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Türkiye'deki Morus türleri üzerinde karşılaştırmalı morfolojik ve anatomik bir çalışma

Comparative morphological and anatomical studies on Morus species (Moraceae) in Turkey

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ÖZ
GİRİŞ ve AMAÇ: Morus alba L., Morus nigra L. ve Morus rubra L. türleri gıdai, ekonomik ve tıbbi değerleri nedeniyle birçok ülkede yaygın olarak yetiştirilmektedir. Bu çalışmada, Türkiye'de bulunan Morus L. türleri üzerinde karşılaştırmalı morfolojik ve anatomik incelemeler yapılmıştır. Elde edilen sonuçlara göre, türlerin morfolojik ve anatomik özellikleri ile ilgili farklılıklar tanımlanmış ve elde edilen veriler detaylı fotoğraflarla gösterilmiştir.
YÖNTEM ve GEREÇLER: Türkiye'nin farklı illerinden toplanan örnekler ele alınmıştır. Anatomik çalışmada, yaprakların enine ve yüzeysel kesitleri üzerinde incelemeler gerçekleştirilmiştir. Tüm kesitler kloralhidrat ve Sartur reaktifi ile boyanmış, ardından Olympus BH2 ışık mikroskobu kullanılarak incelenmiştir.
BULGULAR: Anlamlı diagnostik karakterler olarak trikom tipleri, stoma boyutları ve indeksi, parenkima ve kollenkima tabakalarının yoğunluk oranları belirlenmiştir. Yaprakların bazı morfolojik özellikleri de belirgin farklılıklar göstermektedir.
TARTIŞMA ve SONUÇ: Sonuçlarımızın, Morus türlerinin taksonomisine katkı sağlayabileceğine ve türlerin ayırt edilmesine yardımcı olabileceğine inanıyoruz.
Anahtar Kelimeler: Moraceae, Morus, anatomi, morfoloji, Türkiye
ABSTRACT
INTRODUCTION: Morus alba L., Morus nigra L. and Morus rubra L. are widely cultivated in many countries due to their nutritive, economic and medicinal values. Here, comparative morphological and anatomical studies on three common Morus L. species found in Turkey were carried out. According to the results, differences regarding to morphological and anatomical features of these species were described and the data were displayed by detailed photographs.
METHODS: Specimens collected from different provinces of Turkey were studied. In anatomical study, investigations were performed on transversal and superficial sections of the leaves. All sections were stained with chloral hydrate and Sartur solution, then examined using an Olympus BH2 light microscopy.

RESULTS: Significant diagnostic characteristics were found as types of trichomes, the measurements of stomata, stomatal index, the ratio of density of the parenchyma and collenchyma layers. Some morphological features of the leaf also show prominent differences.
DISCUSSION AND CONCLUSION: We believe that our results may contribute to the taxonomy of Morus species for future work and it can be help to diagnose of species.

Keywords: Moraceae, Morus, anatomy, morphology, Turkey

INTRODUCTION

The genus *Morus* L. belongs to the Moraceae family (the mulberry family) which contains 37 genera and nearly 1100 species distributed throughout tropical and temperate regions worldwide.[1] *Morus* species are generally known as mulberries and their distribution is extent to East, West and South East Asia, South Europe, South of North America, Northwest of South America and some parts of Africa. It can be said that they have high adaptation capacity for various environmental conditions.[1,2] Mulberries are under cultivation in many different world regions, such as tropical, subtropical, and temperate zones of Asia, Europe, North and South America and Africa. These species have economic value in most countries because of their use in sericulture. Moreover, they have widely been used as traditional folk medicine particularly in China and India.[3,4]

Mulberries are grown for the production of edible fruits in other countries like Turkey and Greece.[5] They have a long history of cultivation since they have been cultivated as food plants for more than 400 years in Turkey where is one of the most important centers of diversity.[6] In Turkey, the best known species are black mulberry (*Morus nigra* L.), white mulberry (*Morus alba* L.) and purple mulberry (*Morus rubra* L.).[3,7,8] Besides the traditional medicinal use of various part of these species, their fruits are also used in making syrup, jam, pulp, ice-cream, vinegar, natural dyes.[2,6] Flavonoids, anthocyanin and alkaloids contained in the most of parts of mulberries ensure several pharmacological activities such as antidiabetic, antioxidant, antiinflammatory, antimutagenic, anticarcinogenic and hepatoprotective properties.[4,9]

According to APG IV classification system, the family Moraceae belongs to the order Rosales within the Rosids clade.[10] The presence of milky latex, distinct stipule, anatropous ovules, apical placentation, compound fruits (achenes or syconous) and the presence of cystolith are several diagnostic characteristics of Moraceae.[11] The genus *Morus* has also attracted the attention of many researchers due to its interesting breeding system, interspecific hybridization, wide range distribution, naturalization in different areas, invasiveness of some taxa and taxonomic uncertainty within the genus.[12,13] Taxonomists have reported various species numbers thus, the taxonomy of *Morus* has been unstable. In the first instance, Linnaeus defined seven species for the genus, but then Bureau and Koidzumi noticed five and 24 species, respectively.[14] We currently know the *Morus* comprises about 14 species throughout the world.[15] Although many taxonomic studies and revisions have been conducted on *Morus*, taxonomic difficulties related to the genus is still remain.[7,16,17]

