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Systematics study of *Frankenia* L. (Frankeniaceae) in Iraq.

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ABSTRACT

The species *Frankenia* L. (Frankeniaceae) (*Frankenia pulverulenta* L. and *Frankenia aucheri* Jaub. et Spach.) in Iraq have been systematically studied which involving comparative gross and micro-morphological based on the information that has been obtained from field specimens directly or herbarium specimens, as well as anatomical, palynological, ecological and geographical distribution have been done. The Morphological study included the variation in root features, stems, leaves, flowering and fruiting parts of species were studied. The most important characters for each species in different genera in family identification were determined. All characteristic were used for different species, and found that more characters that have contributed to the process of separation between converged species were vegetation and some reproduction characters. Anatomical characters of leaves epidermises, and A cross section of the stem , leaf blade , in addition leaves venation and indumentum have been studied and their taxonomic importance were assessed. Additionally The study also found the pollen grain has taxonomical importance for isolation the species from the other .

Keywords: *Frankeniaceae, Frankenia pulverulenta, Frankenia aucheri, Taxonomical study, salt gland*

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Introduction

The Frankeniaceae, is a small family of four or five genera and about 75 -90 species is widely distributed in dry climatic regions in deserts and sandy coastal areas throughout the world [1]. [2] explained a family have four genera with thirty-four species occurring on all continents but not widely distributed except in the Mediterranean region [3] and [4] placed the family Frankeniaceae under the order Violales near Violaceae, whereas [5] and [6] Kept the family Frankeniaceae within the order Tamaricales along with Tamaricaceae. Most taxonomists place the Tamaricaceae with the Frankeniaceae as a two family group that constitutes the order Tamaricales [7].

In Phytochemsitry , Frankeniaceae *spp*. contain tannins, proanthocyanidins, ellagic acid, flavonoid bisulphates based on common flavonols and flavonol methyl ethers but no myricetin exactly as in Tamaricaceae [8]. Noted the existence of a similarity between the families Frankeniaceae and Caryophyllaceae. In both families the leaves are opposite, with entire margins, and without stipules. The leaves are small in Frankeniaceae, often so in Caryophyllaceae. In the Frankeniaceae the usually short petioles of each pair of leaves are connected by a scarious membrane, in the Caryophyllaceae each pair of sessile leaves is similarly connected . The inflorescence in both families is usually a dichotomous cyme [9].

Frankenia also known as Sea Heath or MILLAIH is the largest genus and the only genus of the family that is native in the Western Hemisphere . In Iraq it is represented by a single genus with two species i.e. *Frankenia pulverulenta* L. and *Frankenia aucheri* Jaub. et Spach.

These species have synonym names , The first one called *Hypericopsis* Boissier. , *Frankenia canescens* Presl , *Frankenia intermedia* Costa and *Frankenia laevis* Habl. ex Bieb. [10]. The other specie *Frankenia aucheri* Jaub. et Spach has named *Frankenia hirsute* L . var. erecta Boiss.) [11] or *Frankenia hirsuta* L. and *F. hispida* D. C. [12].

None of *Frankenia* species are of economic or of exceptional ecological importance, i.e., they are not dominant species in any plant communities and no species of vertebrates are known to depend on them for livelihood [13] . but in Saudi Arabia, [14] indicated that The powdered rhizome of *Frankenia aucheri* is mixed with milk and is given to cows and camels especially in winter to promote lactation.

MATERIALS AND METHODS

Morphological and Ecology studies

The material of the current study are based on mainly dried specimens were kept in Babylon university herbarium. Morphological characters for all plant part were studied in the laboratory under dissecting microscope (Meiji). All information including habitat, identification, localities flowering period were obtain from the label of the specimens.

Palynological Study

Pollen material of the plant were examined by a light compound microscope. The pollen samples were removed from the anthers of flowers of selected specimens, and put on the slide after that the pollen grains were mounted in glycerine jelly stained with safranin, and the equatorial and polar view were measured for 25 grains.

Anatomical study

From the middle part of the lamina, The epidermal study was collected by peeling and Stripping off method were used to prepare adaxial and abaxial surfaces view of leaf epidermis by using Forceps and Needle, then transferred the epidermis into clean slide contain safranin (1%) prepared in ethyl alcohol (70%) for a period of 2-5 minutes and then wash the epidermis in ethyl alcohol (70%) and a few times to diminish of excess dye then placed under a drop of glycerin and covered with a cover slide and kept in the refrigerator until the examination .

