

## Pollen and Capsule Morphological Studies on *Verbascum* Hybrids (Scrophulariaceae) in Mardin, Turkey and Their Taxonomic Importance

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### Abstract

*Verbascum* (Scrophulariaceae, Lamiales), usually known as “Mullein”, is widely distributed in Eurasia and North Africa, but the highest taxa diversity is in Anatolia, the southern Balkans, the Middle East, the Caucasus and northwestern Iran and is represented by approximately 360 species in the World. As hybridization is very dense in the genus *Verbascum*, the high frequency of morphological variations has been intricated in species delimitation. In this study, pollen and capsule morphology of three hybrid *Verbascum* taxa [*Verbascum* × *calcicola* Hub.-Mor., *V.* × *kotschyoides* Hub.-Mor., and *V.* × *nusaybinense* Hub.-Mor.] were investigated. They are hybrids wild distributed in the province of Mardin in Southeastern Anatolia. Pollen slides were prepared according to the Wodehouse method, pollen and capsule morphologies were examined with microscope. In general terms, aperture types were tricolporate, but also tricolpate aperture types were observed. The shapes of the pollen grains were determined as oblate-spheroidal and subprolate. The sculpture was reticulate in all cases. The seeds not developed. The capsules are pubescent, densely covered by branched hairs, or loosely by glandular hairs, depending on taxa. The results of this study showed that morphological features, such as pollen shape, polar axis (P), equatorial diameter (E), aperture type, exine and intine thickness, colpus, and por measurement, show differences that can be taken into consideration in the systematic discrimination within the taxa. The capsule showed that substantial taxonomic insight can be gained from examining the capsule characteristics of *Verbascum*, particularly at the species level.

### 1. Introduction

The family Scrophulariaceae, mostly known as “figwort”, contains about 62 genera and 1830 species and consists of herbaceous angiosperms and a shrub genus [1, 2]. *Verbascum* (Scrophulariaceae, Lamiales), usually known as “Mullein”, is widely distributed in Eurasia and North Africa, but the highest taxa diversity is in Anatolia, the southern Balkans, the Middle East, the Caucasus and northwestern Iran and is represented by approximately 360 species in the world [3-7]. The gene center of this genus is Turkey with 257 species and 132 hybrids divided into 13 artificial groups [8-10]. The genus *Verbascum* is still not fully understood

and new species are regularly described, especially in Turkey [11]. The endemism ratio of the genus is very high, with 202 endemic species (80%) [8-10, 12-14]. As hybridization is very dense in the genus *Verbascum*, the high frequency of morphological variations has been intricated in species delimitation [8, 15]. The taxonomy of *Verbascum* has been a source of controversy because there is so much interspecific hybridization. The genus is biennial or perennial, characterized by flowers with thyrus or inflorescences and yellow flowers [1, 16]. *Verbascum* extracts, decoctions and infusions have long been used in traditional medicine. The leaves have been used as a diuretic, sudorific, expectorant, sedative and the flowers have mucolytic and expectorant

properties [17-19]. *Verbascum* is a taxonomically difficult genus and the infrageneric classification is informal and partly artificial. Moreover, identification of taxa also might be problematic because of the difficulties of providing a workable key. For this purpose, studies are being carried out by many scientists in Turkey and around the world regarding the systematics and morphology of *Verbascum* taxa [20].

There are many SEM studies based on the pollen morphology of the some *Verbascum* species taxa [15, 20-28]. SEM study based on pollen morphology of *Verbascum* hybrid taxa is only available on *V. × splendidum* by Aktas [29]. The capsule morphology of the genus *Verbascum* is known to have been studied only by Juan et al. [22] and Attar et al. [30]. Although there are studies of pollen morphology in Turkey, there are still deficiencies and unstudied taxa. In addition, studies on capsule morphology are not known in Turkey.

There is no palynological micromorphology and capsule morphology record for *Verbascum × calcicola* Hub.-Mor. (*V. andrusii* x *V. laetum*), *V. × kotschyoides* Hub.-Mor. (*V. andrusii* x *V. kotschyi*), and *V. × nusaybinense* Hub.-Mor. (*V. geminiflorum* x *V. kotschyi*). This study was carried out to understand the relationships between the three hybrid *Verbascum* taxa distributed in Mardin province, to obtain useful comparative information, and to show the fine structure of pollen surfaces and the external morphology of pollen and capsules. Thus, it should be aimed to obtain data that will help the classification of the genus or provide a health evaluation.

## 2. Material and Method

The specimens belonging to three hybrid *Verbascum* taxa were collected from several localities in Mardin.