The morphological and anatomical properties are basic tools used in taxonomical studies for centuries.[18,19] Despite the fact that there are some differences morphologically, sometimes fruits of *M. nigra* and *M. rubra* may not be identified by local people and the sellers replace *M. nigra* with an another black fruit which is cheaper.[20] Moreover, some taxa show minor differences in the leaf morphology.[7] Anatomical studies of leaf provide many important diagnostic characteristics such as size, shape and orientation of stomata, guard cells and subsidiary cells, type and shape of trichomes, structure of epidermal cells.[21] For these reasons, determining the differences between the species morphologically and anatomically could be helpful in resolving challenges of diagnose.

Several studies have been fulfilled on the morphology and anatomy of *Morus*.[1,22-26] However, the leaf anatomy and morphology of *Morus* species from Turkey has not been investigated. This present study aims to investigate the morphological and anatomical features of *M. alba*, *M. nigra* and *M. rubra* distributed in Turkey. We also tried to determine diagnostic anatomical and morphological properties which will contribute to taxonomy of the genus.

EXPERIMENTAL

Herbarium specimens were used in determining the morphological and the anatomical properties**.** *M. alba* collected from Balıkesir (ISTE 109772) and İstanbul (ISTE 116445), *M. nigra* collected from İstanbul (ISTE 80737) and *M. rubra* collected from Gaziantep (ISTE 40076) are stored in the Herbarium of Istanbul University Faculty of Pharmacy (ISTE). Collection data of each studied species were shown in Table 1. Morphological studies were carried out on herbarium materials. For anatomical studies, leaves were pretreated with immersed in warm water. Minimum 15 individual specimens were used. Hand sections from samples were taken with a razor blade, then stained with chloral hydrate and Sartur solution[27]. Sections were examined using an Olympus BH2 light microscopy and detailed photos were taken using Canon Power Shot A640. Measurements of each samples were performed by KAMERAM© software and the obtained data were given below. The stomatal index (SI) was calculated according to the following formula: SI=(S/S+E)×100, where S refers to the number of stomata per unit area and E to the number of epidermal cells in the same unit area.[28]

RESULTS AND DISCUSSION

The lamina anatomical traits of the collected specimens were defined by examination of the lamina transverse and surficial sections.

Morus alba L.

The midrib is rich in collenchymatic elements with 4-5 layered collenchyma located under the lower epidermis, 2-3 layered collenchyma are located under the upper epidermis (Figure 1A-G). 5-6 layers of parenchyma cells exist between the collenchyma layers and the collateral vascular bundles (Figure 1A). The leaf thickness at the midrib was found as average 735.105 µm. Moreover, plenty of druse crystals of calcium oxalate were observed in the midrib and the mesophyll of the leaf (Figure 1C,F,I). Prismatic crystals were observed only in the midrib region. The density of the crystals is increased near the veins in the midrib (Figure 1C). There is a single layered epidermis covered with a thin cuticle on both adaxial and abaxial surface of the lamina. Epidermis has polygonal cells with usually straight anticlinal walls and upper epidermis cells have bigger size than the lower ones. Length and width of epidermis cells are presented in Table 2. Unicellular non-glandular trichomes, varying in length, is also present on the both leaf surfaces. The number of non-glandular trichomes is higher along the veins and the midrib (Figure 1A,H). Glandular trichomes with unicellular stalk and multicellular head are sparse on the lower surface. The leaf is dorsiventral. The mesophyll is composed of 2 layers of palisade cells under the upper epidermis and 5-6 layers of spongy cells under the lower epidermis. Palisade cells were found as cylindrical in transverse section. The spongy parenchyma cells with wide intercellular spaces have ovoid or circular shapes (Figure 1I). The spongy parenchyma occupies about 60.57% of the mesophyll. Stomata cells were found only on the abaxial surface of the leaf (hypostomatic) (Figure 1J,K). The leaf blade thickness ranges from 159.096 to 175.017 µm, with a mean value of 169.112 µm . On the abaxial surface, anomocytic stomata are oval shaped and varying sized. They are situated at the same level as the other epidermal cells (mesomorphic). Each stomata is surrounded by 5-6 subsidiary cells (Figure 1K). Lithocysts, a specific enlarged epidermal cells which calcium carbonate is deposited, and peltate glands were detected on upper surface of the leaf (Figure 1J). The stomatal index for the lower surface of the lamina was calculated as 10.71.

Morus nigra L.