The species samples were examined by a compound microscope and measurements of stomata and epidermal cells using the ocular micrometer and drawn the epidermis with the Camera Lucida installed on the microscope.

Leaf and stem transverse section were prepared by hand cutting. The species samples were fixed in alcohol-glycerin (60:40), then Foliar cross sections were prepared from the central leaf . Transverse sections were stained by Safranin. The observations were carried out by light microscope and photographed with camera. Stomatal index was calculated as mentioned by [15]. Anatomical terms used are cited from [15], [16] and [17].

RESULTS AND DISCUSSIONS

Morphological Descriptions

Frankenia pulverulenta L.

Herbs annual. 8–25 cm. Tap Root, 5-8 cm. Stems diffuse ascending or procumbent, much branched from base, Leaves usually in whorls of 4 leaves, 3.5-5 × 2-3.5 mm, leaf blade narrowly obovate to oblong, obovate, or elliptic, abaxially slightly powdery-puberulous, adaxially glabrous, base attenuate into a short petiole 0.9-2 mm. apex obtuse or retuse. Flowers solitary or in pairs, in short axillary or terminal spikes. subtended by 4 leaf-like floral bracts 1-2 × 0.5-1.2 mm. Calyx tube 3.5–4.8 × 1–1.8 mm, cylindrical, 5-ribbed, lobes lanceolate-linear, ; teeth 5, acute, 1–1.5× 0.6-1mm. Petals 5, 2.9-4.5× 1.8-2.2 mm, pale or pink to violet, oblong to obovate, somewhat clawed at base, minutely denticulate at apex. Stamens 6. Ovary 1-1.8× 0.5-1mm, with numerous ovules on 3 parietal placentas. Capsule 2-3 mm, ovoid or oblong-ovoid . Seeds numerous, golden brown, oblong-ellipsoid. Flowers March- May

Frankenia aucheri **Jaub. et Spach**

Herbs Perennial with woody base. 15–25 cm at high. Tap Root. Stems procumbent, densely branched, puberulent or white-hirsute. Leaves usually in whorls of 3-4 leaves, 4-7 × 1-2 mm, often revolute margined, sessile or tapering to a petiole, leaf blade linear or linear-oblong, spreading white-ciliate hairs at base, The apex acute or subactue. Flowers corymbose terminal clusters .Calyx tube 4.2–5.2 × 1–1.7 mm, cylindrical, 5-ribbed, lobes lanceolate-linear, ; teeth 5, acute, sparingly hirsute. Corolla white or pink, 4.2-6mm, , obovate, long- clawed, finely denticulate at apex. Stamens 6. In 2 whorl , hypogynous , connate at base, often didynamous, anthers 2-celled, 0.40-0.92 × 0.23-0.75 mm, extrorse, versatile, dehiscing longitudinally. Ovary 0.4-1.0× 0.25-0.4 mm, with minute ovules on 3 parietal placentas. The style 1 and slender, 1.6- 4.4 mm, with 3 branches or stigmas , 0.4-0.9mm. Capsule 2.5-3 mm, ovoid or oblong-ovoid . Seeds minute, golden brown, oblong-ellipsoid. Flowers May-September. (Plate 1)

Palynological Descriptions

The result showed that, the pollen grains are trizonocolpate, sometimes dicolpate, isopolar, spinless, In *F.pulverulenta* length of polar axis is (25.0-32.5) µm , and the length if equatorial axis is (25.0-37.5) µm , oblate-spheroidal (P/E = 0.97) . But in *F.aucheri* length of polar axis is (25.0-30.0) µm , and the length if equatorial axis is (25.0-30.0) µm , spheroidal (P/E = 1.03) .

The grains in *Frankenia* species are spheroidal shaped in equatorial outline and triangular- obtuse in polar outline . The pollen has distinct equatorial depressions between the apertures and without distinct lacunae. The exine thickness is (2.5–3.75) µm in *F.pulverulenta* but in *F.aucheri* is (1.25–2.5) µm. At addition the diameter of the poles in polar axis is (5.0–7.5) µm in *F.pulverulenta* and *F.aucheri* is (3.75–7.5) µm (Plate 2).

Pollen morphology of the family has been studied by [18], [19], [20] , [21], [22] and [23] They were described pollen grains at generally as radially symmetrical, isopolar, suboblate, equatorial view elliptic, polar view triangular, colpi long with acute ends, sexine thinner than nexine, tectum densely regulate with scabrae. Furthermore [24] described the pollen grains in *F.pulverulenta* as a type of easily distinguished by its trizonocolpate pollen with striate- regulate tectum.

