Palynological Characteristics of Jasione Species Native to Turkey

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Palynological characteristics of *Jasione* species native to Turkey

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ABSTRACT

Pollen grains of seven *Jasione* (Campanulaceae) taxa from Turkey were investigated: *J. heldreichii* Boiss & Orph., *J. idaea* Stoj., *J. montana* L., *J. supina* subsp. *supina*, *J. supina* subsp. *pontica*, *J. supina* subsp. *akmanii*, and *J. supina* subsp. *tmolea*. Four of the investigated taxa were in the VU (vulnerable) category and one is in the LC (least concern) category (categorized by the International Union for Conservation of Nature). The basic shape of the pollen grains was prolate-spheroidal and oblate-spheroidal; the apertures vary from triporate- to tetra-porate. The sculpturing pattern of exine was microechinate. Two types were recognised according to the pollen shape. Type I is prolate-spheroidal, whereas Type II is oblate-spheroidal. This research will be helpful to explain the relationships among the genera of Campanulaceae and provides insights for future phylogenetic research.

KEYWORDS

Jasione; Turkey; pollen; porate; microreticulate

1. Introduction

The Campanulaceae are a nearly cosmopolitan angiosperm family consisting of latex-bearing, primarily perennial herbs or occasional subshrubs that typically have alternate leaves, sympetalous corollas, inferior ovaries, and capsular fruits. Their species diversity is highest in the Northern hemisphere (Perveen and Qaiser 1999). Taxanomic treatments lack consensus. Campanulaceae in the strict sense comprise 600 to 950 species distributed among 35 to 55 genera. Generic circumscription and intrafamilial classification vary widely according to author (Cosner et al. 2004).

Many authors have divided the family into subtribes. For example, De Candolle (1830) divided the family into the subtribes Campanulae (capsule with apical dehiscence) and Wahlenbergeae (capsule with lateral dehiscence), and placed the genus *Jasione* L. in the subtribe Wahlenbergae. Subsequently, Schönland (1889–1894) divided the family into three subtribes – Campanulinae, Wahlenberginae, and Platycodinae – placing the genus *Jasione* L. in the subtribe Wahlenberginae.

Various authors have used their own modified system with many nomenclatural changes, and great confusion has resulted. The lack of consensus regarding what constitutes a genus and the failure to apply important character combinations (e.g. cytological and palynological characters) have restrained the reconstruction of the phylogeny of the family Campanulaceae (Eddie et al. 2003). Recent studies employing molecular phylogenetic approaches have made progress in resolving the evolutionary relationships of the family (Mansion et al. 2012; Crowl et al. 2014, 2016; Yoo et al. 2018).

Avetisian (1948, 1967, 1986) was the first researcher to pay attention to the different pollen morphologies within the family. She pointed out that pollen with colpate and colporate apertures are typical of those taxa found in the tropics, whereas those with porate apertures are typical of taxa from temperate regions.

The genus *Jasione* L. comprises annual, biennial or perennial herbs. Flowers are small, usually shortly pedicellate, in terminal heads surrounded by one or more rows of involucral bracts. The calyx is 5-fid; the corolla is split nearly to its base into five linear-lanceolate lobes. There are five stamens with subulate filaments. The anthers connate at the base. The ovary is 2-locular; the upper part of the style is hairy, with two short, thick stigmas. The fruit is a small, semiglobose capsule, dehiscing by two apical valves. The seeds are ovate, shiny, and brown, and measure 0.6–1 mm (Davis 1978).

The genus *Jasione* L. is represented by ca. 16 species distributed throughout Europe and the Mediterranean region, from coastal dunes to alpine zones and growing on a wide variety of substrates. The genus shows a high degree of polymorphism, which may be partially caused by its representation across a wide range of ecological niches (Gallego et al. 2015). *Jasione montana* is the most widespread species in the genus, occurring commonly throughout Europe (Parnell 1987).

Sales et al. (2004) obtained Internal Transcribed Spacers (ITS) sequences from five species of *Jasione* (*J. crispa*, *J. laevis*, *J. maritima*, *J. montana*, and *J. sessiliflora*), including three subspecies of *J. montana* and two of *J. maritima*, but found no significant sequence variation among the *J. montana* and *J. maritima* samples. They found the maximum divergence within *Jasione* to be 5.3%, between *J. crispa* and *J. sessiliflora*; this is relatively low compared with divergences of ITS sequences calculated for intrageneric analyses in other families. Also, they included only one representative of the Turkish taxa and indicated that to properly analyse the

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Table 1. Taxa, voucher specimens and collection data.

Taxon	Category	Collection data	Collection date	Features
Jasione heldreichii Boiss. & Orph		Afyon: İscehisar, Konaklı village, 1300 m (H. Altınözlü, H.A. 6310)	30 June 2018	
Jasione idaea Stoj.	VU	Çanakkale, Bayramiç, Kazdağ, Baba hill, Rocky fields, 1740 m (H. Altınözlü, H.A. 6307)	15 June 2018	Endemic to Kaz mountains Euxine element (Davis 1978)
Jasione montana L.		Çanakkale, Lapseki, Şahinli village, Rocky fields, 450–500 m (H. Altınözlü, H.A. 6303)	12 June 2018	
Jasione supina Sieber subsp. *akmanii*	VU	Kütahya, Gediz, Murat Mountain, Rocky fields, 2000–2100 m (H. Altınözlü, H.A. 6313)	21 July 2018	Endemic Euxine element (Davis 1978)
Jasiona supina Sieber subsp. *pontica* (Boiss.) Damboldt	LC	Çankırı, Ilgaz, Ilgaz Mountain, Rocky fields, 2200 m (H. Altınözlü, H.A.6314)	27 July 2018	Endemic Euxine element (Davis 1978)
Jasione supina Sieber subsp. *supina*	VU	Bursa, Uludağ, Ski Center, oteller çevresi, 1950 m (H. Altınözlü, H.A. 6312)	26 July 2018	Endemic to Uludağ Euxine element (Davis 1978)
Jasione supina Sieber subsp. *tmolea* (Stoj) Damboldt	VU	İzmir, Bozdağ, 1200 m (H. Altınözlü, H.A.6316)	29 July 2018	Endemic to Boz Dağları Medit. element (Davis 1978)

relationships among species and variety, more taxa need to be included in future analyses, particularly from Turkey.

Jasione L. has been associated with the Wahlenbergioid taxa because of the apical valvate dehiscence of the capsule according to Alphonse de Candolle's monograph of 1830. Fedorov (1957) treated it as a separate tribe, the *Jasioneae* Fed., within Schönland's subfamily Campanuloideae, and a similar view was adopted in the provisional classification of Eddie et al. (2003).

Eddie et al. (2003) estimated the phylogeny of Campanulaceae based on ITS sequences of nuclear ribosomal DNA. Their results show a major dichotomy between the colpate/colporate pollen alliance (platycodonoid taxa) and the porate pollen alliance (wahlenbergioid and campanuloid taxa). Within the porate alliance there are two major clades, the wahlenbergioids and the campanuloids. The campanuloid clade is further subdivided into two major clades, representing the *Rapunculus* and the *Campanula* s. str. groups, plus three smaller clades that are considered 'transitional' taxa. They evaluated the genus *Jasione* L. in this (transitional) clade and stated the relationship of *Jasione* to other taxa of Campanulaceae in the ITS tree is unresolved. *Jasione* has most frequently been associated with the wahlenbergioid alliance; it does bear some resemblance to *Feeria* Buser with which it shares a similar mode of capsule dehiscence, but it has a chromosome number of $2n = 12$ ($2n = 34$ for *Feeria*).

