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COMPARATIVE MORPHOLOGICAL AND PHYTOCHEMICAL CHARACTERIZATION OF *SALVIA CADMICA* AND *S. SMYRNAEA***

KEMAL HÜSNÜ CAN BAŞER[1], BETÜL DEMIRCI[1], MINE KÜRKÇÜOĞLU[1], FATIH SATIL[2*] AND GÜLENDAM TÜMEN[2]

[1]*Department of Pharmacognosy, Faculty of Pharmacy, Anadolu University, 26470-Eskişehir, Turkey,*
[2]*Department of Biology, Faculty of Science & Arts, Balıkesir University, 10145 Balıkesir, Turkey.*

Abstract

Salvia cadmica Boiss., and *S. smyrnaea* Boiss., (Lamiaceae) differ from each other by the colour of their corolla in that the former is white and the latter is violet-blue, and that calyx widens in fruit in the latter. Both species are characterized by having cryptone in their essential oils as major constituent. Both species are endemic to Turkey. The paper compares morphological and chemical features of the two species with a view to confirm their taxonomical status.

Introduction

The genus *Salvia* L., (Lamiaceae) is represented in Turkey by 95 species and (Hedge, 1982; Davis *et al*., 1988; Adıgüzel & Vural, 1996; Dönmez, 2001; Behcet and Avlanmaz, 2009; Celep et al., 2009). The ratio of endemism in the genus *Salvia* in Turkey is *ca*. 50 %. Many *Salvia* species are aromatic, rich in essential oils and of potential economic interest besides their ornamental uses. *Salvia officinalis* L., and *S. fruticosa* Miller (Syn. *S. triloba* L.) are commonly used as herbal tea, food flavour and as sources of essential oil. They are utilized mainly in food, cosmetic, perfumery and pharmaceutical industries. Previously, we reported the essential oil composition of several *Salvia* species (Başer *et al*., 1993; 1995; 1996; 1997; 1998; Tümen *et al*., 1998).

Salvia cadmica Boiss., and *S. smyrnaea* Boiss., are two endemic species of Turkey with close taxonomical similarity. While *S. cadmica* grows in central and western Anatolia, *S. smyrnaea* has a narrower distribution growing in an area adjoining Izmir and Aydın provinces in western Turkey. The present report gives an account of the morphological features and essential oil compositions of these species in order to provide further proof to their taxonomical status.

To the best of our knowledge, this is the first report on the essential oil compositions of *S. cadmica* and *S. smyrnaea*.

Materials and Methods

Plant materials: The aerial parts of *S. cadmica* were collected in June 1995 from Eskişehir: Çatacık and the aerial parts of *S. smyrnaea* were collected in June 1998 from Izmir: Selçuk in Turkey at an altitude of 1400-1500 m. Voucher specimens are kept at the Herbarium of the Faculty of Pharmacy of Anadolu University in Eskişehir, Turkey (ESSE: 11288 and 12723, respectively).

*Corresponding author E-mail: fsatil@balikesir.edu.tr, fsatil@gmail.com
Phone: ++ 90-266-6121278; Fax: ++ 90-266-6121215
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Morphological studies: Morphological features were determined on herbarium materials and living specimens. Olympus SZX12 Stereomicroscope with drawing tube were used in morphological studies.

Distillation: Air-dried herbs of *S. cadmica* and *S. smyrnaea* were hydrodistilled for 3 h using a Clevenger-type apparatus to yield 0.17 % and 0.41 % essential oils on dry weight basis, respectively.

Gas chromatography mass spectrometry (GC/MS): The essential oils were analysed using a Hewlett-Packard G1800A GCD system. Innowax FSC column (60 m x 0.25 mm Ø, with 0.25 μm film thickness). Helium (0.8 ml/min) was used as carrier gas. GC oven temperature was kept at 60˚C for 10 min., and programmed to 220˚C @ of 4˚C/min., and then kept constant at 220˚C for 10 min to 240˚C @ of 1˚C/min. Mass range was recorded from *m/z* 35 to 425. Injections were applied splitless. Injection port temperature was at 250˚C. MS were recorded at 70 eV. Relative percentage amounts of the separated compounds were calculated automatically from peak areas of the total ion chromatogramme. Alkanes were used as reference points in the calculation of relative retention indices (RRI). Library search was carried out using "Wiley GC/MS Library" and in-house "Baser Library of Essential Oil Constituents".