Anatomical Descriptions

The present results reveal that the anticlinal walls of epidermal cells in Cauline leaves a little difference between the adaxial and abaxial surfaces among the investigated taxa. In *F.pulverulenta* leaf blade anatomy: In frontal view, the abaxial and adaxial epidermis had cells with sinuous walls and ornamented cuticle. The length of epidermal cells in the abaxial surface of leaves ranged between (42.5-80.0) × (37.5-55.0) µm with average (66.8×47.1) µm. and in the adaxial surface the length ranged between (50.0-120.0) × (25.0-87.5) µm with average (86.0 ×59.0) µm. In addition There are usually differences in cell form and dimensions between the adaxial and abaxial surfaces of the leaf in *F.aucheri* , such as anticlinal cell walls in adaxial surface had a curved sometimes and rarely sinuate with a dimension approximately (42.5-9.0) µm in length and (25.0-50.0) µm in width with average (59.2×37.7) µm , but the abaxial surface ranged between (38.5-75.0) × (32.5-50.0) µm with average (49.5×40.3) µm with Undulate walls (Plate 3).

Also, The results of study reveal that the leaf was amphistomatic in *F.pulverulenta* but hypostomatic in *F.aucheri* . Guard cells are kidney shaped and anomocytic occurred more frequently on the lower epidermis and were usually surrounded by three ordinary epidermal cells . [25] emphasized this truth when they pointed that stomata in Frankeniaceae are usually ranunculaceous, usually sunken in some species confined in grooves. Furthermore the measurements of stomata are approximately (25.0-35.0) × (22.5-25.0) µm with average (28.8 ×23.8) µm in the adaxial surface of leaves and (22.0-37.5) × (20.0-27.5) µm with average (32.5 ×23.6) µm in the abaxial surface of leaves, therefore the stomatal index are 10 and 23 in the adaxial and abaxial surfaces respectively in *F.pulverulenta,* but in *F.aucheri* the stomata found only in abaxial surface which had measurements approximately (21.5-35.0) × (20.5-25.0) µm with average (25.5 ×20.5) µm with the stomatal index was 10. The venation pattern in *F.pulverulenta* was pinnate, camptodromous, kladodromous, but in *F.aucheri* was kladodromous with weakly brochidodromous Areolation shape is Polygonal, Complete imperfect or perfect , simple or branched veins according to [26] (Plate 4).

The results of the study show Non-glandular trichomes in the genus *Frankenia* parts growing in Iraq were differed in terms of the density on the surfaces of upper and lower, and the difference in lengths trichomes as well as the differences in the number depending on the type of environment in which the live plant (Plate 5). In addition [27] emphasized that salt glands are present on stems and sunk in the epidermis of both leaf-sides. [28] described the salt gland consists of eight cells. The six upper cells are the excretory cells whereas the two basal cells are the collecting cells. All the excretory cells are characterized by containing dense cytoplasm. In contrast, the collecting cells contain large central vacuoles.

Thus, These result confirmed the characters which have proven to be of systematic value are: cuticular characters, epidermis, stomata, and trichomes [16] (Figure 1).

In the present study, data revealed that the two species of *Frankenia* are shown to have a similar stem anatomy in transverse sections. The outline of shape is a semi-circular, The one layered epidermis, in both species, presents square – rectangular compact cells, with thickened walls, protected by cuticle, followed by multilayered cortex rich of salt gland. The outer part of cortex is constituted with collenchyma cells, but the inner part is parenchyma cell with a large numbers of intercellular spaces are present between these cells. Vascular tissue is a continuous conjoint collateral cylinder in all species. Pith presenting the centre of stem composed of parenchymatous storage cells of isodimetric to polyhederal thin layered cells with more or less large inter-cellular spaces. Cells are rich of druses crystals. Cell dimensions increases towards the center of stem (plate 6).

[17] pointed the Frankeniaceae can provide an opportunity to examine the nature of vasicentric tracheids and comments on the ontogenetic differences between vessel elements and vasicentric tracheids, observations provided in part to refute the idea that vasicentric tracheids are simply vessel elements that are so small as to preclude formation of a perforation plate. In addition , [1] found a numerous anatomical correlations with habit and ecology were noted in American *Frankenia,* including smaller vessel element length and diameter with smaller internode lengths.

