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***Saponaria bargyliana* Gombault (Caryophyllaceae): A New Record for Turkey and Analysis of Its Morphological Characters with Related Species**

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Abstract: Previously, *Saponaria bargyliana* Gombault was known only from its type locality, the north of Syria in the Nosairis mountains, which was published by Gombault in 1962. During a field trip in June 2002 to Erzin (Hatay) district, the species was collected for the second time from a new locality far from its *locus classicus*. Thus, this species was described as a new record for the flora of Turkey. The description of this species was expanded and its geographical distribution, habitat, flowering time and conservation status are discussed. Quantitative and qualitative analysis of *Saponaria bargyliana* and closely related species is discussed. Eleven quantitative characters were used in a linear discriminant analysis. In the discriminant analysis, the most useful characters for separating particular species were selected: seed number, calyx nerve number, coronal scale length, calyx teeth length and petal width. With these 5 most important characters, 100% of plants were correctly classified into the designated groups. The analysis showed that *S. bargyliana*, *S. officinalis* L. and *S. glutinosa* M.Bieb. are distinguished by the quantitative morphological characters. Calyx hair arrangement and the condition of the pedicel hairs are the most important qualitative characters in the identification of these species.

Key Words: *Caryophyllaceae*, *Saponaria*, new record, morphology, linear discriminant analysis

***Saponaria bargyliana* Gombault (Caryophyllaceae): Türkiye İçin Yeni Bir Kayıt ve Yakın Türler ile Birlikte Morfolojik Karakter Analizi**

Özet: Bu zamana kadar, 1962 yılında Gombault tarafından yayınlanan *Saponaria bargyliana* Gombault sadece tip lokalitesi olan Suriye'nin kuzeyindeki Nosairis dağından bilinmekteydi. Erzin (Hatay) bölgesinde Haziran 2002'de yapılan bir arazi çalışmasında tip lokalitesinden oldukça uzak bir bölgeden ikinci kez toplandı. Böylece bu tür Türkiye florası için yeni bir kayıt olarak belirlendi. Türün tanımı genişletildi, coğrafik dağılım, habitat, çiçeklenme zamanı ve tehlike durumu tartışıldı. *Saponaria bargyliana* ve yakın türlerinin nicel ve nitel morfolojik karakterlerinin analizi yapıldı. 11 nicel karakter doğrusal ayrışım analizinde kullanıldı. Ayrışım analizinde türleri birbirinden ayıran en uygun karakterlerin; tohum sayısı, çanak yaprağı damar sayısı, korollapulu boyu, taç yaprağı genişliği ve çanak yaprağı diş boyu olduğu belirlendi. Ayrışım analizi sınıflamasında en önemli beş karakter bitkilerin tamamını tasarlanan gruplara doğru bir şekilde sınıflamıştır. Bu analiz, *S. bargyliana*, *S. officinalis* L. ve *S. glutinosa* M.Bieb'nin nicel morfolojik karakterler ile ayrılabilirliğini göstermektedir. Çanak yaprağı tüy düzenlenmesi ve çiçek sapı tüy durumu bu türlerin tanımlanmasında en önemli nitel karakterlerdir.

Anahtar Sözcükler: *Caryophyllaceae*, *Saponaria*, yeni kayıt, morfoloji, doğrusal ayrışım analizi

Introduction

The author carried out extensive field studies in South-East Anatolia and collected some *Caryophyllaceae* specimens from the area in 2002. At first glance in the field, one of them looked like *Saponaria officinalis* L. and *S. glutinosa* M.Bieb. because of the habit and stem leaf.

After closer examination and consultation with the *Flora of Turkey and the East Aegean Islands* (Hedge, 1965; Davis et al., 1988) it was realised that the specimens were quite different from *Saponaria officinalis* and *S. glutinosa*. The specimens were crosschecked with various *Saponaria* accounts given in relevant floras, e.g.,

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Flora Iranica (Rechinger, 1988), Flora Europaea (Chater, 1964), Flora Palaestina (Zohary, 1966), Flora of Syria, Palestine and Sinai (Post, 1932), Flora of USSR (Komarov, 1939) and Flora of Cyprus (Meikle, 1977).

