Article

Commiphora Jacq (Burseraceae) in Saudi Arabia, Botanical, Phytochemical and Ethnobotanical Notes

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Abstract: Commiphora species are of high medicinal importance. They are distributed in Saudi Arabia, mainly in rocky habitats and regions under mountains, including the east of Tihama, forming a distinct element of Saudi flora. The present study focuses on the botanical characterization of five species of Commiphora, i.e., C. erythraea, C. gileadensis, C. kataf, C. myrrha, and C. quadricincta. The morphological characters for each species were recorded comparatively, and their taxonomic relationships were examined using gross morphology by generating a UPGMA dendrogram, which separated the Commiphora species into two distinct groups. A dichotomous key was generated to facilitate the identification process of the plant, even by naked eye, by obvious characteristics. Because of the similarities in anatomical structure of the stem and petiole of most studied species, only the quantitative variations are illustrated comparatively. Seed macro- and micro-morphological characteristics were recorded comparatively to be used in the identification of a species in the case of leaf absence. The phytochemical study included measurements of total phenolic and flavonoid contents. The phytochemical results were correlated with the ethno-botanic survey. The traditional uses for all species were recorded using the questionnaire and open interviews method for data collecting. The results revealed that the most common Commiphora species that are traditionally used are C. myrrha and C. gileadensis. The study recommends more research on Commiphora species using more advanced techniques and tries to increase public awareness on the importance of these plants.

Keywords: Commiphora; ethno-botany; macro- and micro-morphology; petiole anatomy; phytochemistry

1. Introduction

Commiphora Jacq (Burseraceae) is a genus of 150–185 species distributed in tropical and subtropical regions, occupying an ecological range between 1 and 2100 m above sea level [1,2]. The species are small trees or shrubs with short, thorny branches. Commiphora is distributed on the Red Sea coast in the west and southwest of Saudi Arabia. It is also found in Somalia, with the high concentration in the Horn of Africa. [3–5]. In Saudi Arabia, the genus Commiphora is represented by six species, i.e., C. erythraea, C. gileadensis, C. habessinica, C. kataf, C. myrrha, and C. quadricincta [6,7]. According to [8], there are five Commiphora species, i.e., C. quadricincta, C. gileadensis, C. kataf, C. habessinica, and C. myrrha, in the flora of Jazan, and an additional species, i.e. C. erythraea, was reported in Farasan Island, Jazan by [7].

The distribution of Commiphora species only in the western region of Saudi Arabia can be explained and confirmed by the account of the subdivision of African phytchoria of [9], that the genus is found distributed in the majority of the regional centers of endemism, and two regional mosaic and transitional zones, with the highest genetic diversity in the Somalia–Masai regional center of endemism.

However, some species such as C. myrrha are transcontinental and extend their distribution to Arabia and India [5], C. gileadensis, C. quadricincta, C. kataf, and C. myrrha exist...
beyond the continent and occur in Saudi Arabia, having a disjunctive distribution to their center of endemism [10].

Traditional medicine occupies a significant part of Saudi Arabia’s heritage, and it is widely practiced today [11]; some reports concern the study of medicinal plants in the flora of Saudi Arabia [12,13]. Several species of the genus Commiphora produce fragrant resins used for incense and perfume and are used medicinally in the liver diseases, gastrointestinal disorder, urinary tract infections, rheumatism, scurvy and jaundice [14–19], cancer [20], respiratory, muscular, and kidney complaints [21]. Besides its traditional usage for the treatment of sore stomach, colds, fever, and malaria, wound healing, as an antiseptic, and against skin infections, the resinous exudates produced by the different species of Commiphora have high commercial value [6].

In Arab countries, Commiphora myrrha tree is commonly known as myrrh. It has been used as a traditional remedy for a long time [22]. Myrrh is also used in traditional Chinese medicine for the treatment of trauma, arthritis, fractures, and diseases caused by blood stagnation [23].

Commiphora species have been the subject of many taxonomic and ethnobotanic studies [24–27]; the only previous taxonomic study on the species of genus Commiphora growing in Saudi Arabia was achieved by Majrashi [28] as an MSc thesis in the Arabic language. The ethnobotanical importance of plants including the Commiphora species has been reported in many works [22,29–36]. Some studies focused on the ethnobotanical significance of Commiphora species individually [23,37–43]. The aim of this study is to record the biological (morphological, anatomical, and phytochemical) valuable notes concerning the Commiphora species of Saudi Arabia, as well as to study the obvious features of the Commiphora species to make their identification easier, providing a simple identification key that can be used simply in any plant growing stage, in addition to reporting the ethnic importance and human use of the Commiphora species in Saudi Arabia for conserving and saving these unrecorded data from being lost.

