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## Studies on the morphology and ecology of *Delphinium cyphoplectrum* Boiss. (*Ranunculaceae*) populations

### Abstract

Özçelik, H., Öztürk, M.: Studies on the morphology and ecology of *Delphinium cyphoplectrum* Boiss. (*Ranunculaceae*) populations. — Fl. Medit. 10: 283-302. 2000. — ISSN 1120-4052.

This paper deals with studies on the morphology and ecology of *Delphinium cyphoplectrum*. Morphological observations carried out on several natural populations showed that in nature *D. cyphoplectrum* mainly occurs on slightly calcareous soils with a basic pH and a sandy to sandy-loamy texture. Pollens are tricolpate and spherical. In the light of the results obtained, it is clear that there is no need for dividing this species into varieties in Turkey.

### Introduction

*Delphinium cyphoplectrum* Boiss. is a highly polymorphic species widely distributed in East Anatolia (Ilarslan, 1990; Özçelik, 1996), but known from few specimens being adapted to different habitats and showing high hybridization. Different investigators have put forward different views on the taxonomical characteristics of this species. It is thus accepted as one of the problematical species in Turkish flora. Davis (1965) divided it into three varieties occurring in Flora of Turkey and East Aegean Islands. These varieties are; *vanense* (Rech. f.) Davis, *pallidiflorum* (Freyn) Davis, and *stenophyllum* Boiss. Out of these, type specimens of *vanense* (endemic) and *pallidiflorum* have been collected from Van and Bitlis, whereas *stenophyllum* is reported only from the State of Kars (Iğdir) in Turkey. The latter is however widely distributed in Transcaucasia and Iran. This division into three varieties is based on hairyness, flower color, breadth of leaf segments, shape and apex of spur. Our studies revealed that identification of the varieties in accordance with these criteria is impossible. In order to clarify this situation, morphological, biosystematical and ecological studies were undertaken on the natural populations of *Delphinium cyphoplectrum* occurring in Turkey.

### Materials and Methods

*Delphinium cyphoplectrum* was collected during the years 1981-1991 from 12 populations located in the States of Van, Bitlis, Siirt and Iğdir. Identification was made according

to Davis (1965). Details about the collection sites are given in Table 1. In all 300 specimens were taken, i.e. 25 from each population. On these specimens over 100 characters were investigated and many biometric measurements were made. Transplantation experiments were also set up using plots with garden soil at the Yuzuncuyil University Campus. Soil analysis was carried out according to Öztürk & al. (1983).

## Results

### 1. Morphology and Taxonomy

a) Roots: Well developed perennial thick roots, thickness changing according to the habitat and age, generally deep and  $\pm$  oblong, secondary roots filiform, cylindrical, black in color, 5-10 cm long and 1-3 mm broad (Table 2, Fig. 1).

b) Stem: Erect, herbaceous, slender, terete, lower parts slightly sulcate or striate, upper side with parallel lines, usually unbranched flexuous, yellowish green in color. Indumentum has dense or thin cover of curved puberulent hairs on the lower side; but the upper side is glabrous or glandular-pubescent (Table 3, Fig. 1).

c) Leaves: Lower leaves generally multisect or palmatisect,  $\pm$  circular, linear-oblong; leaf segments numerous and crowded, petiole long and cylindrical, widening towards the base, 1 or few lower leaves present before flowering (Fig. 2). Stem leaves alternate (spiral),  $\pm$  rounded or palmate-ovate, without stipule; the basal leaf covers the stem base fully, stem leaves few, reduced to one or few linear segments towards the apex (Fig. 2); indumentum varies from glabrous to densely or thinly curled puberulent (Table 4).

d) Bracts and bracteoles : Lower bracts membranous, generally smaller than pedicel, reduced, linear-lanceolate, one or more notched at the apex, extending from the base of pedicel. Upper bracts linear-lanceolate, originating from the base of pedicel or near to it, edge membranous (transparent), shorter than pedicel, getting reduced towards the upper part, even disappearing. Bracteoles linear-lanceolate, generally membranous, always shorter than pedicel, alternative or oppositely arranged. All bracts and bracteoles have indumentum like stem leaves but more densely hairy being puberulent-pubescent or glandular (few) or a mixture of two; upper parts generally glabrous (Table 5).

e) Inflorescence and flower: Inflorescence racemose, sometimes compound racemose (panicula), flowers loosely (rarely dense) arranged on main axis of raceme, raceme is linear-oblong, pedicel erect, rarely spreading, indumentum varying much, glabrous, glandular-pubescent, curling puberulent or a mixture of these (Fig. 3). Flowers showy, white to deep violet-blue colored, rarely yellowish (brick colored), hypogynous, zygomorphic, hermaphrodite, perianth calcarate, floral whorls well developed in rows and divided into parts, sepals on the outside (1 + 4), petals inside (2 + 2), perianth scattered (flowers open) in all populations (Tables 6 - 8).

Calyx: Outer sepals bigger than inner ones, obovate, oblong or elliptical, apex acute, obtuse or rotundate, attached weakly rarely strongly, one of the sepals on the outer side lying above, its surface is broader than others forming a spur above, projecting outwards, sepal spur is as long as its surface, it is horizontal, tapering towards the apex or cylindrical, apex is  $\pm$  obtuse, truncate or emarginate-retuse, apex slightly or clearly pouched, rarely pouch lacking, inner surface of sepals glabrous, indumentum on outer surface varying, yellowish glandular tissue on sepal surface with slightly dense cover of hairs, plant shows glabrous,

Table 1. Localities and habitat characteristics of *D. cyphoplectrum* populations.

State	Localities	Population Number	Places	Habitat	Altitude	Slope
Van	Erek Dagi	1	Above Bostanici village, west slope of Kucukerek Dagi	Pebbly shallow soil and openings of rocks	2250-2550	50
Van	Erek Dagi	2	Above Sarmac village slope of Kucukerek Dagi	Pebbly shallow soil and openings of rocks	2250	30
Van	Kepir Dagi	3	Gurpinar, Guzelsu (Hosab), east slopes of Kepir Dagi	Pebbly high mountain steppe	2200-2350	40
Van	Tendurek Dagi	4	Between Ercis-Diyadin, base of Tendurek Dagi	Rock openings and partly wet steppes	2200-2650	35
Van	Aladag	5	Base of Aladag, around Hasanabdal (Ercis) village	Rock openings and partly wet steppes	2300-2450	30
Van	Cadir Dagi	6	Above Gevas, southern slopes of Cadir (Artos) Dagi	High mountain steppes	2450-2500	65
Van	Pelli Dagi	7	Gevas Kuzgunkiran pass, above Pelli village	Pebbly stony high mountain steppe, openings of oak-juniper shrubs	2450	60
Bitlis	Kariz Dagi	8	Above Kucukusu (Kutum) village seven km from Tatavan to Van	Pebbly stony high mountain steppe	1950-2300	35
Bitlis	Suphan Dagi	9	Around Kadife Dagi (Adilcevaz)	Steep calcareous sites	2000	60
Siirt	Kozluk Dagi	10	Stream side, Veyselkarani-Batman road 35 km to V.karani	Moving debris, high mountain steppe	900-1200	40
Igdir	Igdir	11	Melekli village and its environs	High mountain steppe	1100	30
Agri	Tahir Daglari	12	West of Eleskirt seven km in the east of main highway	High mountain steppe	1960	60

glandular-pubescent, pubescent or twisted puberulent characters or one or more of these, one population can show all these characters.

