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NOTES ON THE GENUS *VERONICA* (SCROPHULARIACEAE: TRIBE *VERONICEAE*) IN IRAN: SEED CHARACTERS AND A NEW RECORD

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Abstract

The seed characters of 10 species of *Veronica* in Iran are described. Six distinct types based on seed features such as shape, surface ornamentation and cell shape are distinguished. A diagnostic key for determination of these taxa is provided. One of the examined species i.e., *Veronica davisii*, is recorded for first time from Iran. This species is compared with its closest relatives within sect. *Veronicastntrum*.

Introduction

The genus *Veronica* was placed in the tribe *Veroniceae* by Bentham (1846), but Rechinger (1981) placed it in tribe *Digitaleae*. Tribes *Veroniceae* and *Digitaleae* differ in morphology of the corolla, the number of stamens and the manner of capsule dehiscence which open loculicidally and or rarely septicidally in *Veroniceae* and septicidally in *Digitaleae* (Hong, 1984).

Veronica is distributed world wide and grows in many different habitats. It occurs generally on wet soils, cultivated farms and rocky slopes. Iran with 20 endemic species is one of the important diversification centres of the genus *Veronica*. About 57 species of this genus classified in five sections are present in Iran. *Veronica* comprises annual and perennial herbs with opposite leaves. The flowers are arranged in bracteate racemes. The fruit is a bilocular capsule usually with a persistent style. Seeds are flat or excavate. There are several reports on the seeds of various species of *Veronica* (Thieret, 1955; Yamazaki, 1957; Juan, Pastor & Fernandez, 1994). The objective of the present study was to evaluate the taxonomic importance of seed characters in the identification of the species.

Material and Methods

Seed samples of 10 taxa of *Veronica* belonging to two sections from Iran were examined. Plant material used for this study are deposited in the central herbarium of the university of Tehran (TUH).

A list of species and the voucher specimens is provided in Table 1. At least three mature seeds of each sample were examined and measured under a steromicroscope of type OLYMPUS SZ-40. For scanning electron microscopy, 3-4 mature seeds of each species were mounted on stubs and coated with sputtered gold. Morphological observations were made in a "Philips LX-30Autoscan SEM".

Terminology of seed-coat and surface sculpturing was followed according to Steam (1973) and Chernoff *et al.*, (1992).

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Table 1. List of herbarium specimens used in this study. All voucher specimens are deposited in TUH.

Taxon	Locality	Date	Altitude (m)	Collector	No.
V. davisii Fischer.	Prov. W. Azarbayejan; Uroumieh, Ziveh, Kesian village, Boze-sina mt.	2 July 1999	2000-2400	Saeidi and Asaadi	24195
V. serpyllifolia L.	Mazendran; Kiasar, Do-Dangeh Forests	9 July 1999	1350	Saeidi and Gholipour	24196
"	Mazendran; Pole-sefid, the forests above Sang-deh	30 May 1998	1700-2200	Saeidi	22049
"	Gilan; 3 km from Fuman to Rasht	10 May 1990	70	Ghahreman and Mozaffarian	9633
V. gentianoides Vahl.	Gilan; Siahkal, Espili	20 May 1998	1000-1200	Saeidi	22062
"	Azarbayejan; Kaleibar, Ghale-h Babak	17 May 1993	2000	Ghahreman and Attar	17192
"	Ardebil; Asalem to Khalkhal, near Khalkhal	22 June 1998	1500-1700	Saeidi	24200
V. verna L.	Khorassan; Bojnord, 70 km on the Gifan road, Amirabad village	12 May 1999	1200	"	24197
V. francispetae Fischer.	Gilan; near Langeroud, Talesh-Mahleh	27 April 1999	20	"	24205
V. startensis Lehmann.	Gorgan; Golestan forest, Gol-Loveh	4 April 1998	550	"	24206
V. capillipes Neveski.	Esfahan; Inter Ardakan and Murchekhort, near tar	27 May 1998	1500	"	24201
"	Khorassan; Shirvan, Milanlou	12 May 1998	1700-1800	"	24202
"	Arak; between Arak and Khomein, Varche mountain	10 June 1999	2600	"	24212
"	Khorassan; SE Sabzevar, Hares-abad	25 April 1997	940	Aliabadi	24209
V. compylopoda Boiss.	Prov. Chahar-Mahle Bakhtiari; Sabz-kuh, Chahartagh	16 May 1998	2300	Saeidi	24208
"	Prov. Markazi; from Saveh toward Nobaran	12 May 1998	1300-1400	"	24211
"	Prov. Lorestan; 58 km on road from Aligodarz to Shoul-abad	20 June 1998	2900	"	24207
"	Tehran; 56 km from karaj to Chalus	30 April 1998	1860	"	22057
V. argute-serrata Regel & Schmalh.	Tehran; Tuchal	5 May 1998	1700-1800	"	22003
"	Tehran; Damavand, Larijan	22 May 1998	1200-1400	"	24210
"	Khorassan; Esfrain North of Shah Jahan mt.	10 June 1999	1800-2200	"	22058
V. biloba Schreb.	Tehran; 10 km Kandavan from Karaj	20 June 1998	2500-2700	"	24199
"	Tehran; Chalus road, Kushak	27 May 1998	1800-2100	"	24214