As a result of further comparative studies and discussion (Pers. com. with Mr. I. Hedge), I determined that this specimen was similar to *S. bargyliana* Gomboldt. This species was collected in the north of Syria in the Nosairis mountains and only published in Bulletin Societe Botanique de France, 1962 and the type specimen is found in Paris Natural Museum Herbaria (P). After I had studied the type specimen (Gombault, 1962), I decided that this specimen is *S. bargyliana* and thus a new record for the Flora of Turkey.

At the same time, the purpose of this study was to analyse quantitative characters in order to answer the following questions: (1) Is it possible to recognise particular taxa using quantitative characters? (2) Which quantitative characters are most useful for species identification?

Materials and Methods

The measurements were obtained from either specimens collected in the field or kept in ANK, GAZI and HUB herbaria in Turkey and Paris Natural Museum Herbarium (P) in France. The total number of herbarium specimens analysed in the morphometric multivariate analysis is 41 (Appendix 1). Qualitative characters were chosen from among those used in the most recent taxonomic revision of *Saponaria* (Hedge, 1965) and some of them were used in this study for the first time. Authorities of all cited plant names are given according to Brummitt and Powell (1992).

I tested the utility of 11 characters, including 9 measurements and 2 meristics (of these, 3 were vegetative and 8 were floral), for separating the 3 species using multivariate analysis of variance (MANOVA) in SPSS (Statistical Package for the Social Sciences) (SPSS, 1999). Discriminant analysis was chosen to determine the suitability of specific variables for predictive classification. Linear discriminant analysis (LDA) was selected because it requires the assumption of equal covariance matrices (Özdamar, 2002). The DISCRIMINANT subprogram of SPSS was used for this analysis. The canonical discriminant analysis was computed using the program. First, the entire data set was analysed, and then

taxonomically indistinct species pairs were analysed separately. Characters with the highest coefficient of the canonical structure on the 2 canonical functions were selected. These characters explain the highest proportion of variance between groups (species). Then stepwise discriminant analysis was used to find the best set of discriminate characters. In this analysis, characters were entered one by one and the process stopped when none of the remaining characters significantly improved the discriminant capacity ($P < 0.01$).

Finally, a classification discriminant analysis (cross-validation) of the samples with the classification function combining respective characters and their weights was carried out to determine the group (taxon) into which the classified object belongs with the highest probability.

Results and Discussion

S. officinalis is very widespread in North Anatolia. *S. glutinosa* is spread in North Anatolia, between West and Inner Anatolia and the Anatolian Diagonal. *S. bargyliana* only grows on the north side of Amanos Mountain, southern Anatolia, Hatay. This mountain is remarkable for its numerous Euro-Siberian elements, which have reached it from the north, probably by migration down the Anatolian Diagonal during the glacial (pluvial) phase of the Pleistocene. Because of this reason, it supports numerous endemics and subendemics (Davis, 1971).

S. bargyliana grows in mixed forest where *Fagus orientalis* Lipsky is the dominant tree. *Pinus brutia* Ten., *Carpinus orientalis* Miller, and *Quercus cerris* L. var. *cerris* are other common trees in this area at 1500-1900 m. The range of this new species is restricted to only one location.

Saponaria bargyliana Gombault in Bulletin Société Botanique de France, 109:265 (1962) (Figure 1).

Type: North Syria: Espèce découverte en juillet 1934 et 1938 per le Frère LOUIS qui l'a récoltée à Sléné et au col de Freiket dans les Monts Nosairis (Bargylus mons de Pline) (P)!

Iconography: This species is illustrated in this article for the first time (Figure 1).