Monophyly of the sister families Frankeniaceae and Tamaricaceae has been confirmed by recent molecular phylogeny reconstructions [29] . The main stem anatomical differences between the two families are the large multiseriate rays of Tamaricaceae versus the raylessness of Frankeniaceae, and the lack of

vasicentric tracheids in Tamaricaceae. Likewise, [25] report water-storage tracheids in the cortex of young stems of *Tamarix*, but these were not observed in Frankeniaceae. Similarities that can be cited between the two families include similar pitting patterns at vessel and vessel-ray interfaces and fusiform axial parenchyma cells (Tamaricaceae wood characteristics from [25] and lists of On the other hand, Transverse sections of lamina showed the structure of the leaf is dorsiventral , but the stomata and salt-secreting glands are found on both surfaces, whereas the setaceous hairs are absent on the upper side. [31] emphasized the leaves in *F.pulverulenta* are small and flat with salt-crystals on both faces but in *F.aucheri* are revolute, with scattered hairs and with grains of salt . Thus thickness of lamina ranged between (0.2- 0.34) mm to (0.06-0.1) mm in *F.pulverulenta and F.aucheri* respectively (plate 7).

Cross section of the leaf discloses an upper and lower epidermis, a mesophyll and the veins vascular bundles embedded in it. The one-layered upper and lower epidermis. The lower epidermis consists of smaller cutinized cells than the upper epidermis. in *F.pulverulenta* have a range thickness (25.0-37.5) µm and (17.0-40.0) µm at lower and upper surface respectively, but thickness in *F.aucheri* at the lower surface was (15.0-17.5) µm and upper surface (17.5- 22.5) µm . Mesophyll was composed by one-two layers of palisade cells which were smaller at the inner layer. In some sectors it was difficult to distinct. The spongy parenchyma had layers of cells with various shapes loosely arranged. In the mesophyll, the veins vascular system is embedded and represented by vascular bundles similar with those described in the stem. However in vascular bundles, xylem is near upper and phloem is near lower surface.