Voucher samples were stored in the herbarium of the Department of Plants and Animal Production of Kızıltepe Vocational School, Mardin Artuklu University, Turkey. Collection locations, collector's number and the habitat of investigated samples studied for their morphology features are presented in Table 1. The taxonomic description of the plant was prepared according to Davis et al. [9] and Karavelioğulları [10].

For palynological investigations, all the pollen grains for LM and SEM by the standard methods described by Erdtman [31]. Pollen grains for LM examination were prepared following the standard procedure of Wodehouse [32]. They were observed in glycerin-water using a standard Isolab microscope. Thirty pollen grains per specimen were regarded as sufficient for the palynological analysis [32-34]. For SEM, pollen grains were removed by distilled water treatment, the air-dried, pollen grains were directly mounted on stubs using double-sided adhesive tape and it was covered with gold. The photomicrographs were taken with a ZEISS EVO 50 scanning electron microscope. The values of P (polar axis), E (equatorial diameter), Clg (colpus length), Clt (colpus width), Plg (porus length), Plt (porus latitude), Ex (exine thickness), and In (intine thickness) were measured, and the P/E ratio was calculated, Apt (aperture type), and Or (ornamentation) for 30 pollen grains were measured under light microscope. The terminology of the pollen follows that of Punt et al. [35]. The values are presented as minimum, maximum and mean, that is represented in Table 2.

Capsules were examined using an Isolab stereo microscope. In order to determine the average capsule sizes, 30 unripe capsules were measured. The terminology of the capsule follows that of Attar et al. [30].

**Table 1.** *Verbascum* taxa used for morphology studies and collected localities

Species	Collection areas and habitat	Collector	Collector's number
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<i>V. × calcicola</i>	Turkey, C8 Mardin: Artuklu, roadside, slopes area, 37°23'06"N 40°39'39"E, 1130 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 274</i> <i>M.Kılıç 399-2</i>
	Mardin: Artuklu, Mardin-Diyarbakır road, 26 km north of Mardin, roadside, calcareous slopes, 1039 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 344-2</i>
	Mardin: Kızıltepe, roadside, rocky area, 37°16'14"N 40°38'57"E, 598 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 248</i> <i>M.Kılıç 319</i>
	Mardin: Kızıltepe, roadside, rocky area, 37°16'26"N 40°38'41"E, 620 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 375</i>
	Mardin: Mazıdağı, slopes area, 37°29'11"N 40°30'35"E, 990 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 280</i>
	Mardin: Midyat, roadside, slopes area, 37°26'15"N 41°18'07"E, 928 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 314-1</i> <i>M.Kılıç 403-2</i>
	Mardin: Midyat, roadside, slopes area, 37°27'54"N 41°04'59"E, 1030 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 405-4</i>
	Mardin: Midyat, roadside, slopes area, 37°26'15"N 41°18'07"E, 928 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 404-1</i>
<i>V. × kotschyoides</i>	Mardin: Savur, roadside, rocky area, 37°31'18"N 40°54'26"E, 1070 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 341-2</i> <i>M.Kılıç 410-1</i>
	Mardin: Artuklu, roadside, slopes area, 37°17'07"N 40°46'32"E, 742 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 332</i> <i>M.Kılıç 380-2</i>
	Mardin: Artuklu, roadside, rocky area, 37°13'22"N 40°58'23"E, 701 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 363-1</i>
	Mardin: Derik, Derik-Mazıdağı road, 10 km after Derik, roadside, rocky slope.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 279</i>
	Mardin: Kızıltepe, roadside, slopes area, 37°16'49"N 40°32'36"E, 721 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 325</i>
	Mardin: Mazıdağı, Mardin-Diyarbakır road, 24 km from Çınar, roadside, calcareous slopes, 929 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 345-2</i>
	Mardin: Midyat, roadside, slopes area, 37°27'54"N 41°04'59"E, 1030 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 405-3</i>
	Mardin: Nusaybin, roadside, rocky area, 37°12'00"N 41°01'01"E, 756 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 302</i>
	Mardin: Savur, roadside, 37°27'12"N 40°51'38"E, 940 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 333-2</i>
	Mardin: Savur, roadside, rocky area, 37°32'47"N 40°53'35"E, 833 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 339</i>
	Mardin: Savur, roadside, rocky area, 37°28'28"N 41°01'49"E, 1094 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 343-2</i>

	Mardin: Yeşilli, roadside central median, 37°22'17"N 40°51'38"E, 1158 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 307-1</i> <i>M.Kılıç 401-3</i>
<i>V. × nusaybinense</i>	Mardin: Artuklu, roadside, rocky area, 37°20'44"N 40°43'44"E, 834 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 371-1</i> <i>M.Kılıç 388</i>
	Mardin: Nusaybin, roadside, creek edge, 37°08'11"N 41°04'44"E, 536 m.	F. Mungan Kılıç M. Kılıç	<i>M.Kılıç 300-3</i> <i>M.Kılıç 377-1</i>

### 3. Results and Discussion

In this study, various features of pollen and capsule structure of three hybrid *Verbascum* taxa were stated. The characteristics of pollen grains are summarized in Table 2 and shown in Figure 1. The morphological characters of the capsule grains, including their size, shape, and color are summarized in Table 3 and shown in Figure 2.

