

ANATOMICAL STUDIES OF THE GENUS PYRUS L. (ROSACEAE) IN IRAN AND ITS TAXONOMICAL IMPLICATIONS

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In this study leaf and petiole anatomy of 10 species of the genus *Pyrus* L. belonging to four sections, *Pashia*, *Pyrus*, *Xeropyrenia* and *Argyromalon*, and one cultivated specimen (close to *P. syriaca*) is presented. These species include *Pyrus boissieriana* Buhse, *P. kandevanica* Ghahreman & Khatamsaz, *P. turcomanica* Maleev, *P. hyrcana* Fedor., *P. mazanderanica* Schönbeck-Temesy, *P. syriaca* Boiss., *P. glabra* Boiss., *P. oxyprion* Woron., *P. salicifolia* Pall., *P. elaeagnifolia* Pall. Among 43 studied anatomical characters, 29 characters vary in different localities, seven are constant in all species and four are valuable and can be used in distinguishing species. These characters include number of layers of palisade parenchyma layer, density of palisade parenchyma layers, and presence of lower palisade parenchyma layer between auricles. On the basis of the present study, anatomical characters are useful for separating Zagros species from Alborz ones and also in sectional level.

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(Pyrus)

در این مطالعه، ساختار تشریحی برگ و دمبرگ ۱۰ گونه ایرانی از جنس گلابی متعلق به چهار بخش *Pashia*, *Pyrus*, *Xeropyrenia*, *Argyromalon* به همراه یک گونه کاشته شده نزدیک گونه *Pyrus syriaca* ارائه می شود. این گونه ها عبارتند از: *Pyrus kandevanica* Ghahreman & Khatamsaz, *P. boissieriana* Buhse, *P. mazanderanica* Schonbeck- Temesy, *P. hyrcana* Fedor, *P. turcomanica* Maleev, *P. elaeagnifolia* Pall., *P. salicifolia* Pall., *P. oxyprion* Woron, *P. glabra* Boiss., *P. syriaca* Boiss. از بین ۴۳ صفت آناتومیکی مورد بررسی ۳۲ صفت در افراد یک گونه که از نقاط مختلف جمع آوری شده بودند متغیر بودند، ۷ صفت ثابت و تنها ۴ صفت از نظر جداسازی گونه ها حایز اهمیت بودند. این صفات مهم عبارتند از تعداد و تراکم لایه های پارانشیم نردبانی، وجود پارانشیم نردبانی تحتانی و فاصله بین گوشک ها. بر اساس بررسی های انجام شده مشخص شد که صفات آناتومیکی ابزاری مفید برای جداسازی گونه های البرزی از گونه های موجود در زاگرس و همچنین جداسازی در سطح برخی از بخش ها می باشند.

Introduction

The genus *Pyrus* L. is a tree member of subtribe *Pyrinae* (formerly subfamily *Maloideae*), family

Rosaceae (Campbell & al. 2007). The genus was defined by Linnaeus in 1753 that covered not only pear trees but also apple trees (Browicz 1993). This genus

Table 1. Voucher specimens of *Pyrus* species used in this study.

| Species | Locality |
|---|--|
| <i>P. boissieriana</i> Buhse | Mazanderan: Karaj- Chalous road, ca. 60 km to Chalous; Attar & Zamani; 23.7.2007; 37289- TUH |
| <i>P. boissieriana</i> Buhse | Golestan: Ramian, Raazi village deviation; Zamani ; 2.8.2007; 37730 - TUH |
| <i>P. elaeagnifolia</i> Pall. | Kohgiluyeh va boyer ahmad: vicinity of Yasuj ; Ajani; 12.7.2002; 37392 - TUH |
| <i>P. glabra</i> Boiss. | Kurdistan: Sanandaj to Marivan road, Deviation road of Tij- Tij to Marivan; 3 km after Sheykhe –Attar village; Attar, Maroofi & Zamani; 18.8.2007; 37464 - TUH |
| <i>P. glabra</i> Boiss | Kurdistan: Sanandaj to Marivan road, Deviation road of Tij- Tij to Marivan, 2 km after Sheykhe –Attar village; Attar, Maroofi & Zamani, 18.8.2007; 37552- TUH |
| <i>P. hyrcana</i> Fedor | Mazanderan: Karaj- Chalous road, 20 km after Gachsar to Chalous; Attar & Zamani; 14.10.2007; 37601 - TUH |
| <i>P. kandevarica</i> Ghahreman & Khatamsaz | Mazanderan: Karaj- Chalous road, 20 km after Gachsar; Attar, Zamani & Raei; 14.10.2007; 37598 – TUH |
| <i>P. kandevarica</i> Ghahreman & Khatamsaz | Mazanderan: Karaj- Chalous road, ca. 25 km after Gachsar to Chalous; Attar, Zamani & Raei; 37610 – TUH |
| <i>P. mazanderanica</i> Schönbeck- Temesy | Mazanderan: Karaj- Chalous road, ca. 65 km to chalous; Attar, Zamani & Raei; 23.7.2007; 37291 – TUH; 14.10.2007; |
| <i>P. aff mazanderanica</i> Schönbeck- Temesy | Mazanderan: Karaj- Chalous road, 20 km after Gachsar to Chalous; Zamani & Raei; 23.7.2007; 37300- TUH |
| <i>P. mazanderanica</i> Schönbeck- Temesy | Mazanderan: Karaj- Chalous road, 20 km after Gachsar to Chalous; Attar, Zamani & Raei; 14. 10. 2007; 37604- TUH |
| <i>P. oxyprion</i> Woron. | Lorestan: Khorram- Abad, Nujian pass; Mehrnia, Zamani & Malaki, 8.8.200; 37534- TUH |
| <i>P. salicifolia</i> Pall. | Azerbaijan: 15 km to Kaleybar from Peygham; Attar, Zamani & Raei; 3.6.2007; 37119 – TUH |
| <i>P. syriaca</i> Boiss. | Kurdistan: ca. 50 km to Divan- Darre from Saqez, Jonian village; Attar, Maroofi & Zamani; 19.8.2007; 37482 – TUH |
| <i>P. syriaca</i> Boiss. | Kurdistan: Marivan to Bane road, Before Tut- Sorkhan village; Attar, Maroofi & Zamani; 17.7.2007; 37554- TUH |
| Cultivated(<i>P. syriaca</i> group) | Kurdistan: Sanandaj to Marivan road, deviation road of Tij- Tij to Marivan; Attar, Maroofi & Zamani; 18.8.2007; 37458- TUH |
| <i>P. turcomanica</i> Maleev | Northern Khorasan: North of Bojnord, Amir_Abad village to Gifan village, ca. 3 km after Amir-Abad to Gifan; Zamani, Raei & Zangui; 11.9.2007; 37590- TUH |