Corolla: Color of petals resembles sepals or is lighter, clearly projecting outwards, 2 petals attached to the floral axis in the middle, basal part extends into the sepal - spur as opposite to each other, apex carries nectar secreting gland, breadth of these spur forming petals does not vary from base upwards, slightly bilobed at the apex, glabrous and clearly bluish veined, inner side at the basal part pubescent or glandular-pubescent, other petals do not form spur but differ by broadening abruptly at the apex, more deeply lobed, rough hairy on inner surface, deeply clavate.

Androecium: Stamens apostamenous, many in number, arranged spirally, filaments slightly hairy, broadening towards the base, clearly veined, bluish-white colored and membranous, anthers have two parts and are extrorse, they lie parallel, opening by valves, basifix type, slightly hairy or glabrous.

Gynoecium: Each flower has 3 pistils with one carpel in each, divided singly, each ovary has single style and stigma, carpels stylocarpepodic, gynoecium apocarpus, hypogynous, placentation parietal, pistils shorter than stamens, not clearly visible in the flower, styles teret, ovary  $\pm$  ovate, indumentum varies in pistils, generally glandular-pubescent, compressed pubescent (- puberulent) or glabrous.

f) Fruit and seed: Follicles yellowish-green,  $\pm$  oblong-linear, veins prominent, opening ventrally along the suture upon maturing, generally glabrous, glandular-pubescent or com-

Table 2. Characteristics of tap root in *D. cyphoplectrum* populations.

Population Number	Root length (cm)	Root width (cm)	Shape
1	3.0 – 10.0 5.95 $\pm$ 0.85	0.5 – 1.5 0.92 $\pm$ 0.17	Oblong-tuberous, sometimes cylindrical, or disorderly shaped
2	4.0 – 9.0 6.60 $\pm$ 0.97	1.3 – 1.5 1.35 $\pm$ 0.20	" "
3	2.5 – 7.0 4.94 $\pm$ 0.65	0.6 – 1.5 1.42 $\pm$ 0.26	" "
4	0.7 – 7.5 2.98 $\pm$ 0.33	0.4 – 3.0 1.43 $\pm$ 0.27	" "
5	2.5 – 6.0 4.60 $\pm$ 0.57	0.7 – 2.0 1.38 $\pm$ 0.21	" "
6	3.0 – 6.0 5.0 $\pm$ 0.71	0.8 – 2.0 1.70 $\pm$ 0.29	" "
7	3.0 – 3.5 3.05 $\pm$ 0.48	1.2 – 2.0 1.35 $\pm$ 0.22	Oblong – tuberous
8	3.75	1.10	" "
9	2.5 – 4.0 3.16 $\pm$ 0.44	1.0 – 1.5 1.23 $\pm$ 0.14	" "
10	3.0 – 8.0 4.78 $\pm$ 0.62	0.8 – 2.2 1.47 $\pm$ 0.26	" "
11	2.5 – 4.0 3.0 $\pm$ 0.35	1.0 – 1.6 1.22 $\pm$ 0.1	" "
12	2.5 – 5.0 3.76 $\pm$ 0.33	1.0 – 2.0 1.27 $\pm$ 0.04	More or less oblong