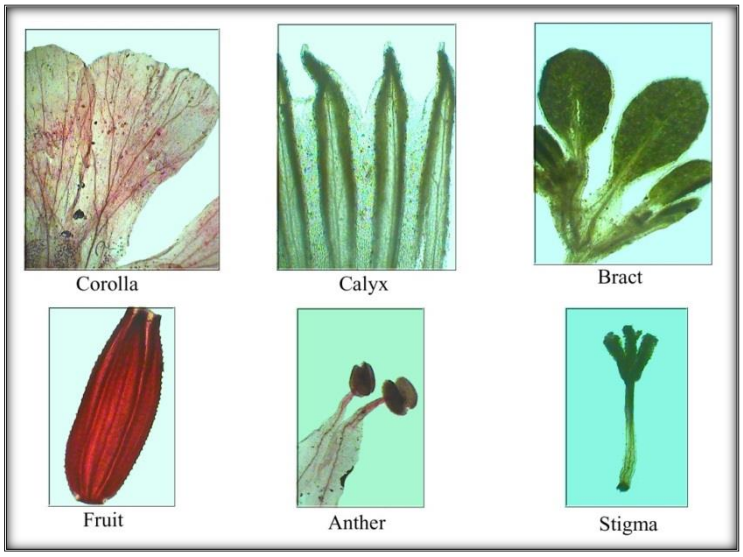

Plate 1: Portion of *Frankenia* species plants

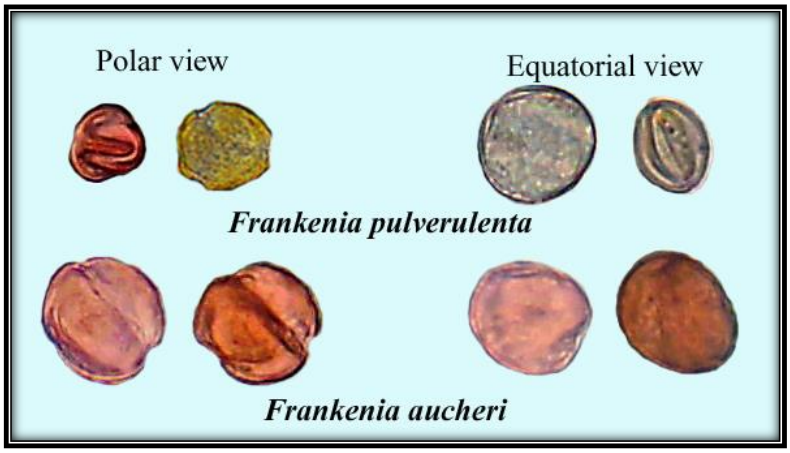

Plate 2: Variations of Pollen grain in *Frankenia* species

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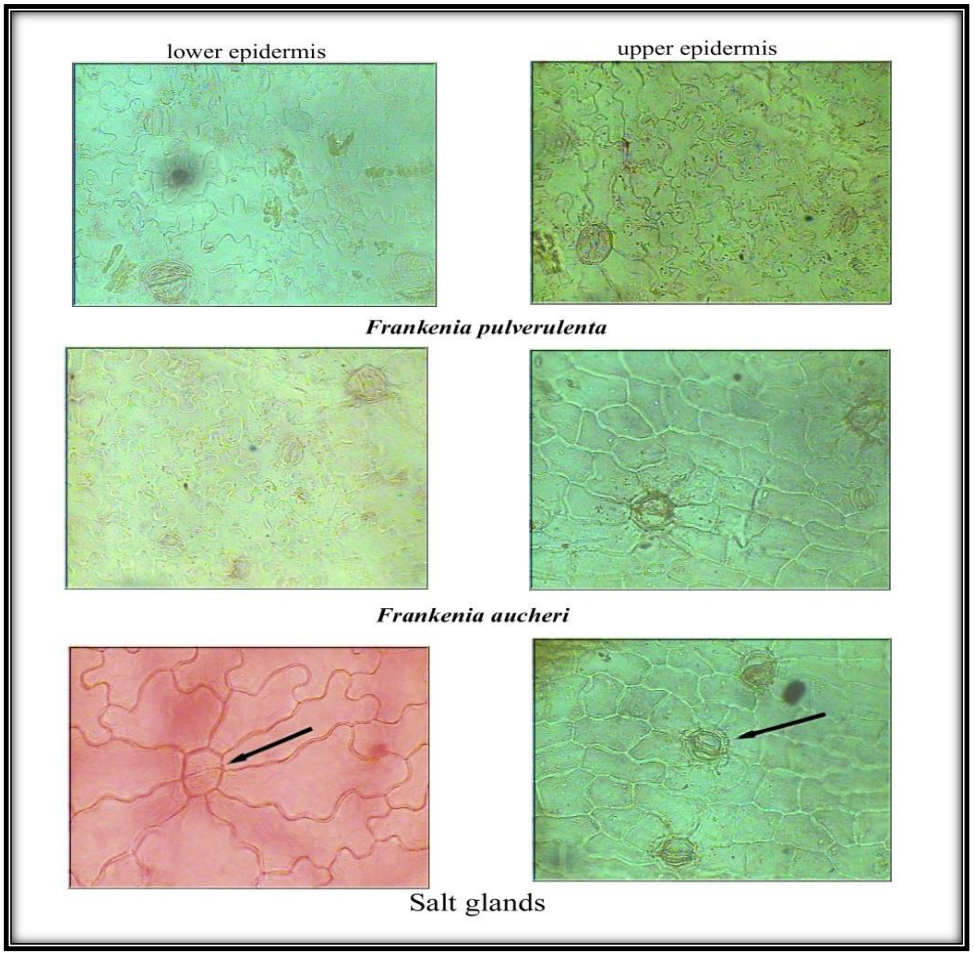