probably originated in the mountainous regions of western and southwestern China and evolved and spread eastward and westward (Rubtsov 1944). The distribution of *Pyrus* lies primarily in the temperate zone of the northern hemisphere and only exceptionally enters the most northwestern tip of Africa (Browicz 1993) but does not occur in North America. *Pyrus* has 10 (Schönbeck-Temesy 1969) to 11 (Khatamsaz 1992) species in Iran and is a taxonomically difficult genus of family *Rosaceae*. Among these species, *P. kandevarica*, *P. farsistanica*, *P. glabra* and *P. mazanderanica* are endemics to Iran. *Pyrus* species habitats are in open forests of west (*P. syriaca*), dense forests of north (*P. boissieriana*), steppe-forests (*P. salicifolia*) and some rocky mountains (*P. syriaca*). This genus is an important element of Irano-Turanian region (species such as *P. syriaca*, *P. glabra* and *P. oxyprion*) and Hyrcanian province (species such as *P. boissieriana*, *P. hyrcana*, *P. mazanderanica*). Distribution zone of *Pyrus* in Iran is Alborz, Zagros Mts., south and some elevations in east of Iran. Species

of Zagros Mts. that include *P. syriaca*, *P. oxyprion*, *P. glabra*, *P. elaeagnifolia*, *P. salicifolia* and also *P. farsistanica* (has been reported from the vicinity of Shiraz) are more xerothermic in comparison with Alborz Mts. species. Metcalfe and Chalk (1957) described some common anatomical features of some genera of family *Rosaceae* as: presence of isolated strands of fibers with intervening unligified parenchyma, presence of vascular bundles separated by narrow primary rays, presence of fibers in the secondary phloem, presence of homogenous pith, solitary crystals in special cells. However, these features are very general and anatomy of this genus has not been studied in details yet. Thus the present study aims to 1) present detailed anatomical data of the genus 2) analyze these data and 3) assess value of anatomical characters in separating the studied species.

Materials and Methods

In this study, 16 specimens representing 10 species and one cultivated specimen (close to *P. syriaca*) were

selected among about 200 specimens collected from different localities. All voucher specimens are deposited in Central Herbarium of Tehran University (TUH). Because of the high variation of morphological diagnostic features of these species and difficulty of their identification, we used only typical specimens that are representative of any species. For assessment of probable influence of ecological conditions on anatomical features of species (especially species which have extensive distribution), we studied different populations of some species (Table 1). Fresh leaves and petioles (leaves next to fruit) of mature fruit were fixed in alcohol - glycerin (1:1) for one month. Cross sections were made at the middle of leaves and petioles with a razor; transverse sections were cleared with sodium hypochlorite, dehydrated and stained with methyl green and bismark brown colors. After preparing the slides, they were photographed by a Leitz light microscope model Wetzlar, Nikon camera model coolpix S10 and required characters were measured by measurepro software version HASP 2.17.

Results

For comparative anatomy of species 43 characters of leaf and petiole were examined. Some of the main characters of the investigated specimens have been summarized in table 2.

LAMINA

Lamina includes midrib region plus blade. In the case of blade, arrangement of cells are as follows: upper epidermis covered with cuticle layer and superficial stomata, 2-3 layers of palisade parenchyma layer, spongy parenchyma layer (bifacial mesophyll), lower epidermis with a cuticle layer (letter 'b' in each presented anatomical Fig., except in Fig. 23). However in a few specimens (clearly observed in *P. salicifolia* and *P. elaeagnifolia*, see Figs 24b, 25b) lower palisade parenchyma layer is present below lower epidermis and hence mesophyll is isobilateral. Upper cuticle thickness (BUCT) ranges from 2.5 µm in *P. glabra* to 14 µm in *P. kandevarica*, lower cuticle thickness (BLCT) ranges from 4 µm in *P. hyrcana* to 19 µm in *P. kandevarica* (table 2), Upper epidermis that is mostly quadrangular and usually thicker than lower epidermis (Table 2) ranges from 10 µm in *P. elaeagnifolia* and *P. aff mazanderanica* to 36 µm in *P. salicifolia* (Table 2), lower epidermis is mostly oblong and its thickness (BLET) ranges from 8.2 µm in *P. boissieriana* to 20 µm in *P. salicifolia* (Table 2), palisade parenchyma layer consists of two to three (Table 2) layers that its cells shape ranges from sub- elliptic (Fig. 15b), oblong (Fig. 9b) to narrow oblong (Fig. 13b) and its thickness (PT) ranges from 60 µm in *P. syriaca* and *P. turcomanica* to 120 µm in *P. salicifolia* (Table 2).

Table 2. Anatomical measured characters in *Pyrus* species.