On the other hand, Cosner (1993), using rearrangements of the chloroplast genome, showed that *Jasione* is, on balance, closer to the campanuloids. It forms a clade with *Adenophora* Fisch., *Campanula* L., *Edraianthus* A.D.C., *Musschia* Dumort., *Symphyandra* A.D.C., and *Trachelium* L., but it has the most highly rearranged chloroplast genotype in the family. Also, Sales et al. (2004) indicated that *Jasione* appears to have more morphological similarity to campanuloids (e.g. coloured pollen and *Adenophora*-like stigmatic lobes) than to wahlenbergioids, and its Mediterranean distribution is typically campanuloid.

Crowl et al. (2014) presented results based on both chloroplast and low-copy nuclear loci and discussed evolutionary relationships within the Campanuloideae clade. They found *Jasione* and *Wahlenbergia hederacea* to be sister taxa.

The comparative pollen morphology of the family was studied by Chapman (1966). Dunbar and Wellentinus (1976) utilised the palynological data of the family Campanulaceae for numerical taxonomy. Dunbar (1975) studied the pollen morphology of Campanulaceae and related families with special reference to ultrastructure. Oybak and Pınar (1995) examined the pollen morphology of some species of the family Campanulaceae from Turkey. The pollen morphology of the family Campanulaceae was also studied by Tarnavschi (1919), Erdtman (1952), Fernandes (1962), Avetisian (1967), Geslot and Medus (1971), Badre et al. (1972), Belem (1976), Inceoglu (1976) and Moore and Webb (1978).

Despite this plethora of phylogenetic investigations, uncertainty about the classification of the Campanulaceae remains. Palynological research can be helpful to explain the systematic relationships between the genera of Campanulaceae. Pollen morphology may be useful in the taxonomic investigation of *Jasione* at various levels.

Since previous authors have already carried out extensive observations on the pollen morphology of *Campanula*, *Asyneuma*, *Legousia*, *Michauxia*, *Zeugandra*, *Theodorovia* (Khansari et al. 2012), *Carania*, *Cyananthus*, *Ostrowskia* (Erdtman 1952), *Echinocodon* (Hong 1984), *Campanumoea*, *Cyclocodon*, *Leptocodon*, and *Codonopdid* (Yuan and Yu 2012), the present study is concerned instead with the pollen morphology of the genus *Jasione*.

In Turkey, four species and a total of seven *Jasione* taxa are recognised: *J. heldreichii* Boiss & Orph., *J. idaea* Stoj., *J. montana* L., *J. supina* subsp. *supina*, *J. supina* subsp. *pontica*, *J. supina* subsp. *akmanii*, and *J. supina* subsp. *tmolea* (Davis 1978).

Within the family Campanulaceae, the genus *Jasione* is an ecologically and evolutionary important member. However, detailed data on the pollen morphology of this genus is lacking. Here we present the results of analysis with SPSS statistical software, to evaluate the addition of each morphometric parameter measured on the pollen grains to the classification of the seven native Turkish *Jasione* taxa listed above. These results will likely be useful for future evolutionary studies of the group.

Additionally, to evaluate the contribution of each morphometric parameter measured on the pollen grains to the ordination of different apricot cultivars, multivariate statistical analysis was performed on standardised data (Chatfield and Collins 1995), using SPSS (Norusis 1988).

2. Material and methods

2.1. Plant materials

Pollen grains of seven taxa of the genus *Jasione* were investigated. A list of voucher specimens used in this research and the collections data are given in Table 1. The distribution of the seven taxa in Turkey is shown in Figure 1.

2.2. Preparation of pollen slides for microscopic analysis

Pollen grains were obtained from mature anthers of fresh flowers. For light microscope (LM) investigation, pollen slides were prepared with glycerin gelatin and basic fuchsine according to the Wodehouse method (Wodehouse 1935).

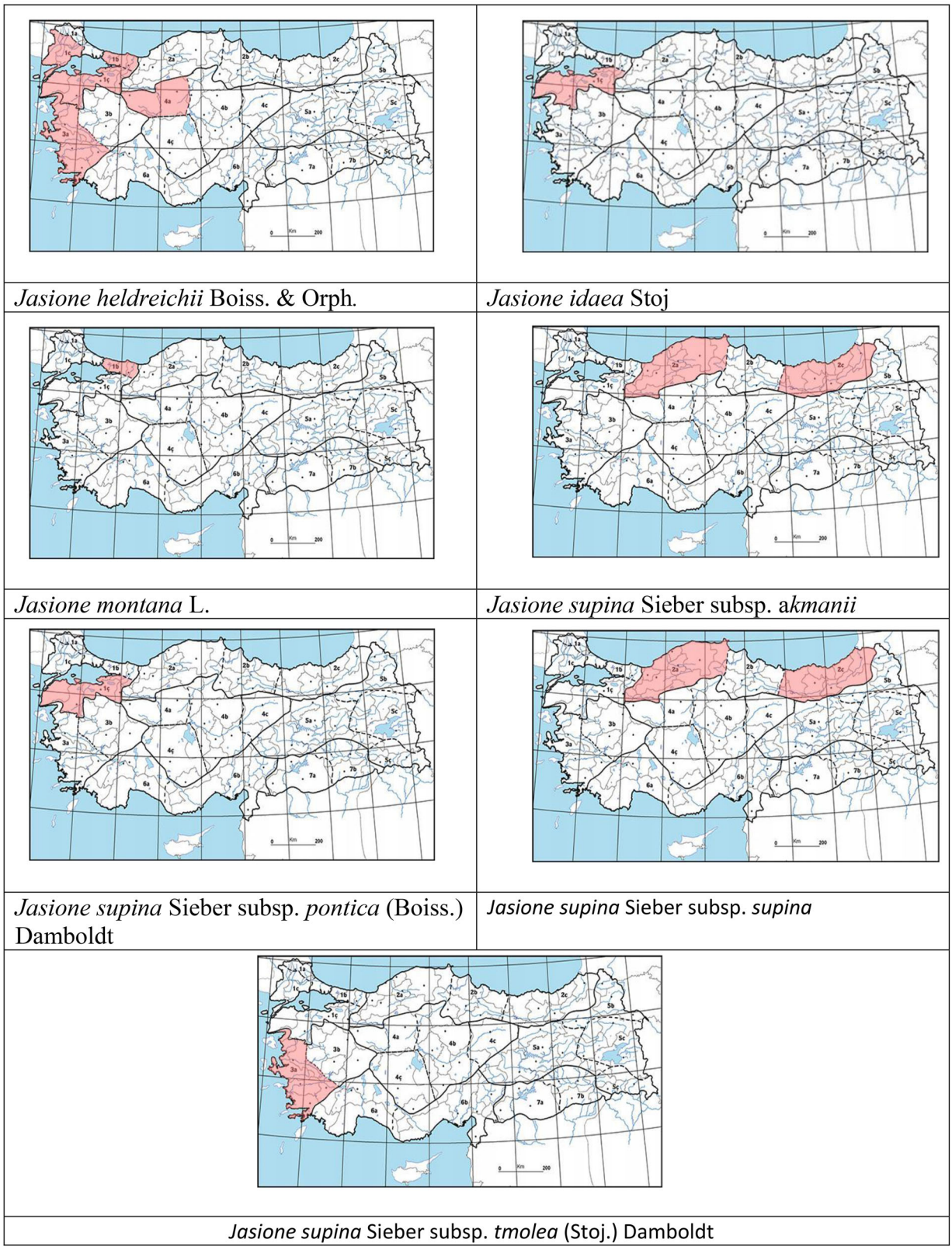

Figure 1. The distribution of the genus *Jasione* in Turkey.