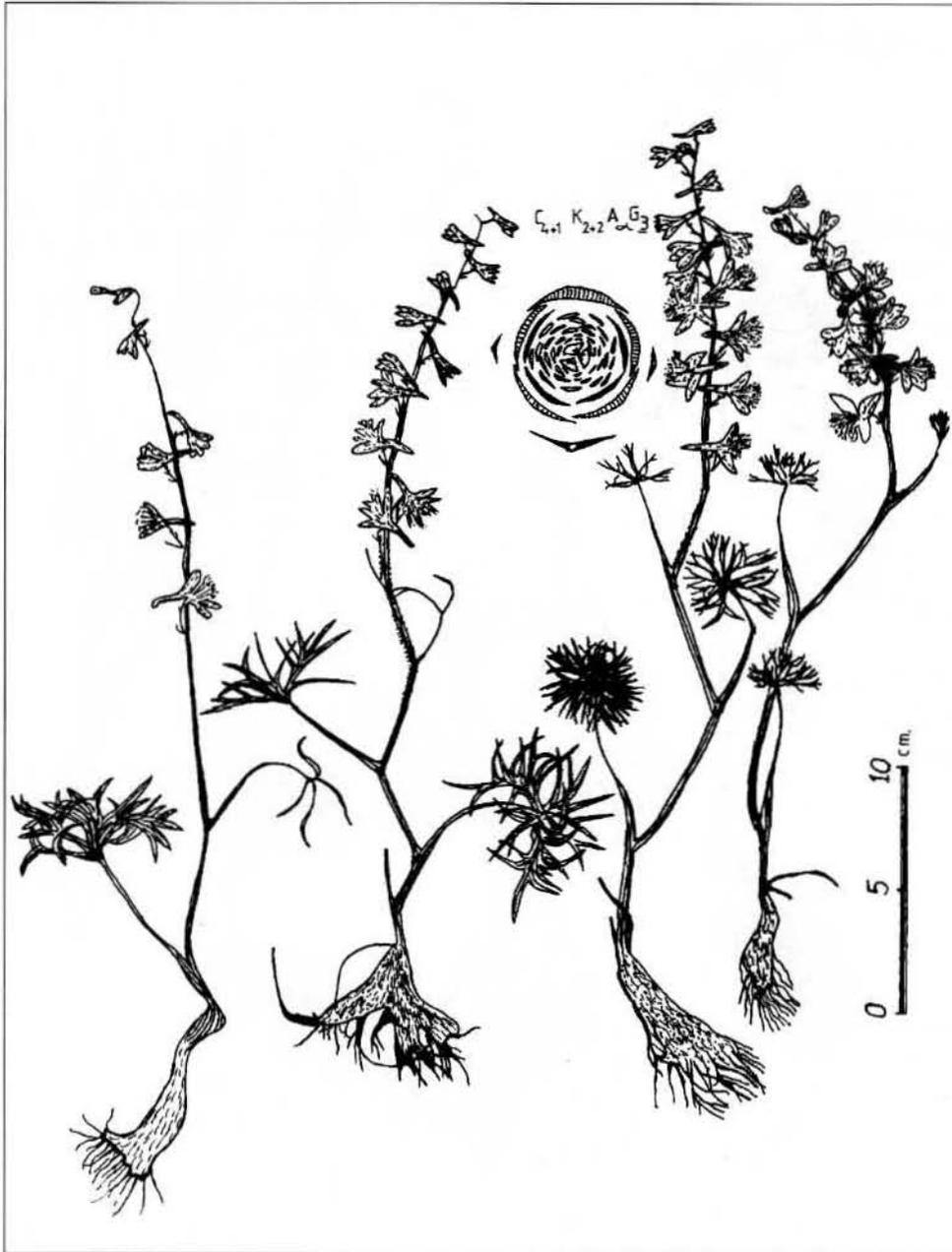


Fig. 1a. General appearance of *D. cyphoplectrum* from different populations in Eastern Anatolia.

- 1) Ereğ Dagi (population number 1, Özçelik 20).
- 2) Aladag (population number 5, Özçelik 66).
- 3) Keper Dagi (population number 3, Özçelik 26).
- 4) Ereğ Dagi (population number 2, Özçelik 19).



Fig. 1b. General appearance of *D. cyphoplectrum* from different populations in Eastern Anatolia.

- 1) Ereğ Dagi (population number 1, Özçelik 90).
- 2) Kehir Dagi (population number 3, Özçelik 28).
- 3) Ereğ Dagi (population number 2, Özçelik 27).
- 4) Tendürek Dagi (population number 4, Özçelik 43).

Table 3. Stem characteristics of *D. cyphoplectrum* populations.

Population Number	Number of stems appearing from the same root	Plant height (cm) (Above ground part)	With of stem (mm) (At the level of 2 <sup>nd</sup> leaf)	Branching
1	1	21.0 – 67.0 34.50 + 5.28	1.5 – 4.8 2.50 + 0.11	Unbranched (simple) or with few branches
2	1	29.0 – 60.0 42.70 + 5.71	1.8 – 3.0 2.50 + 0.07	Unbranched (simple) or with few branches
3	1.0 – 2.0 1.25 + 0.20	32.0 – 68.0 47.87 + 5.89	2.0 – 5.0 3.28 + 0.13	Unbranched (simple) or with few branches
4	1.0 – 3.0 1.23 + 0.25	22.0 – 91.0 47.70 + 6.22	1.3 – 5.0 2.64 + 0.08	Unbranched or more branched
5	1	20.0 – 68.0 43.50 + 4.70	2.0 – 3.1 2.39 + 0.09	Unbranched or with few branches
6	1	32.0 – 65.0 56.0 + 5.47	2.1 – 5.0 2.26 + 0.14	Unbranched or with few branches
7	1.0 – 3.0 1.12 + 0.22	15 – 40.0 28.0 + 4.50	2.0 – 4.0 2.91 + 0.12	Unbranched or with few branches
8	1	20.0 – 38.0 23.0 + 4.20	2.0 – 3.5 2.12 + 0.10	Unbranched or with few branches
9	1.0 – 2.0 1.12 + 0.20	25.0 – 58.0 46.0 + 5.50	1.5 – 2.5 2.12 + 0.08	Unbranched or with few branches
10	1	25.0 – 45.0 37.5 + 4.92	1.5 – 4.5 2.44 + 0.11	Unbranched or with few branches
11	1	28.0 – 44.0 35.0 + 4.21	1.8 – 3.8 2.50 + 0.09	Unbranched or with few branches
12	1	24.0 – 38.0 28.0 + 4.25	1.9 – 3.7 2.80 + 0.05	Unbranched or with few branches