Regarding the midrib region, 2-3 layered collenchyma are presented on the lower surface and 1-2 layered collenchyma are presented on the upper surface (Figure 2A-F). 5-6 layers of parenchyma cells fills between the collenchyma layers and the collateral vascular bundles (Figure 2A,B). The leaf thickness at the midrib is on average 516.083 µm. Many druse crystals of calcium oxalate were observed in the midrib and the mesophyll (Figure 2B,C,E,I,J). Several prismatic crystals were observed only in the midrib region. The crystals are abundant near the veins in the midrib (Figure 2B,C).

The both leaf surfaces have a single layered epidermis covered with a thin cuticle. Epidermis cells which are polygonal in shape have usually straight anticlinal walls. Their sizes are variable. Upper epidermis cells are larger than the lower ones (Table 2). Unicellular non-glandular trichomes were observed on the both leaf surfaces, their amount is higher on the lower surface (Figure 2A,D,G). Glandular trichomes with unicellular stalk and multicellular head are scattered on the both surface (Figure 2H). The mesophyll consists of 2 layers of palisade cells under the upper epidermis and 4-5 layers of spongy cells with wide intercellular spaces under the lower epidermis. Hence, the leaf is dorsiventral. While the palisade parenchyma cells were cylindrical, the spongy parenchyma cells were found as ovoid-circular in transverse section (Figure 2I,J). The spongy parenchyma occupies about 64.46% of the mesophyll. The leaf is also hypostomatic and mesomorphic, stomata cells were found only on the lower surface of the leaf (Figure 2K-M). Leaf blade thickness ranges from 149.042 to 160.843 µm, with a mean value of 158.052 µm.

The stomata are anomocytic. They have oval shape and varying size. Each stomata is surrounded by 5-6 subsidiary cells (Figure 2L). Lithocysts and peltate glands were defined on the upper surface of the leaf (Figure 2I,K). The stomatal index for the lower surface of the lamina was calculated as 13.26.

***Morus rubra* L.**

In the midrib, while 2-3 layered collenchyma are located under the lower epidermis, 1-2 layered collenchyma are located under the upper epidermis (Figure 3A-G). Parenchyma cells form 4-5 layers. They present between the collenchyma layers and the collateral vascular bundles. The leaf thickness at the midrib is on average 740.899 µm. Many druse crystals of calcium oxalate were observed in the midrib and also in the mesophyll (Figure 3B,C,F). Several prismatic crystals were observed only in the midrib region.

The epidermis cells which are covered by a thin cuticula layer in both surfaces of the leaf is single layered. Their shape are polygonal and vary in size (Table 2). However, upper epidermis cells are larger than the lower epidermis cells. They have usually straight anticlinal walls. On the both leaf surfaces, indumentum of unicellular non-glandular trichomes were noticed, but they are more on the lower surface (Figure 3H,I). Glandular trichomes with unicellular stalk and head are rare on the both surfaces. The leaf is dorsiventral and hypostomatic (Figure 3J-L). The mesophyll is differentiated as palisade and spongy parenchyma. It comprises of 1 layered palisade cells under the upper epidermis and 3-4 layered spongy cells with wide intercellular spaces under the lower epidermis. Palisade parenchyma cells are cylindrical and the spongy parenchyma cells are ovoid-circular (Figure 3J). The spongy parenchyma occupies about 61.28% of the mesophyll. Leaf blade thickness ranges from 125.705 to 133.690 µm, with a mean value of 130.398 µm .

Oval-shaped and different sized stomata are anomocytic. Each stomata is surrounded by 5-6 subsidiary cells and the leaf is mesomorphic (Figure 3L). Lithocysts and peltate glands were found on the upper surface of the leaf (Figure 3K). The stomatal index for the lower surface of the lamina was calculated as 11.11.

Morus species could be in various morphological appearance when the climate or habitat change. Hence, it is difficult to make taxonomic classification for these species.[23] The comparative morphological and anatomical studies are the basic tools of the plant taxonomy

and they provide fundamental data which are helpful for a majority of the classification systems.[29] Furthermore, studies based on plant morphology and anatomy help us to understand the phylogeny of life.[30] In this study, *M. alba*, *M. nigra* and *M. rubra* were examined and compared morphologically and anatomically. Differences as a result of investigation are given in Table 3.

Certain morphological characteristics, such as leaf shape, size, base, margin and indumentum were found to be useful in identifying studied species (Figure 4). Moreover, the indumentum of the shoot and the peduncle, the size of the fruit, peduncle and petiole differ in these species. The species with the broadest leaves was found to be *M. alba*. The difference in the color of the fruits of these three species is perhaps the most striking organoleptic feature. Whereas *M. alba* has white, pinkish or purplish fruit, *M. nigra* has blackish-violet or black fruit. And *M. rubra* has dark reddish-purple fruit. Besides, there are some similarities in their mophological feautures such as inflorences of short dense spikes, ellipsoid syncarps and fleshy drupelets.