Table 2. Pollen morphology of *Jasione* (values in µm).

Taxon	Size Min	Size Max	P Mean	P Min	P Max	Mean	E Min	E Max	Mean	P/E ratio and shape	Ex Min	Ex Max	Mean	In Min	In Max	Mean	Ap	Annulus	Ornemantation	Aperture type	Type
Jasione supina subsp. *supina*	17	29	25 ± 3.07	21	29	26.16 ± 2.05	20	30	25.63 ± 2.3	1.02 Prolate-spheroidal	0.5	1	0.98 ± 0.09	0.3	1	0.73 ± 0.27	13.56 ± 2.3	2.7 ± 0.87	Microechinate	96% triporate 4% tetraporate	Type I
Jasione supina subsp.*akmani*	17	30	22.42 ± 2.62	20	29	25.79 ± 2.19	22	28	25.51 ± 1.77	1.01 Prolate-spheroidal	0.98	1	0.99 ± 0.003	0.45	1	0.73 ± 0.25	13.1 ± 2.85	2.5 ± 0.63	Microechinate	triporate	Type I
Jasione supina subsp.*pontica*	19	27	23.3 ± 2.29	22	30	26.2 ± 1.9	19	29	25.86 ± 2.2	1.01 Prolatespheroide	0.5	3	1.04 ± 0.39	0.5	1.2	0.775 ± 0.25	13 ± 3.61	2.83 ± 0.90	Microechinate	73% triporate 27% tetraporate	Type I
Jasione supina subsp *tmolea*	15	30	21.84 ± 3.38	19	31	24.04 ± 2.49	21	30	24.32 ± 2.05	0.99 Oblate-spheroidal	0.27	1	0.64 ± 0.25	0.2	0.7	0.46 ± 0.15	11.69 ± 3.1	3.047 ± 0.94	Microechinate	87% triporate 13% tetraporate	Type II
Jasione *montana*	16.55	25	20.49 ± 2.46	18.6	26	22.75 ± 2.04	16.45	28	21.58 ± 2.57	1.03 Prolate-spheroidal	0.3	1	0.74 ± 0.22	0.2	1	0.69 ± 0.27	11.02 ± 2.44	2.74 ± 0.91	Microechinate	Triporate	Type I
Jasione *heldreichii*	17.23	25	19.82 ± 2.09	17.64	25	21.81 ± 2.15	18.49	29	21.80 ± 2.1	0.97 Oblate-spheroidal	0.34	2	0.90 ± 0.48	0.4	2	0.79 ± 0.45	8.66 ± 1.83	3.02 ± 0.96	Microechinate	Triporate	Type II
Jasione idaea	16.66	25.97	22.06 ± 2.6	19.63	27.96	24.89 ± 2.072	20.95	27.89	24.65 ± 1.80	1.011 Prolate-spheroidal	0.38	1.18	0.66 ± 0.2	0.26	0.66	0.43 ± 0.12	7.95 ± 2.5	2.81 ± 1.06	Microechinate	Triporate	

Note: P: Polar axis; E: Equatorial axis; P/E: Polar axis/Equatorial axis; Ex: Exine; In: Intine; Ap: Apoporium

2.3. Investigation of the pollen slides

All object slides were labelled with names and voucher numbers. The polar axis, equatorial axis, pore length, pore width, exine thickness, intine thickness, apoporium diameter, and annulus were measured from 30 pollen grains of each specimen under a Nikon Eclipse (E 400) microscope using an immersion objective lens (×100; Table 2).

Scanning Electron Microscope (SEM) observations were carried out with an EVO 50 in the Electron Microscopy Laboratory of Hacettepe University.

3. Results

The measurements (all measurements presented are in µm, unless otherwise stated) are as below and the microphotographs are given in Figure 9.

3.1. Jasione heldreichii *Boiss. & Orph*

Measurements: 19.82 ± 2.09; polar axis: 21.81 ± 2.15; equatorial axis: 21.80 ± 2.1; pore latitude: 3.04 ± 0.61; pore length: 3.93 ± 0.77; annulus: 3.02 ± 0.96; exine: 0.9 ± 0.48; intine: 0.79 ± 0.4; apoporium: 8.66 ± 1.83.

Aperture type: triporate
Ornamentation: microechinate
Pollen shape: oblate-spheroidal

3.2. Jasione idaea *Stoj*

Measurements: 22.06 ± 2.6; polar axis: 21.89 ± 2.07; equatorial axis: 24.65 ± 1.8; pore latitude: 3.32 ± 0.99; pore length: 3.32 ± 0.82; annulus: 2.81 ± 1.06 exine: 0.66 ± 0.2; intine: 0.43 ± 0.12; apoporium: 7.95 ± 2.5.

Aperture type: triporate
Ornamentation: microechinate
Pollen shape: prolate-spheroidal

3.3. Jasione Montana *L*

Measurements: 20.49 ± 2.46; polar axis: 22.75 ± 2.04; equatorial axis: 21.58 ± 2.57; pore latitude: 3.24 ± 1.01; pore length: 3.48 ± 0.89; annulus: 2.74 ± 0.91; exine: 0.74 ± 0.22; intine: 0.69 ± 0.27; apoporium: 11.02 ± 2.44.

Aperture type: triporate
Ornamentation: microechinate
Pollen shape: prolate-spheroidal

3.4. Jasione supina *Sieber ssp.* akmanii

Measurements: 22.42 ± 2.62; polar axis: 25.79 ± 2.19; equatorial axis: 25.51 ± 1.77; pore latitude: 4.12 ± 0.67; pore length: 3.48 ± 0.89; annulus: 2.5 ± 0.63; exine: 0.99 ± 0.003; intine: 0.73 ± 0.25; apoporium: 13.1 ± 2.85.