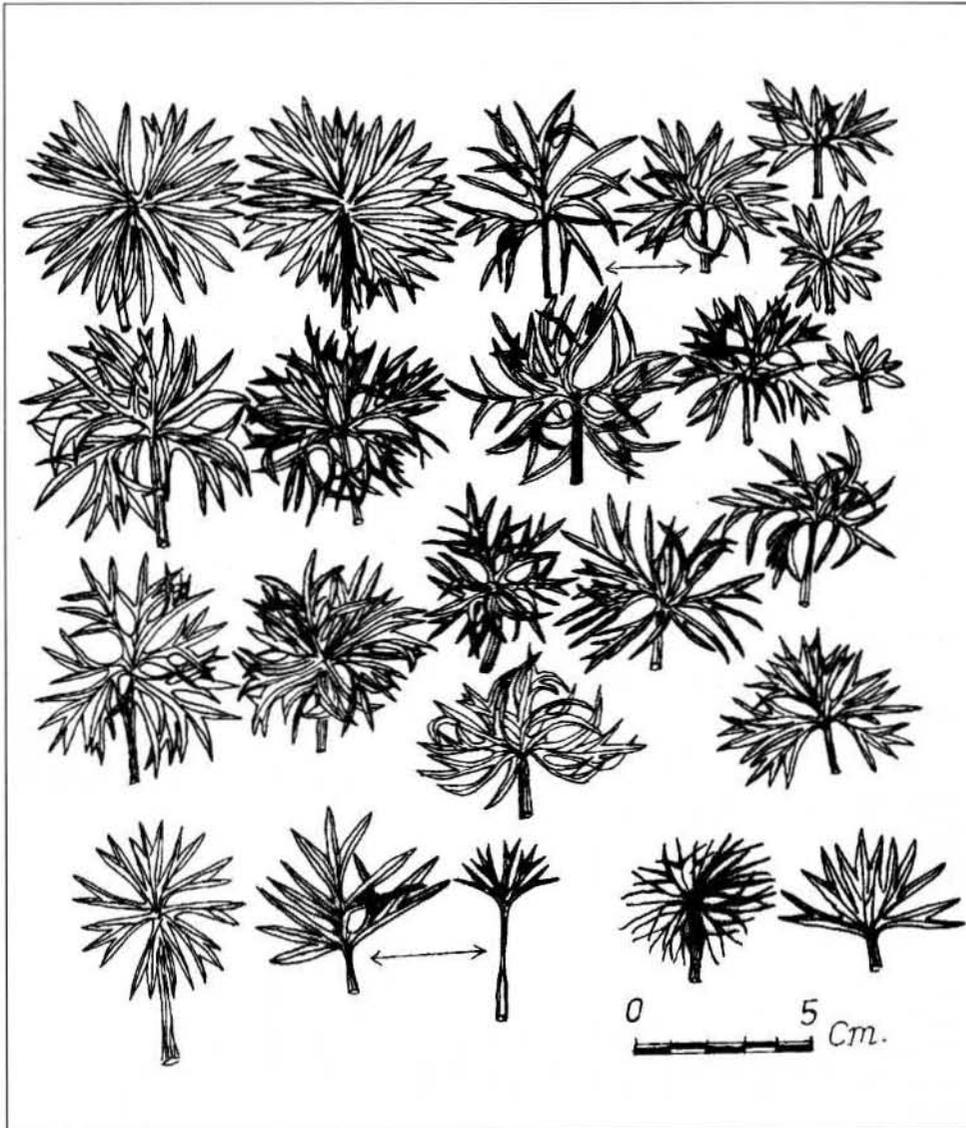


Fig. 2a. Drawings of lower leaves of *D. cyphoplectrum* from different populations in Eastern Anatolia.

Table 4. Leaf characteristics of *D. cyphoplectrum* populations.

Population Number	BASAL LEAVES						STEM LEAVES					
	Number in plant	Leaf length (cm)	Petiole length (cm)	Lamina length (cm)	Lamina width (cm)	Lamina length (cm)	Number in plant	Petiole length (cm)	Lamina length (cm)	Lamina length (cm)	Lamina segment length (cm)	
1	2.0-4.0	7.0-10.5	5.6-7.7	1.2-5.5	1.5-5.5	5.0-11.2	1.0-3.0	4.0-8.5	1.5-7.6	1.5-6.3		
	2.60 ± 0.27	8.75 ± 0.48	6.68 ± 0.65	3.70 ± 0.45	3.18 ± 0.40	7.11 ± 0.52	2.90 ± 0.09	4.95 ± 0.44	3.96 ± 0.45	3.14 ± 0.30		
2	2.0-3.0	8.50	5.0-8.0	1.5-4.0	1.5-6.0	5.6-8.6	2.0-6.0	4.1-6.1	1.6-5.5	1.4-3.0		
	2.40 ± 0.20		6.70 ± 0.70	3.50 ± 0.40	2.0 ± 0.45	6.73 ± 0.45	4.0 ± 0.31	4.83 ± 0.41	3.78 ± 0.42	2.48 ± 0.21		
3	2.0-4.0	7.5-10.0	5.5-9.0	3.0-3.5	1.7-2.5	5.0-13.0	3.0-4.0	3.2-9.0	1.7-6.0	1.5-5.5		
	3.30 ± 0.31	8.78 ± 0.50	6.92 ± 0.75	3.07 ± 0.28	2.04 ± 0.35	7.91 ± 0.55	2.90 ± 0.11	6.45 ± 0.55	4.22 ± 0.52	2.97 ± 0.24		
4	2.0-6.0	5.0-16.7	4.0-17.0	1.5-10.0	1.7-8.0	3.5-13.0	4.0-4.0	2.5-10.5	1.5-6.5	1.3-5.0		
	2.75 ± 0.28	8.27 ± 0.62	7.68 ± 1.08	3.50 ± 0.80	3.07 ± 0.49	7.60 ± 0.57	3.07 ± 0.15	7.57 ± 0.52	3.25 ± 0.27	3.05 ± 0.19		
5	1.0-3.0	8.0-13.0	5.5-11.0	2.0-5.0	2.0-5.50	3.0-10.5	1.0-3.0	1.5-11.0	1.0-5.5	1.0-6.5		
	1.45 ± 0.20	10.05 ± 0.56	7.55 ± 0.59	3.81 ± 0.37	4.06 ± 0.44	7.21 ± 0.43	2.36 ± 0.20	5.36 ± 0.51	3.30 ± 0.26	3.58 ± 0.34		
6	3.0	9.30	7.50	6.0	3.20	7.80	4.0	5.60	3.50	3.0		
7	1.0-4.0	5.0-10.0	5.0-8.0	2.0-4.5	2.0-5.0	3.5-8.0	1.0-8.0	2.0-6.5	1.0-3.0	0.8-3.0		
	2.22 ± 0.32	8.0 ± 0.45	6.5 ± 0.62	3.0 ± 0.48	2.70 ± 0.50	5.94 ± 0.47	3.0 ± 0.94	3.81 ± 0.43	2.16 ± 0.26	2.08 ± 0.25		
8	1.5	5.61	4.30	1.40	1.35	5.30	2.50	3.50	1.20	1.0		
9	1.0-2.0	9.90	4.5-10.0	1.5-4.2	2.0-5.0	6.20	3.0-6.0	4.50	3.80	2.20		
	1.70 ± 0.18		7.20 ± 0.57	3.30 ± 0.50	2.50 ± 0.48		3.60 ± 0.27					
10	1.0-5.0	-	-	-	-	-	1.0-4.0	-	-	-		
	3.27 ± 0.28						2.94 ± 0.15					
11	2.0	8.65	6.60	3.50	3.15	7.0	3.0	4.50	5.0	4.50		
12	3.50	8.10	±7.0	3.45	3.38	5.50	3.0	3.80	4.50	3.0		