Results and Discussion

This study was aimed at comparing morphological and chemical features of the two species with a view to establish further proof to their taxonomical identity. Morphological features are shown in Figs. 1-4. *S. cadmica* and *S. smyrnaea* differ from each other by the colour of their corolla in that the former is white and the latter is violet-blue, calyx widens in fruit and bracteoles are absent in the latter. The differences between *S. cadmica* and *S. smyrnaea* are summarized in Table 1.

Hydrodistilled essential oils of *S. cadmica* and *S. smyrnaea* were analysed by GC/MS (Table 2). Sixty compounds representing 94.6% of the total oil were characterized in the essential oil of *S. cadmica*, while 117 compounds representing 90.7% of the total oil were identified in the essential oil of *S. smyrnaea*. Both species are characterized by having cryptone (13.4% and 20.6%) and 1,8-cineole (29.0% and 12.0%) in respective oils as major constituents. While cryptone (20.6%) was the main constituent in the oil of *S. smyrnaea*, 1,8-cineole (29.0%) was the main component in the oil of *S. cadmica*.

Although chemically quite similar, the two species have obvious morphological differences which, beyond doubt, qualify them as distinct species.

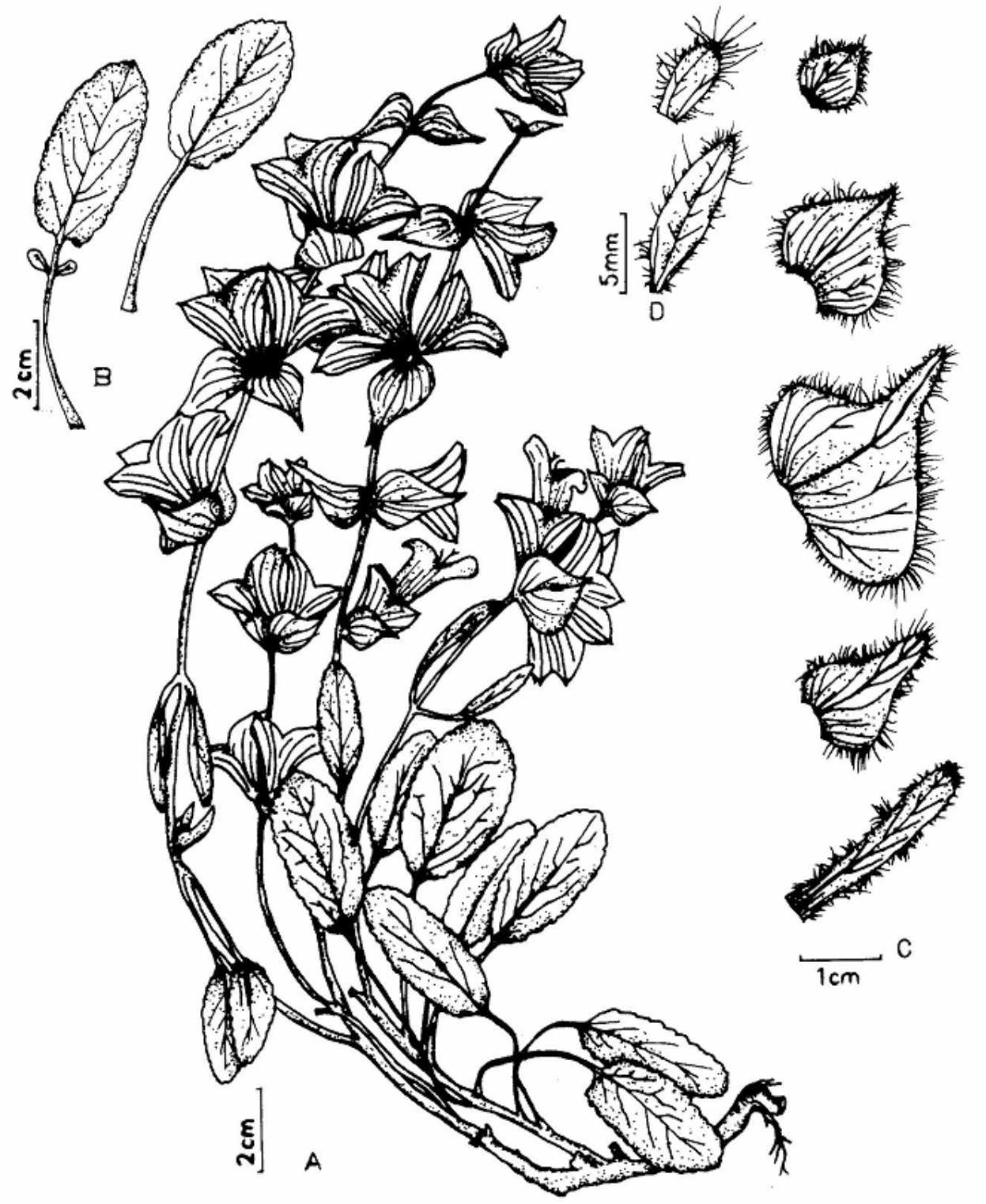

Fig. 1. *S. cadmica* (ESSE: 11288) A-Habit, B-Leaves, C-Bracts, D-Bracteoles.

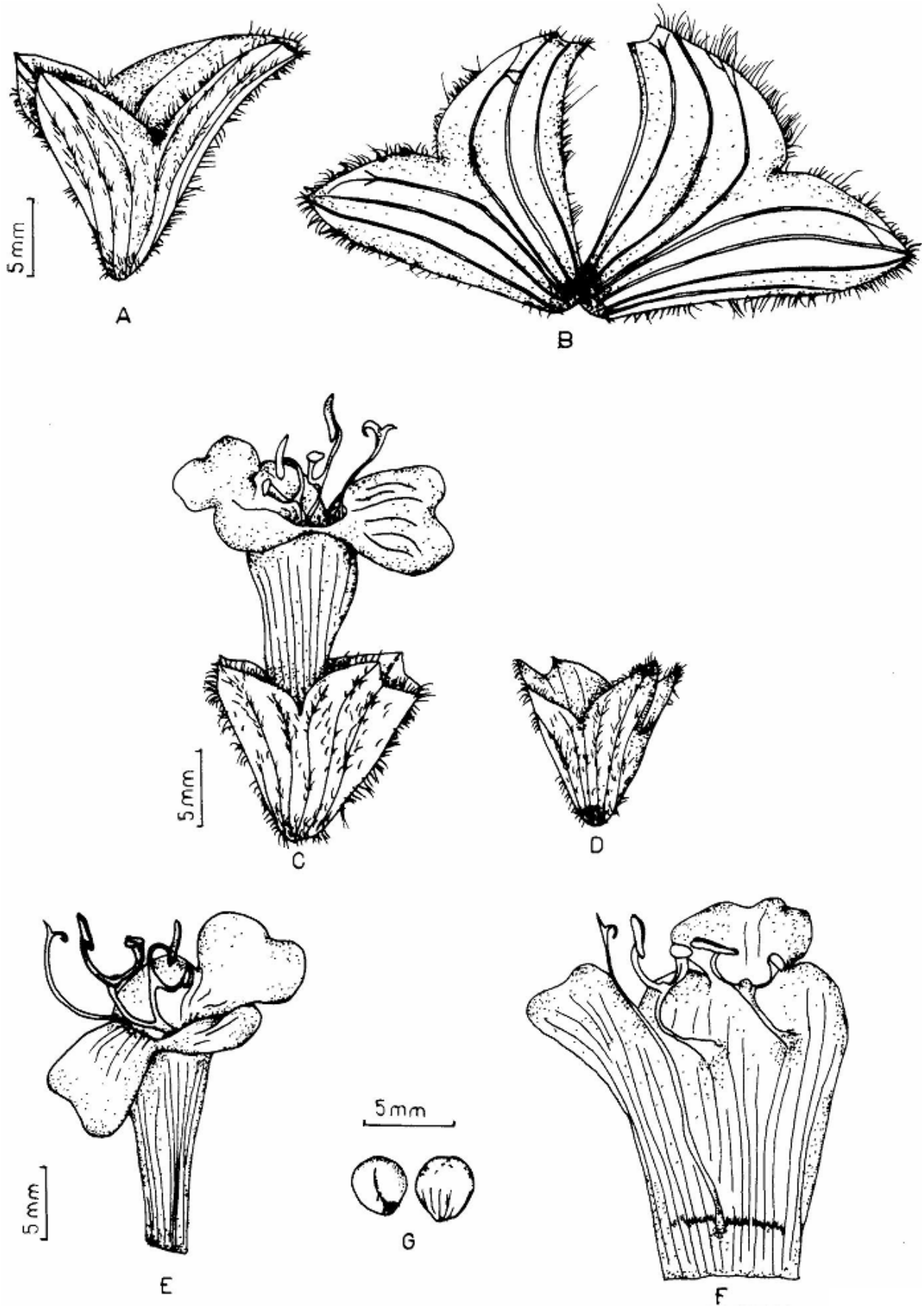

Fig. 2. *S. cadmica* (ESSE: 11288) A-B) Fruiting calyx, C) Flower, D) Calyx, E-F) Corolla, G) Nutlets.