Results

Seeds of the examined taxa are ovate to broadly ovate, oblong and elliptic in outline. They are flattened dorsi-ventrally, plano-convex or cyathiform in shape. The seeds of these species ranged from 0.7 mm (in *V. serpyllifolia*) to 2.5 mm (in *V. francispetae*) in length and from 0.5 mm (in *V. serpyllifolia*) to 2.2 mm (in *V. gentianoides*) in width. Colour of seeds are yellowish to brown. The seeds show various patterns of seed-coat ornamentation (reticulate, verrucate, papillate, alveolate, etc.). Six morphological seed types are recognized based on observations made under SEM.

Type I

Seeds are 1.6-2.4 x 1-2 mm in size, broadly ovate in outline and plano-convex. The funicular attachement is terminal. The seeds are yellowish-brown. The seed-coat surface is reticulate formed by polygonal cells with shallow anticlinal walls, which are evenly thickened and flat periclinal walls. Only one of the investigated species is of this type: *V. gentianoides* (Figs. 1-3).

Type II

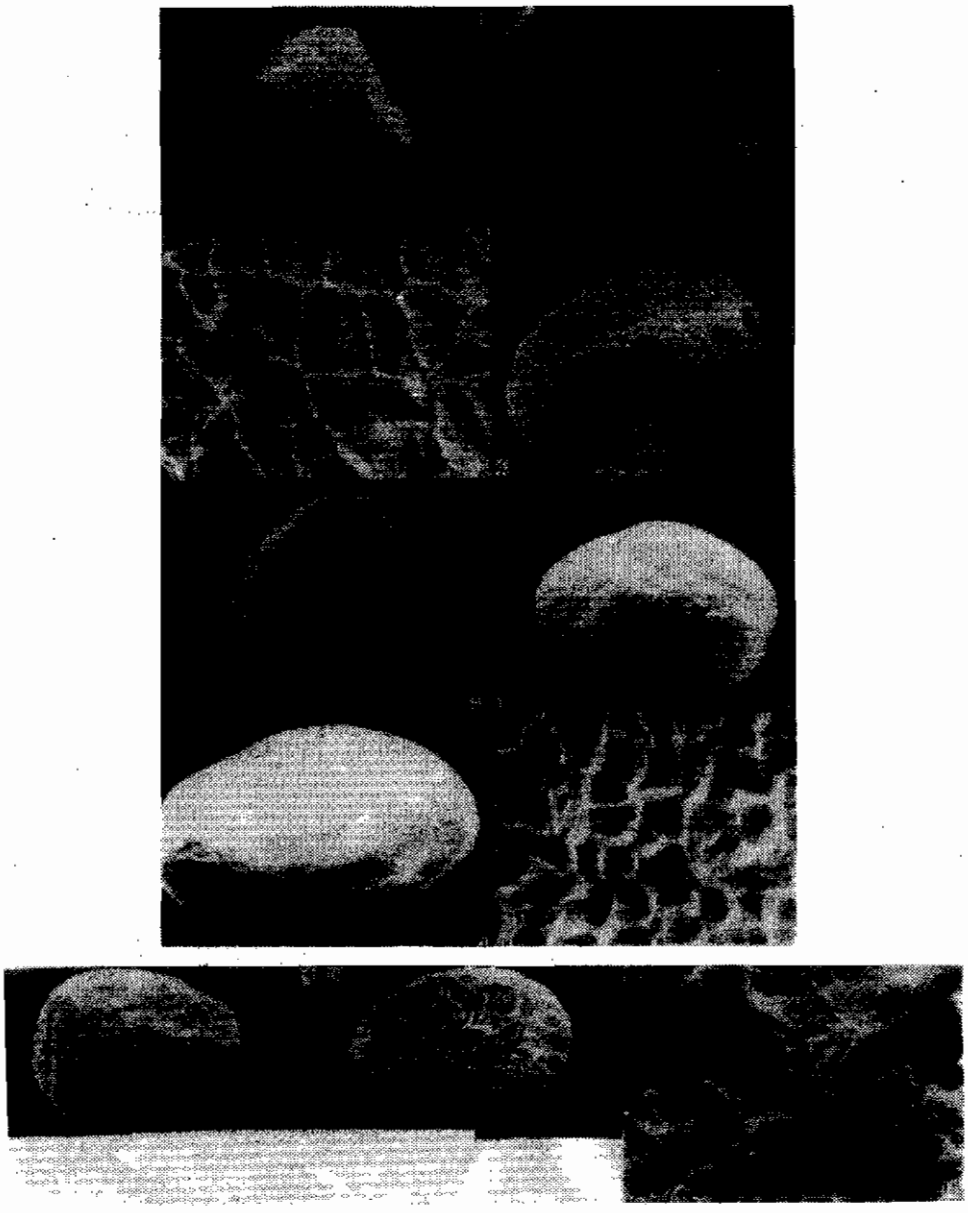
Seeds are 0.7-1.5 x 0.5-1.2 mm in size, elliptical to suborbicular in outline and flattened to plano-convex. The funicular attachment is terminal. The seeds are brown to yellowish-brown. The seed-coat surface is reticulate formed by polygonal cells with shallow anticlinal walls, which are unevenly thickened and depressed periclinal walls. Both *V. davisii* and *V. serpyllifolia* show the seed type II (Figs. 4-8). The seeds of these species are similar in appearance , but seeds of *V. serpyllifolia* (0.7-1 x 0.5-0.7 mm) are smaller than that of *V. davisii* (1-1.5x 0.8-1.2 mm).

