.889	0.746	0.748	0.681	0.704	0.745	0.692	0.674	0.924	0.715	0.839	0.753	0.858	0.863	0.847	0.691	0.693	1						
73	0.706	0.736	0.852	0.804	0.658	0.695	0.718	0.773	0.672	0.692	0.734	0.686	0.745	0.666	0.528	0.858	0.698	0.675	0.763	0.734	0.71	0.724	0.642	0.761	0.718	0.681	0.663	0.671	0.661	0.697	0.728	0.657	0.686	0.717	0.68	0.7	0.716	1					
74	0.577	0.623	0.818	0.77	0.77	0.861	0.667	0.765	0.818	0.734	0.887	0.839	0.869	0.699	0.633	0.781	0.647	0.626	0.767	0.85	0.683	0.673	0.613	0.734	0.733	0.653	0.65	0.916	0.656	0.813	0.716	0.826	0.824	0.823	0.676	0.665	0.887	0.7	1				
75	0.59	0.612	0.715	0.667	0.806	0.862	0.656	0.682	0.82	0.781	0.819	0.841	0.824	0.642	0.68	0.69	0.762	0.685	0.776	0.85	0.673	0.639	0.602	0.724	0.755	0.712	0.686	0.835	0.645	0.826	0.706	0.854	0.799	0.812	0.653	0.761	0.783	0.643	0.799	1			
76	0.601	0.649	0.845	0.816	0.798	0.884	0.675	0.789	0.824	0.789	0.858	0.908	0.874	0.644	0.587	0.786	0.708	0.647	0.831	0.932	0.691	0.7	0.561	0.743	0.787	0.726	0.731	0.846	0.697	0.881	0.767	0.876	0.843	0.808	0.716	0.735	0.844	0.76	0.828	0.829	1		
77	0.659	0.706	0.749	0.719	0.724	0.711	0.66	0.647	0.738	0.713	0.716	0.743	0.719	0.7	0.589	0.705	0.721	0.595	0.712	0.777	0.674	0.688	0.63	0.665	0.797	0.676	0.642	0.728	0.674	0.726	0.743	0.746	0.734	0.681	0.663	0.571	0.726	0.727	0.702	0.692	0.775	1	
78	0.852	0.816	0.663	0.633	0.661	0.643	0.871	0.633	0.69	0.768	0.634	0.614	0.575	0.754	0.755	0.649	0.801	0.808	0.692	0.632	0.842	0.888	0.75	0.605	0.717	0.722	0.718	0.646	0.847	0.598	0.843	0.648	0.652	0.594	0.843	0.581	0.706	0.707	0.651	0.594	0.676	0.743	1
79	0.744	0.704	0.783	0.735	0.684	0.71	0.702	0.653	0.672	0.691	0.664	0.756	0.73	0.668	0.544	0.766	0.7	0.659	0.732	0.735	0.703	0.723	0.64	0.748	0.679	0.595	0.638	0.671	0.668	0.72	0.75	0.686	0.697	0.66	0.687	0.746	0.681	0.845	0.646	0.728	0.76	0.726	0.686