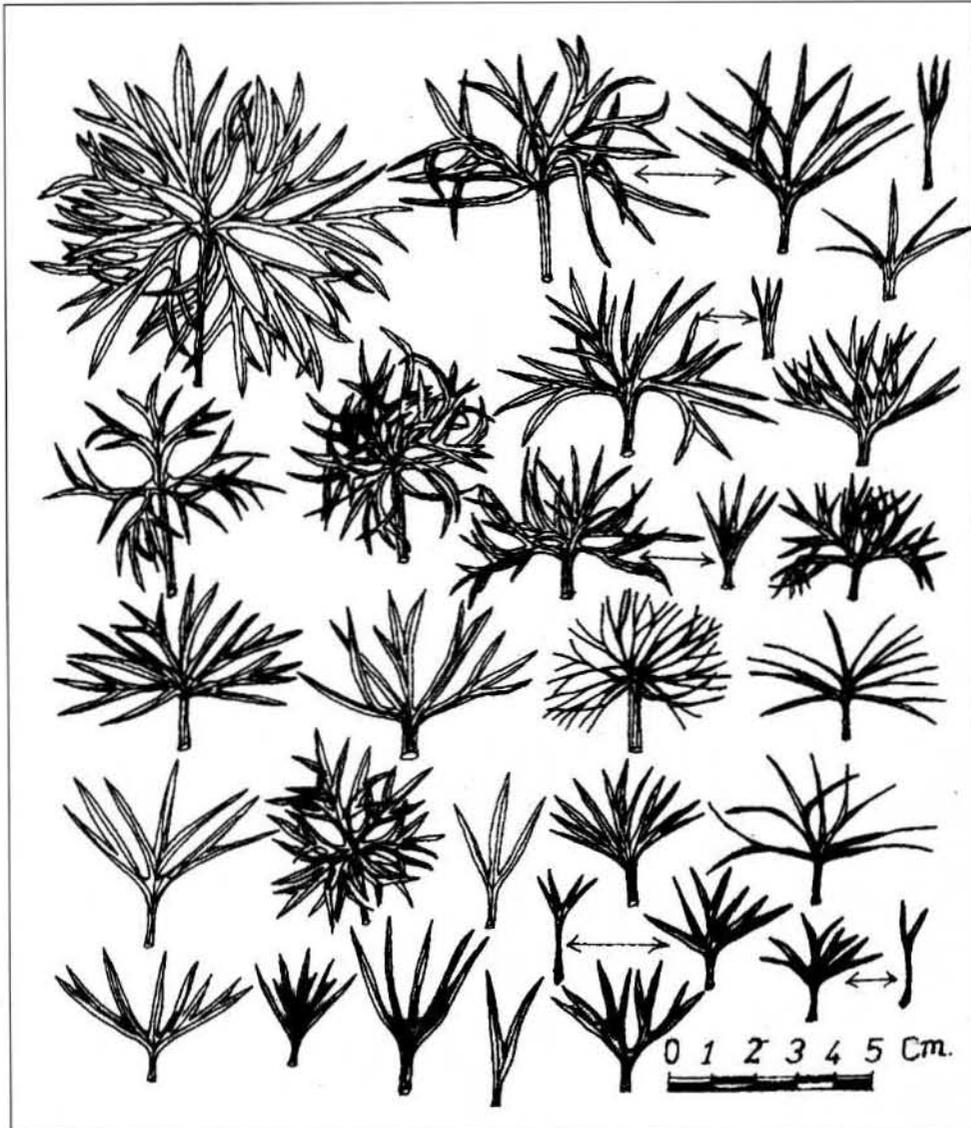


Fig. 2b. Drawings of stem leaves of *D. cyphoplectrum* from different populations in Eastern Anatolia.

Table 5. Bract and bracteol characteristics of *D. cyphoplectrum* populations.

Population Number	Length in relation to pedicel	Lower Length	Bracts Width	Shape	Other Bracts (Length in relation to pedicel)	Bracteoles (Point of origin from pedicel)
1	Big, equal or small	5.0– 22.0 9.90 ± 1.10	0.4 – 2.5 1.0 ± 0.10	Linear-lanceolate, rarely filliform or like upper leaf	Equal or small	From the base of pedicel up to middle
2	"	3.0– 20.0 9.40 ± 2.80	0.6 – 1.6 1.50 ± 0.10	" "	Small	" "
3	"	3.0 – 32.0 2.50 ± 3.60	0.5 – 3.0 2.60 ± 0.30	" "	Big, equal or small	" "
4	"	5.0 – 28.0 11.10 ± 1.90	0.7 – 8.0 2.0 ± 0.60	" "	Equal or small	From the base to middle rarely up to apex
5	"	3.0 – 25.0 10.70 ± 1.90	1.0 – 2.5 1.30 ± 0.10	" "	" "	" "
6	Small	7.0	1.20	Linear – lanceolate	Small	Near the base
7	"	4.0– 10.0 6.50 ± 1.70	1.0 – 1.7 6.50 ± 0.10	" "	" "	From the base up to middle
8	"	8.50	1.10	" "	" "	" "
9	"	4.0 – 10.0 7.40 ± 0.80	10.0 – 20.0 12.0 ± 0.10	" "	" "	" "
10	"	6.72	1.17	" "	" "	" "
11	"	5.0	0.80	Linear	" "	" "
12	Big	10.0 – 15.0 12.0 ± 1.68	10.0 – 15.0 12.0 ± 0.12	" "	" "	" "

Table 6. Raceme characteristics of *D. cyphoplectrum* populations.

Population Number	Number of peduncles in the plant	Pedicel length (mm) (First 5 flowers)	Raceme length (cm)	Raceme width (cm)
1	1.0 – 3.0	4.5 – 30.0	1.0 – 37.0	1.0 – 6.0
	1.30 ± 0.22	11.66 ± 1.25	18.60 ± 2.98	3.25 ± .48
2	1.0 – 2.0	7.5 – 14.9	12.0 – 35.0	2.0 – 3.8
	1.14 ± 0.31	10.50 ± 0.44	23.30 ± 2.78	3.11 ± 0.15
3	1.0 – 2.0	5.0 – 16.2	10.5 – 52.0	2.0 – 3.5
	1.66 ± 0.19	10.80 ± 0.46	30.37 ± 3.60	2.96 ± 0.27
4	1.0 – 6.0	6.0 – 17.0	12.0 – 39.3	1.9 – 3.3
	2.14 ± 0.35	10.03 ± 0.38	26.40 2.68	2.94 ± 0.21
5	1.0 – 2.0	4.0 – 25.0	7.0 – 46.0	1.5 – 4.0
	1.10 ± 0.26	10.71 ± 0.48	23.0 ± 3.06	2.42 ± 0.22
6	2.0	8.75	25.0	2.50
7	1.0 – 2.0	9.50	17.0	2.0
	1.20 ± 0.27			
8	1.50	8.70	9.50	2.0
9	1.0 – 2.0	5.8 – 15.9	15.0 – 48.0	1.1 – 2.1
	1.30 ± 0.28	8.50 ± 0.55	27.8 ± 2.89	2.0 ± 0.21
10	1.0 – 3.0		10.0 – 25.0	2.0 – 3.5
	1.26 ± 0.26		22.0 ± 3.0	2.46 ± 0.25
11	1.0	10.10	15.0	2.40
12	1.0	7.10	9.0 – 23.0	3.0 – 4.0
			10.30 ± 1.75	3.70 ± 0.20

Table 7. Floral characteristics of *D. cyphoplectrum* populations.