Description: Erect perennial, glandular-hispid throughout. Stem 30-60 cm, simple or little branched, hairy, all hairs multicellular glandular-hispid, up to 1-1.5 mm. Leaves oblong-elliptic, (15-) 25-75 x (6-) 12-25



Figure 1. *Saponaria bargyliana* (A) habit; (B) flower; (C) dissected calyx; (D) petal; (E) fruit; (F) hairs.

mm, acute or acuminate, shortly petiolate at the base or sessile at the upper side, distinctly 3 nerved, glabrous on the upper side and pubescent on the under side. Inflorescence compact, terminal corymbose-paniculate, shortly pedunculate, 12-42 flowered with an indumentum of long glandular hairs. Bracts herbaceous, 3 nerved, lanceolate-triangular, 3-12 x 1-3 mm, long eglandular hairy, ciliate margin. Pedicel glabrous, 0.5-1 mm. Calyx green or yellowish green, glandular, hairs only arrangement on the nerves, narrowly oblong-cylindrical, calyx length 12-21 mm, dissected calyx width 5-6 mm, 15 nerves, teeth ovate, acuminate, 4-5.5 mm. Petals pink, 20- 25 x 3-3.5 mm, obovate lamina with 2 small

scales at the base and a narrow claw, scale subulate, 1.5-2 mm. Capsule oblong-ovate, subsesile shorter than calyx. Seed 8-12.

Flowering time: *S. bargyliana* is known to flower in May, June and July.

Distribution and habitat: Turkey/C6 HATAY: Erzin, 30 km from Kuzuculu Village towards Ufacık area, 1200-1350 m, 17/6/2002, *F. orientalis*-*C. orientalis* mixed forest, *B. Mutlu* 8034. (Figure 2).

Conservation status: Its distribution area is less than 10 km² and it is known from only one location (criterion B2) in Turkey. This species should be considered

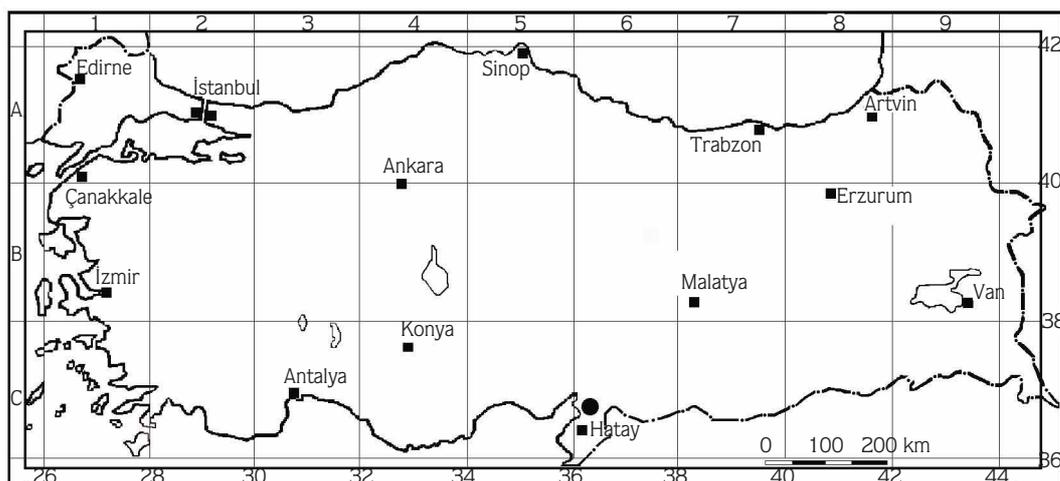


Figure 2. Distribution of *Saponaria bargyliana* (•) in Turkey.

“critically endangered (CR)” according to the new IUCN categories (IUCN, 2001).