Aperture type: triporate
Ornamentation: microechinate
Pollen shape: prolate-spheroidal

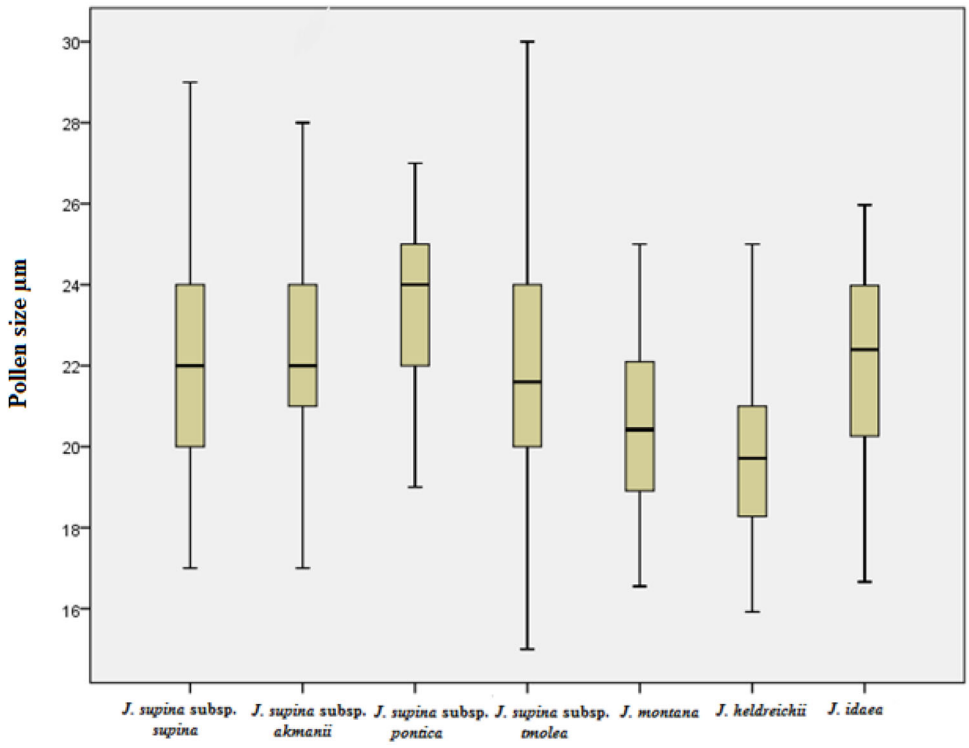

Figure 2. Pollen size variations of seven taxa.

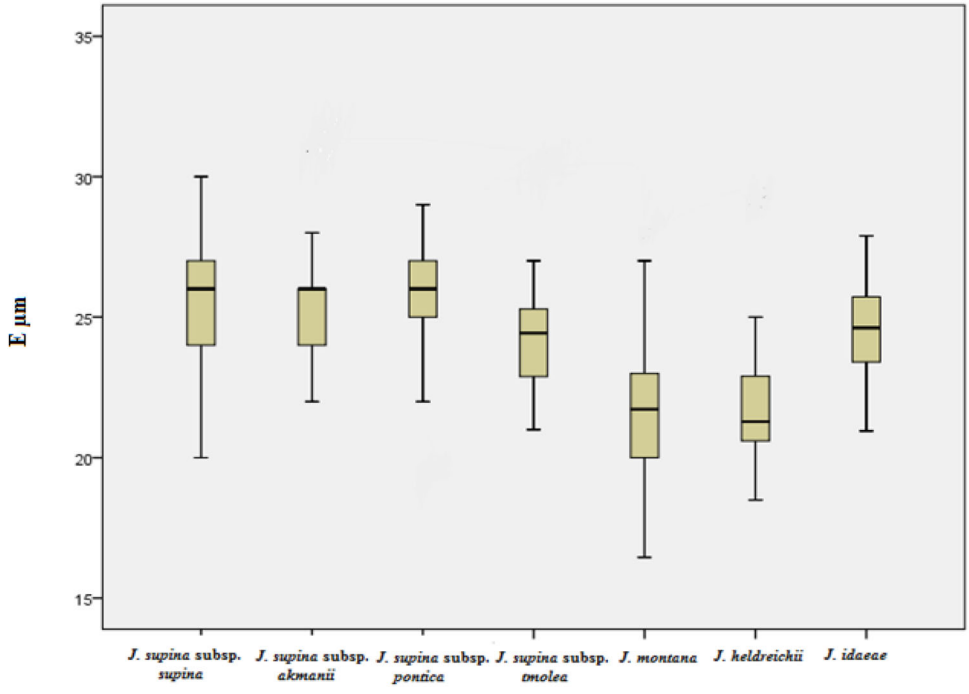

Figure 3. Equatorial axis measurements of investigated pollen.

3.5. Jasiona supina *Sieber ssp.* pontica *(Boiss.) Damboldt*

Measurements: 23.3 ± 2.29; polar axis: 26.2 ± 1.19; equatorial axis: 25.86 ± 2.2; pore latitude: 4.34 ± 0.77; pore length: 4.011 ± 0.8; annulus: 2.83 ± 0.9; exine: 1.04 ± 0.39; intine: 0.77 ± 0.25; apoporium: 13 ± 3.61.

Aperture type: triporate and tetraporate

Ornamentation: microechinate

Pollen shape: prolate-spheroidal

3.6. Jasione supina *Sieber ssp.* supina

Measurements: 25 ± 3.07; polar axis: 26.16 ± 2.05; equatorial axis: 25.63 ± 2.3; pore latitude: 4 ± 0.87; pore length:

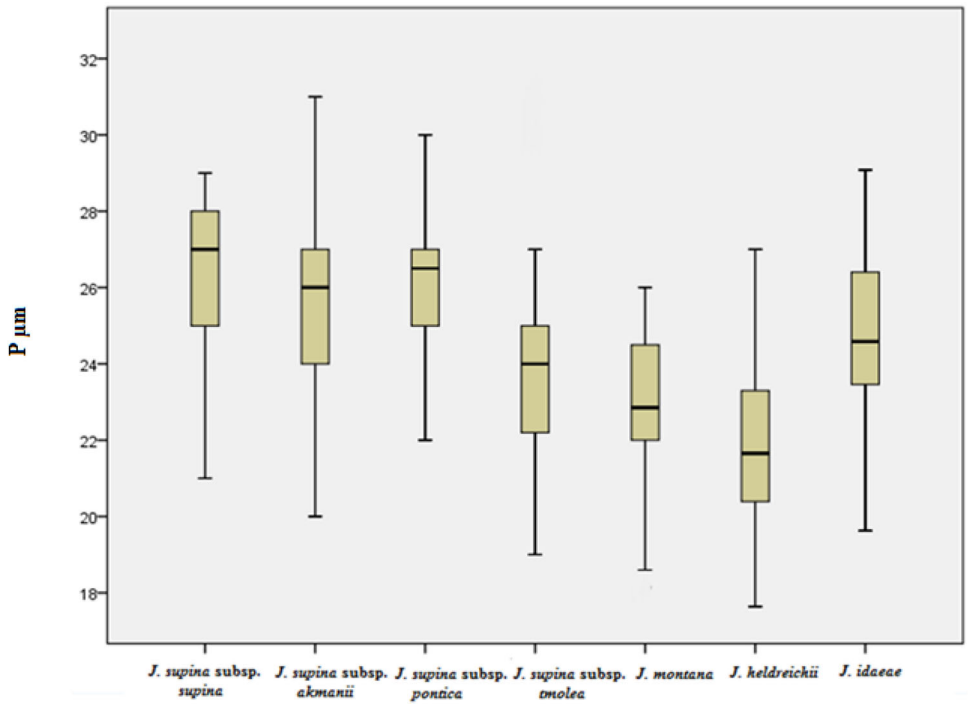

Figure 4. Polar axis measurements of investigated pollen.