Table 6 (cont'd)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
80	0.674	0.87	0.692	0.775	0.586	0.807	0.588	0.737	0.839	0.764	0.887	0.554	0.624	0.558	0.635	0.531	0.773	0.681	0.602	0.612	0.625	0.64	0.837	0.863	0.805	0.648	0.809	0.589	0.519	0.853	0.893	0.829	0.823	0.759	0.682
81	0.738	0.768	0.861	0.681	0.856	0.677	0.818	0.846	0.792	0.789	0.729	0.758	0.765	0.76	0.779	0.807	0.736	0.829	0.855	0.846	0.828	0.82	0.776	0.778	0.696	0.846	0.736	0.77	0.7	0.754	0.723	0.735	0.76	0.641	0.771
82	0.622	0.884	0.781	0.762	0.722	0.772	0.677	0.718	0.847	0.818	0.786	0.643	0.708	0.597	0.708	0.62	0.784	0.764	0.685	0.685	0.714	0.706	0.81	0.847	0.836	0.737	0.817	0.631	0.561	0.846	0.873	0.809	0.796	0.738	0.748
83	0.728	0.807	0.599	0.764	0.61	0.791	0.561	0.652	0.746	0.648	0.747	0.56	0.584	0.625	0.642	0.574	0.803	0.615	0.607	0.616	0.575	0.59	0.811	0.789	0.872	0.598	0.809	0.585	0.562	0.791	0.799	0.802	0.843	0.833	0.725
84	0.683	0.675	0.881	0.553	0.813	0.624	0.874	0.747	0.702	0.767	0.646	0.764	0.719	0.752	0.777	0.791	0.636	0.856	0.762	0.771	0.862	0.847	0.678	0.699	0.618	0.879	0.632	0.756	0.748	0.654	0.696	0.659	0.648	0.681	0.734
85	0.626	0.846	0.684	0.767	0.624	0.823	0.626	0.667	0.796	0.721	0.727	0.638	0.615	0.639	0.704	0.522	0.882	0.657	0.578	0.587	0.616	0.608	0.759	0.796	0.831	0.639	0.812	0.58	0.603	0.841	0.872	0.762	0.745	0.84	0.743
86	0.728	0.728	0.919	0.595	0.828	0.702	0.813	0.762	0.655	0.711	0.648	0.693	0.717	0.671	0.737	0.764	0.59	0.832	0.75	0.759	0.862	0.854	0.629	0.654	0.604	0.881	0.625	0.744	0.674	0.607	0.638	0.651	0.661	0.698	0.706
87	0.744	0.804	0.665	0.825	0.605	0.799	0.603	0.795	0.862	0.678	0.84	0.602	0.704	0.64	0.654	0.585	0.811	0.658	0.626	0.635	0.641	0.632	0.845	0.867	0.848	0.64	0.871	0.604	0.534	0.884	0.846	0.864	0.815	0.794	0.675
88	0.701	0.735	0.828	0.69	0.771	0.66	0.733	0.891	0.724	0.786	0.651	0.754	0.842	0.731	0.711	0.722	0.626	0.837	0.724	0.733	0.805	0.797	0.708	0.71	0.628	0.813	0.699	0.71	0.641	0.697	0.678	0.697	0.692	0.642	0.744
89	0.692	0.742	0.835	0.562	0.847	0.707	0.822	0.773	0.672	0.716	0.625	0.778	0.739	0.76	0.753	0.809	0.663	0.891	0.809	0.799	0.844	0.829	0.686	0.688	0.637	0.833	0.663	0.739	0.716	0.635	0.65	0.675	0.716	0.736	0.764