#### 3.1. Pollen morphology

##### 3.1.1. Size, symmetry and shape

The pollen grains of *Verbascum* are isopolar and radially symmetric. The pollens of the taxa are oblate-spheroidal and subspheroidal with the polar axis 10.11-16.52 µm and the equatorial diameter 5.24-16.48 µm. Their dimensions are smaller in *V. × nusaybinense* and larger in *V. × kotschyoides* (Table 2, Figure 1).

##### 3.1.2. Apertures

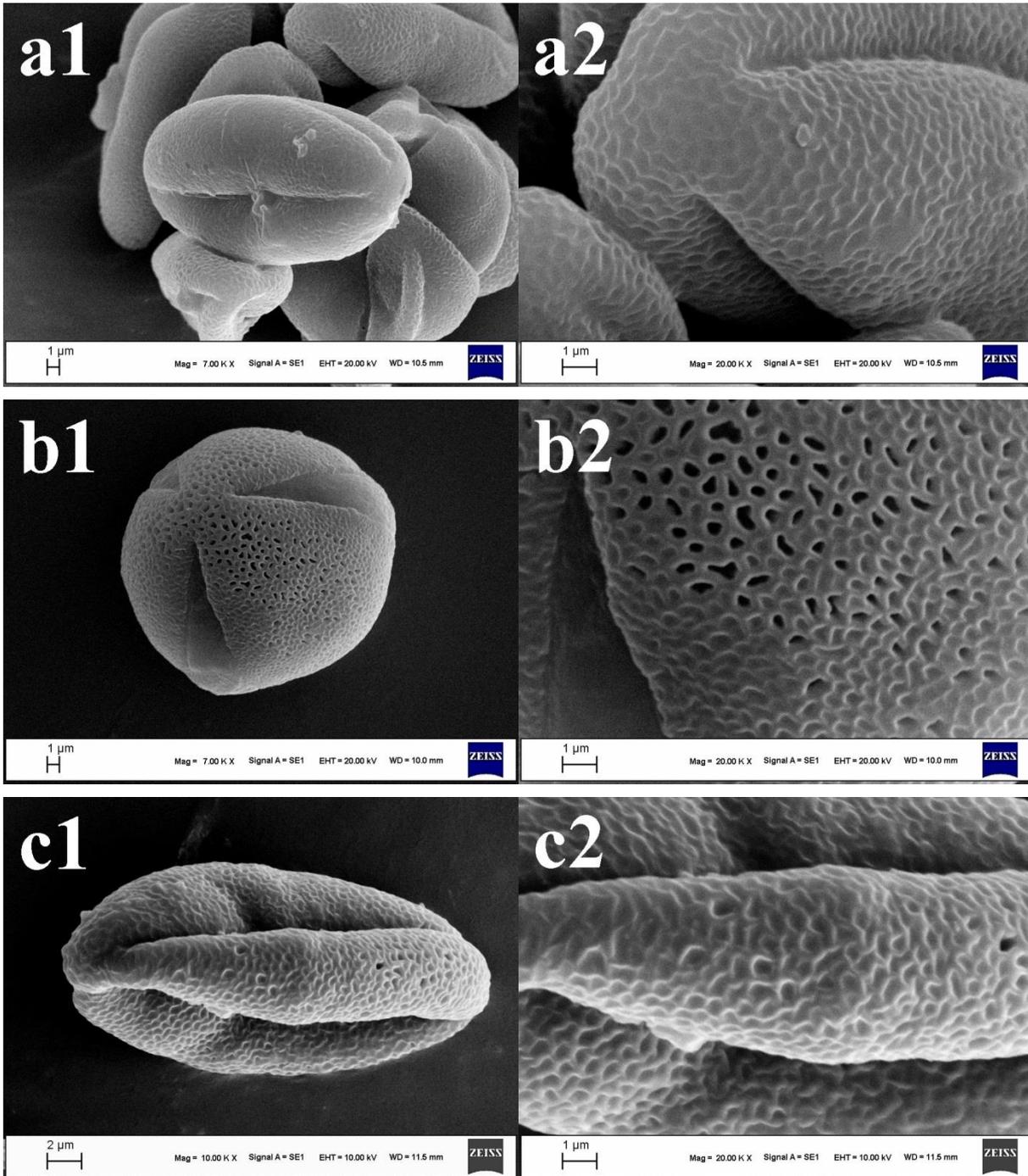
The pollen grains of *Verbascum* are tricolporate (in *V. × calcicola* 13%, *V. × kotschyoides* 29%, and *V. × nusaybinense* 52% tricolporate). The colpus is length (7.49-12.64 µm) and width (2.21-4.94 µm), margins distinct, regular and ends acute. The porus is 2.77-5.38 µm in length and 2.30-5.02 µm in width. (Table 2, Figure 1).