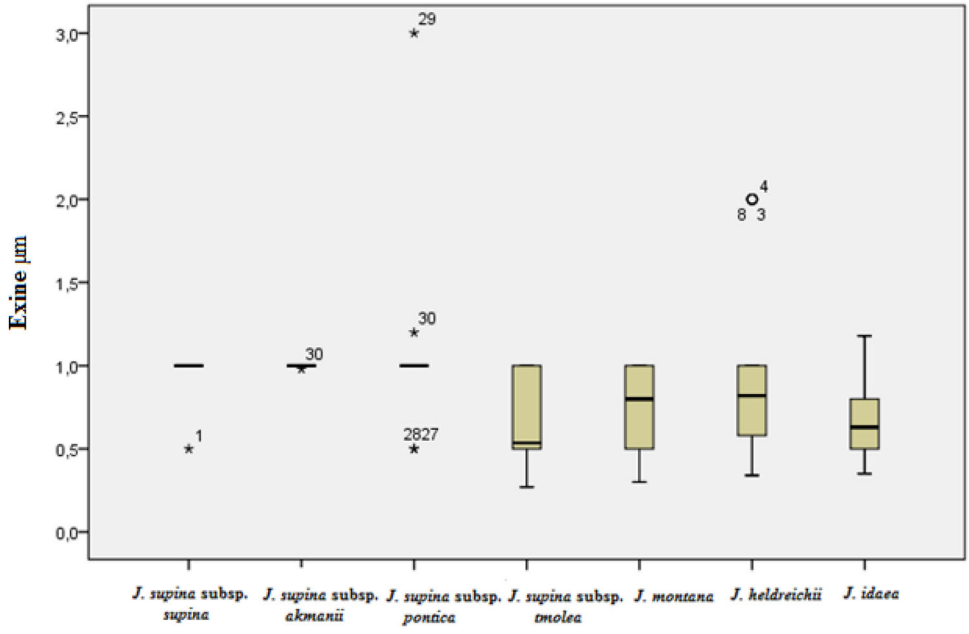

Figure 5. Exine measurements of investigated pollen.

3.9 ± 0.95; annulus: 2.71 ± 0.87; exine: 0.98 ± 0.09; intine: 0.73 ± 0.27; apoporium: 3.56 ± 2.3.

Aperture type: triporate and tertraporate

Ornamentation: microechinate

Pollen shape: prolate-spheroidal

3.7. Jasione supina *Sieber ssp.* tmolea *(Stoj) Damboldt*

Measurements: 21.84 ± 3.38; polar axis: 24.045 ± 2.49; equatorial axis: 24.32 ± 2.05; pore latitude: 3.52 ± 0.67; pore length: 2.88 ± 0.96; annulus: 3.047 ± 0.94; exine: 0.64 ± 0.25; intine: 0.46 ± 0.15; apoporium: 11.96 ± 3.1.

Aperture type: triporate and tetraporate

Ornamentation: microechinate

Pollen shape: oblate-spheroidal

The mean sizes of the seven taxa varied between 19.82 and 25 µm (Figure 2). Equatorial axis values are very similar among the taxa, except *J. montana* and *J. heldreichii* (Figure 3). Polar axis values are very similar among the taxa, except *J. montana* and *J. heldreichii* (Figure 4). Mean exine values were lower in *J. idaeae* and *J. supina* subsp. *tmolea* compared to the other taxa (Figure 5). *Jasione supina* subsp. *tmeloa* and *J. idaea* were more similar to each other than to the others in terms of intine thickness (Figure 6). Measurements showed that *J. heldreichii*

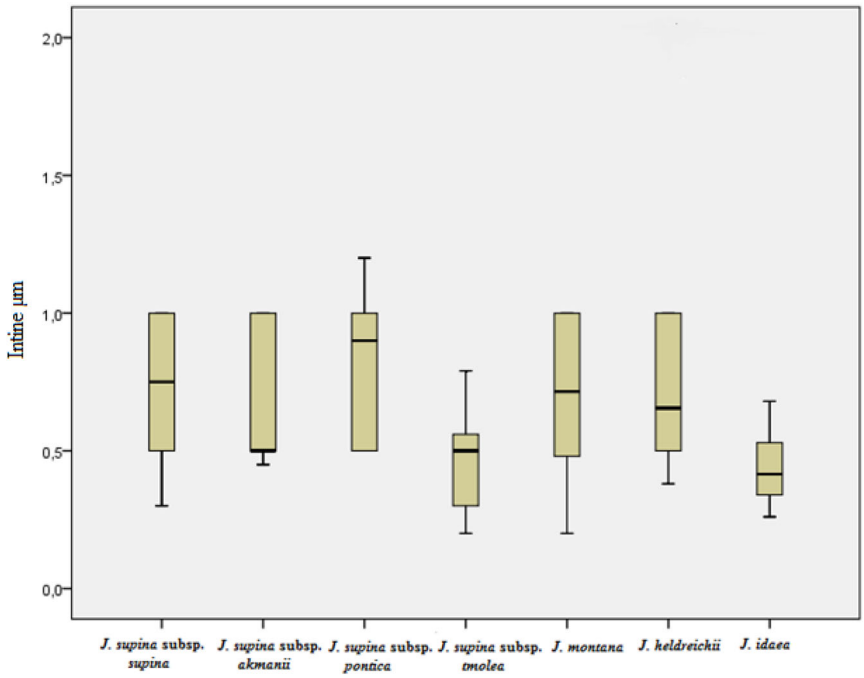

Figure 6. Intine measurements of investigated pollen.

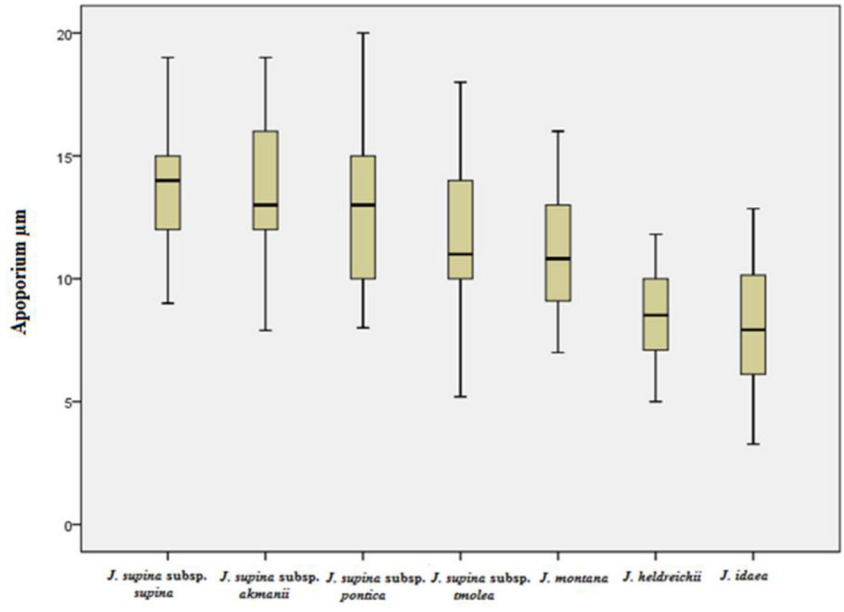

Figure 7. Apoporium measurements of investigated pollen.