Plate 3: lower and upper epidermis leaves and Salt gland in *Frankenia* species

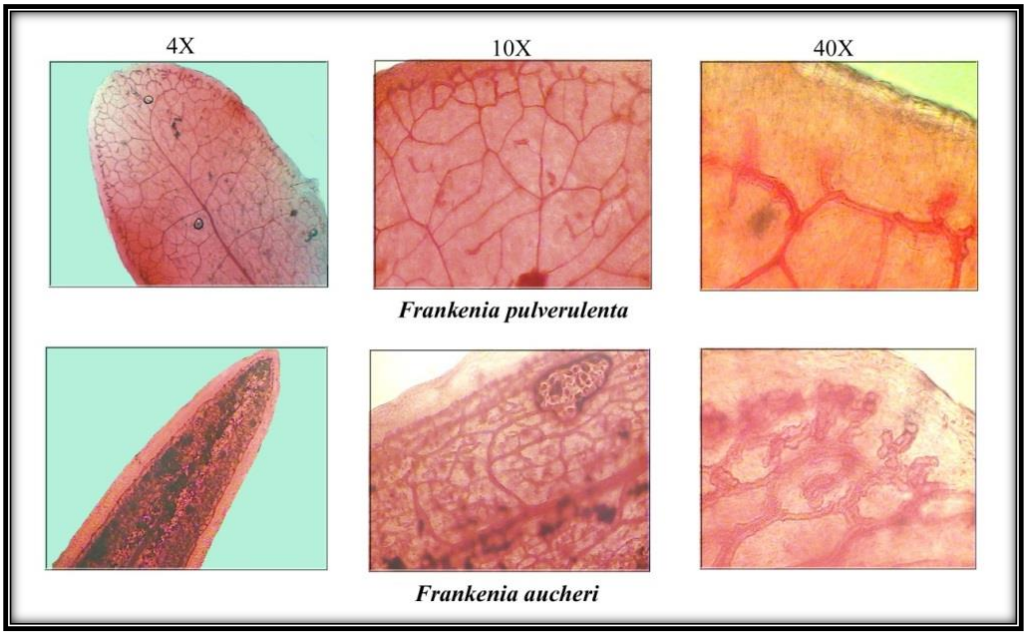

Plate 4: Venation in *Frankenia* species

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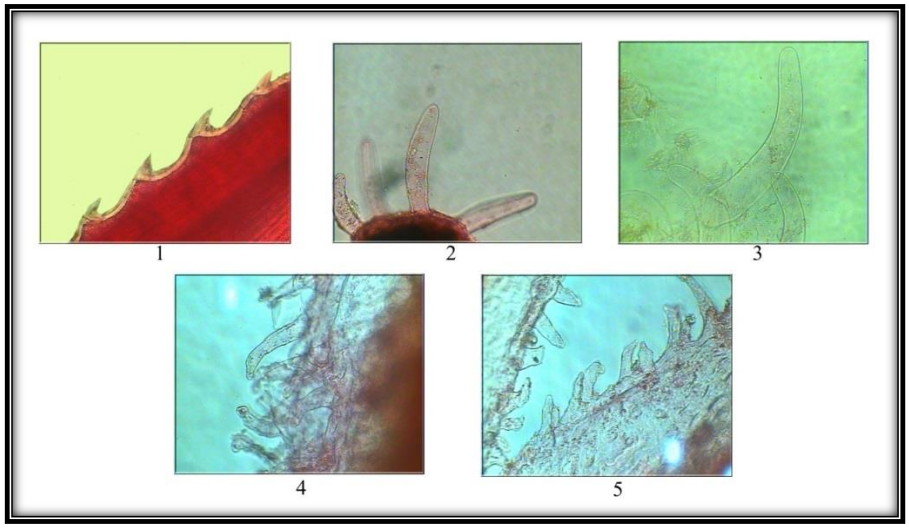

Plate 5: Trichome in different parts in *Frankenia* species
1-in ovary and fruit 2- in stem 3- in leaves 4 &5- Dense trichome in leaf & stem