| Species | MUCT | MLCT | MUET | MLET | MXPTT | HP | MUPT | MLPT | MXL/MXW | MPHL/MPHW | PN/PT | LPL/PT | ST |
|--|-------|-------|--------|--------|-------|----|-------|-------|------------|-------------|-------------|---------|---------|
| <i>P. elaeagnifolia</i> 37392 | 80-90 | 50 | 9.5-10 | 9.5-10 | 40-50 | - | 100 | 70-80 | 420/160 | 490/110 | 2.3/65-75 | +/60-65 | 50-60 |
| <i>P. salicifolia</i> 37119 | 50-60 | 40-50 | 7.5 | 10 | 45 | + | 100 | 120 | 450-500/87 | 500-550/120 | 2.3/110-120 | +/60-65 | 60-70 |
| <i>P. salicifolia</i> group (cultivated) 37458 | 89 | 71 | 9-10 | 8.5-9 | 40-50 | - | 30 | 96 | 410/91 | 450/110 | 2.3/100 | - | 120 |
| <i>P. glabra</i> 37552 | 85 | 70 | 11 | 9.7 | 40 | - | 54 | 48 | 280/100 | 320/73 | 2.3/87 | +/55-60 | 60 |
| <i>P. glabra</i> 37464 | 60 | 75 | 10 | 10 | 48 | - | 54 | 54 | 380/83 | 410/64 | 2.3/80-90 | ± | 100-110 |
| <i>P. oxypetion</i> 37534 | 71 | 52 | 11 | 7.5 | 55 | - | 25-30 | 36 | 330/95 | 340/77 | 2.3/93 | - | 96 |
| <i>P. mazanderanica</i> 37291 | 60 | 32 | 9.7 | 8 | 30-35 | - | 69 | 80 | 300/120 | 300/80 | 2/83 | - | 95 |
| <i>P. aff mazanderanica</i> 37300 | 75 | 58 | 9.7 | 6.2 | 35-40 | - | 46 | 62 | 430/98 | 450/85 | 2/63 | - | 67 |
| <i>P. mazanderanica</i> 37604 | 80-85 | 70-75 | 15 | 15 | 33 | - | 150 | 120 | 600/200 | 600-650/120 | 2/70 | - | 80 |
| <i>P. syriaca</i> 37482 | 43 | 40 | 12 | 8.5 | 37 | - | 75 | 65-70 | 420/85 | 470/83 | 2.3/60 | - | 60-65 |
| <i>P. syriaca</i> 37554 | 87 | 65 | 12 | 6.5 | 41 | - | 72 | 35-40 | 450/110 | 450-500/160 | 2.3/81 | ± | 100 |
| <i>P. boissieriana</i> 37730 | 60-65 | 53 | 8.9 | 8-9.5 | 36 | - | 24 | 33 | 420/98 | 420/70 | 2/75-80 | - | 75-80 |
| <i>P. boissieriana</i> 37289 | 91 | 50-55 | 8.5 | 8.4 | 32 | - | 84 | 73 | 440/100 | 450-500/100 | 2/75-80 | - | 90-95 |
| <i>P. kandevarica</i> 37610 | 51 | 60-65 | 11 | 11 | 45 | - | 58 | 40 | 410/90 | 450/76 | 2/67 | - | 82 |
| <i>P. kandevarica</i> 37598 | 89 | 73 | 13 | 13 | 52 | - | 50 | 56 | 600/110 | 600-650/170 | 2/110 | - | 130 |
| <i>P. turcomanica</i> 37590 | 50 | 30 | 9.5 | 9 | 32 | - | 50-55 | 35-40 | 350/86 | 400/80 | 2/110 | - | 100 |
| <i>P. hyrcana</i> 37601 | 71 | 55 | 7 | 9.2 | 30 | - | 56 | 67 | 400/120 | 450/110 | 2/60 | - | 75 |

Table 2: Continued.

| Species | BUCT | BLCT | FPT | SPT | TPT | BUET | BLET | PL/PW | PET | PUCT | PLCT | PUPT | PLPT | PPPT | PXPTT | PXL/PXW | PEXP/PEXT | AD |
|--|-------|----------|-------|-------|-------|------|------|--------------------|-----|--------|--------|---------|--------|------|-------|-------------|------------|---------|
| <i>P. elaeagnifolia</i> 37392 | 7-12 | 7-11 | 23-25 | 27-29 | 22-25 | 10 | 10 | 800/850-900 | 17 | 120 | 110 | 110 | 90-100 | 44 | 39 | 400-450/170 | +/- 30- 40 | 550 |
| <i>P. salicifolia</i> 37119 | 8-12 | 9-12 | 48-55 | 40-50 | 37-40 | 36 | 20 | 850-900/1100 | 11 | 105 | 81 | 200 | 200 | 47 | 33 | 600/80 | +/- 55- 65 | 1000 |
| <i>P. syriaca</i> group (cultivated) 37458 | ? | ? | ? | ? | ? | 16 | 20 | 950-1000/1000 | 9.8 | 100 | 130 | 100 | 110 | 56 | 32 | 500/180 | ± | 650-700 |
| <i>P. glabra</i> 37552 | 2.5-4 | 6-11 | 22-29 | 16-22 | 15-25 | 15 | 8.3 | 900/1200-1300 | 15 | 150 | 110 | 96 | 95 | 30 | 36 | 700-750/150 | ± | 850-900 |
| <i>P. glabra</i> 37464 | 8-10 | 7-9 | 28-33 | 25-30 | 25-27 | 20 | 11 | 950/900 | 10 | 140 | 140 | 120 | 130 | 55 | 40 | 400-450/150 | ± | 550 |
| <i>P. oxyprion</i> 37534 | 5-7 | 11-13 | 21-24 | 24-30 | 21-24 | 18 | 10 | 850-900/850 | 16 | 140 | 92 | 94 | 160 | 45 | 33 | 300/130 | +/- 35- 40 | 450-500 |
| <i>P. mazanderanica</i> 37291 | 12 | 15 | 35-45 | 29-37 | - | 17 | 11 | 950-1000/900-950 | 10 | 130 | 73 | 160 | 160 | 40 | 26 | 300/66 | +/- 30- 40 | 350 |
| <i>P. aff mazanderanica</i> 37300 | 8-9 | 6-9 | 28-37 | 15-28 | - | 10 | 9.5 | 780-800/1050-1100 | 11 | 70-80 | 93 | 160 | 160 | 29 | 36 | 620/160 | +/- 35- 40 | 650-700 |
| <i>P. mazanderanica</i> 37604 | 7-11 | 5-6.5 | 35-39 | 24-28 | - | 11 | 9.2 | 1100/1200 | 14 | 150 | 180 | 110-120 | 220 | 30 | 56 | 600-650/150 | ± | 700-800 |
| <i>P. syriaca</i> 37482 | 5-7.5 | 5-8 | 32-35 | 27-30 | 27-30 | 22 | 14 | 950-1000/1100-1200 | 14 | 130 | 100 | 110 | 150 | 64 | 38 | 500/200 | ± | 500-550 |
| <i>P. syriaca</i> 37554 | 5-6.5 | 5-8 | 28-34 | 21-31 | 21-23 | 18 | 12 | 950/1100-1200 | 13 | 98 | 87 | 100 | 120 | 31 | 36 | 450-500/170 | +/- 50- 80 | 650 |
| <i>P. boissieriana</i> 37730 | 10-11 | 10-11 | 40-42 | 25-29 | - | 15 | 8.2 | 650-700/800 | 7.6 | 73 | 85 | 120 | 100 | 19 | 35 | 350/76 | ± | 330 |
| <i>P. boissieriana</i> 37289 | 4-6 | 6-9 | 35-47 | 25-38 | - | 11 | 9.4 | 950/800-850 | 9.3 | 80 | 100 | 77 | 150 | 78 | 47 | 500-550/100 | ± | 550-600 |
| <i>P. kandevaranica</i> 37610 | 8-10 | 8-8.5 | 28-33 | 22-23 | - | 22 | 13 | 700-750/1100-1200 | 13 | 80-90 | 85 | 120 | 110 | 33 | 35-40 | 600-650/91 | ± | 550 |
| <i>P. kandevaranica</i> 37598 | 12-14 | 12-19 | 26-32 | 25-32 | - | 20 | 17 | 850/950-1000 | 12 | 80-90 | 95-100 | 100 | 120 | 27 | 29 | 370/180 | ± | 400 |
| <i>P. hyrcana</i> 37601 | 9-12 | 4-9 | 47-66 | 30-49 | - | 15 | 9 | 800/950 | 10 | 95-100 | 100 | 100 | 150 | 25 | 53 | 370/180 | ± | 400 |
| <i>P. turcomanica</i> 37590 | 7-8 | 8.5-10.5 | 30-35 | 26-29 | - | 15 | 12 | 750-800/950 | 12 | 115 | 120 | 80 | 150 | 20 | 30 | 390/140 | +/- 40- 50 | 450 |