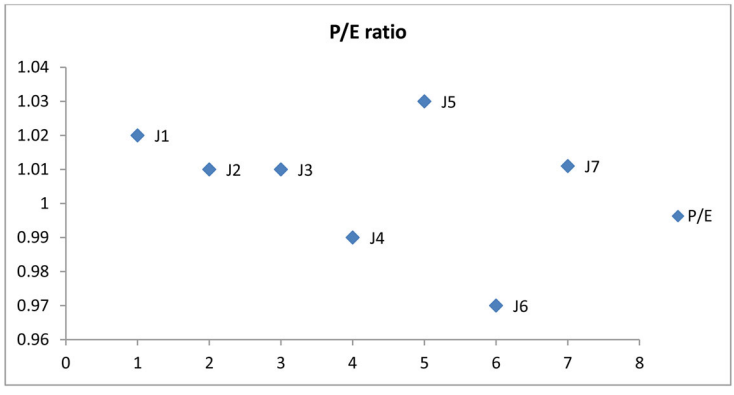

Figure 8. P/E ratios of the investigated seven taxa.

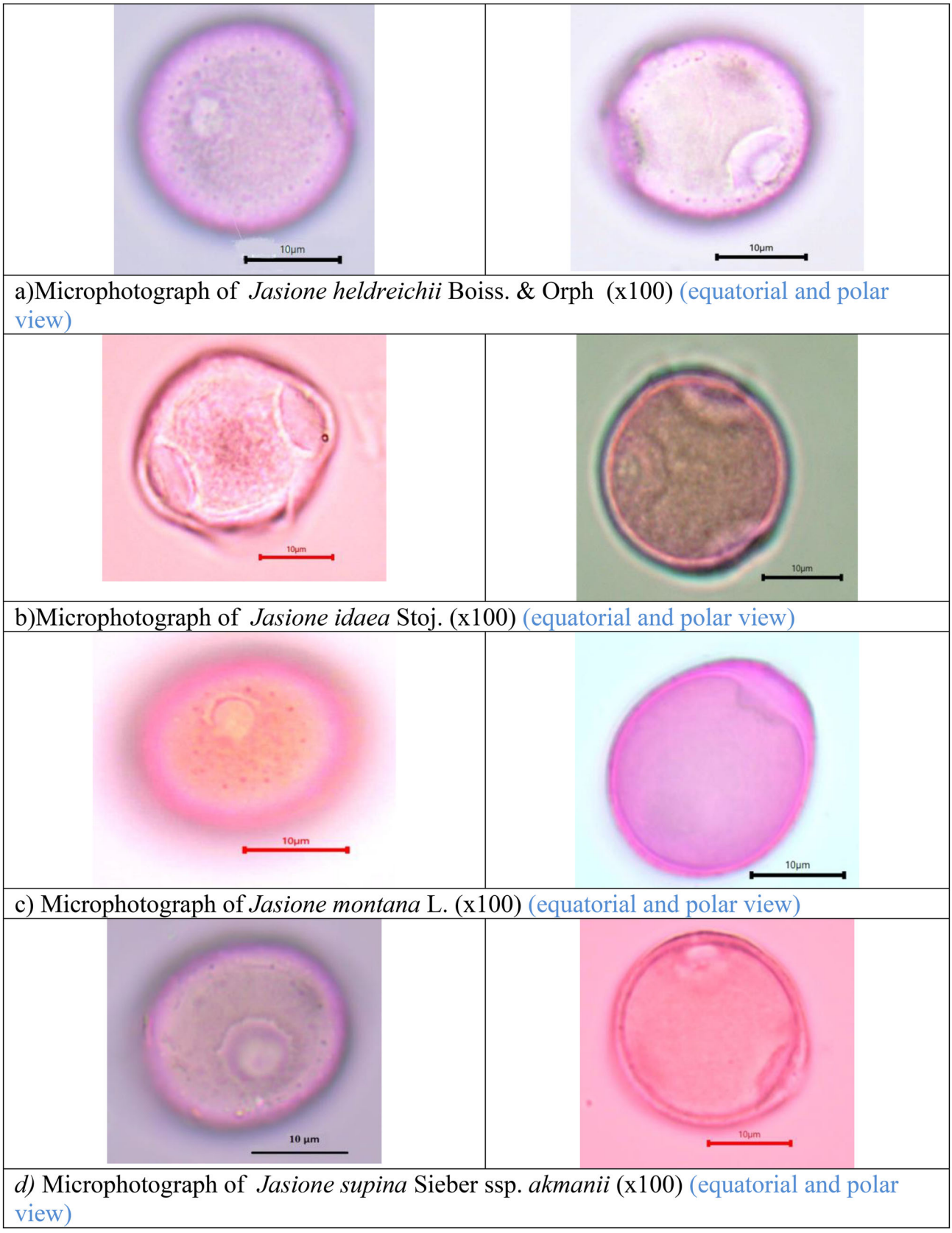

Figure 9. Microphotographs of the pollen (a) *Jasione heldreichii* Boiss. & Orph; (b) *Jasione idaea* Stoj.; (c) *Jasione montana* L.; (d) *Jasione supina* Sieber ssp. *akmanii*; (e) *Jasiona supina* Sieber ssp. *pontica* (Boiss.) Damboldt; (f) *Jasione supina* Sieber ssp. *supina*; (g) *Jasione supina* Sieber ssp. *tmolea* (Stoj) Damboldt.