90	0.729	0.817	0.738	0.726	0.702	0.765	0.747	0.76	0.827	0.706	0.756	0.653	0.67	0.759	0.727	0.673	0.793	0.777	0.698	0.707	0.698	0.689	0.787	0.824	0.79	0.737	0.82	0.591	0.568	0.795	0.76	0.831	0.819	0.807	0.755
91	0.706	0.79	0.707	0.773	0.663	0.727	0.707	0.666	0.846	0.662	0.793	0.613	0.636	0.7	0.696	0.634	0.833	0.675	0.674	0.683	0.681	0.673	0.856	0.866	0.878	0.682	0.87	0.645	0.622	0.868	0.829	0.878	0.873	0.784	0.723
92	0.664	0.779	0.803	0.657	0.743	0.66	0.718	0.745	0.671	0.735	0.602	0.668	0.708	0.649	0.745	0.714	0.642	0.853	0.786	0.795	0.774	0.766	0.689	0.691	0.657	0.801	0.703	0.726	0.656	0.662	0.666	0.734	0.721	0.654	0.759
93	0.689	0.813	0.836	0.644	0.777	0.705	0.738	0.751	0.704	0.78	0.635	0.69	0.714	0.662	0.779	0.728	0.671	0.878	0.799	0.808	0.799	0.79	0.709	0.711	0.677	0.821	0.721	0.739	0.669	0.695	0.711	0.723	0.741	0.686	0.772
94	0.725	0.869	0.732	0.792	0.65	0.841	0.694	0.692	0.798	0.723	0.729	0.623	0.647	0.691	0.659	0.621	0.854	0.755	0.63	0.639	0.715	0.707	0.804	0.818	0.854	0.707	0.861	0.632	0.609	0.843	0.874	0.831	0.836	0.883	0.749
95	0.68	0.747	0.764	0.622	0.696	0.77	0.694	0.63	0.69	0.661	0.646	0.538	0.609	0.622	0.597	0.661	0.68	0.758	0.673	0.664	0.732	0.723	0.688	0.71	0.722	0.762	0.737	0.672	0.602	0.711	0.758	0.722	0.705	0.753	0.634
96	0.666	0.733	0.75	0.608	0.682	0.737	0.727	0.616	0.676	0.647	0.632	0.571	0.595	0.655	0.63	0.647	0.703	0.744	0.65	0.65	0.718	0.709	0.674	0.696	0.708	0.748	0.723	0.658	0.635	0.697	0.744	0.708	0.691	0.785	0.666
97	0.724	0.861	0.751	0.782	0.761	0.798	0.69	0.812	0.828	0.66	0.76	0.665	0.767	0.715	0.678	0.679	0.764	0.767	0.689	0.698	0.727	0.719	0.846	0.848	0.861	0.726	0.853	0.597	0.528	0.804	0.765	0.876	0.878	0.793	0.738
98	0.792	0.765	0.923	0.596	0.841	0.748	0.816	0.802	0.698	0.728	0.676	0.733	0.757	0.749	0.757	0.818	0.621	0.883	0.805	0.814	0.913	0.898	0.693	0.695	0.661	0.899	0.668	0.783	0.713	0.65	0.67	0.708	0.725	0.743	0.754
99	0.707	0.809	0.66	0.827	0.6	0.758	0.621	0.759	0.911	0.766	0.911	0.597	0.663	0.611	0.633	0.564	0.817	0.629	0.597	0.606	0.612	0.627	0.871	0.908	0.897	0.635	0.881	0.576	0.506	0.91	0.892	0.87	0.857	0.776	0.693
[illegible]	0.685	0.858	0.696	0.872	0.659	0.788	0.661	0.748	0.901	0.802	0.832	0.603	0.674	0.628	0.669	0.604	0.893	0.692	0.66	0.669	0.628	0.62	0.864	0.901	0.89	0.674	0.941	0.615	0.545	0.946	0.931	0.867	0.85	0.759	0.709