*Abbreviations: MU(L)CT, midrib upper (lower) collenchyma's thickness; MU(L)ET, midrib upper (lower) epidermis thickness; MXPTT, midrib xylem protective tissue's thickness; HP, hair presence; MU(L)PT, midrib upper parenchyma's thickness; MXL (W), midrib xylem's length (width); MPHL (W), midrib phloem's length (width); PN(T), palisade layer's number (thickness); LPP, lower palisade layer's presence; ST, spongy layer's thickness; BU(L)CT, blade upper (lower) cuticle's thickness; F(S,T)PT, first (second, third) palisade layer's thickness; BU(L)ET, blade upper (lower) epidermis thickness; PL(W), petiole's length(width); PET, petiole epidermis thickness; PU(L)CT, petiole upper (lower) collenchyma's thickness; PU (L)PT, petiole upper (lower) parenchyma's thickness; PP(X)PTT, petiole phloem (xylem) protective tissue's thickness; PXL(W), petiole xylem length (width); PEXP(T), petiole external phloem's presence (thickness); AD, auricle's distance; +, examined character is present; -, examined character is absent; ±, examined character is indistinct; ?, the character has not been measured.

* All quantitative characters are in micrometer (µm).

Thickness of the first layer of palisade layer (FPT) ranges from 21 μm in *P. xyprion* to 66 μm in *P. hyrcana* (Table 2, Figs. 13b, 19b). Regarding spongy layer thickness, the minimum thickness is observed in *P. elaeagnifolia* (50 μm) while the maximum is observed in *P. kandevanica* (130 μm) (Table 2). In some species (especially in *P. elaeagnifolia*, Fig. 25b) hypodermis is observed clearly below epidermis. Regarding midrib region, the shape of midrib is generally elliptic (letter 'a' in each presented anatomical Fig.s, except Fig. 23) and includes: upper and lower epidermis with a cuticle layer, upper and lower collenchyma (2- 4 layers) and parenchyma (2- 5 layers), upper and lower fiber, xylem and phloem (letter 'a' in each presented anatomical Fig.). Upper and lower epidermis are composed of circular- quadrangular cells and their thickness (MUET, MLET) ranges from 7 μm in *P. hyrcana* to 15 μm in *P. mazanderanica*, and from 7.5 μm in *P. oxyprion* to 15 μm in *P. mazanderanica* respectively, upper collenchyma thickness (MUCT) ranges from 43 μm in *P. syriaca* to 91 μm in *P. boissieriana*, lower collenchyma thickness (MLCT) ranges from 30 μm in *P. turcomanica* to 75 μm in *P. glabra*, upper parenchyma's thickness (MUPT) ranges from 24 μm in *P. boissieriana* to 150 μm in *P. mazanderanica*, lower parenchyma's thickness (MLPT) ranges from 33 μm in *P. boissieriana* to 120 μm in *P. salicifolia*, xylem protective tissue's thickness (MXPTT) ranges from 30 μm in *P. hyrcana* to 55 μm in *P. oxyprion*.

PETIOLE

Generally, several shapes of petiole such as square (Figs. 9c, 22c), oblong (23b), orbicular (Figs. 11c, 13c), semi-orbicular (Figs. 19c, 24c, 25c) and rhombus (20c) are distinguished. Midrib region is composed of: one layer of epidermis covered with a cuticle layer, 1- 6 layers of upper and lower collenchyma, 3- 6 layers of upper and lower parenchyma, upper and lower fiber, external xylem, phloem and internal xylem (letter 'c' in each presented Fig., except Fig. 23). Thickness of epidermis layer that is composed of quadrangular-circular cells ranges from 7.6 μm in *P. boissieriana* to 16 μm in *P. glabra* (table 2). Collenchyma is arranged as a complete cylinder surrounding inner tissues. This tissue is divided into two types: Tangential (or plate) collenchyma that consists of several orbicular layers (3- 6) of cells and is observed beneath the epidermis throughout the petiole except in auricles and angular collenchyma that is composed of 4- 5 layers of polyhedral cells and is present in auricles (letter 'c' in