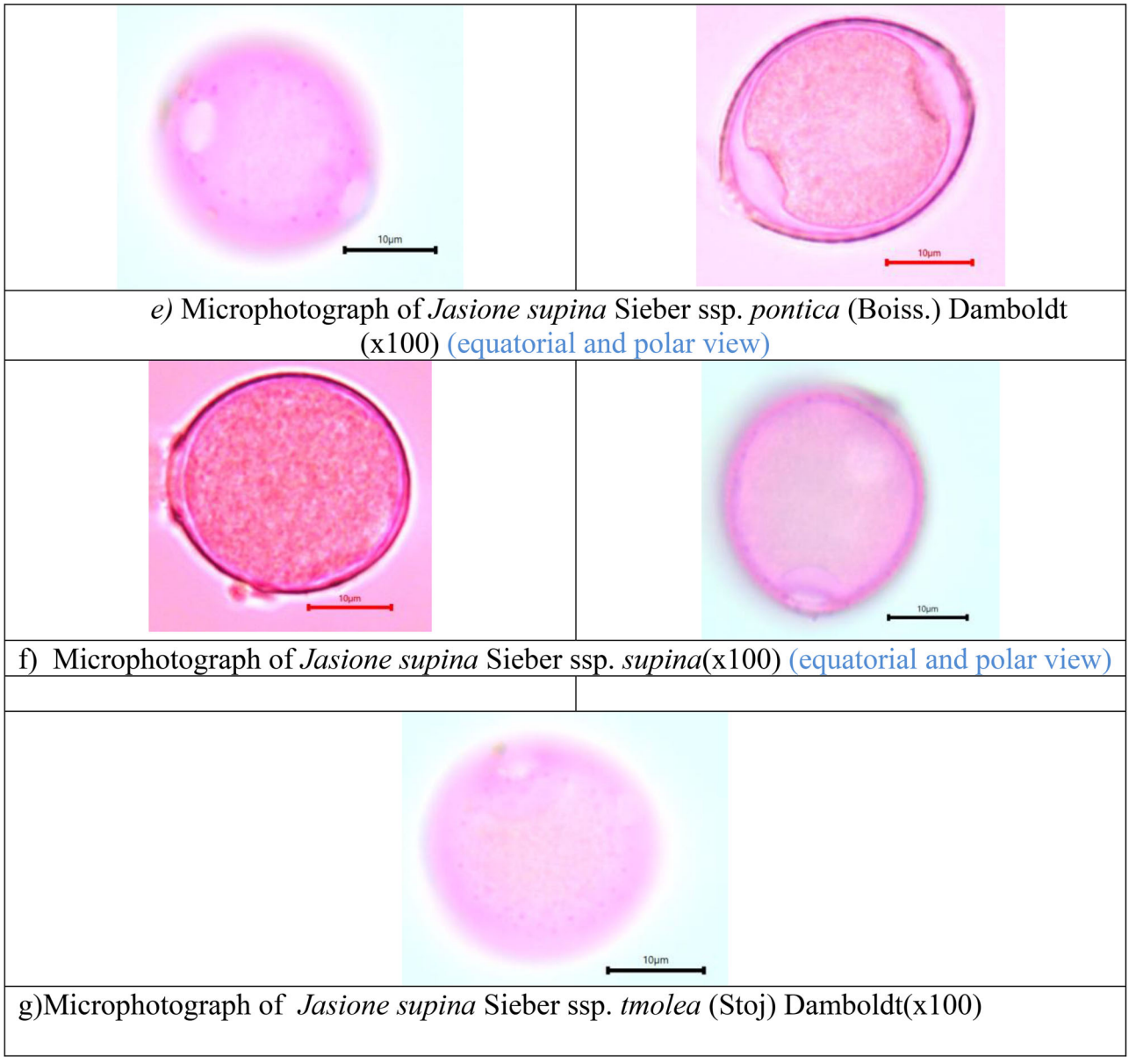

Figure 9. Continued

and *J. idaea* have lower apoporium values (Figure 7). As shown in Figure 8, J4 (*Jasione supina* subsp. *tmolea*) and J6 (*Jasione heldreichii*) have the same pollen shape and are classified as Type II. To observe the ornamentation of the pollen grains, SEM photographs were taken and are shown in Figure 10.

4. Discussion

Previous palynological investigations of the Campanulaceae family are limited. Past researchers mentioned the stenopalynous feature of pollen grains in *Campanula* and its relatives (Erkara et al. 1970; Perveen and Qaiser 1999; Khansari et al. 2012). The current research suggests *Jasione* individuals collected from Turkey have porate apertures, as is common for taxa from temperate regions (Avetisian 1948).

Khansari et al. (2012) investigated the pollen morphology of 35 taxa of *Campanula*, five species of *Asyneuma*, and one species each of the genera *Legousia*, *Michauxia*, *Zeugandra*, and *Theodorovia*. They found the type of aperture in all examined taxa was porate but the number of pores was variable, with the majority possessing 3–4 pores. They also mentioned the diameter of the pores was 3–7 µm, and that the pores were located equatorially and have an operculum in all investigated species. They measured the thickness of exine as 1–1.92 µm. According to their results the surface of the exine is rugulate or rugulate-microreticulate; the size of the longest echini on pollen surface ranges from 0.10 µm to 2.21 µm. Similar to the present study, the apertures of the investigated *Jasione* taxa were found to be porate (3–4) and the diameter of the pores was 3.04–4.34 µm.

Yuan and Yu (2012) observed the pollen of *Platycodon* to be 5–6-colporate with medium–large spinules (1.5 µm) and called it the *Platcodon* type; the genus *Ostrowskia* was 6–7 colpate with large verrucose sexine and was called the *Ostrowskia* type; *Echinocodon* D.Y.Hong was 4–5 colpate with short colpi

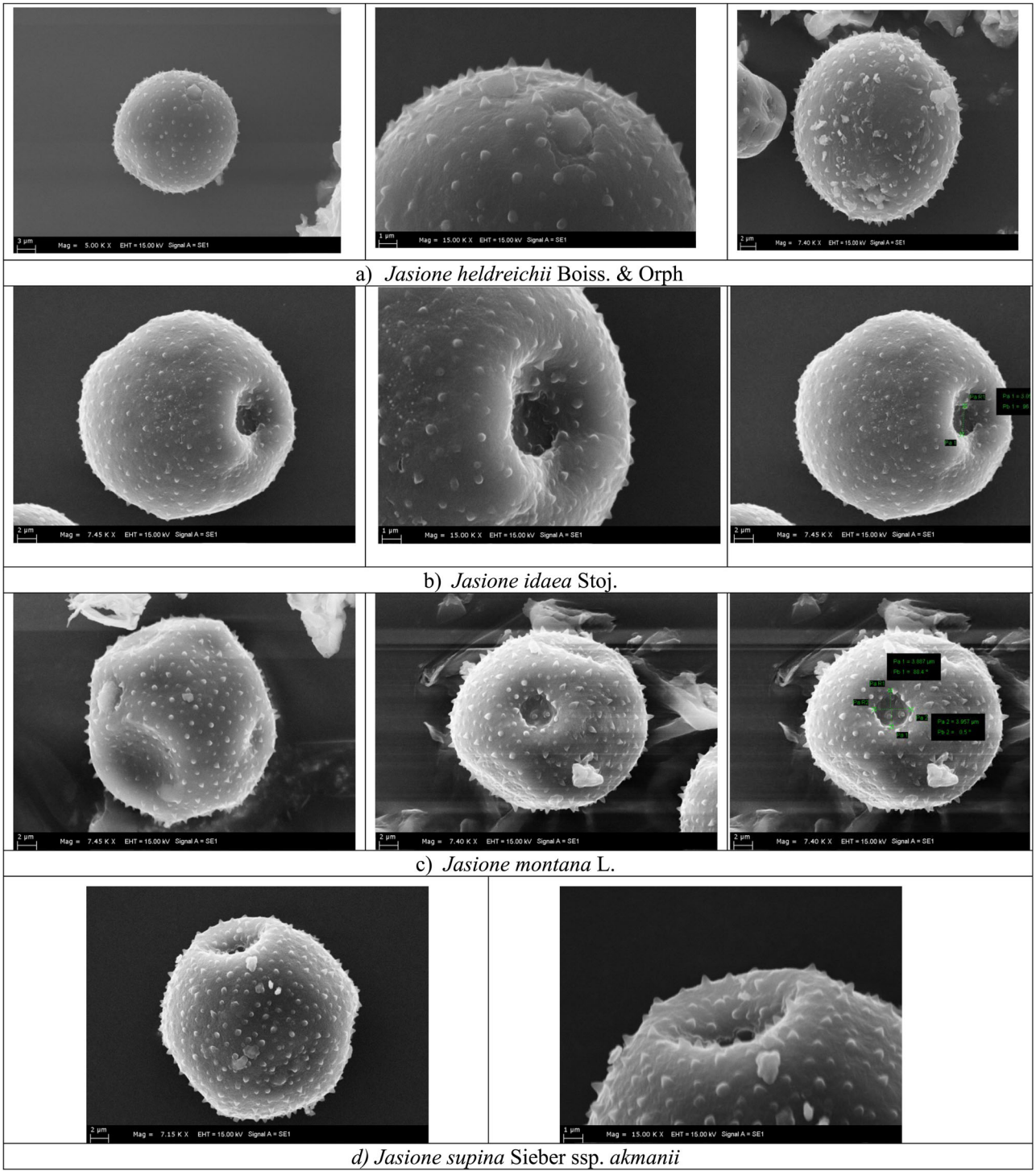

Figure 10. SEM micrographs of the pollen (a) *Jasione heldreichii* Boiss. & Orph; (b) *Jasione idaea* Stoj.; (c) *Jasione montana* L.; (d) *Jasione supina* Sieber ssp. *akmanii*; (e) *Jasiona supina* Sieber ssp. *pontica* (Boiss.) Damboldt; (f) *Jasione supina* Sieber ssp. *supina*; (g) *Jasione supina* Sieber ssp. *tmolea* (Stoj) Damboldt.

and basally divided sexine spinules and was classified as *Echinocodon* type. As a result they recognised and name nine pollen types and two subtypes in the platycodonoid group.