We also know that some anatomical traits are very diagnostic. Thus, they are frequently used in routine identification. Since the leaf is regard as the most varied organ of the angiosperms, the taxonomic studies of various taxa were carried out on the basis of leaf anatomy.[29,31-34] These studies present many anatomical characteristics of potential taxonomic significance.[29] The results of our detailed anatomical study revealed that there were some differences amongst the leaf anatomy of these three taxa. Metcalfe & Chalk[35] have reported the epidermis of the Moraceae generally comprises of a single layer of quadrangular or elongated anticlinal cells. Although upper epidermis cells were found to be larger than the lower ones in all studied taxa, length and width of epidermis cells were measured to be different values on the both sides. Accordingly, the size of the epidermis cells on the lower and upper surfaces of the *M. nigra* were found to be smaller than those in the other two taxa. Since the stomatal size may change properly to environmental conditions, some authors don't regard as diagnostic characteristic. But the stomatal size is mostly accepted, because the size of the stomata is generally stable enough to be used as a diagnostic characteristics.[36,37] In Moraceae family, stomata usually do not have special subsidiary cells.[38,39] Leaves of the three taxa were determined as hypostomatic (stomata were only observed on the abaxial surface) with anomocytic type stomata. However, concerning size, the width and length of stomata were significantly different. The mean value of the stomata size of *M. rubra* was found to be the highest species. The term stomatal index is used for define stomatal frequency, the size of the epidermal cells is neglected. Since taxa from distinct localities have more or less constant stomatal index values, the stomatal index is considered as a significant taxonomic characteristics.[36,40] In the taxa studied, different value of the stomatal index was calculated in this study.

Many studies revealed the taxonomic value of trichomes in angiosperm.[41,42] Glandular and nonglandular trichomes are common in the Moraceae.[18,22,38] According to the previous study, while simple unicellular non-glandular trichomes and multicellular capitate glandular trichomes are common in *Morus* taxa, conical unicellular nonglandular trichomes and bicellular capitate glandular trichomes are rare.[38] Abbasi & al.[26] indicated that unicellular non-glandular and glandular trichomes and also hooked hairs are present on the leaf surfaces of *Morus* species. Moreover, multicellular glandular trichomes, unicellular non-glandular trichomes and cystolith trichomes were observed in *M. alba* and *M. nigra*.[22] In this present study, unicellular non-glandular trichomes in various sizes were found on the both leaf surfaces of the studied taxa, but their densities are changing. Glandular trichomes with unicellular stalk and multicellular head were detected in *M. alba*, *M. nigra* and glandular trichomes with unicellular stalk and head were observed in *M. rubra*. We also found peltate glands on the upper surfaces of all studied taxa, as in the previous studies.[24,26,43]

In the Moraceae family, calcium oxalate and carbonate crystals are mostly present in the leaves.[18,25,33,44,45] Regarding calcium oxalate, two types of crystals (druse crystals in the cells of the mesophyll and bundle sheaths, prismatic crystals only in the cells of the bundle sheath) are located in the leaves of the Moraceae.[44] The most seen calcium carbonate crystal type cystolith (a calcified body) are located in a several families such as Urticaceae, Ulmaceae, Moraceae, Cucurbitaceae and Acanthaceae.[1,18,46] Many species of the Moraceae are recognized with the presence of cystolith. Cystolith is deposited in a specialized cell called a lithocyst which is known as excretory idioblast.[18,44,46,47,48] Lithocysts are very common for Moraceae family and they were observed in many anatomical studies on Moraceae. *Ficus* L. species mostly have lithocysts, also they were reported on *Morus* leaves.[33,37,44,45] According to Esau[49] the presence and location of crystals may be distinctive and useful in taxonomic classification. In our study, while many druse crystals were found in the mesophyll and also in the midrib region, prismatic crystals were only found in the midrib. Furthermore, lithocysts were noticed only on the upper surface of the leaves of all investigated taxa. In contrast to our study, lithocysts were not observed in some studies on *Morus* taxa.[22,24,26]

As seen in the transverse sections, spongy and palisade parenchyma cells can be easily distinguished from each other in the mesophyll. However, palisade parenchyma layers and its ratio of occupation are various. The leaves of the studied taxa are dorsiventral. The dorsiventral leaf is characteristic in the some members of the Moraceae family and is therefore not useful for species identification.[18,35] Besides, in some works on Moraceae family dorsiventral and isobilateral leaves were reported.[33,37,50,51,52] In this study, collateral vascular bundles were seen in the midrib region. The differences were determined concerning collenchymatic elements which are located with various layers between epidermis and parenchyma cells on the midrib of the three taxa.

CONCLUSIONS

In conclusion, some differences were determined in the morphological and anatomical properties of all studied taxa. It is obvious that certain characteristics such as size, shape and indumentum of leaves are indicated to be helpful in the recognition of taxa. Furthermore, some anatomical characteristics of the leaves were found to be of diagnostic importance such as the ratio of density of the palisade parenchyma, collenchyma layers in the midrib region, types and density of trichomes, the length and width of stomata and stomatal index. Although all of these characteristics are environmentally affected and future studies that analyze plants from several localities are needed, but nevertheless, they can be very useful delimitation of species.

