

COMPARATIVE ANATOMY IN SOME SPECIES OF PAPAVER L. (PAPAVERACEAE) IN IRAN AS TAXONOMICAL IMPLICATION

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In this survey, basal leaf midrib region and peduncle anatomy of 15 species of the genus *Papaver* L. was studied. Species examined include *Papaver argemone*, *P. bracteatum*, *P. chelidoniifolium*, *P. cylindricum*, *P. decaisnei*, *P. dubium*, *P. fugax*, *P. gaubae*, *P. glaucum*, *P. hybridum*, *P. macrostomum*, *P. orientale*, *P. pavoninum*, *P. persicum* and *P. tenuifolium*. Among 27 anatomical characters examined (18 for midrib region and nine characters for peduncle), five characters in midrib region including midrib shape, presence of upper collenchyma, presence of sclerenchyma together with parenchyma layer, number of lateral vascular bundles and growth's range of lateral vascular bundles and five characters in peduncle including peduncle shape, pattern of epidermis surface, presence of collenchyma in cortex, type of supporting tissue near vascular bundles and circles of vascular bundles are useful for separating the annual, biennial and perennial species.

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تشریح مقایسه‌ای در چند گونه از جنس خشخاش در ایران به عنوان ابزار تاکسونومیک

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در این مطالعه، ساختار تشریحی رگبرگ میانی برگ قاعده‌ای و دمگل در ۱۵ گونه از جنس خشخاش ارائه می‌شود. این گونه‌ها شامل *P. fugax*، *P. dubium*، *P. decaisnei*، *P. cylindricum*، *P. chelidoniifolium*، *P. bracteatum*، *Papaver argemone*، *P. tenuifolium*، *P. persicum*، *P. pavoninum*، *P. orientale*، *P. macrostomum*، *P. hybridum*، *P. glaucum*، *P. gaubae* هستند. از بین ۲۷ صفت مورد بررسی (۱۸ صفت برای ناحیه رگبرگ میانی و نه صفت برای دمگل) پنج صفت در ناحیه رگبرگ میانی شامل شکل رگبرگ میانی، وجود کلانشیم فوقانی، وجود سلول‌های اسکلرانشیمی در مجاورت دستجات آوندی، تعداد دستجات آوند فرعی و میزان مشخص بودن رشد دستجات آوند فرعی، و پنج صفت برای دمگل شامل شکل دمگل، تزئینات سطح اپیدرم، وجود کلانشیم در پوست، نوع بافت استحکامی نزدیک دستجات آوندی و تعداد ردیف‌های دستجات آوندی برای جداسازی گونه‌های یکساله، دوساله و چند ساله مناسب هستند.

Introduction

Papaveraceae is an important family economically and medicinally (Simpson 2006), and is located in order *Ranunculales* (Simpson 2006, APGIII 2009). As the largest genus of subfamily *Papaveroideae*, family

Papaveraceae (Kadereit 1993), *Papaver* L. with approximately 80 annual, biennial and perennial herbs distributed in temperate and subtropical regions of northern hemisphere (Judd et al. 2002) including central and south-western Asia, central and southern

Table 1. Voucher specimens of *Papaver* species used in the study.

Species	Locality
<i>P. argemone</i> L.	Lorestan: Khorramabad, Sefid kuh; Veiskarami; 14.5.1999; 23629- TUH
<i>P. bracteatum</i> Lind.	Mazandaran: Siah-bishe on road to Chalous; Ghahreman & Aghustin; 19.6.1978; 8906- TUH
<i>P. chelidoniifolium</i> Boiss. & Buhse	Gillan: Langerud, Chamkhaleh; Naqinezhad; 6.4.2001; 27836- TUH
<i>P. cylindricum</i> Cullen	Kohgiluyeh: Yassuj, Dena Mt., Gardaneh Bijan; Vaezi-Hakimi; 16.8.1995; 19368- TUH
<i>P. decaisnei</i> Hochst. & Steud.	Qazvin: 26 km to Lowshan from Qazvin; Zamani & Rahmatpour; 15.4.2009; 39262-TUH
<i>P. dubium</i> L.	Tehran: Amir-abad; Heydari; 22.4.2009; 39263-TUH
<i>P. fugax</i> Poir.	Azerbaijan: between Khalkhal and Ardebil, Bobalalou, Neur lake; Ghahreman, Mozaffarian & Sheikholeslami; 15.5.1993; 17482-TUH
<i>P. gaubae</i> Cullen & Rech. f.	Qazvin: 26 km to Lowshan from Qazvin; Zamani & Rahmatpour; 15.4.2009; 39255- TUH
<i>P. glaucum</i> Boiss. & Hausskn.	Azerbaijan: Arasbaran, Kaleibar to Makidi; Ghahreman, Attar & Hamzehee; 14.5.2005; 35514- TUH
<i>P. hybridum</i> L.	Qazvin: 26 km to Lowshan from Qazvin; Zamani & Rahmatpour; 15.4.2009; 39254- TUH
<i>P. macrostomum</i> Boiss. & Huet	Azerbaijan: Nazarkahrizi village, Hashtroud to Maragheh; Zamani; 6.6.2008; 38340- TUH
<i>P. orientale</i> L.	Azerbaijan: Ghaleh Babak; Zamani; 14.6.2008; 38338- TUH
<i>P. pavoninum</i> Fisch. & C. A. Mey	Khorassan: 15 km after Mashad toward Sarakhs; Ghahreman, Attar, Mehdigholi & Okhovvat; 3.5.2002; 28820- TUH
<i>P. persicum</i> Lind.	Azerbaijan: Orumieh, Band to Ziveh; Ghahreman, Tarighi & Aghustin; 4.5.1978; 8905- TUH
<i>P. tenuifolium</i> Boiss. & Hohen.	Qazvin: 20 km to Lowshan from Qazvin; Zamani & Rahmatpour; 15.4.2009; 39272- TUH