Type III

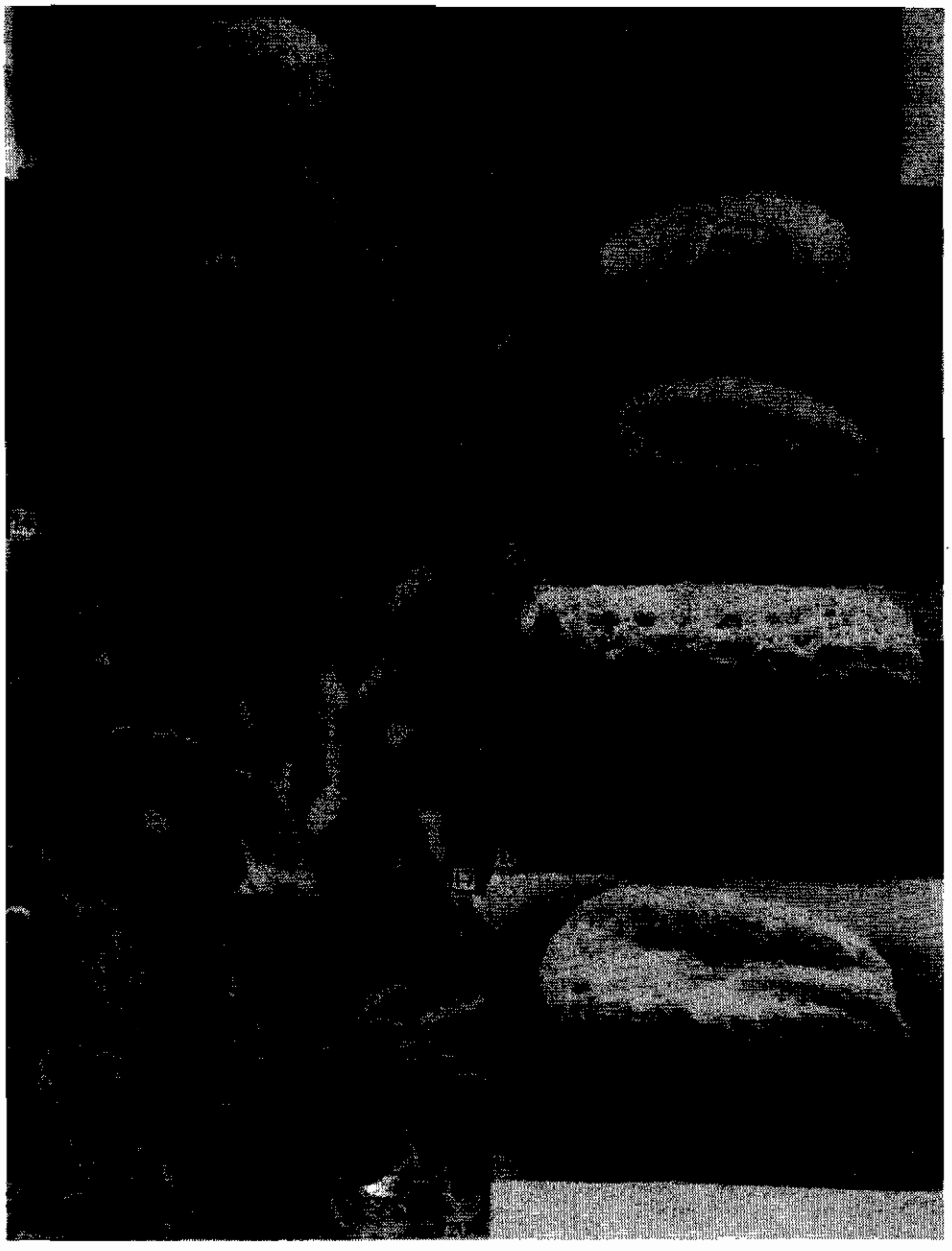
Seeds are 1-1.5 x 0.7-0.9 mm in size, broadly ovate to suborbicular in outline and flattened or with dorsal face slightly convex. The funicular attachment is terminal.The seeds are yellowish. The seed-coat surface is reticulate-verrucate formed by polygonal cells with shallow anticlinal walls which are unevenly thickened and rugulate periclinal walls with central wart. Among the species examined, only *V. verna* seeds showed this type (Figs. 9-11).

Type IV

Seeds are 1-2.5 x 0.8-1.6 mm in size, ovate to elliptical in outline and cyathiform. The funicular attachment is ventral. The seeds are yellowish to yellowish-brown. The seed-coat surface is papillate formed by polygonal cells with obscure or shallow anticlinal walls; the periclinal walls are uniformly thickened with central papillae. This type includes *V. francispetae* and *V. siartensis* (Figs. 12-17). Although seed surface ornamentation of *V. francispetae* is similar to that of *V. siartensis* i.e., reticulate, but some distinct differences are remarkable. Seed size are 2-2.5 x 1-1.6 mm in *V. francispetae* and 1-1.5 x 0.8-1 mm in *V. siartensis*. The seeds of *V. francispetae* have obscure anticlinal walls and compressed periclinal walls with long papillae, while the seeds of *V. siartensis* show shallow anticlinal walls, which are uniformely thickened and periclinal walls with short papillae.



Figs. 1-11. Scanning electron micrographs of seeds in *Veronica*.
1-3, Type I: *V. gentianoides*,
4-8, Type II: *V. serpyllifolia* (4 and 5), *V. davisii* (6 and 8). 9-11, Type III: *V. verna*.
Figs. 1,4,6,9: Whole seed, dorsal face. Figs. 2,5,7,10: Whole seed, ventral face.
Figs. 3,8,11: Seed surface ornamentation.