Table 6 (cont'd)

	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
80	0.77	0.799	0.645	0.597	0.701	0.676	0.824	0.677	0.738	0.786	0.677	0.646	0.592	0.751	0.787	0.62	0.803	0.778	0.705	0.673	0.834	0.803	0.685	0.554	0.743	0.74	0.737	0.679	0.833	0.578	0.791	0.663	0.642	0.69	0.798	0.583	0.723	0.682	0.668	0.634
81	0.699	0.74	0.834	0.805	0.763	0.848	0.752	0.759	0.755	0.761	0.877	0.876	0.806	0.784	0.66	0.788	0.733	0.665	0.732	0.854	0.769	0.79	0.698	0.745	0.779	0.687	0.692	0.851	0.764	0.817	0.82	0.857	0.839	0.852	0.759	0.716	0.892	0.716	0.857	0.8
82	0.757	0.811	0.684	0.645	0.798	0.744	0.826	0.655	0.804	0.824	0.682	0.711	0.665	0.802	0.713	0.647	0.795	0.762	0.757	0.747	0.841	0.815	0.749	0.597	0.749	0.798	0.71	0.78	0.845	0.688	0.854	0.745	0.743	0.661	0.798	0.625	0.778	0.669	0.695	0.708
83	0.738	0.737	0.603	0.601	0.682	0.611	0.804	0.551	0.619	0.767	0.614	0.659	0.526	0.657	0.714	0.578	0.777	0.751	0.665	0.585	0.76	0.787	0.645	0.605	0.731	0.744	0.811	0.539	0.789	0.552	0.764	0.567	0.546	0.667	0.825	0.626	0.584	0.666	0.572	0.607
84	0.618	0.609	0.769	0.721	0.734	0.824	0.661	0.713	0.787	0.736	0.802	0.824	0.821	0.671	0.627	0.733	0.683	0.68	0.769	0.903	0.677	0.659	0.646	0.672	0.7	0.693	0.605	0.879	0.627	0.897	0.688	0.911	0.875	0.806	0.623	0.752	0.908	0.661	0.814	0.842
85	0.771	0.769	0.632	0.631	0.7	0.659	0.838	0.606	0.706	0.786	0.622	0.614	0.567	0.742	0.755	0.642	0.795	0.804	0.697	0.649	0.79	0.82	0.781	0.588	0.712	0.801	0.712	0.682	0.792	0.628	0.794	0.685	0.645	0.658	0.796	0.621	0.726	0.672	0.644	0.656
86	0.564	0.656	0.758	0.71	0.694	0.823	0.632	0.801	0.758	0.745	0.863	0.855	0.809	0.667	0.528	0.744	0.664	0.577	0.838	0.891	0.632	0.629	0.585	0.69	0.705	0.734	0.67	0.847	0.605	0.815	0.636	0.799	0.84	0.835	0.615	0.692	0.861	0.704	0.793	0.77
87	0.839	0.869	0.68	0.632	0.701	0.7	0.882	0.694	0.707	0.849	0.656	0.655	0.592	0.847	0.725	0.721	0.811	0.836	0.746	0.65	0.868	0.881	0.823	0.659	0.666	0.752	0.78	0.663	0.82	0.605	0.88	0.633	0.646	0.686	0.844	0.668	0.723	0.797	0.668	0.657
88	0.708	0.715	0.755	0.707	0.78	0.83	0.684	0.836	0.81	0.728	0.775	0.791	0.806	0.714	0.579	0.749	0.681	0.674	0.781	0.836	0.731	0.703	0.628	0.674	0.744	0.67	0.597	0.806	0.686	0.781	0.749	0.818	0.803	0.714	0.669	0.737	0.801	0.795	0.813	0.777
89	0.595	0.645	0.788	0.758	0.756	0.844	0.646	0.733	0.797	0.748	0.897	0.811	0.854	0.633	0.647	0.743	0.726	0.665	0.767	0.854	0.663	0.671	0.594	0.745	0.766	0.776	0.679	0.825	0.645	0.879	0.721	0.837	0.793	0.826	0.652	0.718	0.835	0.716	0.843	0.88