Europe and northern Africa; however two species *P. aculeatum* Thunb. and *P. californicum* A. Gray are indigenous to South Africa and western North America, respectively (Kadereit 1988). The genus is usually characterized with white sap, solitary racemes or panicle inflorescence, numerous stamens and stigmas born on a sessile disc (Cullen 1965). *Papaver* L. consists of 26 (Cullen 1966) to 28 species in Iran (Assadi 1988) distributed in most parts of the country. Habits of the genus include road sides (e.g. *P. argemone*), farms (e.g. *P. macrostomum*), and rocky places (e.g. *P. hybridum* and *P. gaubae*). *Papaver gaubae* and *P. tenuifolium* are endemics to Iran (Cullen 1966). Metcalfe and Chalk (1957) described some anatomical features of *Papaveraceae*. The main characters include of presence of a single ring of widely spaced vascular bundles in stem's transverse sections which are nearly always collateral, frequently tendency of the xylem group to being V-shaped, presence of several rings of bundles sometimes in *Papaver*, scanty hairs arranged uniseriately, biseriately or multiseriately and presence of an arc of vascular bundles in petiole in transverse sections not accompanied by sclerenchyma. In spite of above

mentioned characters, any investigation on anatomy of the genus was not found. Therefore, this study aims to: 1) to present common anatomical features of *Papaver*, 2) to assess taxonomical application of these characters in species determination.

Materials and Methods

In this study, 15 species were examined. Voucher specimens are listed in Table 1. All voucher specimens are deposited in Central Herbarium of Tehran University (TUH) (Acronyms according to Holmgren & al. 1990). All specimens, almost were collected in the same season, otherwise we tried to select the most mature leaves. Basal leaves and peduncles were fixed in alcohol-glycerin (1:1) for one month. Cross sections were made at middle of basal leaves and peduncles with a razor; transverse sections were cleared with sodium hypochlorite, dehydrated and stained with methyl green and bismark brown colors, then photographed in $\times 40$, $\times 100$ and $\times 320$ magnification by light microscopy Leitz model Wetzlar, camera Nikon model coolpix S10, Photoshop software was used for some detailed measurements.

Results

MIDRIB REGION

For comparative anatomy of species, 18 characters of midrib region were examined. These characters summarized in Table 2. Midrib characters are shown in Figs. 1-15. Arrangement of cells in midrib region are as follows: upper epidermis covered with cuticle layer, in some species multicellular and multiseriate hairs could be observed in upper and lower epidermis (e.g. Figs. 7b, 8b, 9b, 13b), upper collenchyma, upper parenchyma, upper phloem, xylem, lower phloem, lower parenchyma, lower collenchyma, lower epidermis covered with cuticle layer. Generally, the shape of midrib region was distinguished as orbicular (Figs. 1, 7a, 9a), triangular (Figs. 2, 3, 4, 5, 6, 10, 11a, 12a, 13a), crown-like with three lobes (Figs. 8a, 14), crown-like with five lobes (Fig. 15a) (Table 2). Upper cuticle thickness (UCT) ranges from 5 μm in *P. glaucum* and *P. dubium* to 20 μm in *P. gaubae* (Table 2). Upper epidermis thickness (UET) ranges from 20 μm in *P. hybridum*, *P. chelidoniifolium*, *P. fugax*, *P. gaubae*, *P. macrostomum*, *P. orientale*, *P. persicum* and *P. tenuifolium* to 40 μm in *P. dubium*, *P. glaucum* and *P. pavoninum* (Table 2). Collenchyma layer was distinguished as lamellar. Upper collenchyma, in some species including *P. decaisnei*, *P. gaubae*, *P. glaucum* and *P. tenuifolium* is not observed (Figs. 3, 5, 6, 10) (Table 2), in *P. orientale*, upper collenchyma thickness (UCOT) is the thickest (70 μm) (Table 2). Upper parenchyma thickness (UPT) ranges from 50 μm in *P. chelidoniifolium* to 320 μm in *P. macrostomum* (Table 2). Phloem exists in both upper and lower surfaces of xylem (Amphicribal). Upper phloem thickness (UPHT) ranges from 20 μm in *P. persicum* to 90 μm in *P. gaubae* and *P. tenuifolium* (Table 2), xylem thickness (XT) ranges from 70 μm in *P. argemone* to 280 μm in *P. orientale* (Table 2). Lower phloem thickness (LPHT) ranges from 40 μm in *P. persicum* to 190 μm in *P. orientale* (Table 2). Lower parenchyma thickness (LPT) ranges from 70 μm in *P. cylindricum* to 490 μm in *P. orientale* (Table 2). Lower collenchyma thickness (LCOT) ranges from 30 μm in *P. hybridum* and *P. tenuifolium* to 250 μm in *P. orientale* (Table 2). Lower epidermis thickness (LET) ranges from 10 μm in *P. cylindricum*, *P. fugax*, *P. gaubae*, *P. hybridum* and *P. macrostomum* to 30 μm in *P. argemone*, *P. dubium*, *P. glaucum* and *P. pavoninum* (Table 2). Lower cuticle thickness (LCT) in all studied species is 10 μm with one exception in *P. gaubae*, which is 20 μm (Table 2). Lateral vascular bundles (LVB) exist in all studied species. In spite of the above-mentioned common structure, remarkable

differences among studied species can be observed. Regarding presence of sclerenchyma within upper and lower parenchyma tissue, only *P. cylindricum* and *P. fugax* show this character (Figs. 11 b, 11c, 12 b).