##### 3.1.3. Exine, intine and ornamentation

The exine thickness ranges from 0.54 to 1.50 µm. The intine thickness is 0.28-0.79 µm thin (Table 2). Exine sculpturing is reticulate in all investigated species (Table 2, Figure 1).

**Table 2.** Pollen morphological characters in taxa of *Verbascum* (µm)

Species	P min (mean ) max	E min (mean ) max	P/E rati o	Shape	Clg min (mean ) max	Clt min (mea n) max	Plg min (mea n) max	Plt min (mea n) max	Ex min (mea n) max	In min (mea n) max	Apt	Or
<i>V. x calcicola</i>	12.34 (14.0 6) 16.52	6.00 (8.85) 11.38	1.5 9	Subprolate	8.41 (10.7 8) 12.51	2.22 (3.17) 4.35	3.13 (3.93) 5.14	2.30 (3.11) 4.23	0.64 (0.84) 1.06	0.30 (0.46) 0.68	87% Tricolporate 13%	Reticulate
<i>V. x kotschyoides</i>	11.92 (13.6 9) 14.94	12.66 (14.6 7) 16.48	0.9 3	Oblate-spheroidal	9.42 (10.9 2) 12.64	2.80 (3.59) 4.94	3.70 (4.52) 5.38	2.80 (3.89) 5.02	0.75 (1.09) 1.50	0.40 (0.59) 0.79	71% Tricolporate 29%	Reticulate
<i>V. x nusaybinense</i>	10.11 (11.4 8) 13.61	5.24 (7.24) 8.69	1.5 9	Subprolate	7.49 (9.39) 11.85	2.21 (2.66) 3.68	2.77 (3.43) 4.32	2.58 (3.01) 3.68	0.54 (0.69) 0.87	0.28 (0.40) 0.56	48% Tricolporate 52%	Reticulate



**Figure 1.** Scanning electron micrographs of pollen in taxa *Verbascum*. 1- General view, 2- Exine sculpturing. (a1-a2) *V. x calcicola* (M.Kılıç 248), (b1-b2) *V. x kotschyoides* (M.Kılıç 325), (c1-c2) *V. x nusaybinense* (M.Kılıç 300-3)

### 3.2. Capsule morphology

#### 3.2.1. Capsule size

According to the measurements made, the dimensions vary between species from 1.86 to 3.61 mm in length and 1.47 to 3.26 mm in width. Their dimensions are

smaller in *V. x calcicola* and larger in *V. x nusaybinense* (Table 3, Figure 2).

truncated beak in *V. x nusaybinense* (Table 3, Figure 2).

### 3.2.2. Capsule shape

Oblong and ovate are the shapes of capsules observed among the studied taxa (Table 3, Figure 2).