Perveen and Qaiser (1999) investigated the pollen morphology of 10 species belonging to the three genera of the family Campanulaceae under light and scanning electron microscopy. On the basis of the aperture, two distinct pollen types are recognised – viz. the *Campanula latifolia* type (*Asyneuma thomsonii*, *Campanula leucociada*, *C. aristata*, *C. latifolia*, *C. tenuissima*, *C. argyrotricha*, *C. cashmeriana*, *C. pallida*) with three pores (rarely 4–7), tectum finely striate-rugulate, or rarely finely punctate with spinules; and the *Codonopsis clematidea* type (*Codonopsis clematidea*, *C.obtusa*) with 6–10 colpate pollen grains, and tectum finely reticulate to striate-rugulate with spinules. The *Jasione* taxa from Turkey investigated in the present study are similar to the *Campanula latifolia* aperture type.

Erkara et al. (1970) investigted the pollen morphology of 12 Turkish species of *Campanula* (*C. argaea*, *C. cymbalaria*, *C. glomerata* subsp. *hispida*, *C. latiloba* subsp. *latiloba*, *C. lyrata*

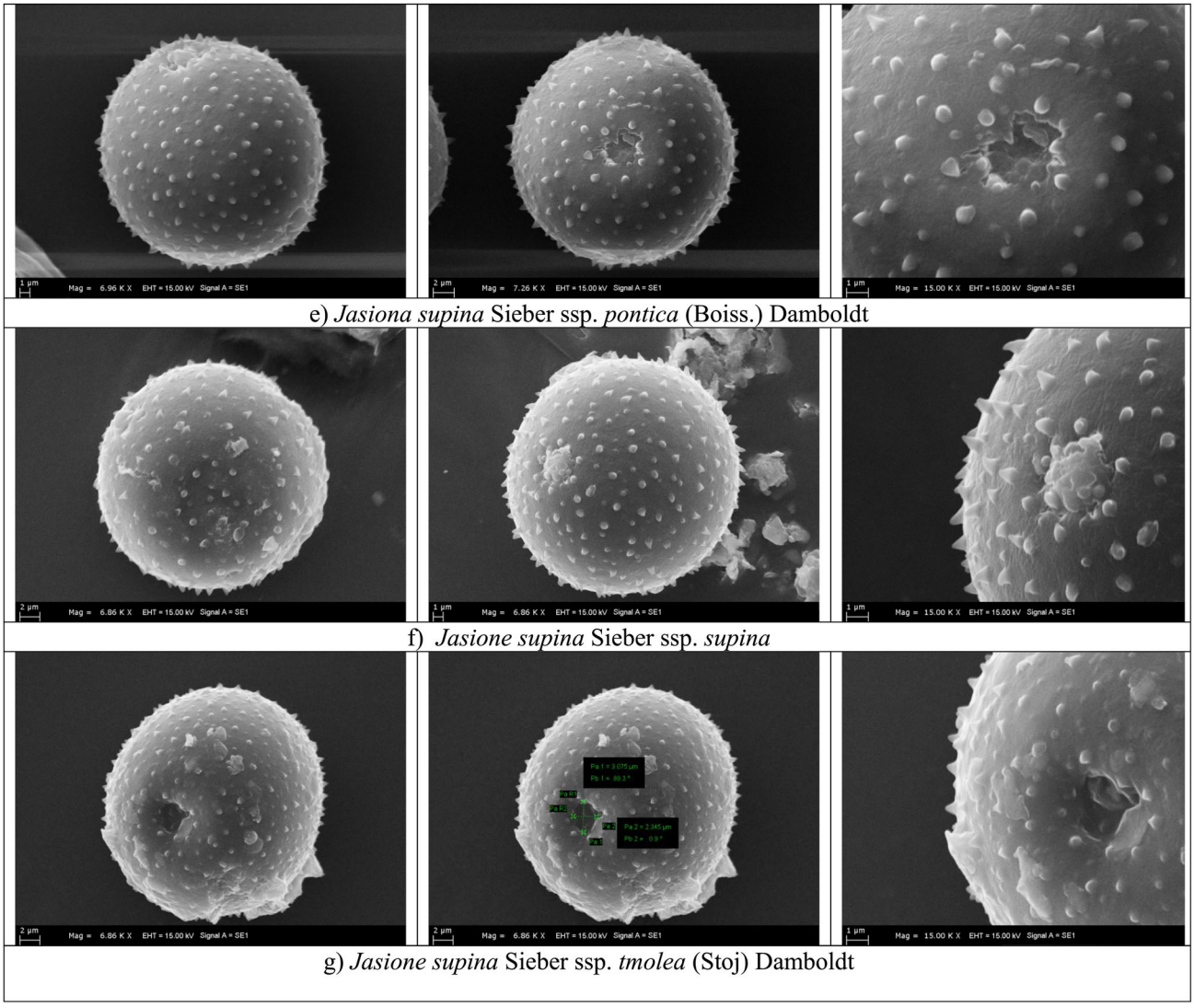

Figure 10. Continued

subsp. *lyrata*, *C. olympica*, *C. persicifolia*, *C. pterocaula*, *C. rapunculoides* subsp. *cordifolia*, *C. rapunculus* var. *rapunculus*, *C. stricta* var. *stricta*, and *C. pamphylica* subsp. *tokurii*) under light and scanning electron microscopy. They observed the 12 taxa are more or less oblate-spheroidal, triporate (and/or tetraporate), tectum-scabrate, or with circular amb. The aperture types of the *Jasione* taxa investigated here showed similarities to Erkara et al.'s results.

5. Conclusion

In all the investigated taxa, the aperture type was determined to be porate and the ornamentation microechinate. The annulus was observed distinctly in all samples. No previous reports are available that deal with the pollen morphology of the genus *Jasione* from Turkey. This research, therefore, is the first detailed study of the palynological characteristics of *Jasione* taxa native to Turkey. The results will be helpful for future taxonomic research on Campanulaceae.

Disclosure statement

No potential conflict of interest was reported by the author.

Notes on contributor

Associate Professor Ömür Gençay Çelemli has conducted research at Hacettepe University, Science Faculty, Biology Department since 2003 and has a PhD degree. He studied for a Masters and PhD thesis on Turkish propolis and is interested in plant anatomy, palynology and bee products especially propolis.

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