Figs. 12-16. Type IV: *V. siartensis* (12 and 14), *V. francispetae* (15-17), 18-20, TypeV: *V. argute-serrata*.
Figs. 12,15,18: Whole seed, dorsal face. Figs. 13,16,19: Whole seed, ventral face.
Figs. 14,17,20: Seed surface ornamentation.

Type V

Seeds are 1.5-2.4 x 0.8-1.5 mm in size, ± oblong in outline and cyathiform. The funicular attachment is ventral. The seeds are yellowish. The seed-coat surface is alveolate and formed by polygonal cells with shallow anticlinal walls, which are evenly thickened and depressed to pitted periclinal walls. This type is confined to the *V. argute-serrata* (Figs. 18-20).

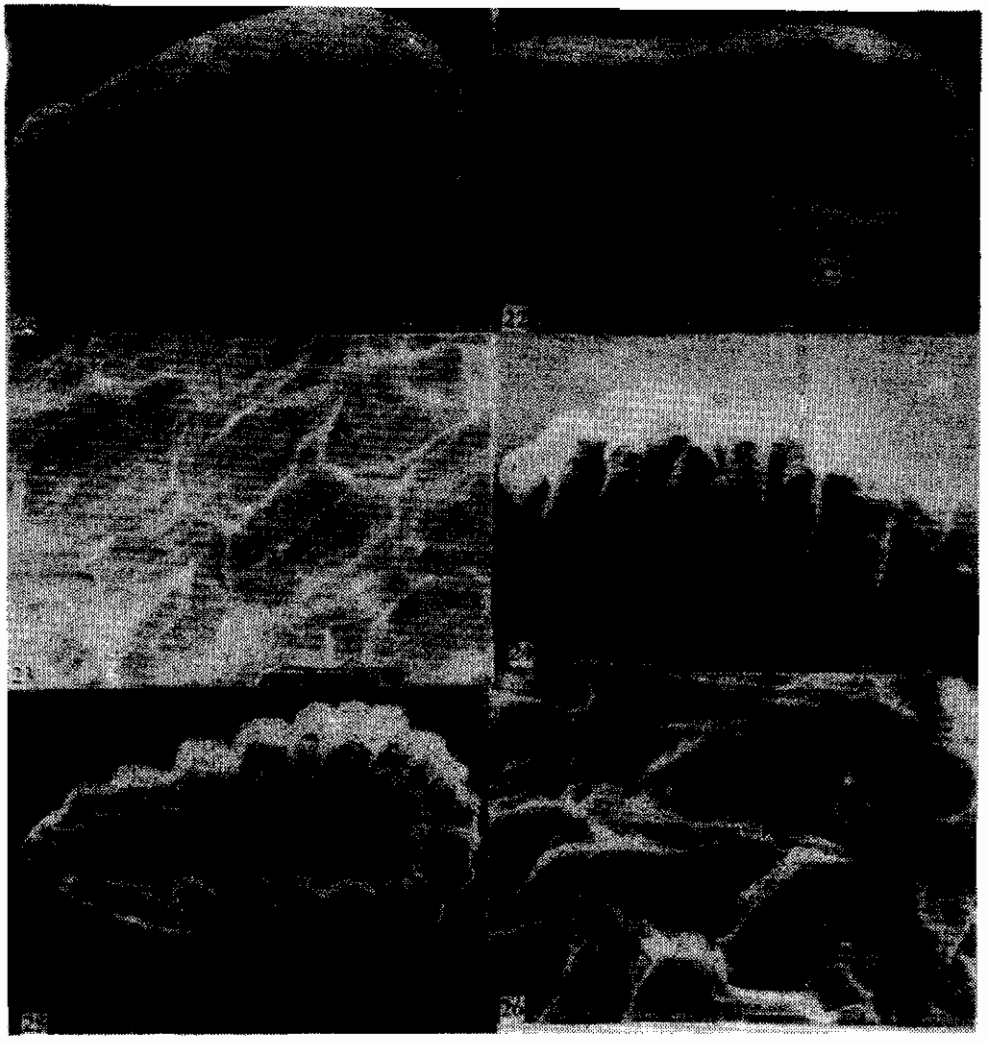
Type VI

Seeds are 1-2.2 x 0.7-1.4 mm in size, ovate to elliptical in outline and cyathiform. The funicular attachment is ventral. The seeds are yellowish to dark brown. The seed-coat surface is reticulate formed by polygonal cells with shallow anticlinal walls, which are evenly thickened, and depressed to plicate-striate periclinal walls. Seeds in *V. biloba, V. campylopoda* and *V. capillipes* show this type (Figs. 21-26). There are several differences between *V. biloba* and the other two species of this type. Seeds of *V. biloba* possess plicate-striate periclinal walls, while they show depressed periclinal ones in *V. campylopoda* and *V. capillipes*. In addition, the size of the seeds in *V. biloba* is much larger.

New record: *V. davisii* was found in mountain Boze-sina which is located in S.W. Uroumieh, Ziveh, Dizaj, Kesian village (Fig. 28). Until now, *V. davisii* was only known from Kurdstan mountains of S.E. Turkey and W. Iraq by Fischer (1977). This species grows on the eastern slopes near the stream and on sandy soil. It is restricted to altitudes 