### 3.2.3. Capsule colour

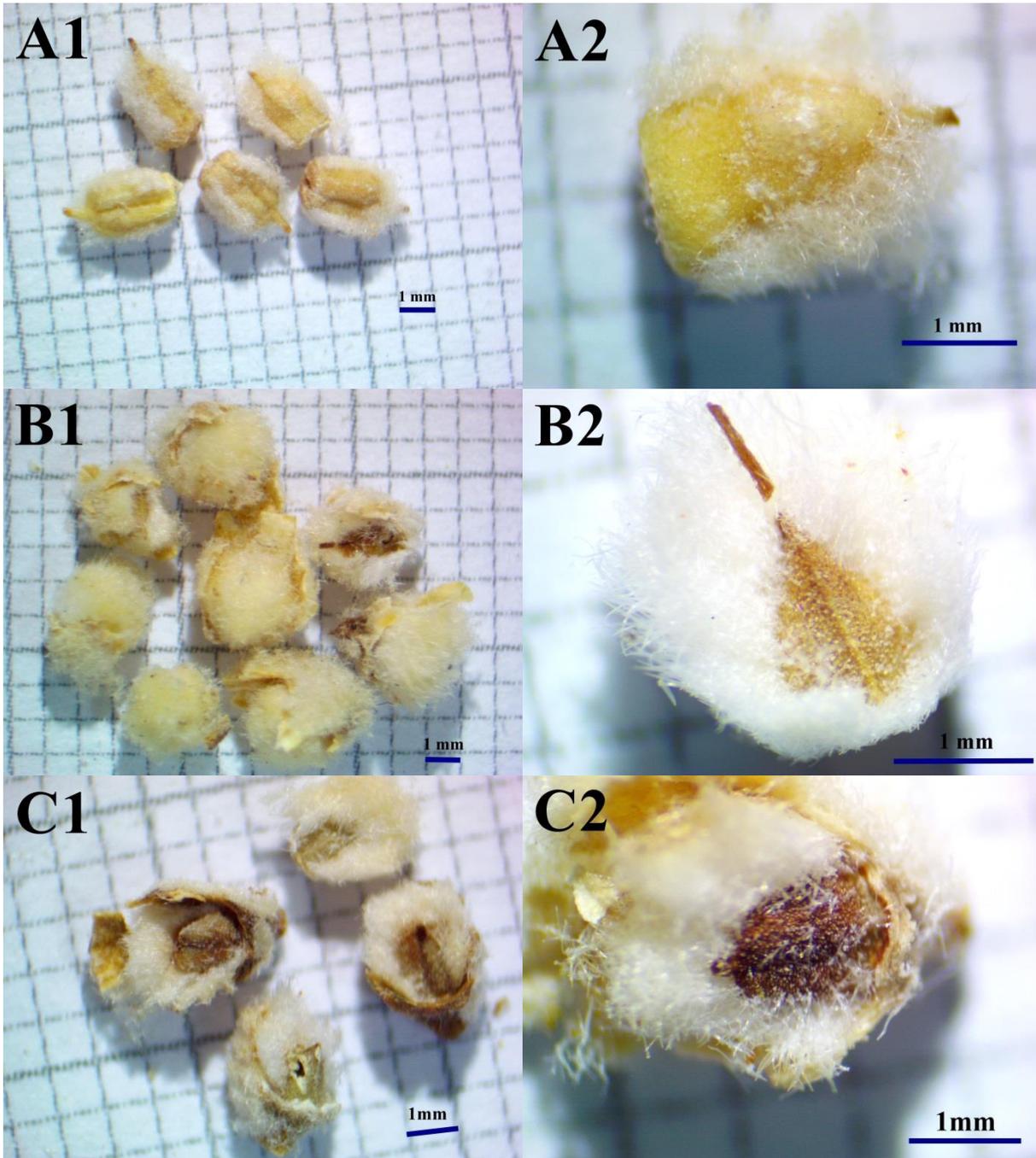
In this study there are three different capsule colour observed as light brown, brown, and dark brown (Table 3, Figure 2).

### 3.2.3. Apex of the capsules

The capsules have acute beak in *V. x kotschyoides*, acute beak to obtuse beak in *V. x calcicola* or

**Table 3.** Capsule morphological characters in taxa of *Verbascum*

Species (Collector number)	Length (mm) min (mean) max	Width (mm) min (mean) max	Colour	Shape	Hair
<i>V. x calcicola</i> (M.Kılıç 375)	1.86 (2.69) 3.61	1.78 (2.03) 2.34	Light brown	Ovate, oblong, often with acute beaks, and some with obtuse beaks	Densely stellata, branched, glandular
<i>V. x kotschyoides</i> (M.Kılıç 332)	2.10 (2.85) 3.38	1.47 (2.38) 3.26	Brown	Ovate, acute long beaks	Densely stellata, branched, sparsely glandular
<i>V. x nusaybinense</i> (M.Kılıç 377-1)	2.35 (2.95) 3.45	1.95 (2.22) 2.72	Brown-dark brown	Oblong, ovate, often with short obtuse beaks, and some with truncate beaks	Densely stellata, branched, sparsely glandular



**Figure 2.** Stereo microscopy photographs of capsule in taxa *Verbascum*. 1- General view, 2- Close view. (A1-A2) *V. x calcicola*, (B1-B2) *V. x kotschyoides*, (C1-C2) *V. x nusaybinense*

#### 4. Conclusion and Suggestions

Analyzes of pollen grains and capsules of the three hybrid *Verbascum* taxa studied for the first time in this study make them comparable to some of the other *Verbascum* members investigated.