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Table 1. Collection data of *Morus* taxa examined.

Taxon	Locality, Voucher number (ISTE)
M. alba	B1 Balıkesir: Kepsut, Büyükkatrancı village, 800 m elevation, 30.05.2015, ISTE 109772.
M. nigra	A2(E) İstanbul: Çatalca, İnceğiz gateway, field border, 50 m elevation, ISTE 80737.
M. rubra	C6 Gaziantep: Between Nizip-Gaziantep , Altındağ village, 650 m elevation, 30.05.1978, ISTE 40076.

Table 2. Measurements from leaf anatomical traits of *M. alba*, *M. nigra* and *M. rubra* (mean, min-max values).

	M. alba	***M. nigra***	***M. rubra***
	Length × Width (µm)	**Length × Width (µm)**	**Length × Width (µm)**
UEC	32.93 (23.62-44.06) × 24.41 (18.34-33.63)	20.14 (15.55-28.67) × 18.24 (15.21-19.87)	38.50 (37.81-40.42) × 20.51 (19.15-2.38)
LEC	19.73 (13.13-29.40) × 11.43 (8.00-12.94)	18.25 (16.03-22.41) × 8.31 (8.05-8.64)	28.13 (26.95-30.18) × 13.61 (13.05-14.86)

LS	18.99 (15.39-23.37) × 14.22 (11.81-17.36)	19.12 (16.71-21.19) × 13.97 (12.76-15.48)	34.22 (31.39-36.98) × 23.44 (19.84-26.33)
PPL (thickness)	56.139	40.081	45.008
SPL (thickness)	86.254	72.685	71.222

UEC - Upper epidermis cell, LEC - Lower epidermis cell, LS – Stomata of abaxial epidermis, PPL - Palisade parenchyma layer, SPL - Spongy parenchyma layer.

Table 3. Morphological and anatomical comparison of studied taxa.

	M. alba	***M. nigra***	***M. rubra***
Shoots	Slender, glabrous	Stout, pubescent	Slender, pubescent
Peduncle	Hairy	Hairy	Pubescent
Peduncle length	(1-)2 cm, circa as long as syncarp	1-1.5 cm	0.5-1 cm, 1/2 as long as syncarp
Fruit length	(1-)1.5-2.5 cm	(1.5-)2-2.5 cm	(1.5-)-2-3 cm
Fruit color	White, pinkish or purplish	Blackish-violet or black	Dark reddish-purple
Leaf shape	Ovate to broadly ovate	Broadly ovate	Broadly ovate to oblong-ovate
Leaf size	3-10(-18) × 2-12 cm	5-12(-20) × (4)-5.5-13 cm	6-12(-20) × 4-10 cm
Leaf apex	Acute or shortly acuminate	Acute or shortly acuminate	Abruptly long-acuminate
Leaf base	Rounded or obliquely cordate	Deeply cordate	Truncate or subcordate
Leaf margin	Crenate-dentate	Serrate	Serrate
Indumentum of leaf	Upper surface glabrous/lower surface pubescent on the midrib and the veins	Upper surface scabrous/lower surface pubescent	Upper surface slightly scabrous/lower surface roughly hairy

Non-glandular trichomes	Unicellular trichomes on the both leaf surfaces (density is higher along the veins and the midrib)	Unicellular trichomes on the both leaf surfaces (density is higher on the lower surface)	Unicellular trichomes on the both leaf surfaces (density is higher on the lower surface)
Glandular trichomes	Trichomes with unicellular stalk and multicellular head on the lower surface (sparsely)	Trichomes with unicellular stalk and multicellular head on the both surface	Trichomes with unicellular stalk and head on the both surfaces (rarely)
Epidermal cells	Upper epidermis cells are larger than the lower ones.	Upper epidermis cells are larger than the lower ones.	Upper epidermis cells are larger than the lower ones.
Mesophyll type	Dorsiventral	Dorsiventral	Dorsiventral
Mesophyll	38-45% palisade parenchyma (2 layer)	35-38% palisade parenchyma (2 layer)	35-40% palisade parenchyma (1 layer)
Location of stomata	Hypostomatic	Hypostomatic	Hypostomatic
Stomatal index	10.71	13.26	11.11
Collenchyma cells layers of midrib	4-5 layered on the lower surface, 2-3 layered on the upper surface	2-3 layered on the lower surface, 1-2 layered on the upper surface	2-3 layered on the lower surface, 1-2 layered on the upper surface
Thickness of leaf blade (average)	169.112 µm	158.052 µm	130.398 µm
Thickness of midrib (average)	735.105 µm	516.083 µm	740.899 µm
Petiole length	1-3.5(-4) cm	1.5-3.5 cm	(1-)1.5-3 cm