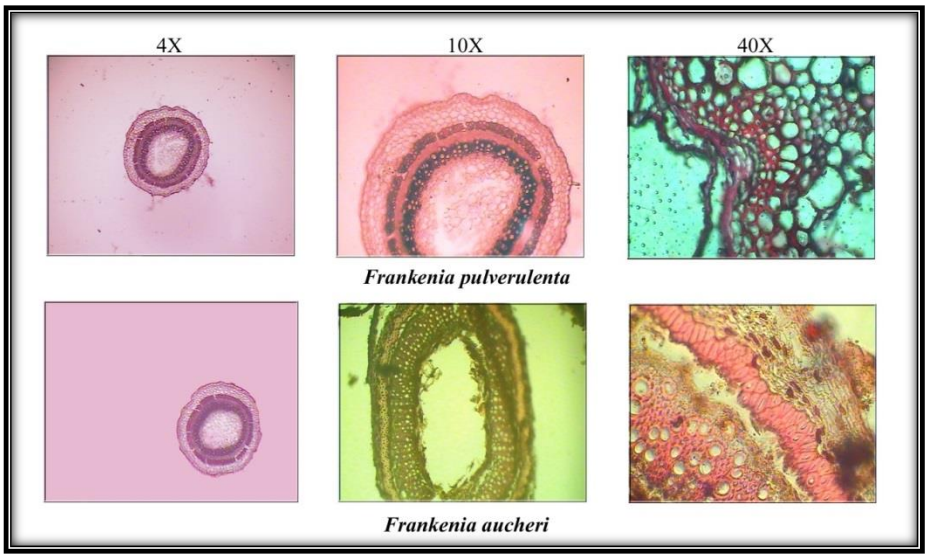

Plate 6: Cross section of stems in *Frankenia* species

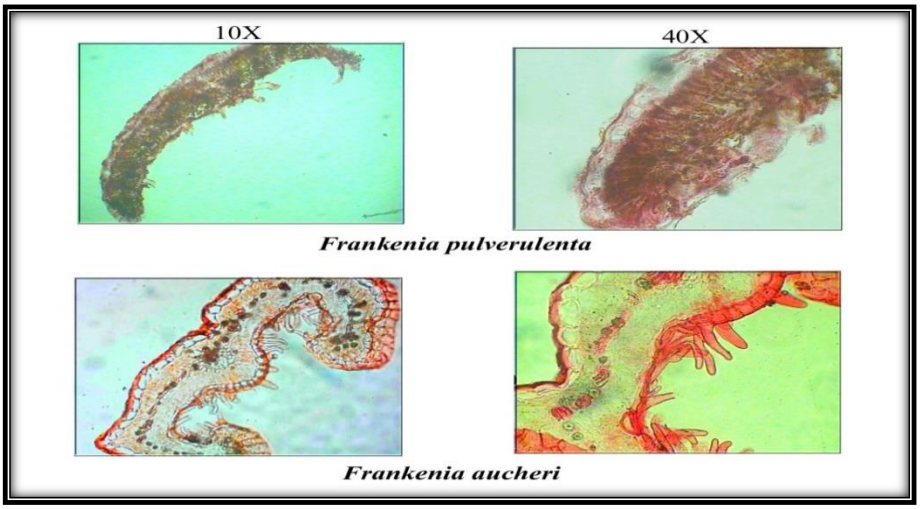

Plate 7: Cross section of leaves in *Frankenia* species

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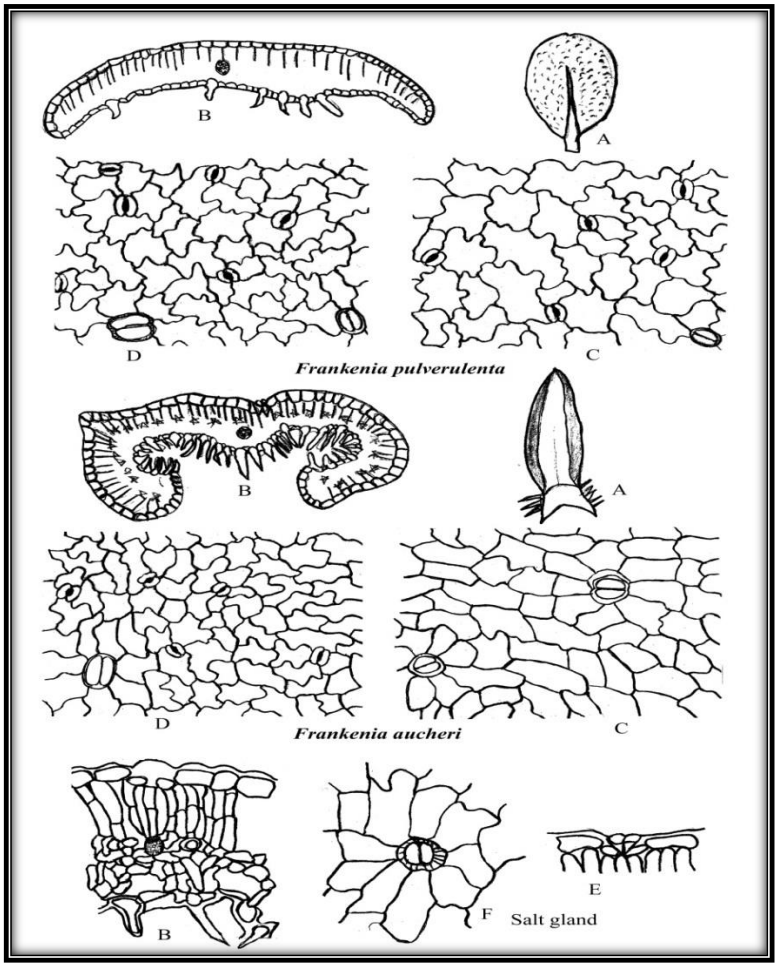
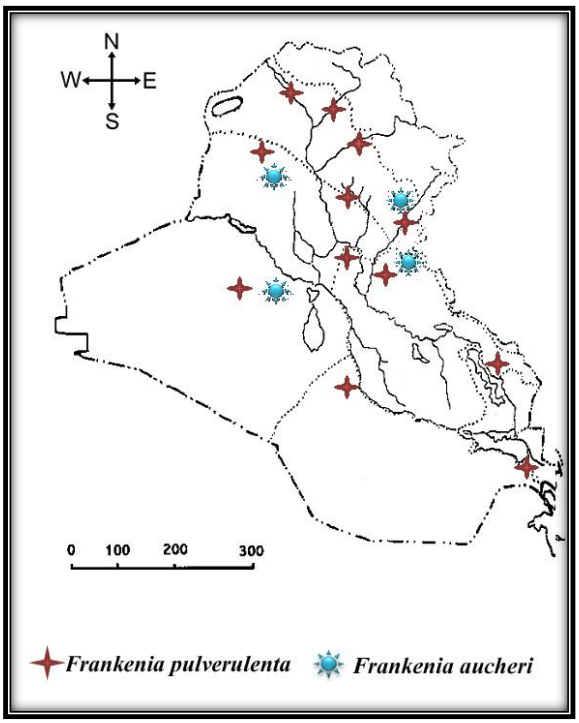