The pollen of three hybrid *Verbascum* taxa isopolar and radially symmetric, oblate-spheroidal, subprolate, tricolporate (there is tricolpate), the exine exhibits a tectate structure and reticulate

ornamentation. Baser [28], in his study on *Verbascum* (8 species), established the pollen grains as tricolporate and tricolpate. Aktas et al. [27] determined the pollen grain as tricolpate in their study on the endemic *Verbascum* species. Aktas [29] noted the pollen grain as tricolpate in his study on *Verbascum x splendidum* taxa. Öztürk et al. [20] reported that there were tricolporate and tricolpate aperture types in their pollen study on *Verbascum*. Al-Hadeethy et al. [26] stated that the aperture types of

*Verbascum* species (20 species) were tricolporate. Çakir and Bağcı [36] determined the tricolporate aperture types of *Verbascum* species in their study. Aperture type of *Verbascum* reported to have tricolporate aperture type [25, 37].

In the pollen of three investigated species determined oblate-spheroidal and subprolate shape. However, Aktas et al. [27] recorded the prolate pollen shape in the endemic *Verbascum* species examined. Aktas [29] stated that the pollen shape of the *V. x splendidum* he researched has subprolate. Nevertheless, Baser [28] recorded the prolate pollen shape in the *Verbascum* (8 species) taxa in the studied. Öztürk et al. [20] stated that pollen shapes were prolate-spheroidal and oblate-spheroidal in the taxa studied. Asmat et al. [25] determined that the pollen grains of *V. thapsus* was oblate-spheroidal. Kheiri et al. [37] determined that the pollen of *V. mucronatum* species was prolate-spheroidal. In addition, Al-Hadeethy et al. [26] observed the presence of prolate-spheroidal and oblate-spheroidal pollen in *Verbascum* (20 species). Morphological pollen traits observed through LM proved not very important in their taxonomic use, but sculpting examined by SEM was found to be more significant in the classification of taxa [28, 38].

Since exine thickness did not make a significant difference between the studied taxa, this character was ignored for taxonomic discrimination [26]. The results obtained from this study are compatible with studies on *Verbascum* [20, 25-28]. However, all taxa included in our study showed a reticulate exine sculptural pattern.

Capsules of the three hybrid *Verbascum* taxa are densely covered with stellate, branched, and more or less glandular hairs. In some *Verbascum* species distributed in Spain [22] and Iran [30], the capsules have a similar hair indumentum. Based on the available findings, one of the reliable features for classification in *Verbascum* is the indumentum of the capsule.

The results of this study predicted that it is the first study on capsule and pollen characteristics of three hybrid *Verbascum* taxa and will form a comprehensive taxonomic awareness, especially at the species level. The results of this study showed that morphological features, such as pollen shape, polar axis, equatorial diameter, aperture type, exine and intine thickness, colpus, and porus measurement, show differences that can be taken into consideration in the systematic discrimination within the taxa. The capsule showed that substantial taxonomic insight can be gained from examining the capsule characteristics of *Verbascum*, particularly at the species level. Based on the available findings, one of the reliable characteristics for grouping in *Verbascum* is the indumentum and shape of the capsule.

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### Contributions of the authors

MK and FMK planned the study. MK carried out fieldwork. All authors analyzed the data and provided comments on the study. MK wrote the manuscript. All authors read and approved the final manuscript.

### Conflict of Interest Statement

The authors declare that they have no conflict of interest.

### Statement of Research and Publication Ethics

The study is complied with research and publication ethics.