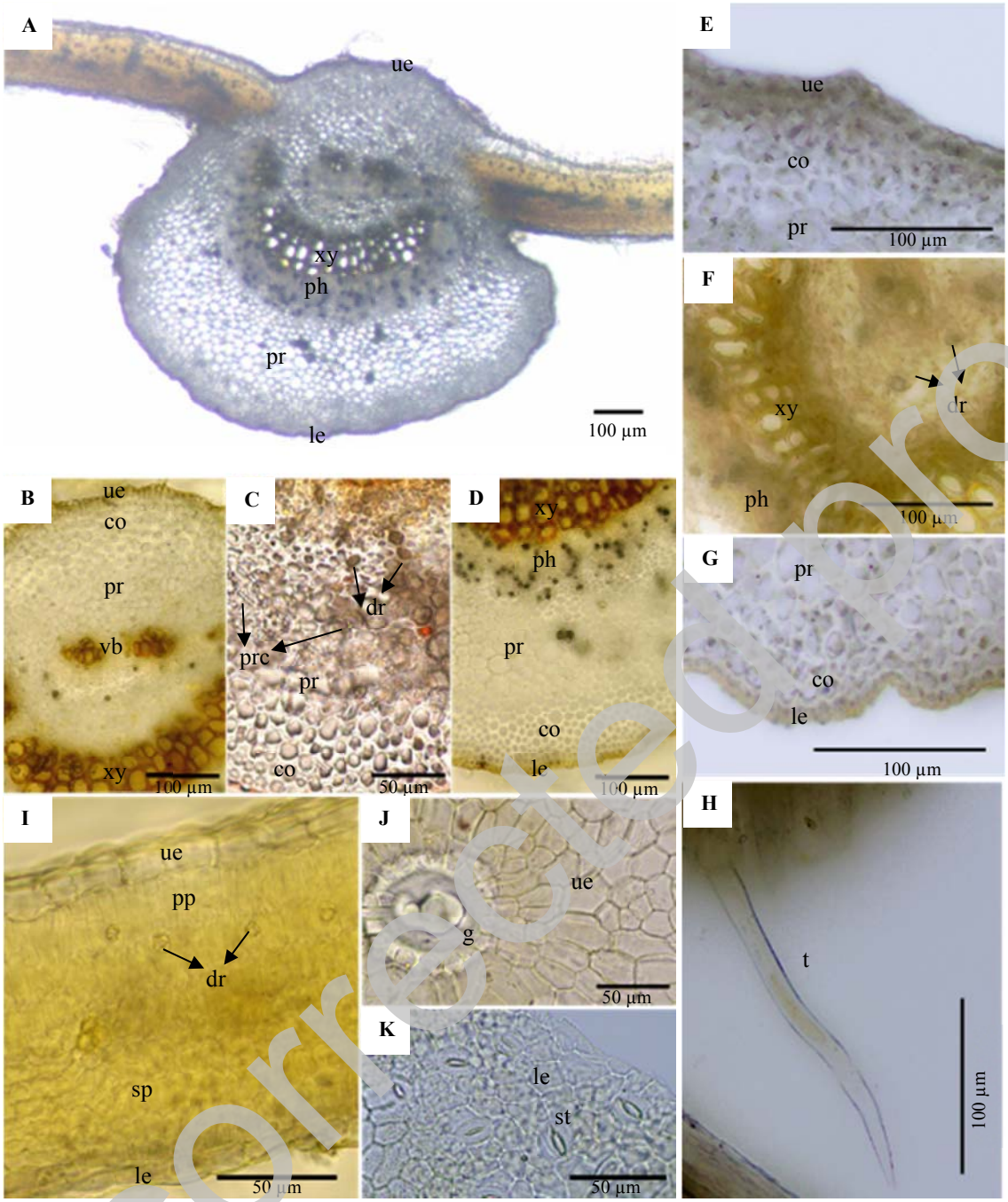

Figure 1. The transverse and surface sections of the leaf of *M. alba*. The midrib region (A), (B), (C), (D), (E), (F), (G), (H), mesophyll (I), adaxial surface (J), abaxial surface (K).

co - collenchyma, dr - druse, g - peltate gland, le - lower epidermis, ph - phloem, pp - palisade parenchyma, pr - parenchyma, prc - prismatic crystal, sp - spongy parenchyma, st – stomata, t - non-glandular trichome, ue - upper epidermis, xy - xylem, vb - vascular bundle.