Character analysis: *S. bargyliana*, *S. officinalis* and *S. glutinosa* are more closely related to each other than the remaining species. The MANOVA demonstrated that 8 characters varied significantly among the 3 species ($P < 0.01$). All of these characters are floral. These characters are given in Table 1 in bold. Multivariate statistical analysis indicated that the 3 species differed significantly with respect to their morphologies (Wilks’ lambda: 0.001; $F: 88.842$; $df: 22$; $P < 0.001$).

The quantitative characters of these species are given in Table 1 and qualitative characters are given in Table 5. The correlations between quantitative characters were tested using the Pearson test (Table 2). High correlations were found for the character pair’s *sen* and *cxnn* (0.850, $P < 0.01$), and *cxnn* and *cxtl* (0.832, $P < 0.01$). *Sen*, *cxw* and *pel* are correlated with other 6 characters significant at the 0.01 and 1 character significant at the 0.05 levels (Table 2). For this reason, *sen*, *cxw* and *pel* are the most important characters for the discrimination of these species.

Table 1. List of the quantitative characters and results of measurements. Statistical significant ($P < 0.001$) characters shown in bold.

Acronym	Character	<i>S. bargyliana</i>	<i>S. officinalis</i>	<i>S. glutinosa</i>
CXL	calyx length (mm)	12-21	18-25	18-28
CXW	dissected calyx width (mm)	5-6	8-16	6.5-11
CXTL	calyx teeth length (mm)	4-5	1.5-3	4-6
CXNN	number of calyx nerve	15	24-33	15-24
PEL	petal length (mm)	17-25	25-36	14-17
PEW	petal width (mm)	2.5-4	4-7	0.5-2
COSL	coronal scale length (mm)	1-2	1-2	0.5-1.5
SEN	seed number	8-12	52-80	20-30
LEL	middle stem leaf length (mm)	4-7	5-10	4.5-8.1
LEW	middle stem leaf width (mm)	1.3-2.5	1.1-2.3	1.3-3.7
LEL/ LEW	ratio of leaf length to leaf width (mm)	2.5-4.8	2.9-5.1	1.8-6.2

Table 2. Pearson correlation coefficients between quantitative characters and species (groups) discriminate ratio of character pairs.

		Discriminate ratio (%)										
		CXL	CXW	CXTL	CXNN	PEL	PEW	COSL	SEN	LEL	LEW	lel/lew
C O R R E L A T I O N	CXL	-	92.7	97.6	95.1	95.1	97.6	87.8	97.6	80.5	80.5	80.5
	CXW	0.378*	-	95.1	92.7	87.8	100	85.4	100	85.4	87.8	85.4
	CXTL	0.327*	-0.529**	-	87.8	75.6	100	92.7	97.6	75.6	80.5	82.9
	CXNN	-0.005	0.691**	-0.832**	-	80.5	97.6	90.2	100	80.5	80.5	73.2
	PEL	0.198	0.757**	-0.650**	0.747**	-	97.6	85.4	100	70.7	70.7	70.7
	PEW	-0.387*	0.499**	-0.822**	0.765**	0.702**	-	95.1	100	97.6	97.6	97.6
	COSL	-0.409**	-0.244	-0.146	-0.100	0.054	0.344*	-	100	61.0	53.7	63.4
	SEN	0.120	0.766**	-0.805**	0.850**	0.805**	0.730**	.039	-	100	97.6	100
	LEL	0.192	0.401**	-0.266	0.358*	0.422**	0.236	-.057	0.344*	-	46.3	48.8
	LEW	0.152	0.037	0.262	-0.228	-0.064	-0.222	-0.181	-0.193	0.259	-	46.3
	lel/lew	0.091	0.233	-0.328*	0.391*	0.325*	0.267	0.121	0.401**	0.470**	-0.681**	-