## References

- [1] E. Fischer. "Scrophulariaceae. In: J. W. Kadereit (ed), Flowering Plants Dicotyledons," *The Families and Genera of Vascular Plants, Paris*, vol.7 pp. 333-432, 2004.
- [2] M. J. Christenhusz & J. W. Byng. "The number of known plants species in the world and its annual increase." *Phytotaxa*, vol.261 no.3, pp. 201-217, 2016.
- [3] S. Murbeck. "Weitere Studien über die Gattungen *Verbascum* und *Celsia*," *Acta Univ. Lund.* vol. 2 no. 35, pp. 1-70, 1939.
- [4] D. J. Mabberley. "Mabberley's plant book: a portable dictionary of plants, their classifications and uses," *Cambridge Univ. Press.*, 2008.
- [5] M. I. Georgiev, K. Ali, K. Alipieva, R. Verpoorte & Y. H. Choi. "Metabolic differentiations and classification of *Verbascum* species by NMR-based metabolomics." *Phytochemistry*, vol.72 no.16, pp.2045-51, 2011.
- [6] M. Riahi & F. Ghahremaninejad. "The tribe Scrophulariaceae (Scrophulariaceae): A Review of Phylogenetic Studies." *Hacquetia*, vol.18 no. 2, 2019.
- [7] M. Hassler. "Synonymic Checklists of the Vascular Plants of the World. In: O. Bánki, Y. Roskov, L. Vandepitte, R. E. DeWalt, D. Remsen, P. Schalk, T. Orrell, M. Keping, J. Miller, R. Aalbu, R. Adlard, E. Adriaenssens, C. Aedo, E. Aescht, N. Akkari, M. A. Alonso-Zarazaga, B. Alvarez, F. Alvarez & Anderson, G. (eds), *Catalogue of Life Checklist* (Version 2021-08-06), 2021.
- [8] A. Huber-Morath. "*Verbascum* L. In: P. H. Davis (ed.)," *Flora of Turkey and the East Aegean Islands*, *Edinburgh Univ. Press*, vol. 6 pp. 461-603, 1978.
- [9] P. H. Davis, R. R. Mill and K. Tan. "Flora of Turkey and the East Aegean Islands (Suppl. 1)", *Edinburgh Univ. Press*, vol. 10. pp. 191-193, 1988.
- [10] F. A. Karavelioğulları. "*Verbascum* L. In: A. Güner (ed.), Türkiye Bitkileri Listesi (Damarlı Bitkiler)," *Nezahat Gökyiğit Botanik Bahçesi ve Flora Araştırmaları Derneği Yayını, İstanbul*, pp. 850-870, 2012.
- [11] F. Ghahremaninejad, M. Riahi, M. Babaei, F. Attar, L. Behcet & A. Sonboli. "Monophyly of *Verbascum* (Scrophulariaceae: Scrophulariaceae): evidence from nuclear and plastid phylogenetic analyses." *Australian Journal of Botany*, vol.62 no.8, pp. 638-46, 2015.
- [12] T. Ekim. *Verbascum* L. In: Güner, A. (ed.), *Flora of Turkey and the East Aegean Islands* (Suppl. 2), *Edinburgh Univ. Press.* vol. 11, p. 193, 2000.
- [13] F. A. Karavelioğulları. "A new record *Verbascum szovitsianum* Boiss. var. *szovitsianum* (Scrophulariaceae) from Turkey." *Biodicon.*, vol. 2, pp. 68-70, 2009.
- [14] M. Firat. "*Verbascum zerdust* (Scrophulariaceae), a new species from Bitlis province (Turkey) belonging to section *Bothrosperma*." *Nordic Journal of Botany*, doi: 10.1111/njb.03649, 2022.
- [15] F. A. Karavelioğulları, E. Yüce & B. Başer. "*Verbascum duzgunabadagensis* (Scrophulariaceae), a new species from eastern Anatolia, Turkey." *Phytotaxa*, vol.181, pp. 47-53, 2014.
- [16] B. Oxelman, P. Kornhall, R. G. Olmstead & B. Bremer. "Further disintegration of Scrophulariaceae." *Taxon*, vol. 54 no. 2, pp.411-25, 2005.
- [17] J. B. Lust and M. Tierra. "The Natural Remedy Bible," *Simon and Schuster*, 2003.
- [18] S. Vogl, P. Picker, J. Mihaly-Bison, N. Fakhrudin, A. G. Atanasov, E. H. Heiss, C. Wawrosch, G. Reznicek, V. M. Dirsch & J. Saukel. "Ethnopharmacological in vitro studies on Austria's folk medicine