2000-2400 m. Flowering and fruiting time are June-July and July-Agust, respectively. *V. davisii* is an Irano-Turanian element. *Veronica davisii* is a new record for Iran. *V. davisii* (Fig. 27) is a creeping and herbaceous plant with woody base from a branched rhizome 4-10 cm long. This species is characterized by oblong to obovate or spathulate leaves which are cuneate at the base, truncate at apex and crenate to crenulate at margins. The style length is 3-4.5 mm and exceeding the sinus. The main diagnostic characters for separating *V. davisii* from other two Iranian species of sect. *Veronicastrum* are presented in Table 2.

Table 2. Diagnostic characters of three species of *Veronica* of seet. *Veronicastrum* from Iran.

Characters	*V. davisii*	*V. gentianoides*	*V. serpyllifolia*
Height (cm)	2-8	5-60	5-30
Leaves:			
Shape	oblong to obovate, spathulate	obovate, lanceolate, oblanceolate	oblong-ovate, subelliptic
Base	cuneate	connate to vaginate	± rounded
apex	truncate	acute-obtuse	obtuse
margin	crenate to crenulate	narrowly cartilaginous, entire remotely and irregularly denticulate	serrulate to crenate, subentire
Size (mm)	6-14x3-7	15-8x3-15	8-20x5-13
Style length (mm)	3-4.5	3-8	2-2.7



Figs. 21-26. Type VI: *V. biloba* (21-23), *V. campylopoda* and *V. capillipes* (24-26).
Figs. 21 and 24: Whole seed, dorsal face. Figs. 22 and 25: Whole seed, ventral face.
Figs. 23 and 26: Seed surface ornamentation.

Discussion

The objective of this study was to evaluate the present groupings in *Veronica* and to find additional features for better delimitation of taxa using seed characters. According to our morphiogical studies, six seed types can be recognized in the material from Iran, of which two are monospecific.