PEDUNCLE

Nine characters of peduncle were examined. These characters summarized in Table 3. Arrangement of cells in peduncle are as follows: epidermis covered with cuticle layer, layer of laticifer tubes, collenchyma, supporting tissue near vascular bundles, vascular bundles (some laticifer tubes are found near phloem) and pith cells. Peduncle shape was distinguished as orbicular (e.g. Figs. 16a, 18a) and elliptic (e.g. Figs. 22a, 26a) (Table 3). Cuticle thickness (CT) was 10 μm in all studied species (Table 3). Epidermis thickness (ET) ranges from 10 μm in *P. gaubae*, *P. glaucum* and *P. macrostomum* to 30 μm in *P. orientale*. (Table 3). Epidermis surface (ES) was distinguished as smooth (e.g. Figs. 16a, 26a), striate (e.g. Figs. 19a, 24a) and more or less striate (e.g. Figs. 23a, 27a) (Table 3). Laticifer layer thickness (LLT) ranges from 10 μm in *P. glaucum* and *P. macrostomum* to 70 μm in *P. bracteatum* (Table 3). Collenchyma layer (lamellar collenchyma) is found in *P. bracteatum* and *P. orientale* in cortex (Figs. 29a, 30a) (Table 3). Two types of supporting tissue (ST) were distinguished; Sclerenchyma (e.g. Figs. 17b & 18b) and fiber (e.g. Figs. 24b, 26b) (Table 3). There is one circle of vascular bundles (CVB) in *P. argemone*, *P. cylindricum*, *P. decaisnei*, *P. hybridum* and *P. pavoninum* (Figs. 16a, 26a, 18a, 22a, 24a) (Table 3), but in some species including: *P. fugax*, *P. glaucum*, *P. macrostomum* and *P. persicum*, there are two distinct circles of vascular bundles (Figs. 27a, 21a, 23a, 28a) (Table 3) and some species including: *P. chelidoniifolium*, *P. dubium*, *P. gaubae* and *P. tenuifolium* show two indistinct circles of vascular bundles (Figs. 17a, 19a, 20a, 25a) (Table 3). *Papaver bracteatum* and *P. orientale* show more than two circles of vascular bundles (Figs. 29a, 30a) (Table 3). The range of most mature vascular bundles (RMVB) varies from 80-90 μm in *P. decaisnei* to 180-200 μm in *P. bracteatum*. (Table 3). Laticifer tubes, which were not recognizable in midrib region, are observed in peduncles.

Discussion

As mentioned above, the genus *Papaver* is the largest and most taxonomically difficult member of the family *Papaveraceae*. In this section, probable coincidence of anatomical evidence with morphological classifications is presented. According to previous references (Popov 1937, Kadereit 1988), several sections have been

Table 2. Anatomical measured characters of midrib region in studied *Papaver* species.

Species	Midrib shape	UCT	UET	UCOT	UPT	S	UPHT	XT	LPHT	LPT	S	LCOT	LET	LCT	HP	HT	NLVB	GLVB
<i>P. argemone</i> 23629	O	10	30	30	120	-	40	70	80	150	-	40	30	10	-	-	2	-
<i>P. bracteatum</i> 8906	CL3L	10	30	30	60	-	70	120	120	340	-	100	20	10	-	-	4	+
<i>P. chelidonium</i> 27836	T	10	20	20	50	-	50	160	90	260	-	40	20	10	-	-	2	-
<i>P. cylindricum</i> 19368	T	10	30	20	60	+	50	110	170	70	+	100	10	10	-	-	5	-
<i>P. decasneii</i> 39262	T	10	30	0	180	-	40	110	90	190	-	40	20	10	-	-	2	-
<i>P. dubium</i> 39263	T	5	40	40	110	-	50	80	80	190	-	70	30	10	-	-	2	-
<i>P. fugax</i> 17482	T	10	20	20	60	+	50	140	70	80	+	100	10	10	-	-	4	-
<i>P. gaubae</i> 39255	T	20	20	0	310	-	90	110	80	250	-	110	10	20	-	-	2	-
<i>P. glaucum</i> 35514	T	5	40	0	220	-	50	180	100	190	-	100	30	10	-	-	2	-
<i>P. hybridum</i> 39254	O	10	20	20	140	-	50	140	70	350	-	30	10	10	+	M	2	-
<i>P. macrosomum</i> 38340	CL3L	10	20	20	320	-	70	140	100	360	-	90	10	10	+	M	5	+
<i>P. orientale</i> 38338	CL5L	10	20	70	310	-	60	280	190	490	-	250	20	10	+	M	10	+
<i>P. pavoninum</i> 28820	O	10	40	40	210	-	40	110	70	300	-	40	30	10	+	M	2	-
<i>P. persicum</i> 8905	T	10	20	20	300	-	20	100	40	270	-	150	20	10	+	M	2	-
<i>P. tenuifolium</i> 39272	T	10	20	0	280	-	90	100	70	250	-	30	20	10	-	-	2	-

*Abbreviations: O, orbicular; CL3L, crown-like with three lobes; T, triangular; CL5L, crown-like with five lobes; UCT, upper cuticle thickness; UET, upper epidermis thickness; UCOT, upper collenchyma thickness; UPT, upper parenchyma thickness; S, sclerenchyma; UPHT, upper phloem thickness; XT, xylem thickness; LPHT, lower phloem thickness; LPT, lower parenchyma thickness; LCOT, lower collenchyma thickness; LET, lower epidermis thickness; LCT, lower cuticle thickness; HP, hair presence; HT, hair type; M, multicellular multiseriate; NLVB, numbers of lateral vascular bundles; GLVB, growth of lateral vascular bundles; +, examined character is present; -, examined character is absent. *All quantitative characters are in micrometer (μm).

Table 3. Anatomical measured characters of peduncle in studied *Papaver* species.