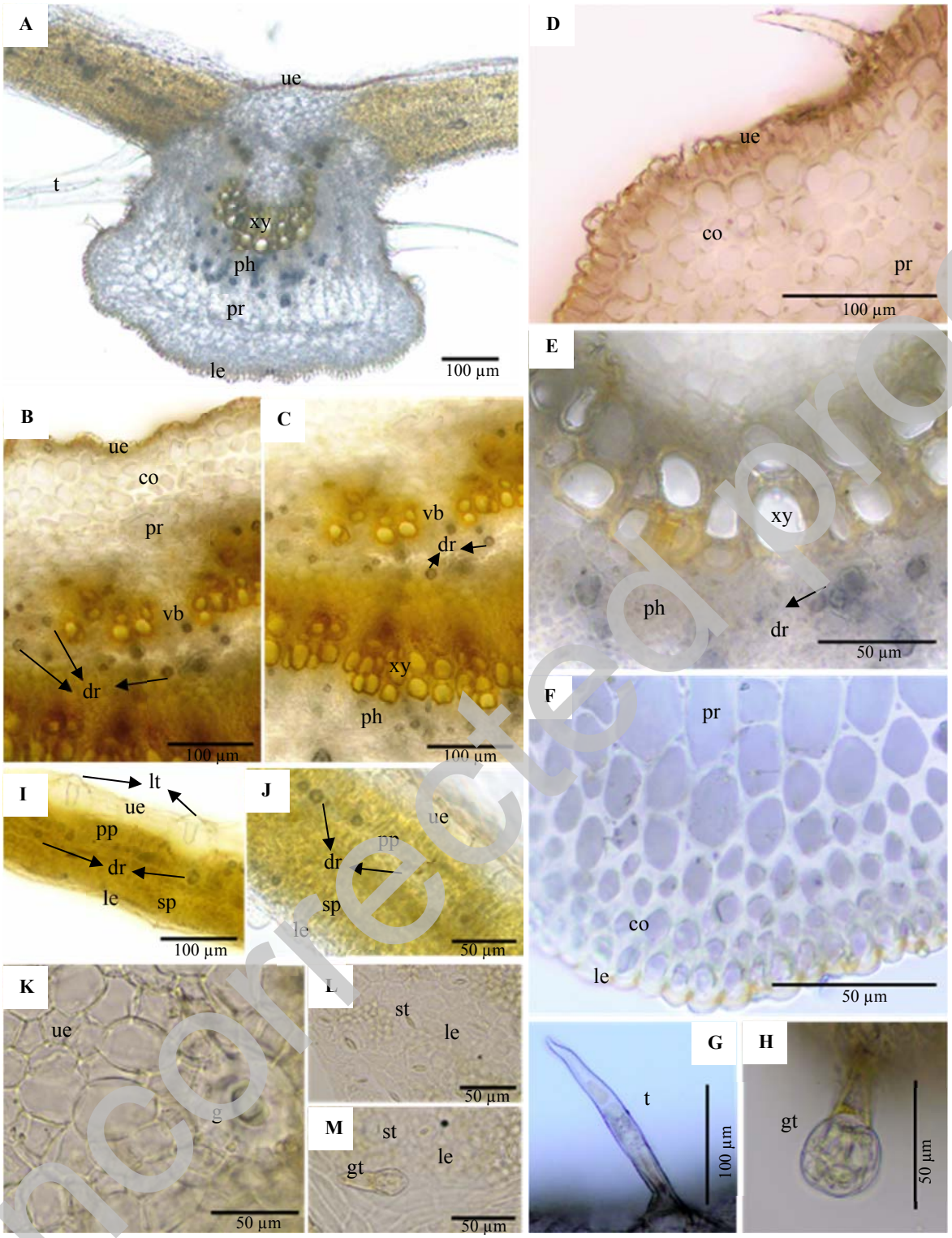

Figure 2. The transverse and surface sections of the leaf of *M. nigra*. The midrib region (A), (B), (C), (D), (E), (F), (G), (H), mesophyll (I), (J), adaxial surface (K), abaxial surface (L), (M).

co - collenchyma, dr - druse, g - peltate gland, gt - glandular trichome, le - lower epidermis, ph - phloem, pp - palisade parenchyma, pr - parenchyma, sp - spongy parenchyma, st – stomata, t - non-glandular trichome, ue - upper epidermis, xy - xylem, vb - vascular bundle.