* $P < 0.05$; ** $P < 0.01$

Linear discriminant analysis was successful in grouping species (Figure 3). Figure 3 shows samples of *Saponaria* species arranged in the 2-dimensional space. Stepwise discriminant analysis, run in 22 steps, selected 5 uncorrelated characters for distinguishing between *Saponaria* species. These 5 characters were used in the classification discriminant analysis that classified 100% of the samples to the designated assumed groups. The standardised coefficients of the canonical functions are given in Table 3. The largest absolute correlation between each variable and any discriminant function are given in bold in this table. The first discriminant function is most highly correlated with *sen*, *cxnn* and *cxtl* while the second is with *pew* and *cosl*. The scatterplot of specimens against 2 functions provides good discrimination for *S. bargyliana*, *S. officinalis* and *S. glutinosa*. The first 2 discriminant functions together explain 100% of variance. In the analysis of the entire data set, the 2 canonical functions accounted for 100% of currently classified individuals (Table 4).

The uncorrelated characters useful for distinguishing between particular taxonomically complicated species pairs were also selected by this method. *Saponaria* species were 100% classified by characters of *sen*. Other characters were not fully classified, but only *pew-cxtl* and *pew-cxw* character pairs classified samples of these

species 100%. *Lel-lew* and *lew-lel/lew* character pairs separated the least samples of these species (Table 2). *Pew* (*S. bargyliana*-*S. glutinosa* and *S. officinalis*-*S. glutinosa*), *cxtl* (*S. bargyliana*-*S. officinalis* and *S. officinalis*-*S. glutinosa*) and *cxnn* (*S. bargyliana*-*S.*

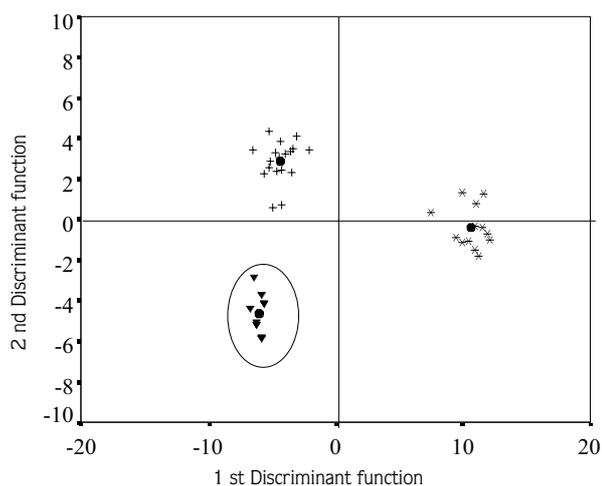


Figure 3. Discriminant scores for individuals of *Saponaria bargyliana* (\blacktriangledown), *S. officinalis* (*); *S. glutinosa* (+), and the scores of all individuals are projected onto the 2-dimensional space defined by first and second discriminant functions. The black point symbols are the unstandardised canonical discriminant functions evaluated at the group means (centroids).

Table 3. The standardised coefficients for 2 discriminate functions, the Eigenvalue, cumulative percent of the total variance accounted for, and the canonical correlation from analysis of quantitative characters. Largest absolute correlation between each variable in any discriminate functions are shown in bold. See text for details and Table 1 for abbreviations of characters. (°): this variable not used in the analysis.

No.	Character	Function	
		1	2
1	SEN	0.530	0.211
2	CXNN	0.310	0.052
3	LEL ^a	-0.304	-0.163
4	CXTL	-0.296	0.199
5	CXL ^a	-0.035	0.026
6	PEW	0.410	-0.561
7	LEW ^a	-0.162	-0.337
8	PEL ^a	0.227	-0.305
9	LEL/LEW ^a	-0.087	0.305
10	COSL	0.006	-0.289
11	CXW ^a	-0.043	-0.155
	Eigenvalue	72.080	16.638
	Cumulative %	81.2	100.0
	Canonical correlation	0.993	0.971

Table 4. Results of classification discriminant analysis (cross-validation): 1-*S. bargyliana*, 2-*S. officinalis*, and 3-*S. glutinosa*.