Species	Peduncle shape	CT	ET	ES	LLT	C	ST	CVB	RMVB
<i>P. argemone</i> 23629	O	10	20	SM	20	—	F	1	160-180
<i>P. bracteatum</i> 8906	O	10	20	ST	70	+	S	5	180-200
<i>P. chelidoniifolium</i> 27836	E	10	20	SM	20	—	S	2	130-140
<i>P. cylindricum</i> 19368	E	10	20	SM	20	—	F	1	130-140
<i>P. decaisnei</i> 39262	O	10	20	ST	20	—	S	1	80-90
<i>P. dubium</i> 39263	O	10	20	ST	20	—	S	2	160-180
<i>P. fugax</i> 17482	E	10	20	±ST	20	—	F	2	150-170
<i>P. gaubae</i> 39255	O	10	10	ST	20	—	F	2	150-190
<i>P. glaucum</i> 35514	O	10	10	ST	10	—	F	2	120-130
<i>P. hybridum</i> 39254	E	10	20	±ST	20	—	F	1	10-120
<i>P. macrostomum</i> 38340	E	10	10	±ST	10	—	F	2	130-150
<i>P. orientale</i> 38338	E	10	30	ST	50	+	S	3	140-150
<i>P. pavoninum</i> 28820	O	10	20	ST	20	—	F	1	110-120
<i>P. persicum</i> 8905	E	10	20	±ST	20	—	F	2	140-150
<i>P. tenuifolium</i> 39272	O	10	20	ST	20	—	S	2	100-110

*Abbreviations: O, orbicular; E, elliptic; CT, cuticle thickness; ET, epidermis thickness; ES, epidermis surface; SM, smooth; ST, striate; ±ST, more or less striate; LLT, laticifer layer thickness; C, collenchyma; ST, type of supporting tissue; F, fiber; S, sclerenchyma; CVB, circles of vascular bundles; RMVB, range of most mature vascular bundles.

*All quantitative characters are in micrometer (µm).

introduced; however, because of lack of such a classification in Flora Iranica (Cullen 1966), in one hand, and the presence of two endemic species in Iran in the other hand, most of the presented groupings follow Kadereit's classification (1988). On the basis of morphological similarities, two endemic species are classified in these groups.

Group I

This group includes *P. bracteatum* and *P. orientale*. According to the latest revision by Kadereit in 1988, who divided the genus *Papaver* L. into 11 sections, these two species belong to section *Macrantha* (Elk) = *Oxytona* Bernh. The main morphological features of this group are as following: perennial habit, rosette with long, thick and bristly pinnately dissected or incised leaves, a main thick root and a flat disc. However these species differ in presence of bracts (with bract vs. without bract respectively), color of petals (red vs. orange respectively) and shape of flower buds (orbicular vs. ovate respectively). Regarding to midrib anatomy, upper collenchyma thickness (UCOT), xylem thickness (XT), lower phloem thickness (LPHT), lower parenchyma thickness (LPT) and lower collenchyma thickness (LCOT), in *P. orientale* are thicker than all other species. In both species, the number of lateral vascular bundles is more than two (4 in *P. bracteatum* and 10 in *P. orientale*) (Figs. 14, 15, 15b). The growth of the lateral vascular bundles is also remarkable in these species (Figs. 14, 15, 15b).

Peduncle shape is orbicular and elliptic in *P. bracteatum* and *P. orientale* respectively. Epidermis surface has striate pattern, collenchyma layer only observed in their cortex, supporting tissue is sclerenchyma and circles of vascular bundles in peduncle is more than two (five in *P. bracteatum* and three in *P. orientale*) (Figs. 29a, 30a). These anatomical features can separate these two species from other groups.

Group II

This group includes *P. cylindricum*, *P. fugax* and *P. persicum*, which according to Kadereit's revision are placed in section *Meconidium* Bernh. The main morphological features of this group are as following: biennial habit, setose pinnatisect basal leaves and pyramidal disc. These species differ in shape and indumentum of capsule (glabrous cylindrical, glabrous narrowly ovate and setosely ovate-globose respectively). From midrib anatomical point of view, the presence of sclerenchyma tissue among lower and upper parenchyma tissues in *P. cylindricum* (Figs. 11b, 11c) and *P. fugax* (Figs. 12a, 12b) is characteristic feature which is not found in all other species. Upper phloem thickness (UPHT) and lower phloem thickness (LPHT) in *P. persicum* is less than all other species. These three species have elliptic peduncle, (Figs. 26a, 27a, 28a) and fiber layer as supporting tissue (Figs. 26b, 27b, 28b). Smooth surface epidermis and one circle of vascular bundles is found in *P. cylindricum*

(Fig. 26a) but epidermis surface with more or less striate pattern and two circles of vascular bundles is found in *P. fugax* and *P. persicum* (Figs. 27a, 28a).

Group III

This group includes *P. decaisnei*, *P. gaubae* and *P. glaucum*. *Papaver decaisnei* and *P. glaucum* are from section *Papaver* L. based on Kadereit's revision (1988). *Papaver gaubae*, which is an endemic species to Iran, based on annual habit and auriculate-amplexicaulous upper leaves, is placed in this group. These species differ in capsule shape (long obovate, wide obovate and orbicular respectively). With respect to midrib anatomical features, these species have triangular midrib with two lateral vascular bundles (Figs. 3, 5, 6). Interestingly, upper collenchyma was not found in these species (Figs. 3, 5, 6). Also the thickest upper and lower cuticle is observed in *P. gaubae*. These species have orbicular peduncle and striate epidermis surface (Figs. 18a, 20a, 21a). One circle of vascular bundles is found in peduncle in *P. decaisnei* (Fig. 18a) and two circles in *P. gaubae* and *P. glaucum* (Figs. 20a, 21a). The supporting tissue is sclerenchyma in *P. decaisnei* (Fig. 18b) but in *P. gaubae* (Fig. 20b) and *P. glaucum* is fiber (Fig. 21b).