Population Number	Number of flowers Per raceme	Flower length (mm) (First 5 flowers)	Position of spur towards apex	Length of spur (mm) (First 5 flowers)	Ratio of spur to (spur length: flower length)
1	2.0 – 20.0	15.0 – 28.0	Smooth, curved (falcate) curved inwards slightly or strongly	6.0 – 17.0	0.40 – 0.60
	9.95 ± 1.29	23.69 ± 0.46		12.11 ± 0.34	0.50 ± 0.007
2	5.0 – 13.0	14.0 – 25.0	" "	6.0 – 15.0	0.42 – 0.60
	10.0 ± 0.78	22.31 ± 0.22		11.60 ± 0.39	0.52 ± 0.01
3	5.0 – 16.2	15.0 – 29.0	" "	8.0 – 16.0	0.40 – 0.61
	10.80 ± 0.85	23.29 ± 0.72		11.94 ± 0.23	0.49 ± 0.01
4	6.0 – 17.0	15.0 – 22.0	" "	8.0 – 15.0	0.40 – 0.68
	10.03 ± 0.86	19.44 ± 0.48		10.50 ± 0.41	0.53 ± 0.01
5	5.0 – 18.0	20.0 – +30.0	" "	10.0 – 15.0	0.46 – 0.65
	10.92 ± 1.26	23.14 ± 0.81		12.71 ± 0.01	0.55 ± 0.01
6	1.45	-	" "	-	-
7	7.0	20.0 – 24.0	± Curved inwards	10.0 – 13.0	0.50 – 0.60
		21.50 ± 0.95		12.0 ± 0.70	0.55 ± 0.02
9	1.0 – 14.0	18.0 – 23.0	" "	10.0 – 12.0	0.45 – 0.60
	7.20 ± 1.29	20.72 ± 0.61		11.88 ± 1.07	0.52 ± 0.01
11	17.0	20.0 – 22.0	Smooth	10.0 – 12.0	0.50 – 0.60
		21.60 ± 0.26		11.40 ± 0.22	0.52 ± 0.01
12	6.0 – 15.0	17.0 – 26.0	Smooth or slightly curved inwards	7.0 – 12.0	0.45 – 0.55
	10.20 ± 0.84	22.16 ± 1.42		10.50 ± 0.76	0.47 ± 0.01

Table 8. Floral characteristics of *D. cyphoplectrum* populations (for first 5 flowers).

Population Number	SEPAL		NONSPURED PETAL		REPREDUCTIVE PARTS	
	Length (mm)	Width	Length (mm)	Width (mm)	Length of stamen	Hairs in the pistil
1	8.9 - 12.4	2.0 - 4.9	9.0 - 12.1	1.0 - 2.8	5.0 - 10.0	Glabrous, glandular-pubescent or only pubescent
	10.65 ± 0.32	3.44 ± 0.15	10.98 ± 0.31	2.12 ± 0.19	8.06 ± 0.35	
2	8.2 - 12.0	2.6 - 4.2	8.2 - 12.1	2.2 - 3.5	4.0 - 10.0	" "
	10.26 ± 0.40	3.70 ± 0.07	10.44 ± 0.38	2.54 ± 0.11	7.66 ± 0.55	
3	7.0 - 11.0	2.1 - 3.7	6.8 - 11.5	1.8 - 2.5	5.0 - 10.0	" "
	8.06 ± 0.41	2.64 ± 0.08	8.15 ± 0.50	2.04 ± 0.12	8.16 ± 0.70	
4	7.4 - 13.0	2.0 - 4.0	7.5 - 13.0	1.7 - 2.4	5.0 - 10.0	" "
	9.76 ± 0.52	2.83 ± 0.10	9.95 ± 0.55	2.06 ± 0.11	7.54 ± 0.23	
6	-	-	-	-	8.01	Glandular hairy
7	8.0 - 9.5	2.0 - 4.0	8.0 - 9.5	1.8 - 2.3	4.5 - 9.5	" "
	8.35 ± 0.15	2.62 ± 0.11	8.90 ± 0.15	2.14 ± 0.10	6.14 ± 0.50	
9	9.0 - 11.0	3.0 - 4.5	8.2 - 11.5	2.1 - 2.9	4.0 - 9.0	Glabrous
	9.73 ± 0.20	3.20 ± 0.09	10.50 ± 0.31	2.20 ± 0.14	6.68 ± 0.32	
11	-	-	-	-	6.10	" "
12	10.0	3.50	10.26	2.0 - 2.5	4.0 - 8.0	Pubescent hairy
				2.90 ± 0.15	5.85 ± 0.34	

Table 9. Fruit and seed characteristics of *D. cyphoptectrum* populations.

Population Number	FOLLICLE				SEED			
	Length (mm)	Width (mm)	Number of ripe fruits on the pedicel (first 5 flowers)	Length of style in fruit (first 5 flowers)	Indumentum in the fruit	Number of seeds Per follicle (100)	Length (mm)	Width (mm)
1	9.0–20.0	2.1–5.0	1.0–3.0	1.0–3.0	Generally glabrous, sometimes basic	3.0–16.0	1.0–2.7	0.9–2.2
	14.47 ± 0.28	3.64 ± 0.05	2.84 ± 0.06	1.94 ± 0.09	puberulent (pubescent) or glandular hairy	7.67 ± 0.45	2.07 ± 0.04	1.51 ± 0.05
2	8.0–20.0	2.0–4.8	1.0–3.0	1.2–3.0	"	5.0–15.0	1.2–2.5	1.0–2.0
	13.08 ± 0.26	3.55 ± 0.10	2.92 ± 0.07	1.87 ± 0.12	"	8.01 ± 0.50	2.11 ± 0.04	1.56 ± 0.01
3	7.0–20.0	2.3–4.9	1.0–3.0	1.0–2.9	"	4.0–15.0	1.5–2.5	1.0–1.9
	13.15 ± 0.28	3.60 ± 0.07	2.79 ± 0.09	1.76 ± 0.14	"	7.49 ± 0.41	2.10 ± 0.06	1.50 ± 0.05
6	7.0–15.0	2.0–3.6	1.0–3.0	1.2–2.6	Glandular-pubescent	3.0–13.0	1.2–2.6	0.8–1.9
	11.95 ± 0.53	2.95 ± 0.12	2.86 ± 0.08	2.0 ± 0.15	"	7.51 ± 0.61	2.08 ± 0.07	1.48 ± 0.06
7	8.0–11.0	2.0–3.5	1.0–3.0	1.3–2.7	"	4.0–16.0	1.3–2.5	0.9–2.0
	9.66 ± 0.42	3.05 ± 0.22	2.90 ± 0.10	1.98 ± 0.12	"	9.01 ± 0.75	2.0 ± 0.04	1.50 ± 0.06
8	10.0–12.0	2.5–4.0	1.0–3.0	1.3–2.8	Glabrous	5.0–17.0	1.3–2.6	1.0–2.0
	10.75 ± 0.25	3.17 ± 0.31	2.90 ± 0.11	1.86 ± 0.13	"	8.25 ± 0.71	2.05 ± 0.10	1.39 ± 0.08