each presented Fig., except Fig. 23). Thickness of upper collenchyma (PUCT) ranges from 73 μm in *P. boissieriana* to 150 μm in *P. glabra*, while lower collenchyma (PLCT) ranges from 73 μm in *P. mazanderanica* to 140 μm in *P. glabra*, thickness of upper parenchyma (PUPT) ranges from 77 μm in *P. boissieriana* to 200 μm in *P. salicifolia*, thickness of lower parenchyma (PLPT) ranges from 95 μm in *P. glabra* to 220 μm in *P. mazanderanica* (Table 2). Regarding fiber, lower fiber is clearer than upper fiber and is arranged in separate aggregates (Fig. 24c) or in a more or less a united aggregate (Fig. 17c). In some specimens apex of auricle is obtuse (Figs. 12c, 13c, 14c) while in some others is acute (Figs. 9c, 10c). Angle between auricle and horizontal axis of petiole is between 130° (Fig. 23b) and 175° (Figs. 24c, 25c). Distance of two auricles also ranges from 330 μm in *P. boissieriana* (Fig.10c) to 1000 μm in *P. salicifolia* (Fig. 24c). One interesting character in species of *Pyrus* is presence of external xylem (letter 'c' in each presented anatomical Fig., except Fig. 23). As indicated in table 2, this character is remarkable in some specimens while is indistinct in other ones. Shape of vascular bundles in petiole appears to be a relatively variable character so that it varies from semi-elliptic (Figs. 15c, 17c), elliptic (Fig. 19c), horse-shoe (Fig. 23b), crescent (24c) to oblong (22c).

Discussion

The delimitation of the genus *Pyrus* is very difficult so that number of its species has increased to 80, although with precise studies (Browicz 1993) this number reduced to 38 species. The most important factor of this difference in number of species is the high variation of morphological characters that is probably caused by ease of hybridization between pears (Browicz 1993). Moreover, the presence of different ecological conditions, specifically in species such as *P. boissieriana* and *P. syriaca*, results to the formation of remarkable differences between several populations of the same species. According to Flora Iranica (Schönbeck-Temesy 1969) on the basis of some morphological features, the genus *Pyrus* is divided into four sections *Pashia*, *Pyrus*, *Xeropyrenia* and *Argyromalon*. In these sections, anatomical characters of each section and their taxonomical implications are assessed.

Section *Pashia* Koehne

This section includes *P. boissieriana* and *P. kandevanica* in Iran. The main morphological features of this section is as follows: Fruits densely white-punctuate, sepals deciduous in fruits, style with 2-5 necks (Figs. 1, 2) (Browicz 1993). In the other hand, these two species differ in size of fruit and density of inflorescence (Khatamsaz 1992). The former species is distributed throughout Alborz Mts. and northern Khorassan while the later species is found in a few localities of central Alborz. According to anatomical characters, petiole epidermis thickness (PET) in *P. boissieriana* is less than all other species, especially *P. kandevanica* (Table 2). Both of these species have two layers of palisade layer that have been arranged densely and lack lower palisade layer (Figs. 12- 14a). As illustrated in the corresponding Fig.s, it seems that the presence of two layers of palisade layer in the blade is a constant character that separates this section from the sections *Xeropyrenia* and *Argyromalon*. In this section, except the number of layers of palisade layer, most of studied characters are variable in the same species (Table 2) and therefore are not applicable in separating of these two species from each other. In spite of presence of morphologically diagnostic features of the new species *P. kandevanica*, we did not find any anatomically separating character in this species.

Section *Pyrus*

This section includes *P. hyrcana* and *P. turcomanica* in Iran. The main morphological features of this section is as follows: Fruits mostly not punctuate, sepals persistent in fruit, style with 5 necks (Browicz 1993). Morphologically differentiation of mentioned species are as follows: *P. hyrcana* has erect sepals (Fig. 3a) (Komarov 1971), *P. turcomanica* has broadly oval sepals that are appressed to fruit (Fig. 4a, b) (Komarov 1971). The former species is reported from Gilan province while *P. turcomanica* is reported doubtfully from Golestan National Park, although we found specimens from a few northeastern localities of Iran that are very close to *P. turcomanica* description. At the anatomy point of view, these species have some important features as: midrib's lower collenchyma thickness (MLCT) in *P. turcomanica* is less than all other species (Table 2). Moreover, midrib's upper collenchyma, lower parenchyma, phloem protective tissue, blade's palisade and spongy layers in *P. hyrcana* are thicker than those in *P. turcomanica*. In case of petiole, lower parenchyma

thickness in *P. turcomanica* is less than all other *Pyrus* species. Species of this section have 2 layers of palisade layer and lack lower palisade layer (Fig. 13- 14 c).

Section *Xeropyrenia* Fedor.

This section includes *P. syriaca*, *P. glabra*, *P. oxyprion* and *P. mazanderanica* in Iran. Species of this section have a few morphological similarities: Fruits not punctuate, sepals persistent in fruit, style with 3-5 necks, leaves oblong to ovate (Schönbeck-Temesy 1969). In this section, three former species are distributed in Zagros Mts. (from north to south) while the later species is distributed in Alborz Mts. In addition to geographical difference, these species have some morphologically differentiating features, especially in relation to *P. mazanderanica*. On the basis of palisade layer's number (Table 2), these species are divided into two groups: a) species with two layers in palisade layer that include *P. mazanderanica* (Figs. 20-22c) and b) species with two to three layers in palisade layer that include *P. syriaca*, *P. oxyprion* and *P. glabra* (Fig. 15-19c). Morphological differences among later group's species are very ambiguous so that recognizing them is difficult. After examining the cross sections, we found that not only morphological but also anatomical features of these taxa are very variable in the same species (Table 2). For example, lower palisade layer is observed in some specimens, while is not observed in other specimens of the same species (Table 2). In case of these species, we suggest that it is better to examine several specimens from different localities of their distribution range not only from Iran but also adjacent countries for more precise judgment about them. On the basis of this study, reduction of the species *P. oxyprion* (Schönbeck-Temesy 1969) to the variety *P. syriaca* var. *oxyprion* (Khatamsaz 1992) is verified.

Section *Argyromalon* Fedor.

This section includes *P. salicifolia* and *P. elaeagnifolia* in Iran. In view of morphology, these species have more or less dense indumentum, oblanceolate to linear-lanceolate leaves with a short petiole (Schönbeck-Temesy 1969) (Fig. 8 a, b). On the other hand, these species indicate remarkable geographically and morphologically differences. *P. elaeagnifolia* that is distributed in central Zagros has longer petiole, pedicel and laxer indumentum in comparison with *P. salicifolia* that is distributed in northern Zagros, Azerbaijan. One remarkable character observed in these species is

presence of lower palisade layer. Although this character is observed in a few other species (Table 2), this character is observed in this section clearly. Moreover, species of this section also have two layers of palisade layer (Figs. 24- 25c). Some of the main differences of these species are as follows: midrib's upper collenchyma in *P. elaeagnifolia* is more than all other species, especially *P. salicifolia*. Moreover, palisade layer thickness and distance of auricles in petiole of *P. salicifolia* are more than all other species (Table 2, Figs. 24- 25c).