Group IV

This group consists of only *P. macrostomum*, which according to Kadereit's classification (1988) is the only member of section *Carinatae* Fedde. It is characterized by annual habit, petiolated pinnatisect basal leaves with oblong-lanceolate segments, pinnatisect upper leaves with linear-lanceolate segments, red petals with their breadth greater than their length, filiform and black filaments, glabrous capsules with elliptic-oblong shape and keeled stigmatic rays. Interestingly, its midrib region is more similar to perennial species rather than annuals so that five lateral vascular bundles is observed in midrib which in two of them growth was observed (Figs. 8a, 8b). Upper parenchyma thickness (UPT) in *P. macrostomum* is more than other species. Peduncle shape is elliptic, epidermis surface with more or less striate pattern, supporting tissue is fiber and two circles of vascular bundles are observed in peduncle (Figs. 23a, 23b).

Group V

This group consists of *P. chelidoniifolium*, *P. dubium* and *P. tenuifolium* which according to Kadereit's revision are from section *Rhoeadium* Spach. The former species is characterized by annual habit, petiolated and pinnatisect basal leaves with orbicular dentate segments, sessile and pinnatisect upper leaves with

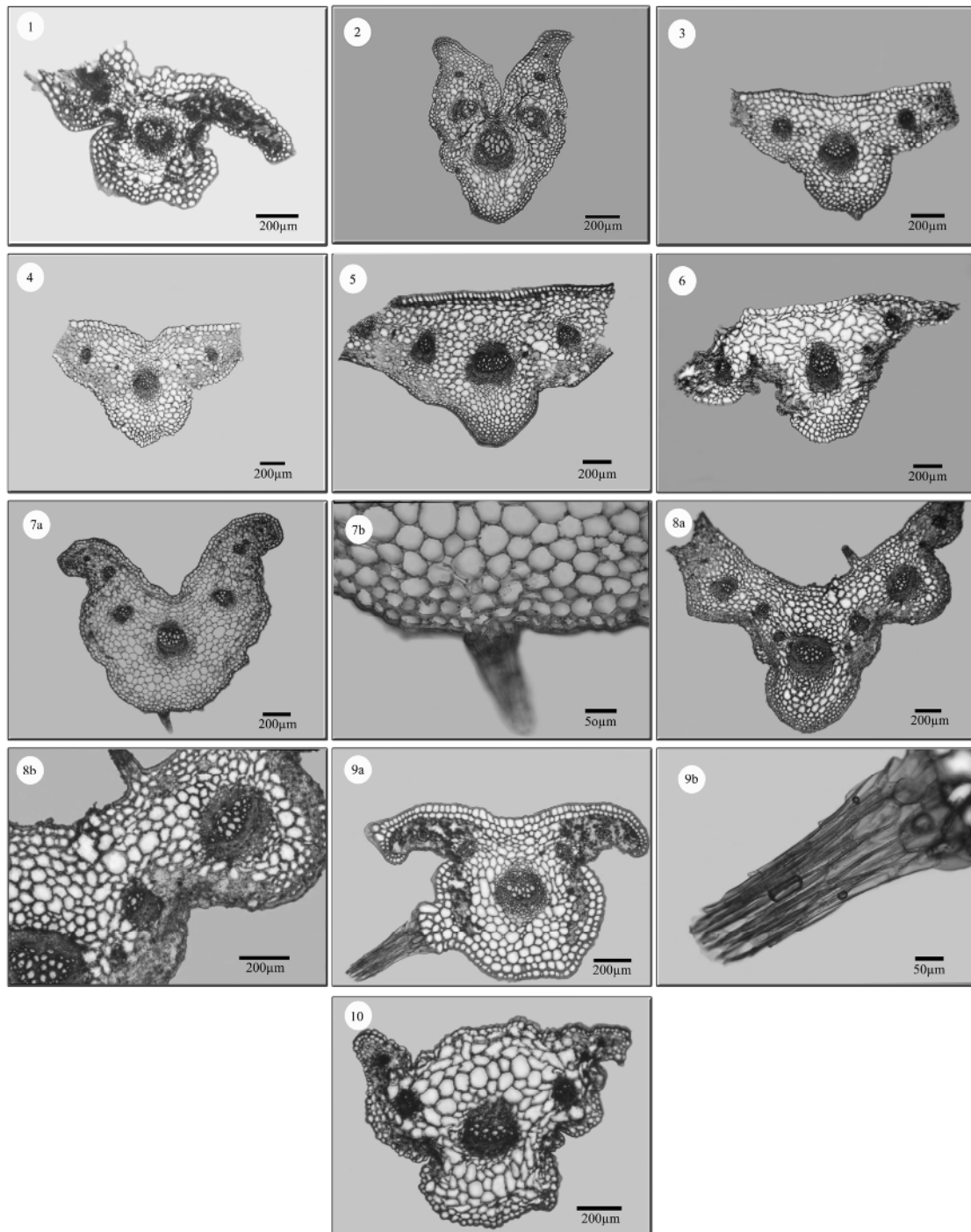
lanceolate segments, glabrous and subglobose capsules which are 6-10 mm long and slightly convex disc. The two species, *P. dubium* and *P. tenuifolium* are characterized by having annual habit, flat disc and oblong-obovate capsules. They differ in divisions of leaves (simple pinnatifid or pinnatisect vs. bi- or tri-pinnatifid). Midrib region is triangular with two lateral vascular bundles (Figs. 2, 4, 10). Moreover, upper collenchyma is not found in *P. tenuifolium* (like group III) (Fig. 10) and upper parenchyma thickness (UPT) in *P. chelidoniifolium* is 50 μm and less than all others. Peduncle anatomy features in *P. chelidoniifolium*, show sclerenchyma cells as supporting tissue, two circles of vascular bundles, smooth epidermis surface and elliptic shape of peduncle (Figs. 17a, 17b). In both of two species (*P. dubium* and *P. tenuifolium*), peduncle shape is orbicular, epidermis surface is striate, supporting tissue is sclerenchyma and there are two circles of vascular bundle (Figs. 19a, 19b, 25a, 25b).