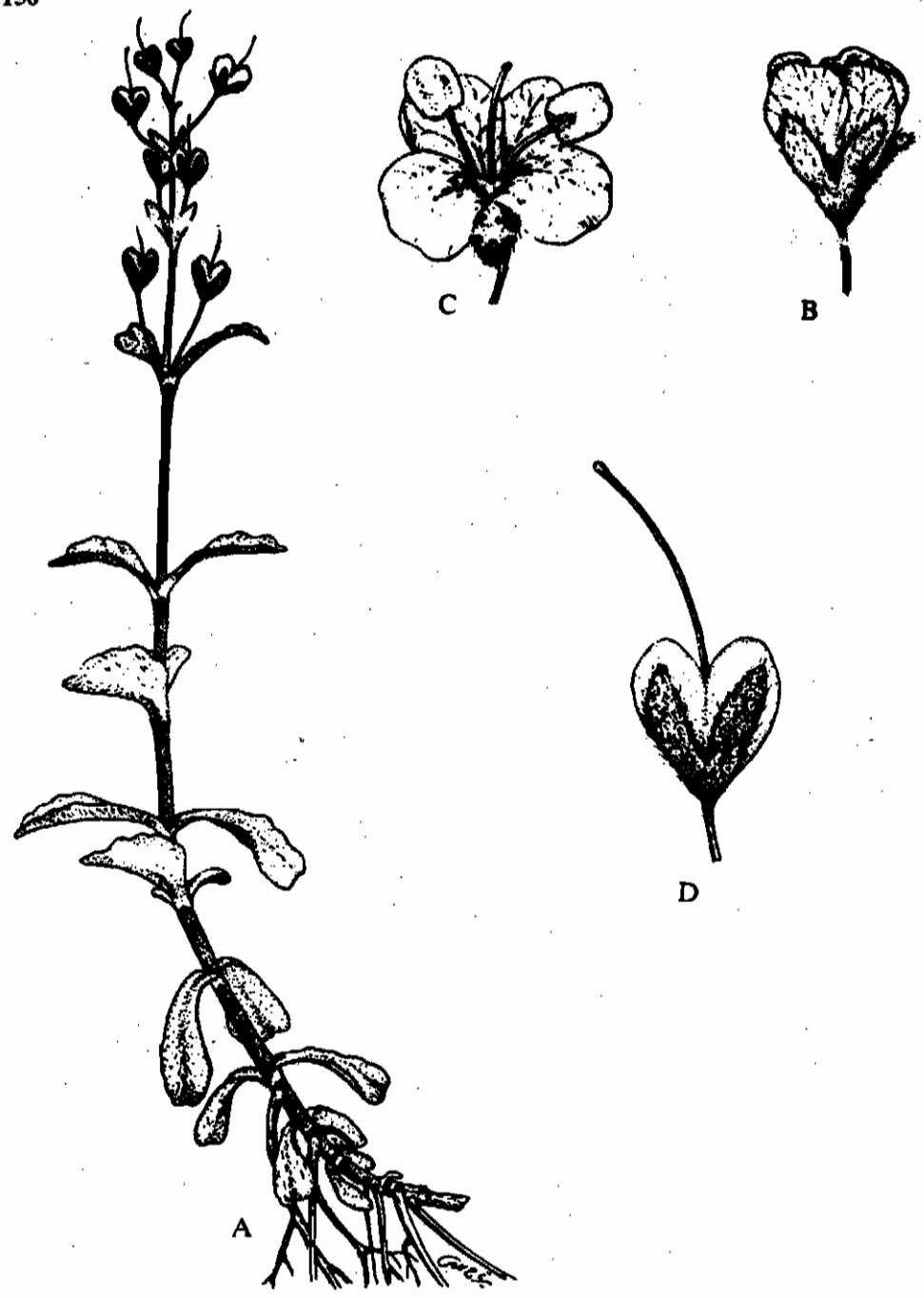


Fig. 27. *Veronica davisii* A: Whole plant (x3). B: Flower in early stage of anthesis (x 12). C: Same flower in final stage of anthesis with expanded corolla and exserted anthers (x 12). D: Mature fruit with a persistent style (x12).

V. gentianoides, *V. davisii* and *V. serpyllifolia* constitute type I and type II, respectively, although all three species belong to sect. *Veronicastrum* by Fischer, (1981). The periclinal walls are flat in *V. gentianoides* (Fig. 3) and depressed in other type (Fig. 8). In addition, seed outline is broadly ovate in *V. gentianoides* (Figs. 1-2), and elliptical to suborbicular in type II (Figs. 4-7).

Sect. *Pocilla* contains the remaining species from the present study. *V. verna* constitute type III. It appears closely related to *V. arvensis* on the base of seed characters, the seed-coat is alveolate in *V. arvensis* (Juan *et al.*, 1994) and verrucate in *V. verna* (Fig. 11). Juan *et al.*, (1994) proposed that the seed-coat of *V. persica* and *V. polita* are papillate. Moreover, there is a close relationship between these species and type IV in our classification including *V. siartensis* and *V. francispetae* in respect to presence of papillae in periclinal walls (Figs. 14-17) and ventral funicular attachment.