Conclusion

In this study, we found that on the basis of palisade layer number, *Pyrus* species are divided into two groups that are also geographically distinct. The first group includes *P. boissieriana*, *P. kandevanica*, *P. mazanderanica*, *P. hyrcana* and *P. turcomanica*. These species have two layers of palisade layer and distributed in Alborz Mts. and some elevations in NE of Iran that has a wet climate while the second group that includes *P. syriaca*, *P. glabra*, *P. oxyprion*, *P. salicifolia* and *P. elaeagnifolia* has two to three layers in palisade layer and distributed in Zagros Mts. and Azerbaijan with dry climate. Regarding anatomy, ecological difference plays a major role in the genus so that in the Alborz group that has a wet climate; number of palisade layer is two that is an adaptation to the wet conditions. On the other hand, in the Zagros group number of this layer is 2-3 that reflexes the ecological adaptation of this group to the dry conditions of this region. One other important character is the presence of lower palisade layer in species of section *Argyromalon* and some specimens of section *Xeropyrenia* (Table 2). Finally, it seems that anatomical features further reflex ecological differences among the studied species so that *P. mazanderanica* that is morphologically from section *Xeropyrenia* (with 2-3

layers of palisade layer) because of its distribution in wet conditions of north of Iran has two layers of palisade layer.

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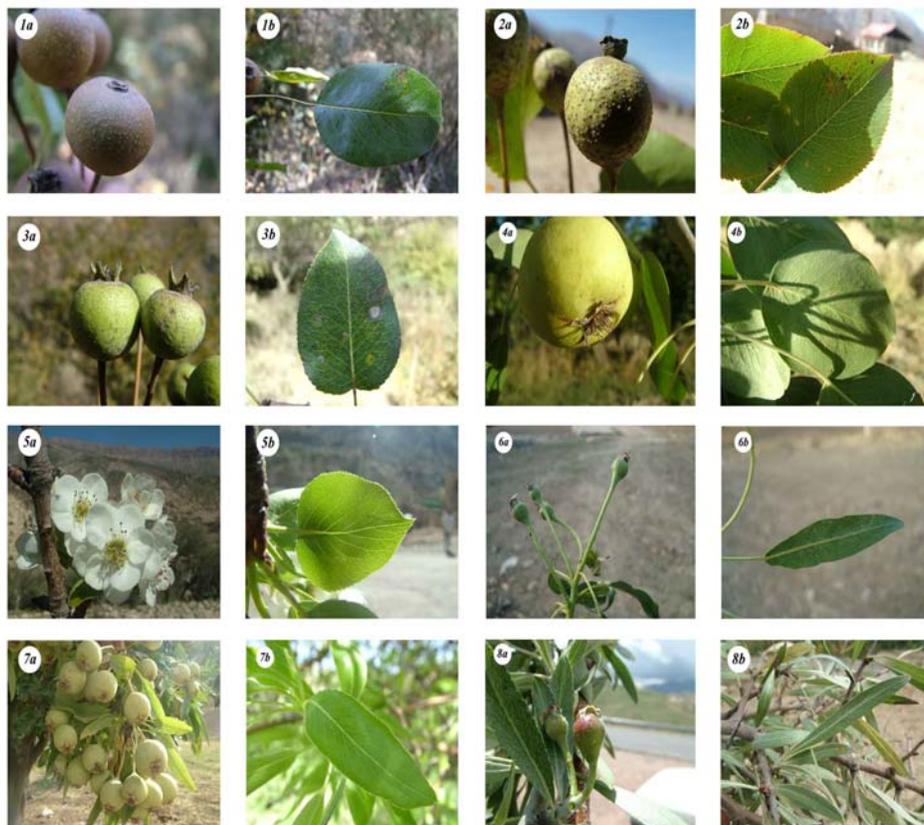
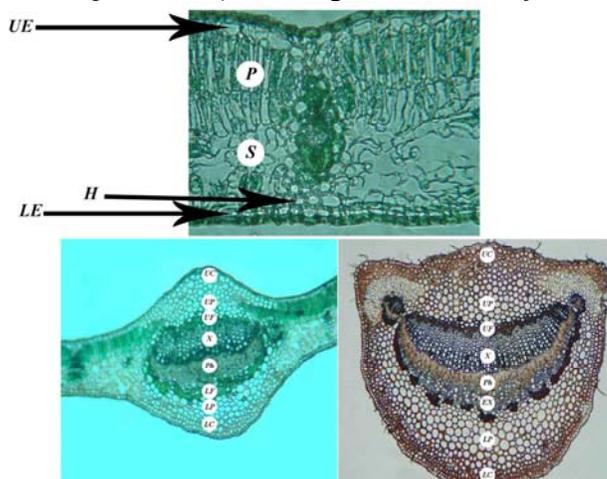


Fig. 1a, b: *P. kandevanica*; Fig. 2a, b: *P. boissieriana*; Fig. 3a, b: *P. hyrcana*; Fig. 4a, b: *P. turcomanica*; Fig. 5a, b: *P. farsistanica*; Fig. 6a, b: *P. glabra*; Fig. 7a, b: *P. syriaca*; Fig. 8a, b: *P. salicifolia*.