Group VI

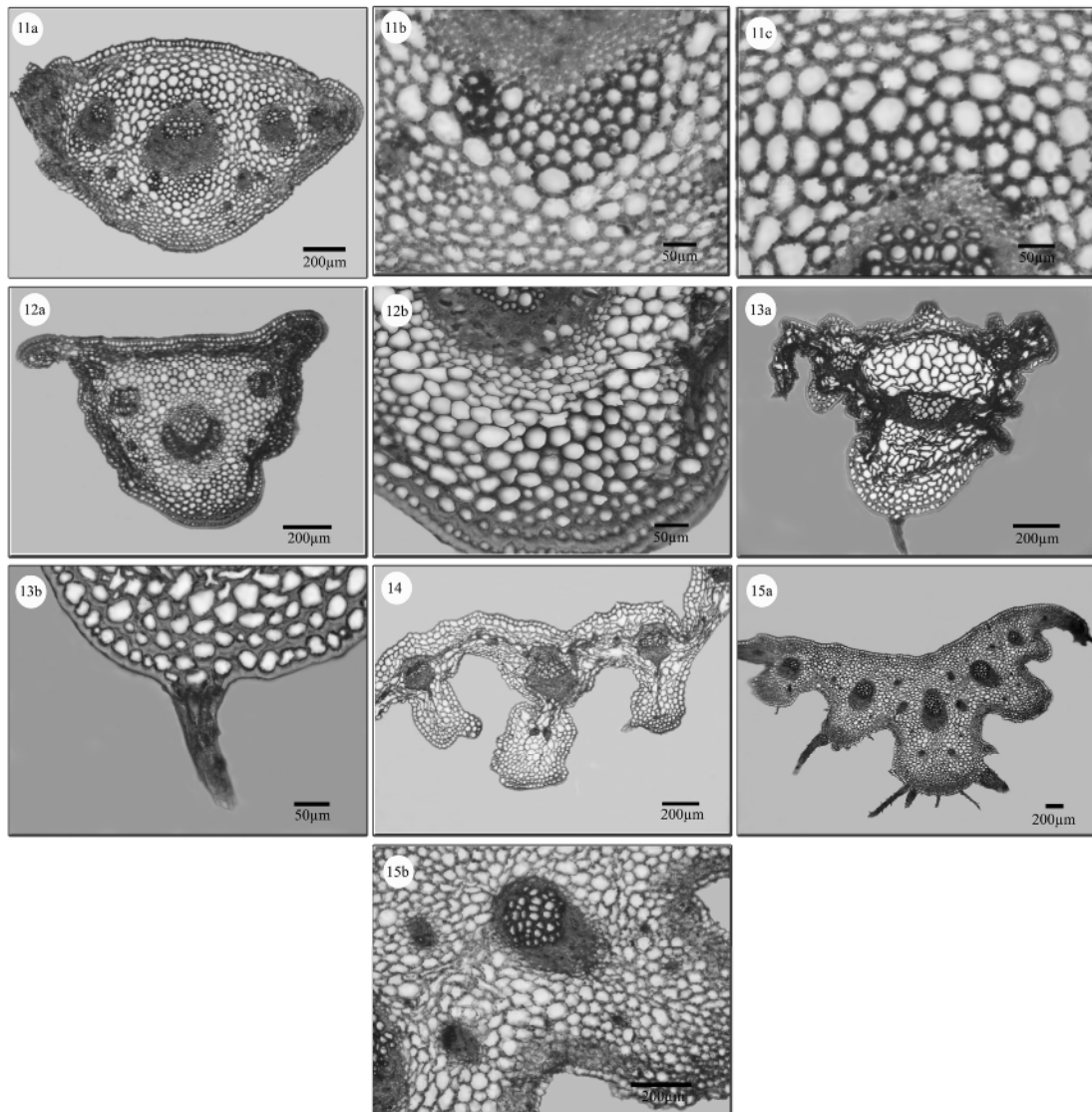
This group including *P. argemone*, *P. hybridum* and *P. pavoninum* which are from section *Argemonidium* Spach. (Kadereit 1988). Morphologically, they are very similar in annual habit, bipinnatisect basal leaves, setose capsules and slightly pyramidal discs. On the other hand, these species differ in shape of capsule so that the former species is characterized by long cylindrical while two latter species have ellipsoid-subgloboseovate capsule. Moreover, capsule of *P. hybridum* is larger than *P. pavoninum* in size. Results of midrib anatomical evidence do not show any separating data for species of this group. Midrib region is observed as orbicular with two lateral vascular bundles (Figs. 1, 7a, 9a). Peduncle shape is orbicular in *P. argemone* and *P. pavoninum* (Figs. 16a, 24a) but elliptic in *P. hybridum* (Fig. 22a). Epidermis surface is smooth, more or less striate and striate in *P. argemone*, *P. hybridum* and *P. pavoninum* respectively (Figs. 16a, 22a, 24a). Fiber layer as supporting tissue and one circle of vascular bundles in peduncle is found in all three species (Figs. 16b, 22b, 24b).