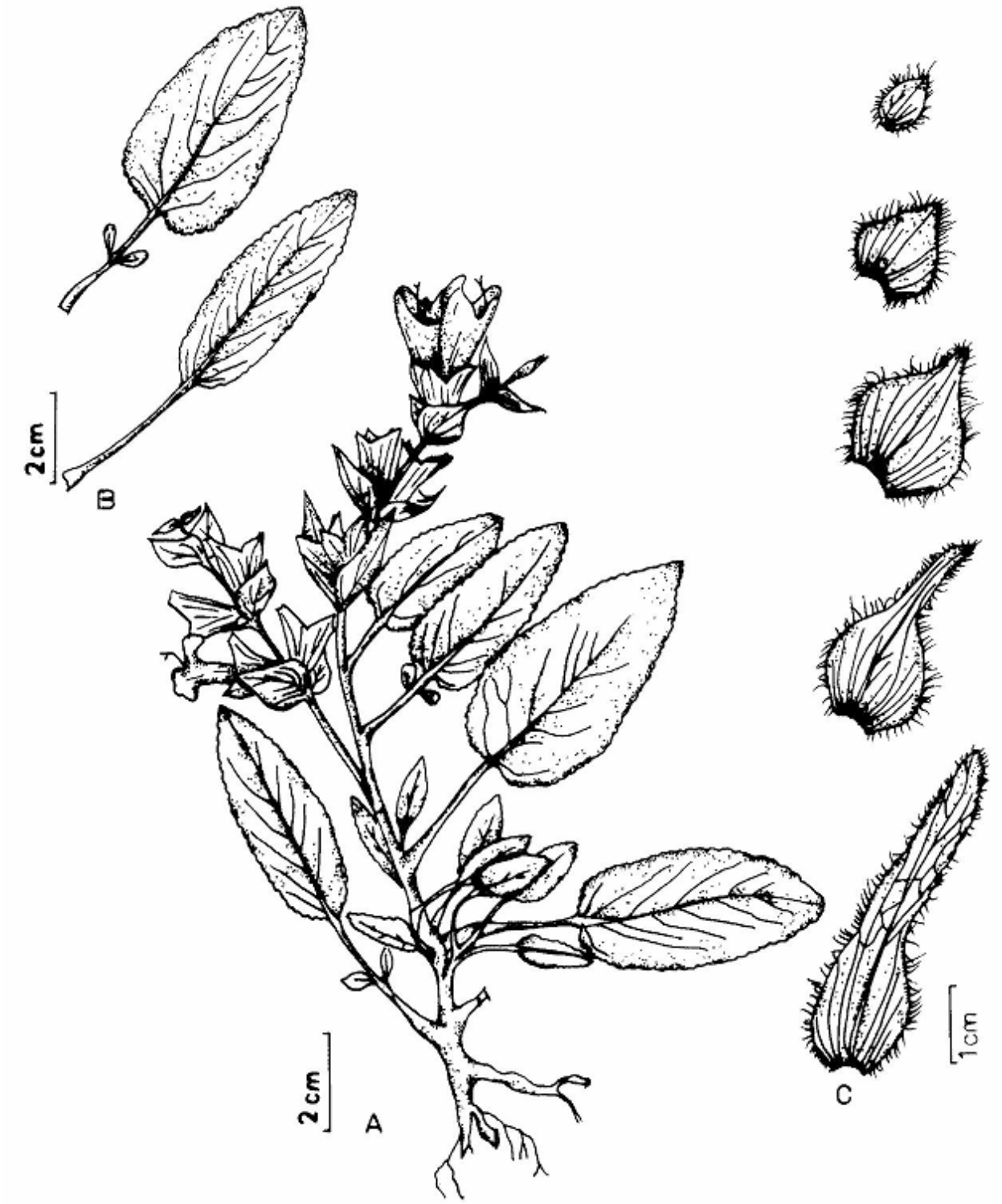

Fig. 3. *S. smyrnaea* (ESSE 12723) A-Habit, B-Leaves, C-Bracts.