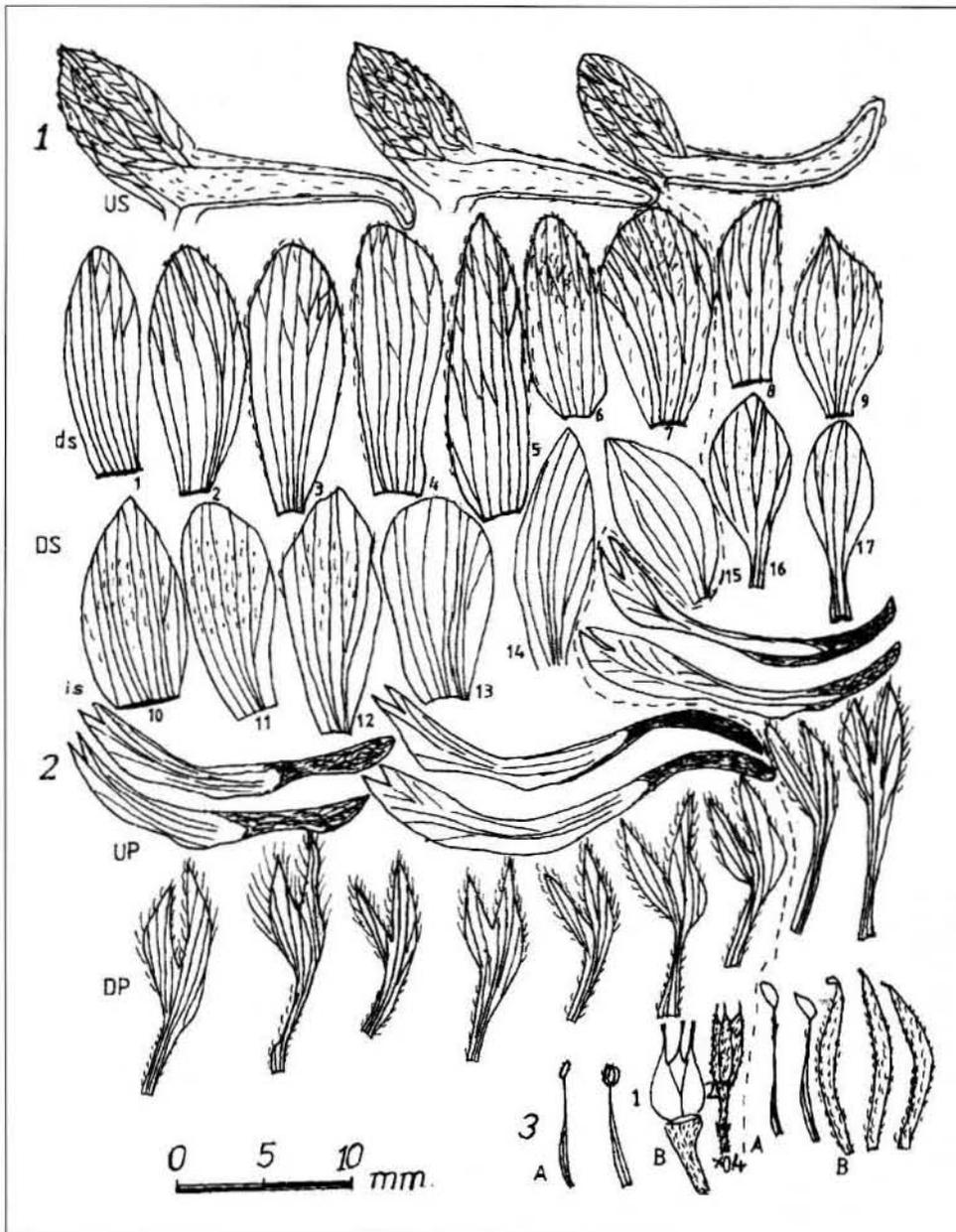


Fig. 3. Drawings of flower parts of *D. cyphoplectrum* populations. (The part on the right with broken line belongs to the first plant figure 1b.)

Calyx: US- upper sepal, DS- other sepals, ds- outer sepal, 1-5 appearance from outer side, is- inner sepal, 10-13 outward appearance, 14-17 inward appearance.

Corolla: up- Spur forming petals, DP- Other petals.

Reproductive organs: A- Stamen, B1- Carpels, B2- Follicular fruit.

Table 10. Soil analysis of *D. cyphoplectrum* populations.

Population Number	Maximum water holding capacity (%)	% Sand	% Clay	% Silt	Texture	PH	CaCO3 (%)	Total Salt (%)	Organic Matter (%)
1	34.84	91.66	3.88	4.46	Sandy	6.70	0.352	0.035	1.680
2	82.41	84.56	2.40	13.04	Loamy-Sand	7.60	11.891	0.048	1.680
3	22.50	73.68	2.50	23.82	" "	7.53	13.326	0.028	1.540
4	70.31	66.56	8.88	24.56	Sandy-loam	6.58	0.246	0.055	4.327
5	72.27	88.66	4.88	6.46	Sandy	6.71	0.287	0.095	4.525
6	68.47	72.56	4.88	22.56	Sandy-Loam	7.22	20.092	0.081	7.111
7	63.45	67.56	4.88	27.56	" "	7.62	10.046	0.045	4.266
8	82.30	72.56	6.88	20.56	" "	6.02	0.181	0.075	7.370
9	35.62	85.56	4.88	9.56	Loamy-sand	6.16	0.114	0.049	2.586
10	27.48	82.21	3.11	14.68	" "	7.11	6.452	0.032	1.635
11	58.96	68.56	6.88	24.56	Sandy-Loam	7.39	2.099	0.087	1.047
12	44.55	78.56	2.88	18.56	Loamy-Sand	7.56	0.967	0.045	2.068

pressed pubescent ( $\pm$  curved puberulent). Seeds in two rows in the follicle, many in number, developing from anatropous ovule, embryo small with fleshy endosperm, whitish-black (dirty white), unripe seeds brown colored, a few white colored seeds also seen, angled or triangular with imbricately arranged membranous white scales, length and density of scales varies (Table 9).