Conclusions

Finally, it should be noted that midrib anatomical characters sometimes could help to separate annual, biennial and perennial species, which is sometimes difficult, by morphological characters. Because of pinnatifid or pinnatisect structure of leaves in the genus, lateral vascular bundles are found in midrib region of all studied species, but in some species like *P. bracteatum* and *P. orientale*, which are perennial, more than two lateral vascular bundles with remarkable



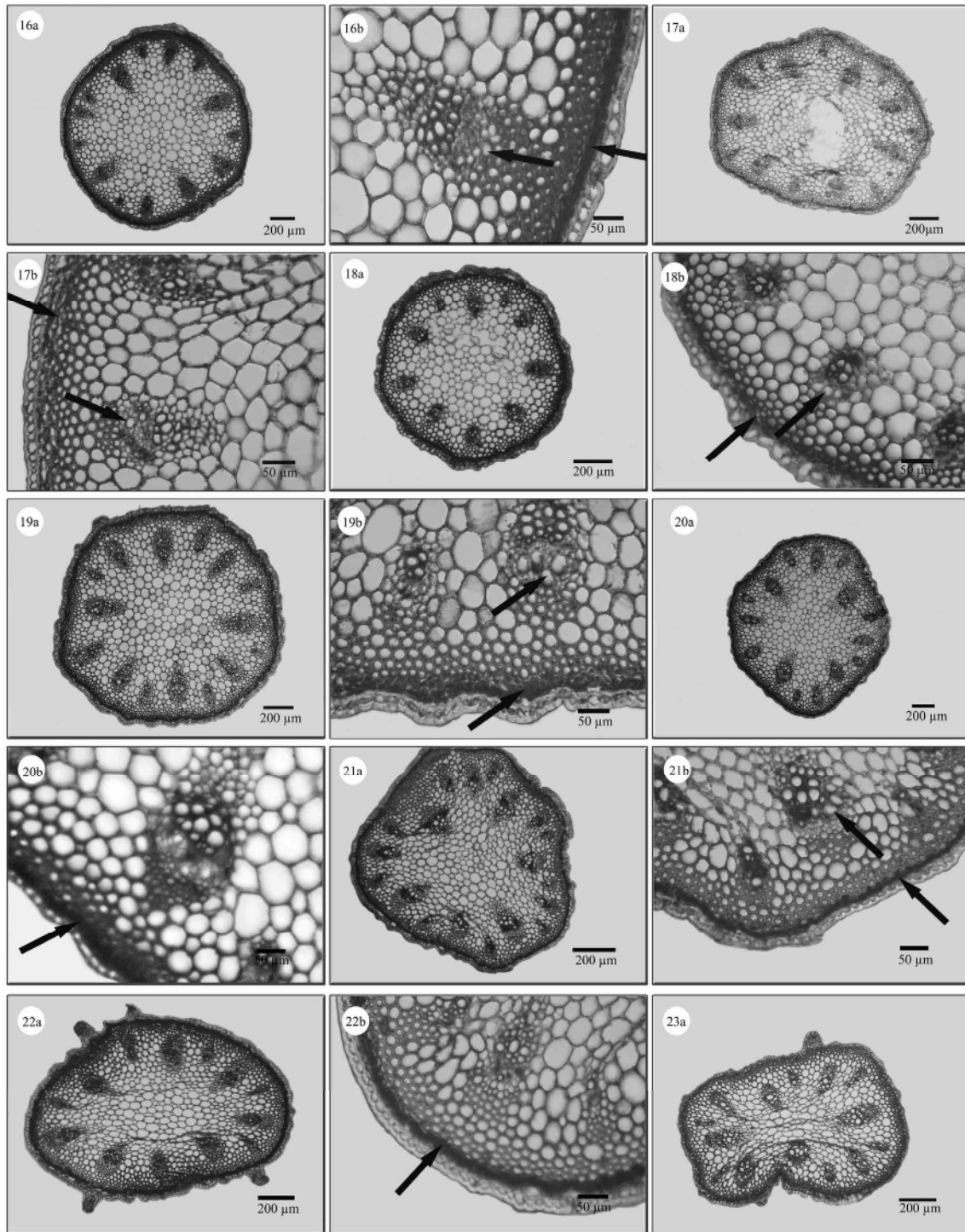
Figs. 1-10: Midrib anatomical features of *Papaver* species. Fig. 1, *P. argemone* (23629); Fig. 2, *P. chelidoniifolium* (27836); Fig. 3, *P. decaisnei* (39262); Fig. 4, *P. dubium* (39263); Fig. 5, *P. gaubae* (39255); Fig. 6, *P. glaucum* (35514); Fig. 7a, *P. hybridum* (39254); Fig. 7b, hair in *P. hybridum*; Fig. 8a, *P. macrostomum* (38340); Fig. 8b, lateral vascular bundle in *P. macrostomum*; Fig. 9a, *P. pavoninum* (28820); Fig. 9b, hair in *P. pavoninum*; Fig. 10, *P. tenuifolium* (39272).