90	0.744	0.75	0.682	0.634	0.75	0.729	0.802	0.633	0.741	0.893	0.706	0.728	0.687	0.765	0.737	0.646	0.886	0.838	0.712	0.769	0.818	0.762	0.764	0.702	0.733	0.835	0.762	0.69	0.768	0.732	0.828	0.745	0.703	0.757	0.764	0.672	0.734	0.668	0.688	0.816
91	0.799	0.735	0.693	0.645	0.657	0.656	0.857	0.566	0.663	0.835	0.651	0.696	0.617	0.804	0.767	0.715	0.891	0.842	0.726	0.699	0.821	0.856	0.815	0.672	0.698	0.727	0.708	0.647	0.8	0.681	0.808	0.675	0.636	0.727	0.831	0.633	0.722	0.684	0.656	0.699
92	0.681	0.688	0.759	0.711	0.745	0.784	0.662	0.729	0.771	0.739	0.747	0.769	0.775	0.66	0.569	0.738	0.752	0.605	0.73	0.834	0.677	0.669	0.578	0.633	0.891	0.683	0.673	0.731	0.667	0.75	0.734	0.775	0.777	0.696	0.68	0.63	0.729	0.737	0.729	0.785
93	0.668	0.675	0.772	0.724	0.77	0.81	0.682	0.72	0.784	0.759	0.781	0.796	0.789	0.662	0.589	0.724	0.731	0.603	0.763	0.847	0.682	0.702	0.58	0.658	0.907	0.715	0.704	0.776	0.701	0.775	0.732	0.813	0.802	0.741	0.7	0.65	0.774	0.719	0.749	0.817
94	0.788	0.741	0.684	0.636	0.706	0.696	0.855	0.638	0.735	0.852	0.7	0.699	0.666	0.697	0.731	0.671	0.87	0.879	0.752	0.724	0.812	0.838	0.743	0.686	0.754	0.841	0.799	0.684	0.818	0.726	0.799	0.724	0.697	0.73	0.84	0.666	0.728	0.724	0.689	0.725
95	0.689	0.662	0.639	0.61	0.645	0.675	0.709	0.553	0.698	0.807	0.703	0.707	0.691	0.691	0.591	0.649	0.693	0.679	0.777	0.772	0.665	0.726	0.668	0.683	0.632	0.746	0.695	0.715	0.657	0.729	0.711	0.718	0.721	0.645	0.704	0.62	0.744	0.632	0.651	0.686
96	0.675	0.629	0.625	0.586	0.631	0.661	0.695	0.539	0.684	0.793	0.68	0.693	0.677	0.678	0.624	0.635	0.725	0.712	0.763	0.758	0.651	0.703	0.7	0.66	0.618	0.76	0.672	0.701	0.643	0.762	0.687	0.75	0.708	0.677	0.69	0.652	0.73	0.618	0.637	0.719
97	0.776	0.822	0.708	0.66	0.811	0.758	0.811	0.711	0.747	0.914	0.719	0.764	0.678	0.817	0.703	0.691	0.851	0.818	0.724	0.737	0.85	0.818	0.735	0.687	0.769	0.844	0.779	0.691	0.824	0.68	0.885	0.696	0.697	0.749	0.809	0.638	0.736	0.732	0.708	0.744
98	0.591	0.682	0.836	0.787	0.769	0.835	0.68	0.794	0.798	0.771	0.891	0.89	0.864	0.679	0.561	0.787	0.701	0.647	0.827	0.922	0.689	0.686	0.597	0.71	0.766	0.747	0.729	0.863	0.669	0.866	0.723	0.845	0.86	0.875	0.666	0.718	0.861	0.781	0.834	0.8
99	0.821	0.82	0.651	0.603	0.696	0.683	0.957	0.657	0.702	0.792	0.651	0.673	0.563	0.764	0.751	0.661	0.81	0.893	0.702	0.645	0.925	0.894	0.787	0.603	0.671	0.711	0.786	0.658	0.854	0.577	0.836	0.604	0.617	0.703	0.85	0.663	0.702	0.731	0.64	0.629
#	0.898	0.827	0.644	0.596	0.712	0.717	0.943	0.618	0.718	0.844	0.657	0.672	0.603	0.8	0.767	0.654	0.853	0.863	0.709	0.685	0.895	0.924	0.793	0.67	0.747	0.743	0.77	0.694	0.897	0.616	0.852	0.674	0.68	0.67	0.901	0.656	0.738	0.684	0.656	0.692