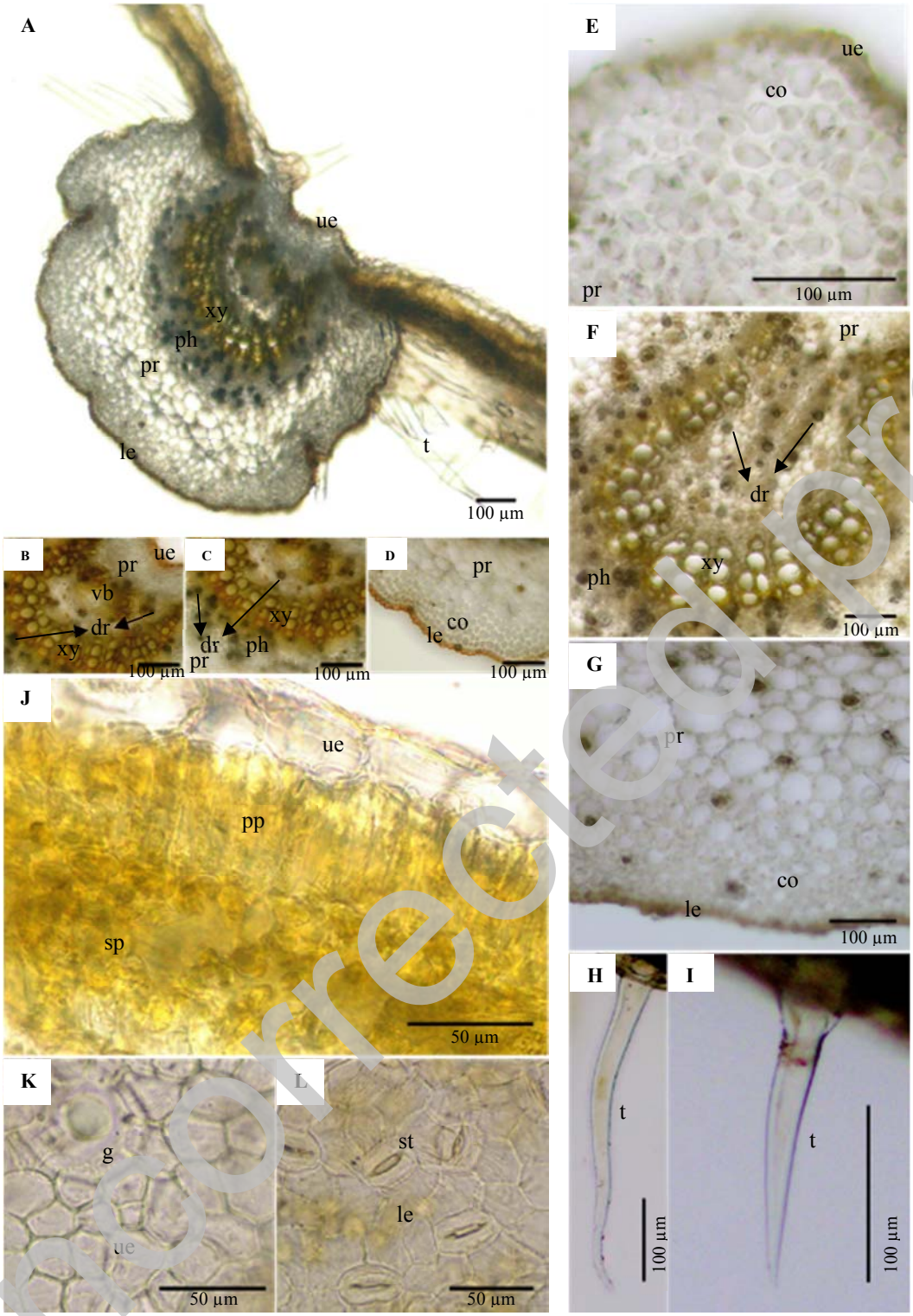

Figure 3. The transverse and surface sections of the leaf of *M. rubra*. The midrib region (A), (B), (C), (D), (E), (F), (G), (H), (I), mesophyll (J), adaxial surface (K), abaxial surface (L).

co - collenchyma, dr - druse, g - peltate gland, le - lower epidermis, ph - phloem, pp - palisade parenchyma, pr - parenchyma, sp - spongy parenchyma, st – stomata, t - non-glandular trichome, ue - upper epidermis, xy - xylem, vb - vascular bundle.

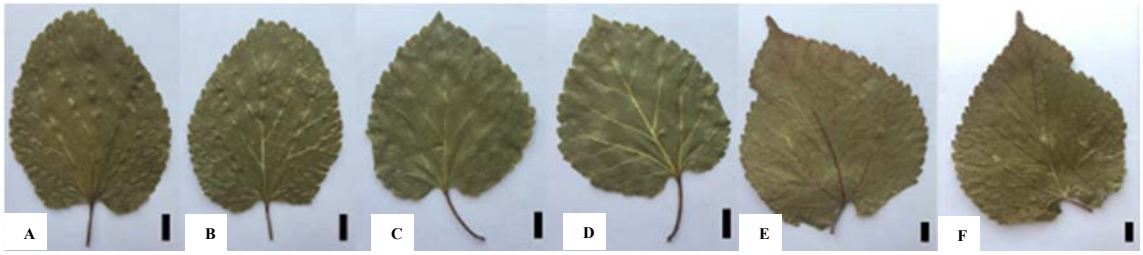

Figure 4. General view of the leaves of *Morus* species. Upper surface of the leaf of *M. alba* (A), lower surface of the leaf of *M. alba* (B), upper surface of the leaf of *M. nigra* (C), lower surface of the leaf of *M. nigra* (D), upper surface of the leaf of *M. rubra* (E), lower surface of the leaf of *M. rubra* (F), bar = 1cm.