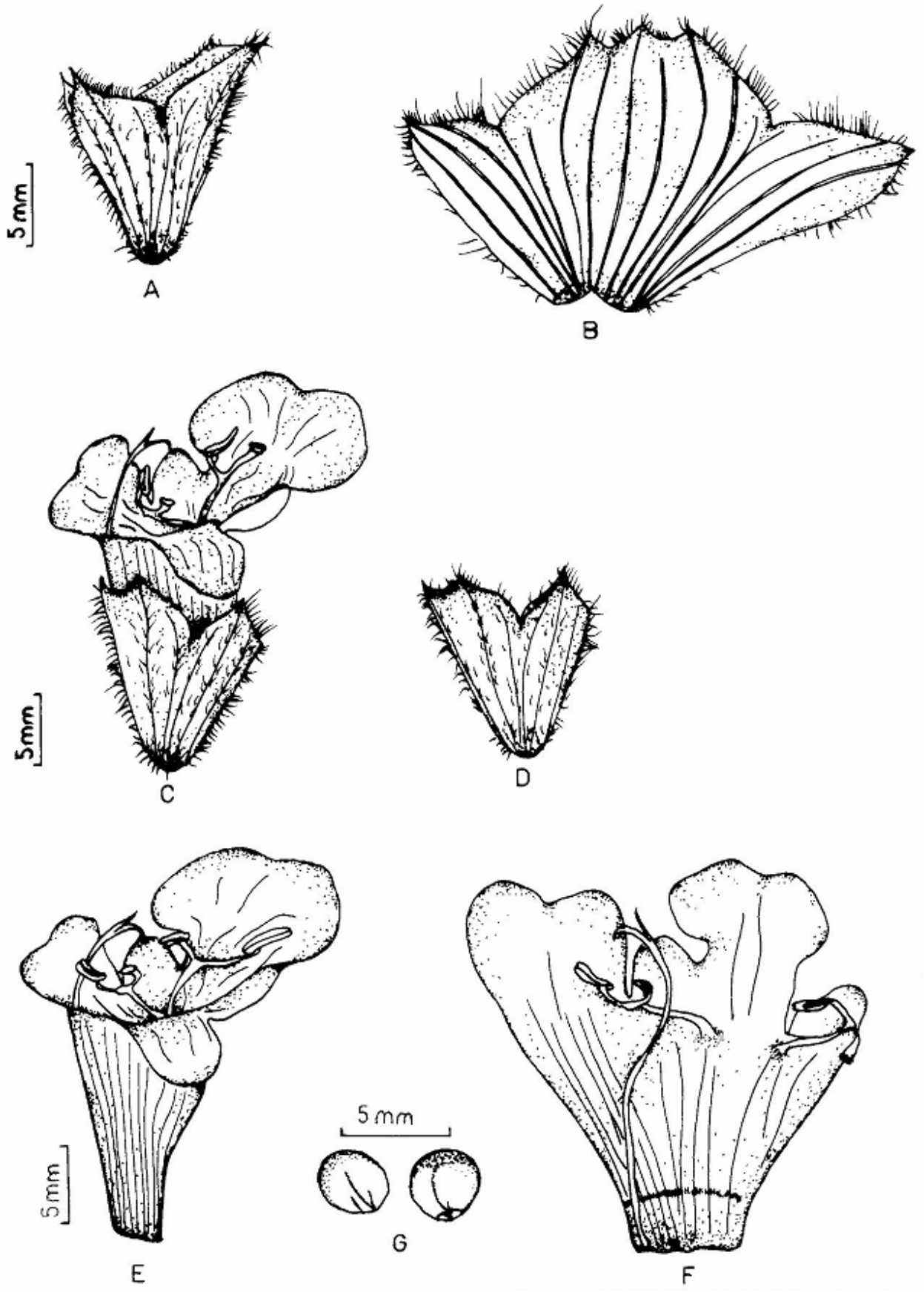

Fig. 4. *S. smyrnaea* (ESSE 12723): A-B) Fruiting calyx, C) Flower, D) Calyx, E-F) Corolla, G) Nutlets.

Table 1. The morphological differences between *S. cadmica* and *S. smyrnaea*.