Table 6 (cont'd)

	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	#
77	0.775	1																							
78	0.676	0.743	1																						
79	0.76	0.726	0.686	1																					
80	0.676	0.712	0.846	0.575	1																				
81	0.828	0.744	0.709	0.739	0.705	1																			
82	0.759	0.739	0.816	0.66	0.843	0.757	1																		
83	0.634	0.607	0.749	0.641	0.798	0.641	0.75	1																	
84	0.836	0.704	0.635	0.692	0.635	0.83	0.736	0.515	1																
85	0.652	0.651	0.802	0.609	0.798	0.696	0.893	0.805	0.685	1															
86	0.847	0.738	0.59	0.657	0.668	0.787	0.705	0.601	0.825	0.623	1														
87	0.653	0.674	0.819	0.726	0.802	0.73	0.804	0.783	0.654	0.813	0.655	1													
88	0.838	0.754	0.684	0.794	0.691	0.792	0.749	0.565	0.785	0.651	0.753	0.716	1												
89	0.874	0.685	0.658	0.692	0.632	0.834	0.684	0.582	0.846	0.67	0.776	0.624	0.765	1											
90	0.749	0.706	0.729	0.698	0.761	0.734	0.784	0.719	0.742	0.779	0.684	0.78	0.72	0.774	1										
91	0.655	0.679	0.802	0.686	0.75	0.726	0.741	0.77	0.707	0.788	0.657	0.827	0.611	0.688	0.817	1									
92	0.837	0.888	0.681	0.759	0.68	0.764	0.733	0.622	0.737	0.651	0.764	0.677	0.813	0.757	0.739	0.654	1								
93	0.85	0.861	0.67	0.725	0.725	0.809	0.778	0.654	0.762	0.696	0.782	0.681	0.804	0.782	0.748	0.668	0.955	1							
94	0.75	0.689	0.847	0.661	0.8	0.682	0.802	0.802	0.713	0.855	0.674	0.786	0.683	0.768	0.854	0.863	0.699	0.723	1						
95	0.724	0.701	0.72	0.655	0.653	0.685	0.757	0.633	0.761	0.71	0.722	0.726	0.668	0.697	0.747	0.763	0.663	0.694	0.777	1					
96	0.701	0.678	0.688	0.641	0.639	0.662	0.743	0.619	0.794	0.742	0.709	0.712	0.654	0.71	0.78	0.796	0.649	0.68	0.809	0.967	1				
97	0.762	0.719	0.761	0.716	0.749	0.747	0.832	0.794	0.667	0.789	0.689	0.844	0.756	0.734	0.855	0.805	0.734	0.738	0.834	0.733	0.719	1			
98	0.902	0.793	0.655	0.719	0.7	0.826	0.737	0.651	0.853	0.646	0.907	0.705	0.793	0.826	0.72	0.705	0.815	0.828	0.744	0.73	0.716	0.768	1		
99	0.648	0.617	0.844	0.675	0.862	0.725	0.799	0.835	0.634	0.795	0.637	0.889	0.657	0.619	0.775	0.826	0.62	0.64	0.817	0.67	0.656	0.778	0.694	1	
#	0.664	0.662	0.861	0.691	0.856	0.778	0.858	0.817	0.673	0.872	0.635	0.872	0.686	0.658	0.815	0.846	0.686	0.731	0.867	0.745	0.731	0.801	0.658	0.9	1

APPENDIX D

PHENOGRAM SUMMARY

Table 7. The summary for the phenogram.

Node	Group 1	Group 2	Similarity	Objects in group
1	cadmica var. bozkiriensis	cadmica var. cadmica	0.991	2
2	caespitosa A	caespitosa B	0.985	2
3	adenophylla	marashica	0.972	2
4	viridis A	viridis B	0.967	2
5	candidissima subsp. candidissima	candidissima subsp. occidentalis	0.965	2
6	Node 3	cedronella	0.963	3
7	verticillata subsp. amasiaca	verticillata subsp. verticillata	0.961	2
8	frigida	xanthocheila	0.957	2
9	euphratica var. euphratica	euphratica var. leiocalycina	0.952	2
10	argentea	microstegia	0.951	2
11	Node 5	cyanescens	0.95	3
12	bracteata	rosifolia	0.942	2
13	chionantha	yosgadensis	0.938	2
14	Node 11	cilicica	0.931	4
15	cerino-pruinosa A	cerino-pruinosa B	0.93	2
16	Node 10	Node 8	0.93	4
17	Node 2	pachystachys	0.928	3
18	Node 13	modesta	0.924	3
19	Node 6	wiedemannii	0.922	4
20	odontochlamys	poculata	0.922	2
21	nydeggeri	potentillifolia	0.921	2
22	forskahlei	glutinosa	0.919	2
23	aethiopis	ekimiana	0.917	2