	Actual group	Predicted group membership			% Correctly classified
		1	2	3	
	1	10	0	0	100
	2	0	13	0	100
	3	0	0	18	100

officinalis) characters classify 100% of the species pairs in parentheses.

Leaf shape (oblong-elliptic), leaf nerve number (distinctly 3 numbers), petiole condition (petiolate or sessile) and stem length (25-70 cm) as vegetative characters of these species are similar. *S. bargyliana* differs from *S. officinalis* because it has a thick and cylindrical root (not creeping rhizome); calyx teeth shape lanceolate-acuminate (not ovate-acuminate); upper shape of petal entire (not entire or slightly retuse); coronal scale

shape subulate (not lanceolate); it differs from *S. glutinosa* because it is perennial (not biennial); calyx hairs monotypic only long (not long and short); upper shape of petal entire (not bifid). Calyx hair arrangement and pedicel hair condition are good taxonomical qualitative characters which distinguished *S. bargyliana* from *S. officinalis* and *S. glutinosa*. Calyx hairs are only on the calyx nerve in *S. bargyliana* but in *S. officinalis* and *S. glutinosa* hairs covered the entire outer surface of the calyx. Pedicels of *S. bargyliana* are glabrous, but pedicels of other *Saponaria* species are hairy (Table 5).

Table 5. A comparison of qualitative characters in *S. bargylia* and the most similar taxa, *S. officinalis* and *S. glutinosa*.

Characters	<i>S. bargylia</i>	<i>S. officinalis</i>	<i>S. glutinosa</i>
Root	perennial, thick and cylindrical	perennial with a creeping rhizome	biennial, thick and cylindrical
Pediceal hairs	glabrous	hairy	hairy
Petal colours	dark pink, purple or rose	white or pink	dark pink
Calyx teeth shape	lanceolate-acuminate	ovate-acuminate	lanceolate-acuminate
Calyx hairs arrangements	on the nerves	throughout	throughout
Calyx hairs shape	long	short	long and short
Upper shape of petal	entire	entire or slightly retuse	bifid
Coronal scale shape	subulate	lanceolate	subulate

The genus *Saponaria* L. was first revised by Hedge (1965) in *Flora of Turkey and the East Aegean Islands*. Since the first revision, a new taxon has been described from Turkey, *S. pinetorum* Hedge var. *elatior* Ekim & Hedge (Davis et al., 1988). Thus, *Saponaria* has 18 species, 2 subspecies and 1 variety in Turkey. Finally, species number has increased to 19, including *S. bargylia*, with this new record.

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Appendix 1. List of localities studied.

Locality reference and voucher specimens of populations studied. Abbreviations of herbaria, which follow Holmgren et al. (1990), are given at the end of the localities.

Saponaria bargyliana Gombault: SYRIA-species discovered in July 1934 and 1938 by Brother LOUIS who collected it in Slenfé and the Freiket pass in the Nosairis mountains (Bargylus mons de Pline). (P, type specimens); TURKEY-C6 Hatay, Erzin, 30 km from Kuzuculu Village towards Ufacık area, 1200-1350 m, 17/6/2002, *F. orientalis*-*C. orientalis* mixed forest, *B. Mutlu*-8034 (HUB);