Figure 1: *Frankenia* species. A: Normal leaf B:Outline of leaf in Transverse section with epidermis, palisade cells and hairs indicated, and Part of leaf in transverse section C: Upper epidermis D: Lower epidermis E: Lateral view in salt gland F: Frontal view in salt gland

Figure 2: Map of distribution for *Frankenia* species



Ecological and geographical distributions

A result of present study found *Frankenia* sp. as separated individuals within the area or as a population in dry or saline environments. And found the species *F.pulverulenta* is more commonly than *F.aucheri* in Iraq because the first species recorded in twelve Province distributed from north to south of Iraq such as (FNI, FUJ, FKI, FPF, DLJ, DGA, LCA, LEA, DWD, DSD, LSM and LBA) [32] Also, Blakelock in [33] reveled the species *F.pulverulenta* is growing on desert plains, hills and depressions, generally on saline soils- whether caly, loam, sandy, gravel, gypsaceous, edges of fields and roadsides, wadis, at altitude up to 300m . These results agreed with [29] study on the family under study when said Frankeniaceae are plants of dry or saline environments in which very low water potentials are regular occurrences. In light of this, we consider selected adaptive aspects of *Frankenia* xylem, and propose a potential reason for raylessness in Frankeniaceae. Furthermore, [10] emphasized that *F.pulverulenta* can grow *in* high-salinity grasslands of flood lands, by lakes, always on moist and slightly alkaline soils in desert regions.

The second species *Frankenia hirsuta* (Syn: *Frankenia aucheri* Jaub. et Spach.) has native name MILLAIH or SHUWAIWA (meaning " salt ") can grow in saline desert soils, sometimes with high water table or even waterlogged, on banks of a wadi, on the edge of an oasis, at altitude up to 150m, camels and sheep are only able to eat this when they can get fresh grass at the same time [11]. [34] Confirmed that *Frankenia hirsuta* is usually grown as patch form in low parts and water intake of this rangelands.

This species have limited its spread to four provinces (FPF, LEA, DLJ and DWD) according to [32] likes Jabal Hamrin, Mandali, 13 km. S.W. of Wadi Thirthar on pipeline, banks of Euphrates near old Qa'im , Kubaisi near Hit and north of Shithatha (Figure 2).

These results came as a result of the distribution of species near neighboring areas such as in Irano-Turanian and Mediterranean [35], In Turkey [36], in Syria [37] , in Egypt [28] ; In Qatar [38] and Kuwait [39]. Also recorded in Lebanon, Jordan, and Palestine [33].

In spite of these results were obtained, we need to future molecular study to differentiate between two species in Frankeniaceae and other taxa of Tamaricaceae and Caryophyllaceae.

CONCLUSION

From the above observation, it can be concluded that combination of morphological, anatomical, Palynological features and Ecological and geographical distributions play significant role for delimitation and isolation of taxa.

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