## 2. Ecology

*D. cyphoplectrum* is an attractive but poisonous species. It is generally found on steep slopes with less soil and among agile stony heaps, in oak and juniper forests or rock openings, biotic factors like grazing and mowing very common in the area do not effect this plant much. Altitudinal distribution ranges between 900-2850 m, and is abundantly seen at sunny places where it well flourishes but rarely grows in shady places and wet habitats. Generally it prefers dry areas, lime stones, calcified sand-stones, silt-stones or volcanic rock openings. Life cycle of this species is very short, restricted to the late spring season. Seeds are produced in the second half of July. But on wet places sometimes flowering continues till July. Soils *D. cyphoplectrum* populations mainly have loamy-sandy or sandy-loam texture, with a low water holding capacity, low organic matter and  $\text{CaCO}_3$  contents (Table 10); pH varies between strongly acidic to weakly alkaline. Growth is favoured more by soils poor in  $\text{CaCO}_3$  but rich in organic matter. Pollination generally is carried out by insects due to its showy flowers and nectar produced in the spur. The pollen production too is very high, pollens are spheroidal in shape, tricolpate (zonocolpate) but not isoporous.

Transplantation experiments showed that length of plant increased, flower color changed from blue to white, lower leaf segments did not fall down during flowering but gathered together and breadth of segments also increased. This clearly showed that these characters are not inherited, but only modifications in response to the habitat.

## Discussion

*Ranunculaceae* family is widely distributed in mesophytic areas and abounds in herbaceous representatives. It is one of the plant groups where one faces many difficulties in identification (Lawrence 1951, Chowdhuri 1958, Townsend & Guest 1980). Many members of this family show great variations due to polymorphism, hybridization, polyploidy and habitat differences (Tan & Ilarslan 1990, Ilarslan 1996, Özçelik 1996), as such their taxonomical status has not been revealed fully. For example *Delphinium altissimum* Wall. has been divided into subspecies, each with two varieties by Brühl, on the basis of hairiness of stem, leaf and carpels, twistedness of spur and distance of the bracteoles to flower. Later studies proved that these characters are changing as such these subspecies were abolished. Same was done with the varieties of *D. viscosum* Kook. as well as *D. fissum* Waldst. & Kit (Tamura 1962, Blanche & Molero 1983). Many discussions have been done on the systematic position of *D. cyphoplectrum* too uptill now. Davis & al. (1965) give the status of varieties to *D. vanense*, *D. pallidiflorum* and *D. laxiusculum*, reported from localities very near to each other and placed them under *D. cyphoplectrum* due to variations in type specimens, but stressed the need for detailed

field studies, covering different geographical races from different localities of this species. According to these investigators (Davis & al. 1965) characters used in the identification of *D. vanense* represent only one out of the two type specimens collected, in particular spur characters are reported to be given wrongly. In *D. pallidiflorum* important variations were observed as regards the hairiness, shape of spur and position of bracteole. In the latest revision of this genus, Ilarslan (1996) mentions some references, but this author has not been able to investigate these specimens. *D. cyphoplectrum* seems related to *D. cyphoplectrum* and its close relatives. In this paper the varieties have been given the status of species again by omitting some of the criteria used for identification of varieties. However, still great difficulties are met with in the identification, while using this key at the species level or the one at the variety level. In particular there is a great contradiction as regards the hairs between the type specimens and characters used here (Davis & al. 1965, Davis 1965). Mostly identifications of this taxon have been done by using few specimens.

Ecological and morphological studies undertaken by us at population level have permitted to reveal the disputable position of *D. cyphoplectrum* in a better way. Its populations deviate from its close relatives *D. carduchorum* and *D. dolichostachyum* populations in qualitative and quantitative characters such as length of roots, general appearance of plant as well as stem number of lower leaves in the plant, petiole length of stem leaves and their number, peduncle number in plants, length and breadth of racemes, shape and size of lower bracts; length of flower, sepal, petal, stamen, follicle and style of follicle, number of matured seeds in follicle, length and breadth of seeds as well as ratios of petals to sepals. Another close relative of this species is *D. ilgazense* Davis. It is distinguished from *D. cyphoplectrum* by dense short racemes, relatively long spur, short length and existence of bracteoles very near to the apex of pedicel. Our results show clearly that, even in the same population one can find plants with bracteoles on different positions on the pedicel, flowers can be few or many in number, arranged densely or loosely, with short or long racemes. Although number of dense racemes in *D. cyphoplectrum* populations observed by us in general is low, but the report on *D. ilgazense* mentions about many dense racemes, however, loosely arranged racemes too seem to occur in the photographic plates of *D. ilgazense* (Davis & al. 1965). It is reported that it does not mix up with *D. cyphoplectrum* in the new revision but we feel that more studies are needed on the populations of *D. ilgazense* to avoid any confusion.

Out of the specimens investigated by us two were observed to appear rarely in our populations (Plant number 1 in Fig. 1b). These plants differ from other specimens of *D. cyphoplectrum* in the sense that unmaturing fruits are longer than the follicles of *D. cyphoplectrum*, linear-cylindrical in shape with shorter styles, attached strongly to the perianth, flowers are shorter, spur is quite short, pedicels are long and spreading and raceme is wide. They differ from *D. cyphoplectrum* but do not resemble other plants too and fit nowhere in the key. In our opinion it is preferable to accept it as a local variant of *D. cyphoplectrum* for the time being.

## Conclusions

*D. cyphoplectrum* is a polymorphic species distributed in Iran, Transcaucasia and East

Anatolia. Morphological characters of this species respond immediately to the habitat they grow in, as such; the color of flowers varies in accordance with soil pH; hairiness in relation to soil, wind and moisture content. Plant height, leaf length as well as segmentation of leaves varies with soil pH, CaCO<sub>3</sub> and organic matter contents. Tap root shape and size depends upon the age of plant and soil moisture. Other modifications like length of flower, smoothness of stems or their flexuous nature and position of spur at the apex probably are habitat dependent too. The characters that do not change are ratio of spur to sepal which are equal, non-dispersion nature of flowers, petals being always longer than sepals and number of mature seeds.

The specimens collected from Ereğ Dagi, Pelli Dagi, Kepir Dagi, and Hizan (Kolludere site) grow on sunny places, eroded soils, steep and pebbly habitats. They resemble var. *vanense* and var. *pallidiflorum*. The specimens from Aladag and Tendurek on wet and productive soils resemble var. *stenophyllum*. Specimens resembling these varieties do exist in the same population but most individuals show transitive features. Some characters of the plant coincide with one, some with other variety. Average values in the population keep them away from these varieties. Biometric measurements clearly depict that there is no grouping and variations are randomly distributed. Average values always overlap each other. These findings clearly support the fact that there is no need for dividing *D. cyphoplectrum* into varieties in Turkey, only the distributional map should be changed.

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