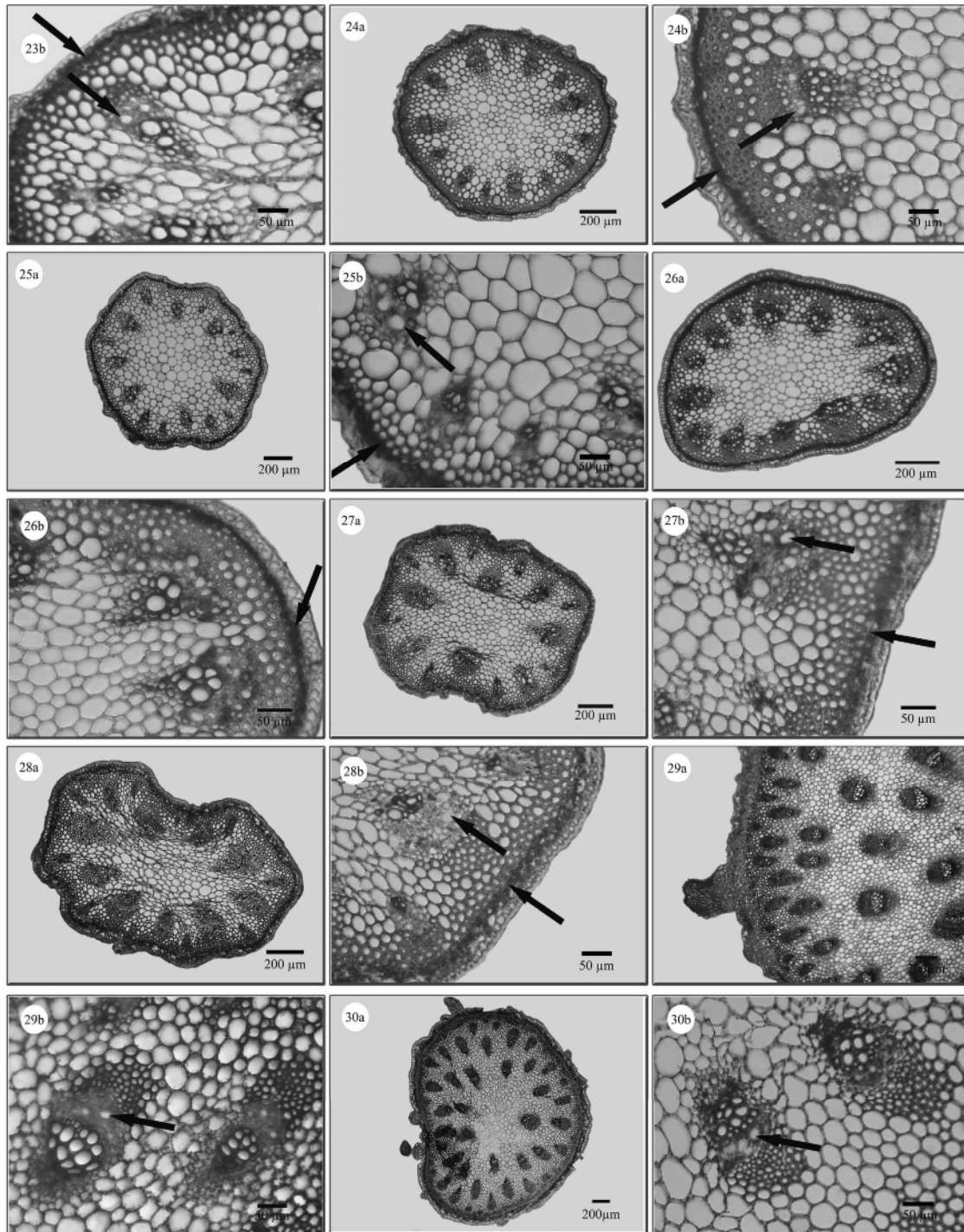
Figs. 11-15: Midrib anatomical features of *Papaver* species. Fig. 11a, *P. cylindricum* (19368); Figs. 11b & 11c, sclerenchyma in *P. cylindricum*; Fig. 12a, *P. fugax* (17482); Fig. 12b, sclerenchyma in *P. fugax*; Fig. 13a, *P. persicum* (8905); Fig. 13b, hair in *P. persicum*; Fig. 14, *P. bracteatum* (8906); Fig. 15a, *P. orientale* (38338); Fig. 15b, lateral vascular bundle in *P. orientale*.

growth are observed. In most of biennial species, more than two lateral vascular bundles is found, but with no growth. In contrast to two above groups, always two lateral bundles without growth is observed in annual species. Moreover the presence of sclerenchyma tissue among parenchyma tissue is a unique feature only observed in *P. cylindricum* and *P. fugax*. Based on midrib shape in cross section, annual species can be divided into two groups: one group with

triangular midrib shape, which includes: *P. gaubae*, *P. glaucum*, *P. decaisnei*, *P. chelidoniifolium*, *P. dubium* and *P. tenuifolium* and another group with orbicular midrib shape includes: *P. argemone*, *P. pavoninum* and *P. hybridum*. However, one exception in annual species could be named, *P. macrostomum*, which its midrib region is more similar to perennial species (crown like with three lobes) rather than annuals.



Figs. 16-23a: Peduncle anatomical features of *Papaver* species. Figs. 16a & 16b, *P. argemone* (23629); Figs. 17a & 17b, *P. chelidoniifolium* (27836); Figs. 18a & 18b, *P. decaisnei* (39262); Figs. 19a & 19b, *P. dubium* (39263); Figs. 20a & 20b, *P. gaubae* (39255); Figs. 21a & 21b, *P. glaucum* (35514); Figs. 22a & 22b, *P. hybridum* (39254); Figs. 23a & 23b, *P. macrostomum* (38340). Laticifer tubes are illustrated by arrows.



Figs. 23b-30: Peduncle anatomical features of *Papaver* species. Figs. 24a & 24b, *P. pavoninum* (28820); Figs. 25a & 25b, *P. tenuifolium* (39272); Figs. 26a & 26b, *P. cylindricum* (19368); Figs. 27a & 27b, *P. fugax* (17482); Figs. 28a & 28b, *P. persicum* (8905); Figs. 29a & 29b, *P. bracteatum* (8906); Figs. 30a & 30b, *P. orientale*. Laticifer tubes are illustrated by arrows.

Peduncles anatomical features can separate perennial species from annuals and biennials, some characters like presence of collenchyma cells in cortex and more than two circles of vascular bundles are only found in perennial species, but any special character to separate biennials from annuals species is not found.

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