- an unexplored lore in vitro anti-inflammatory activities of 71 Austrian traditional herbal drugs.” *Journal of Ethnopharmacology*, vol.149 no.3, pp.750–71, 2004.
- [19] V. Kaur & K. Upadhyaya. “Antibacterial activity of *Verbascum chinense* (Scrophulariaceae) extracts.” *International Journal of Current Microbiology and Applied Sciences*, vol.5 no.4, pp. 578–84, 2016.
- [20] A. Öztürk, K. B. Güney, B. Bani, K. Güney, F. A. Karaveliogullari, N. M. Pinar & T. Çeter. “Pollen morphology of some *Verbascum* (Scrophulariaceae) taxa in Turkey.” *Phytotaxa*, vol.333 no.2, pp.209-218, 2018. <https://doi.org/10.11646/phytotaxa.333.2.4>
- [21] J. P. Minkin & W. Hardy-Eshbaugh. “Pollen morphology of the Orobanchaceae and Rhinanthoid Scrophulariaceae.” *Grana*, vol.28, pp. 1-18, 1989. <https://doi.org/10.1080/00173138909431007>
- [22] R. Juan, I. Fernandez & J. Pastor. “Systematic consideration of microcharacters of fruits and seeds in the genus *Verbascum* (Scrophulariaceae).” *Annals of Botany*, vol.80, pp. 591-598, 1997. <https://doi.org/10.1006/anbo.1997.0472>
- [23] F. Dane and G. Yilmaz. “Palynological study on some *Verbascum* L. species. The third international conference “Falz Fein Reading”, p. 151, 25-27 April 2002. Training University, Kherson, Ukraine.
- [24] S. Kheyri. “Identification of breeding system of some species of *Verbascum* (Scrophulariaceae) in north-west of Iran on the basis of the ratio of pollen to ovule number.” *Biological Journal of Islamic Azad University, Garmsar Branch*, vol.4, pp. 67-74, 2009.
- [25] T. Asmat, M. A. Khan, M. Ahmed, M. Zafar, F. Manzoor, M. Munir, K. Akhtar, S. Bashir, T. Mukhtar, M. Ambreen & S. N. Abbasi. “Pollen morphology of selected species of Scrophulariaceae of District Dir Upper, Pakistan.” *Journal of Medicinal Plants Research*, vol.5, pp. 6423-6428, 2011. <https://doi.org/10.5897/JMPR11.723>
- [26] M. Al-Hadeethy, A. Al-Mashhadani, T. Al-Khesraji, S. Barusrux, H. Al-Jewari, P. Theerakulpisut & P. Pornpongrungrueng. “Pollen morphology of *Verbascum* L. (Scrophulariaceae) in Northern and Central Iraq.” *Bangladesh Journal of Plant Taxonomy*, vol. 21, pp. 159-165, 2014. <https://doi.org/10.3329/bjpt.v21i2.21355>
- [27] K. Aktas, C. Özdemir & B. Özdemir. “Morphology, Anatomy, Palynology and Seed Micromorphology of Turkish Endemic *Verbascum exuberans* Hub.-Mor. (Scrophulariaceae).” *Planta Daninha*, v38:e020191125, 2020.
- [28] B. Baser. “Pollen and Seed Morphology of *Verbascum* Species (Group D) (*Scrophulariaceae*) in Turkey.” *Fresenius Environmental Bulletin*, vol.30 no.7, pp. 8978-8987, 2021.
- [29] K. Aktas. “Morphology, Anatomy, Palynology and Seed Micromorphology of Turkish Endemic *Verbascum x splendidum* Boiss. (Scrophulariaceae).” *Fresenius Environmental Bulletin*, vol.28 no.12, pp. 10004-10010, 2019.
- [30] F. Attar, A. Keshvari, A. Ghahreman, S. Zarre & F. Aghabeigi. “Micromorphological studies on *Verbascum* (Scrophulariaceae) in Iran with emphasis on seed surface, capsule ornamentation and trichomes.” *Flora*, vol. 202, pp. 169-175, 2007. <https://doi.org/10.1016/j.flora.2006.04.001>
- [31] G. Erdtman. “Pollen Morphology and Plant Taxonomy: Angiosperms.” *Chronica Botanica Co., Massachusetts, USA*, pp. 1-553, 1952.
- [32] R. P. Wodehouse. “Pollen Grains, their structure, identification and significance in science and medicine.” *Hafner Publishing Company, New York*, 1935.
- [33] E. Cabi, B. Baser, A. Yavru, F. Polat, U. Toprak & F. A. Karaveliogullari. “Scanning electron microscope (SEM) and Light microscope (LM) studies on the seed morphology of *Verbascum* taxa

- (Scrophulariaceae) and their systematic implications.” *Australian Journal of Crop Science*, vol.5, pp. 660-667, 2011.
- [34] S. Kheiri, M. Khayami & A. Mahmoudzadeh. “Micromorphological and anatomical studies of certain species of *Verbascum* (Scrophulariaceae) in West Azerbaijan, Iran.” *Iran Journal of Botany.*, vol.15, pp. 105-13, 2009.
- [35] W. Punt, P. P. Hoen, S. Blackmore, S. Nilsson & A. Le-Thomas. “Glossary of pollen and spore terminology.” *Review of Palaeobotany and Palynology*, vol.143, pp. 1-81, 2007.
- [36] T. Çakir & E. Bağcı. “A taxonomical study on the *Verbascum euphraticum* Bentham and *Verbascum melitenense* Boiss (Scrophulariaceae).” *Firat University Journal of Engineering Science*, vol.18 no.4, pp. 445-58, 2006.
- [37] S. Kheiri, M. Khayami, S. K. Osaloo & A. Mahmoodzadeh. “Pollen morphology of some species of *Verbascum* L. (Scrophulariaceae) in Urmia.” *Pakistan Journal of Biological Sciences*, vol.9, pp. 434-436, 2006.
- [38] S. Pehlivan, B. Baser B & F. A. Karaveliogullari. “Pollen morphology of the genus *Verbascum* L. (Group A) in Turkey.” *Biodicon.*, vol.1, pp. 1-24, 2008.