U(L)E, upper (lower) epidermis; P, palisade parenchyma layer; S, spongy parenchyma layer; H, hypodermis; U(L)C, upper (lower) collenchyma; U(L)P, upper (lower) parenchyma; U(L)F, upper (lower) fiber; X, xylem; Ph, Phloem; EX, external xylem

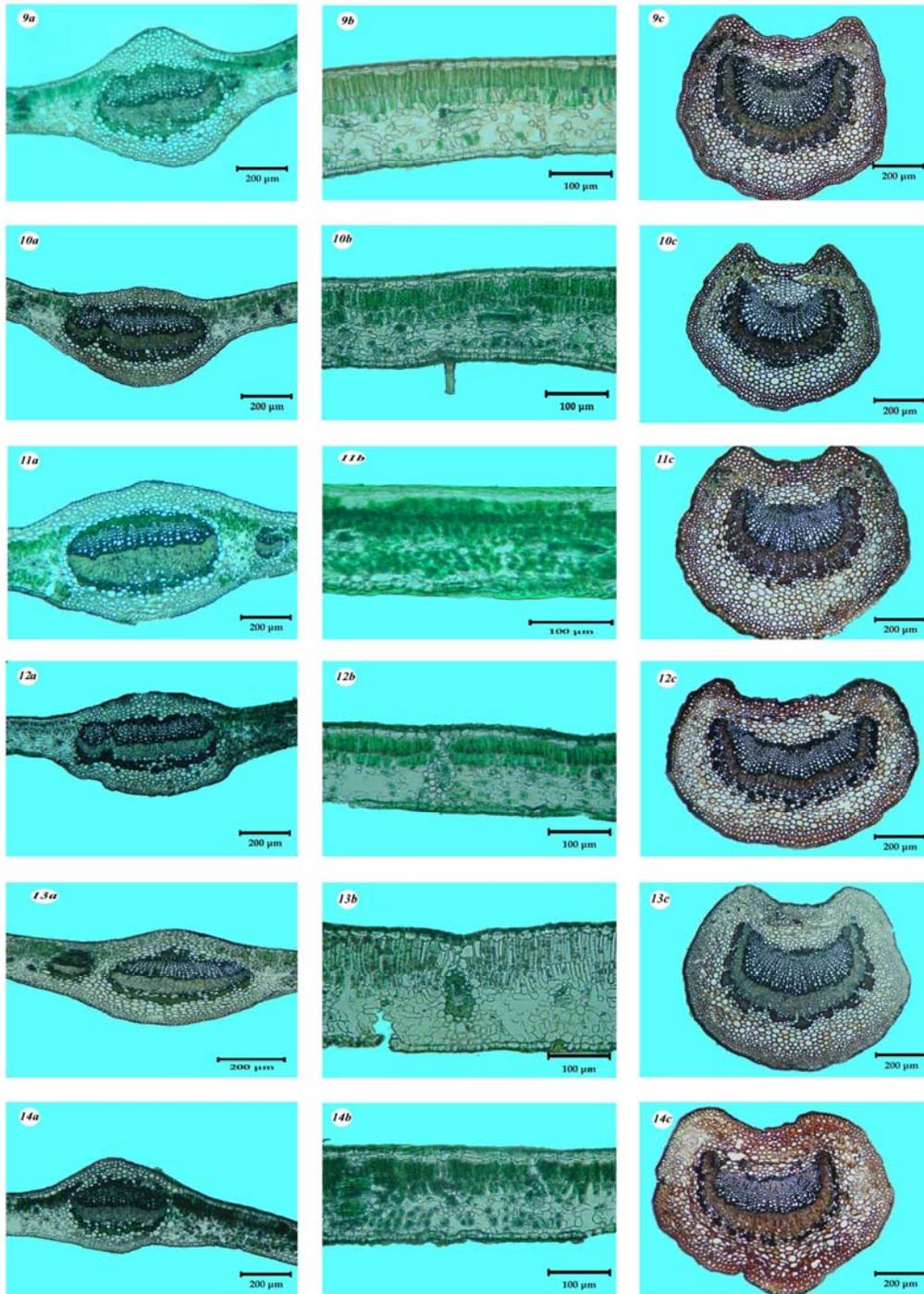


Fig. 9, *P. boissieriana* (37289); Fig. 10, *P. boissieriana* (37730); Fig. 11, *P. kandevarica* (37598); Fig. 12, *P. kandevarica* (37610); Fig. 13, *P. hyrcana* (37601); Fig. 14, *P. turcomanica* (37590).
 (In each number, letters a, b and c denote cross sections of midrib, blade and petiole respectively).