Morphological characters	*S. cadmica*		*S. smyrnaea*	
	Flora of Turkey	**The findings of this study**	**Flora of Turkey**	**The findings of this study**
Leaf	Ovate-oblong to elliptic -	Ovate-oblong to elliptic, obovate Rotund to mucronate	Ovate-oblong to oblong -	Ovate-oblong to oblong Rotund to acute
Leaf width	1.5-5 x 1-2 cm	1-5 x 0.6-2 cm	2-5 x 1-2 cm	1-5.5 x 0.4-2
Petiole	1.5-5 cm	1.5-5 (5.5) cm	-	1.5-4.5 cm
Bract	15 x 15 mm	7-30 x 6-20 mm	-	10-23 x 6-10 mm
Bracteole	-	5-12 mm	-	-
Pedicel	2-3 mm	3-9 (10) mm	3-5 mm	2.5-9 mm
Calyx	Broadly-campanulate 17 mm -	Broadly-campanulate 14-20 mm in fruit 19-22 mm	Tubular-campanulate 15 mm in fruit 16-17 mm	Tubular-campanulate 14-17 mm in fruit 17-18 mm
Corolla	30 mm white	28-32 mm white	30-35 mm violet blue	30-35 mm light violet blue
Nutlet	3.5 x 3.2 mm	2-3.5 x 2-3 mm	-	2.5-3.5 x 2-3 mm

Table 2. The composition of the essential oils of *Salvia* species.

RRI	Compound	*S. cadmica* (%)	*S. smyrnaea* (%)
931	3-Methyl butanal (*Isovaleraldehyde*)	-	0.02
1017	4-Methyl-2-pentanone	-	0.03
1032	α-Pinene	2.61	0.34
1035	α-Thujene	-	0.04
1048	2-Methyl-3-buten-2-ol	0.12	0.14
1076	Camphene	0.28	0.11
1093	Hexanal	-	0.01
1118	β-Pinene	0.59	0.08
1132	Sabinene	1.07	0.21
1174	Myrcene	0.31	0.03
1176	α-Phellandrene	0.10	0.02
1183	*p*-Mentha-1,7(8)-diene (=*Pseudolimonene*)	1.25	0.94
1188	α-Terpinene	-	0.04
1195	Dehydro-1,8-cineole	-	0.04
1203	Limonene	2.96	1.00
1213	**1,8-Cineole**	**29.04**	**12.01**
1218	β-Phellandrene	7.58	0.20
1220	*cis*-Anhydrolinalool oxide	-	0.03
1224	*o*-Mentha-1(7),5,8-triene	-	0.01
1232	(*E*)-2-Hexenal	0.30	0.06
1244	Amyl furan	-	0.01
1246	(*Z*)-β-Ocimene	2.96	0.02
1247	6-Methyl-2-heptanone	-	0.01
1253	*trans*-Anhydrolinalool oxide	-	0.02
1255	γ-Terpinene	0.10	0.22
1265	5-Methyl-3-heptanone	-	0.10
1266	(*E*)-β-Ocimene	3.82	-
1278	*m*-Cymene	-	0.04
1280	*p*-Cymene	2.02	2.92
1290	Terpinolene	-	0.04
1345	3-Octyl acetate	-	0.03
1348	6-Methyl-5-hepten-2-one	-	0.03
1398	2-Nonanone	0.87	0.27
1400	Nonanal	0.09	0.03
1415	Rose furan	0.71	0.29
1416	3-Octen-2-one	-	0.01
1429	Perillen	-	0.02
1430	α-Thujone	-	0.55
1435	γ-Campholene aldehyde	-	0.02
1450	*trans*-Linalool oxide (*Furanoid*)	-	0.46
1451	β-Thujone		11.16
1474	*trans*-Sabinene hydrate	0.08	0.11

Table 2. (Cont'd.).