Table 7 (cont'd)

Node	Group 1	Group 2	Similarity	Objects in group
24	Node 16	Node 18	0.911	7
25	Node 19	Node 12	0.911	6
26	blepharochlaena	Node 1	0.911	3
27	pilifera	pinnata	0.909	2
28	Node 26	hydrangea	0.907	4
29	Node 9	kronenburgii	0.906	3
30	amplexicaulis	dichroantha	0.906	2
31	hypargeia	montbretii	0.906	2
32	albimaculata	huberi	0.904	2
33	Node 14	palaestina	0.902	5
34	halophila	viscosa	0.9	2
35	cassia	chrysophylla	0.899	2
36	aucheri subsp. aucheri	aucheri subsp. canescens	0.899	2
37	Node 25	Node 17	0.897	9
38	napifolia	Node 7	0.896	3
39	Node 21	quezelii	0.895	3
40	heldreichiana	trichoclada	0.895	2
41	Node 24	ceratophylla	0.893	8
42	spinosa	syriaca	0.893	2
43	aramiensis	tomentosa	0.891	2
44	Node 27	suffruticosa	0.891	3
45	Node 41	Node 35	0.885	10
46	limbata	verbenaca	0.884	2
47	Node 33	Node 20	0.881	7
48	adenocaulon	Node 34	0.88	3
49	Node 37	Node 32	0.877	11
50	atropatana	siirtica	0.877	2
51	absconditiflora	multicaulis	0.876	2
52	longipedicellata	virgata	0.875	2
53	eriophora	tobeyi	0.875	2
54	Node 45	Node 47	0.874	17
55	anatolica	recognita	0.866	2
56	Node 39	smyrnaea	0.863	4
57	Node 49	Node 44	0.863	14
58	Node 22	freyniana	0.863	3
59	ballsiana	divaricata	0.857	2

Table 7 (cont'd)

Node	Group 1	Group 2	Similarity	Objects in group
60	Node 57	tchihatcheffii	0.853	15
61	Node 23	Node 53	0.853	4
62	Node 48	Node 46	0.853	5
63	Node 40	Node 56	0.851	6
64	Node 60	Node 63	0.85	21
65	Node 30	nemorosa	0.848	3
66	Node 43	fruticosa	0.848	3
67	Node 54	sclarea	0.848	18
68	Node 29	pseudeuphratica	0.847	4
69	Node 52	vermifolia	0.845	3
70	Node 38	russellii	0.844	4
71	Node 55	Node 28	0.844	6
72	Node 67	Node 50	0.84	20
73	Node 51	aytachii	0.838	3
74	Node 61	Node 72	0.834	24
75	brachyantha subsp. brachyantha	Node 42	0.833	3
76	Node 64	pisidica	0.832	22
77	Node 62	Node 69	0.828	8
78	Node 76	Node 71	0.826	28
79	Node 77	Node 74	0.816	32
80	nutans	staminea	0.815	2
81	Node 79	Node 75	0.81	35
82	Node 36	Node 58	0.799	5
83	Node 15	Node 68	0.793	6
84	Node 65	Node 80	0.793	5
85	macrochlamys	pomifera	0.786	2
86	Node 81	Node 31	0.782	37
87	Node 78	Node 82	0.78	33
88	Node 73	Node 83	0.774	9
89	Node 88	sericeo-tomentosa var. hatayica	0.769	10
90	Node 86	indica	0.764	38
91	Node 87	Node 66	0.763	36
92	aristata	Node 59	0.759	3
93	Node 91	Node 92	0.757	39
94	Node 93	Node 85	0.75	41
95	Node 90	Node 84	0.75	43
96	Node 94	Node 70	0.743	45

Table 7 (cont'd)

97	Node 89	Node 96	0.721	55
98	Node 95	Node 4	0.695	45
99	Node 97	Node 98	0.66	100