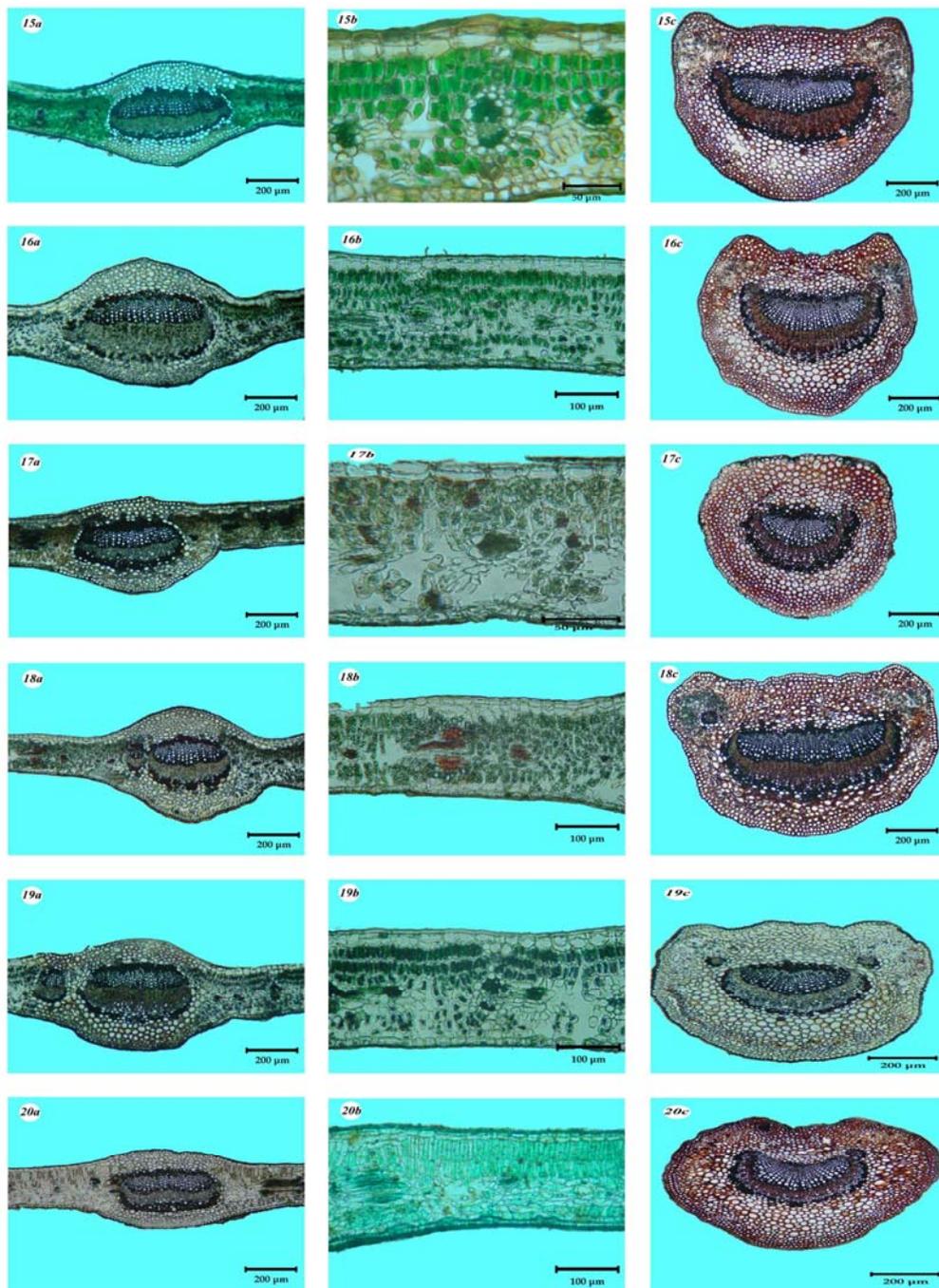


Fig. 15, *P. syriaca* (37482); Fig. 16, *P. syriaca* (37554); Fig. 17, *P. glabra* (37464); Fig. 18, *P. glabra* (37552); Fig. 19, *P. oxyprion* (37534); Fig. 20, *P. mazanderanica* (37291). (In each plate, letters a, b and c denote cross sections of midrib, blade and petiole respectively).

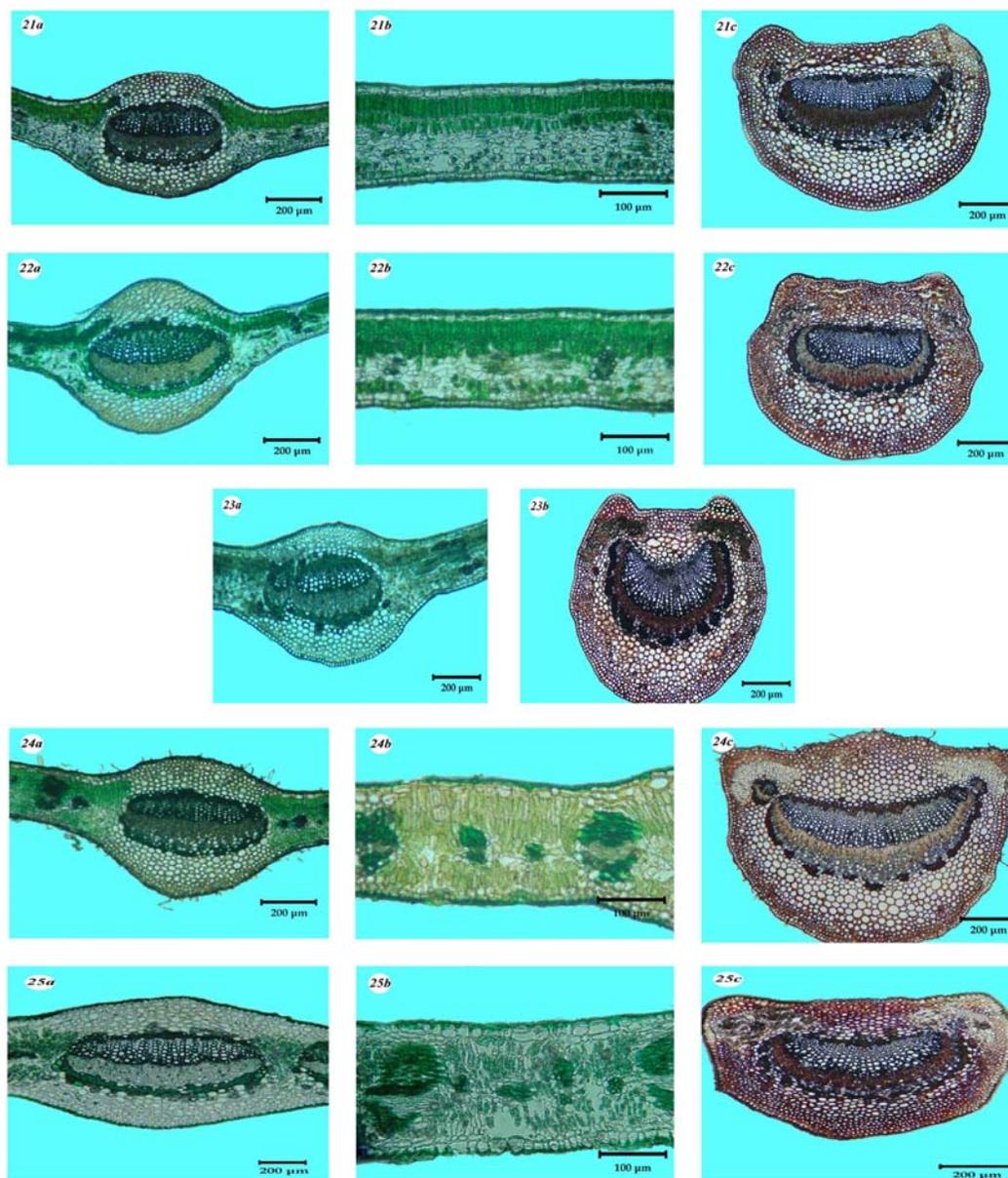


Fig. 21, *P. mazanderanica* (37300); Fig. 22, *P. mazanderanica* (37604); Fig. 23, *P. syriaca* (cultivated) (37458); Fig. 24, *P. salicifolia* (37119); Fig. 25, *P. elaeagnifolia* (37392) (In each number, letters a, b and c denote cross sections of midrib, blade and petiole respectively)