RRI	Compound	*S. cadmica* (%)	*S. smyrnaea* (%)
1478	*cis*-Linalool oxide (*furanoid*)	-	0.24
1497	α-Copaene	0.99	-
1500	α-Campholene aldehyde	-	0.37
1505	Dihydroedulane II *	-	0.15
1522	2-Nonanol	-	0.04
1532	Camphor	3.41	1.48
1541	Benzaldehyde	-	0.05
1553	Linalool	0.57	0.40
1556	*cis*-Sabinene hydrate	-	0.10
1565	Linalyl acetate	-	0.25
1571	*trans*-*p*-Menth-2-en-1-ol	0.23	0.37
1586	Pinocarvone	0.09	0.06
1597	Bornyl acetate	-	0.20
1602	6-Methyl-3,5-heptadiene-2-one	0.21	0.22
1604	2-Undecanone	-	0.09
1611	Terpinen-4-ol	0.51	1.27
1614	Carvacrol methyl ether	-	0.03
1624	*cis*-Dihydrocarvone	-	0.02
1630	4-Terpinenyl acetate	-	0.02
1638	*cis*-*p*-Menth-2-en-1-ol	-	0.42
1639	*cis*-*p*-Mentha-2,8-dien-1-ol	0.26	-
1641	*cis*-β-Terpineol	-	0.06
1642	Thuj-3-en-10-al	-	0.29
1648	Myrtenal	0.19	0.10
1651	Sabina ketone	-	0.96
1658	Sabinyl acetate	-	0.10
1663	cis-Verbenol	0.32	0.06
1664	*trans*-Pinocarveol	0.53	0.35
1674	*p*-Mentha-1,5-dien-8-ol	0.08	0.03
1678	*trans*-*p*-Mentha-2,8-dien-1-ol	-	0.19
1683	δ-Terpineol	0.22	0.18
1690	**Cryptone**	**13.38**	**20.59**
1700	*p*-Mentha-1,8-dien-4-ol (=*Limonen-4-ol*)	-	0.08
1707	α-Terpineol	0.40	0.22
1709	α-Terpinyl acetate	-	0.24
1720	*trans*-Sabinol	-	0.40
1719	Borneol	0.36	0.81
1725	Verbenone	0.25	0.25
1740	*trans*-*p*-Menth-2-en-1,8-diol	0.30	0.09
1742	β-Selinene	0.36	1.38
1744	Phellandral	0.99	0.50
1748	Piperitone	0.21	0.26

Table 2. (Cont'd.).

RRI	Compound	*S. cadmica* (%)	*S. smyrnaea* (%)
1751	Carvone	0.54	0.83
1758	*cis*-Piperitol	0.10	0.23
1765	Geranyl acetate	0.21	1.80
1797	*p*-Methyl acetophenone	0.10	0.19
1802	Cumin aldehyde	4.23	8.91
1804	Myrtenol	0.25	-
1810	*trans*-*p*-Mentha-1(7),8-dien-2-ol	-	0.21
1811	*p*-Mentha-1,3-dien-7-al	0.50	0.90
1845	*trans*-Carveol	0.52	0.72
1857	Geraniol	-	0.15
1864	*p*-Cymen-8-ol	0.43	1.00
1868	(*E*)-Geranyl acetone	-	0.03
1882	*cis*-Carveol	-	0.14
1896	*cis*-*p*-Mentha-1(7),8-diene-2-ol	-	0.06
1912	*p*-Cymen-9-ol	-	0.02
1940	α-Calacorene	0.09	-
1941	4-Isopropyl salicylaldehyde	0.12	0.26
1956	*p*-Isopropenyl benzaldehyde	-	0.03
1958	β-Ionone	-	0.02
1981	Cuminyl acetate	-	0.15
2008	Caryophyllene oxide	0.70	0.47
2029	Perilla alcohol	-	0.20
2073	*p*-Mentha-1,4-dien-7-ol	0.12	0.61
2084	Octanoic acid	-	0.19
2113	Cumin alcohol	0.91	4.86
2144	Spathulenol	-	0.01
2179	3,4-Dimethyl-5-pentylidene-2(5H)-furanone	-	0.01
2192	Nonanoic acid	-	0.25
2198	Thymol	0.31	0.28
2221	Isocarvacrol (=*4-Isopropyl-2-methyl phenol*)	-	0.03
2239	Carvacrol	4.08	1.21
2241	*p*-Isopropyl phenol	0.27	1.68
2256	Cadalene	0.28	-
2257	β-Eudesmol	-	0.14
2300	Decanoic acid	-	0.17
2500	Pentacosane	0.09	-
2503	Dodecanoic acid	-	0.21
2622	Phytol	-	0.02
2700	Heptacosane	-	0.03
2931	Hexadecanoic acid	-	0.03
	Total	**94.6**	**90.7**

RRI = Relative retention indices on a polar column

*Tentative

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