Types V and VI include a group of closely related species which is attributed to *V.* sect. *Pocilla* by Wlaters & Webb (1972) and Fischer (1981). Hybrids with clear, intermediate characters are frequent within this group, some instances of such hybrids are: *V. biloba* x *campylopoda*, *V. argute-serrata* x biloba, *V. argute-serrata* x *campylopoda* and *V. campylopoda* x *capillipes* (Fischer, 1981). The results of the present study show that the seeds of *V. argute-serrata* are alveolate on surface and belong to type V (Fig. 20), whereas *V. biloba*, *V. capillipes* and *V. campylopoda* with a reticulate seed-coat constitute type VI (Figs. 23-26).

Among the taxa studied, two groups according to general morphology are distinguished. The first group consists of *V. gentianoides*, *V. davisii*, *V. serpyllifolia* and *V. verna* whose seeds are flattened to plano-convex with terminal funicular attachment. The second group contains the remaining taxa belonging to *V.* sect. *Pocilla* with cyathiform seeds and ventral funicular attachment which includes *V. siartensis*, *V. francispetae*, *V. biloba*, *V. campylopoda*, *V argute-serrata* and *V. capillipes*.

Some possible evolutionary trends are suggested in tribe *Veroniceae* based on palynology (Hong, 1984), floral anatomy, embryology and seed structure (Yamazaki, 1957) and seed features (Thieret, 1955; Juan *et al.*, 1994). According to these known trends, *V. davisii*, *V. serpyllifolia* and *V. gentianoides* would be the most primitive in the sect. *Vemnicastrum*. They possess flattened to plano-convex seeds and terminal funicular attachment. Types IV, V and VI with cyathiform seeds and ventral funicular attachment can be considered as advanced. Type III, represented by *V. verna* (sect. *Pocilla*) have intermediate position, with flattened to slightly convex dorsal face and terminal funicular attachment. *V. verna* should remain in sect. *Pocilla*, despite having seeds similar to sect. *Veronicastrum*. However, *V.* sect. *Pocilla* and *V.* sect. *Veronicastrum*, according to Walters & Webb (1972), differ in other characters such as habit, capsular dehiscence and capsule shape. In *V.* sect. *Veronicastrum*, the species are always perennial and woody at base, have capsule mostly longer than wide and dehiscing loculicidally, whereas in *V.* sect. *Pocilla*, they are annual and herbaceous at base, capsule rather wider than long and dehiscing loculicidally to a variable degree septicidally. However, seed characters, especially surface ornamentation is frequently diagnostic and can provide further valuable characters. This study also supports Juan, Pastor & Fernandez's view (1994) that the cyathiform seeds of *Veronica* are more advanced than flattened ones.

A KEY TO TREATED SPECIES BASED ON SEED CHARACTERS:

1. Seeds flattened or with dorsal face slightly to clearly convex and ventral face plane 2
1. Seeds cyathiform 5
2. Seed-coat surface verrucate ..... *V. verna*
2. Seed-coat surface reticulate 3
3. Cells with flat periclinal walls, seeds > 1.5 mm in length ..... *V. gentianoides*
3. Cells without flat periclinal walls, seeds < 1.5 mm in length 4
4. Seeds > 0.7mm in width ..... *V. davisii*
4. Seeds < 0.7mm in width ..... *V. serpyllifolia*
5. Seed-coat surface papillate 6
5. Seed-coat surface non papillate 7
6. Cells with shallow anticlinal walls, seeds < 1.5 mm in length ..... *V. siartensis*
6. Cells with obscure anticlinal walls, seeds > 1.5 mm in length ..... *V. francispetae*
7. Seed-coat surface alveolate ..... *V. argute-serrata*
7. Seed-coat surface reticulate 8
8. Cells with plicate-striate periclinal walls ..... *V. biloba*
8. Cells with depressed periclinal walls ..... *V. capillipes* and *V. campylopoda*

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