Saponaria officinalis L.: TURKEY-A9 Artvin, from Şavşat-Veliköy road junction, towards Pınarlı village, woodland and meadows, 165-1850 m, 1/8/1982, *N. Demirkuş*-1700 (HUB); A9 Kars, Posof, between Kodiyan nursery garden and Doğrular village, 1800-2200 m, 30/7/1985, *N. Demirkuş*-3130 (HUB); A4 Amasya, Direkli village, Hıdırpınarı, 850 m, stream side, 25/7/1987, *S. Peker* 1508 (GAZI); C2 Denizli, Babadağ district, open areas of *P. brutia* woodland and road side, 870-1200 m, 29/7/1988, *Z. Aytaç* 2462 (GAZI); C5 Mersin, *Siehe* 279 (ANK); C5 Mersin, Tarsus, Namrun, 1200 m, 1/8/1972, *Y. Akman* 1120 (ANK); A4 Ankara, Keçiören, Hacıkadın Stream, 900 m, 13/10/1945, *B. Kasaplıgil* (ANK); B2 Bursa, Gemlik, Karacalı village, 8/8/1962, *K. Karamanoğlu* 857 (ANK); A3 Zonguldak, Kozlu, *B. Kasaplıgil* (ANK); A7 Trabzon, Maçka, Meryemana Stream, 340 m, 26/8/1945, *B. Kasaplıgil* (ANK).

S. glutinosa Bieb.: TURKEY-A2 İstanbul, Anadolu Hisarı, 9/1949, *A. Berk* (HUB); A4 Kırıkkale, around Hıdırşeyh village, steppe, 1000 m, 2/6/1990,

A.A. Dönmez-2282 (HUB); B7 Tunceli, Ovacık, upper side of Tornava, Munzur Mountains, 1100 m, 26/7/1979, *Ş. Yıldırım* (HUB); B1 Manisa, Sipil Mountain, Beypınar area, 19/7/1971, *Ö. İnCEOğlu* (HUB); Fl. de Orient, 1855, *B. Balansa* (P); B1 Manisa, in mount Sypila, 1837, *M. Aucher-Eloy* (P); Casmus in herbudin, 1842 (P); Fl. de Orientalis, Cappadocia, Hadjin (P); Paphlagonia, Wilajet Kastambuli, 16/7/1892, *P. Sintenis*-4652 (P); C2 Manisa, Manisa Mountain, Çırpıcı Dede Hill, 1200 m, 21/6/1984, *H. Duman* 1812 (GAZI); C5 Adana, Pozantı, Börücek, *Abies cilicica*, rocky slopes, 1380-1450 m, 18/7/1997, *Z. Aytaç* 7754 (GAZI); B4 Ankara, Beynam forest, 28/6/1948, *H. Bağda* 248 (ANK); B2 Afyon, Bayat, Taşlığın Hill, 1390 m, 23/6/1975, *M. Vural* 203 (ANK); A4 Kastamonu, stone mines of Daday, 950 m, 23/6/1980, *O. Ketenoğlu* 886 (ANK); B3 Eskişehir, Türkmen Mountain, between Ilica and Meşale area, road side, 900-1000 m, 14/6/1976, *T. Ekim* 2084 (ANK); A5 Kastamonu, Tosya, Yağcılar village, Karanlık Mountain, woodland of *A. bornmulleriana*, 1600 m, 18/7/1976, *M. Kılıç* 7131 (ANK); B5 Yozgat, Akdağmadeni, Ortaköy, Gölderesi, Kayataşı area, open areas of *P. sylvestris*, limestone, 1550 m, 7/7/1979, *T. Ekim* 4147 (ANK); B3 Eskişehir, Karakütük Güven meadow, 1300 m, 1/7/1970, *T. Ekim* 356 (ANK); C4 Antalya, Elmalı, Çiğlikara *Cedrus libani* woodland, between Kavakçılar area and guesthouse, 1750-1850 m, 29/6/1974, *R. Çetik* 1617 (ANK); A4 Bolu, Gerece, Aktaş forest, 1300 m, 19/10/1976, *O. Ketenoğlu* 430 (ANK); A4 Kastamonu, between Kastamonu and Araç, Kızıltepe, 900 m, 19/7/1981, *M. Demirörs* 157 (ANK); B4 Ankara, Beynam forest, 1400 m, 18/6/1970, *Y. Akman* 8206 (ANK); A3 Bolu, Yedigöller National Park, 900 m, 12/7/1977, *R. İlarıslan* 24 (ANK).