2. Materials and Methods

Twenty-three field trips were organized to different localities in the western area of Saudi Arabia. There were no significant variations in the Commiphora specimens according to the different localities, so most specimens were collected and recorded from the Jazan area. The Jazan region has variable land forms, including Red Sea coastal plain to the west, the stony transitional region of Tihama Hills in the middle, and high mountains to the east [44]. The climate is influenced by the tropical maritime air mass [45,46]. High summer temperatures in this region are also associated with spells of strong sand storms that add to the harshness of the environment. The Tihama area in Jazan is generally hot throughout the year, except for a brief mild winter. Rainfall in the entire Tihama region is too scarce to support any significant vegetation [47,48]. This is based on five species of Commiphora (Burseraceae) collected from eight hilly/mountainous regions in the Jazan area, SW Saudi Arabia from June 2018 to June 2019. (Figure 1, Table 1).

For morphological study, at least ten specimens for each species at their fully adult stage were collected during different seasons (Table 1). Stems, leaves, flowers, fruits, and seeds were collected during flowering and fruiting stages. A total of 12 characters of micro- and macro-morphological types (7 binary and 4 multistate) were recorded comparatively, either directly from fresh specimens in their natural habitats or at the lab prior to preservation as voucher material. These characters were coded by 0 and 1 according to the character states absence and presence, and then used in the data matrix creation, which was subjected to the software program “NTSys v. 2.02” for examining the similarities and dissimilarities among the studied species and producing the relationship “UPGMA” dendrogram. Some photos were taken of the plants in the field.
The anatomical investigation was carried out on hand-prepared transvers sections (T.S.) of petioles and stems of the five Commiphora species using light microscope (LM). Seeds were examined directly to record macro-morphological features by LM, and micromorphological features and sculpture pattern were recorded using scanning electron microscopy (SEM). For SEM observations, approximately 7 seeds from each taxon were analyzed; the seeds were mounted on SEM stubs using double sided cellotape, coated with gold and palladium in a vacuum evaporator, and examined and photographed in a JEOL JSM-6380LA scanning electron microscope, which operated at an accelerated voltage of 30 KV, at the electron microscopy unit, King Saud University, Riyadh, Saudi Arabia.

Phytochemical screening of plant methanolic extracts was carried out using standard procedures. The Folin–Ciocalteu method was adopted to determine the total phenolic contents of the different extracts [49]. All tests were carried out in triplicate, and the results were expressed as gallic acid equivalents (eq.GA mg/g dry weight of the different extracts). Flavonoid contents were determined based on the formation of flavonoid–aluminum complex [50]. The amounts of flavonoids were expressed as rutin equivalents (mg RE/g dry weight).

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Table 1. The plant sample of Commiphora species collected from Jazan area with scientific and local names.

| No. | Scientific Name and Author Citation | Collection Localities | Dates of Collection | Coordinates (Latitude and Longitude) of Localities |
|-----|-------------------------------------|-----------------------|---------------------|---------------------------------------------------|
| 1   | Commiphora erythra (Ehrenb.) Engler. | Hebar Island          | 10 October 2018     | 03.64'16"53–52.17'42"24  |
|     | In DC Monog. Phan. 1 V.: 20 (1883).  | Frasan Island         | 5 April 2019        | 54.12'16"48–7.84'41"51   |
| 2   | Commiphora gileadensis (L.) C. Chr. | South of Fayfa       | 25 August 2018      | 0.38'17"11–57.42'543     |
|     | in Dansk Bot. Arkiv, 4 (3): 18 (1922). | East of Sabya       | 14 September 2018   | 20.93'17"13–52.32'42"48  |
|     |                                       | North of Al-Ardah    | 18 June 2019        | 19.97'817–14.09'443      |
| 3   | Commiphora kataph (Forssk.) Engl. in | Al-Rayth Mountains ( | 25 August 2018      | 20.93'17"13–52.32'42"48  |
|     | DC., mono. Phan. 4:19 (1883).         | Black Mountain)      | 13 September 2018   | 02.02'17"35–38.29'42"53  |
|     |                                       | East of Ahd-Almsarha | 25 March 2019       | 56.72'16"46–38.76'343    |
|     |                                       | East of Abu-arish    | 2 June 2018         | 4.07'11"7–2.48'42"53     |
| 4   | Commiphora myrrha (Nees) Engl. in DC.,| East of Sabya        | 11 August 2018      | 35.30'317–4.99'42"55     |
|     | mono. Phan. 4:19 (1883).              | North of Al-Ardah    | 25 August 2018      | 19.97'817–14.09'443      |
|     |                                       | Al-Rayth Mountains   | 18 June 2019        | 02.02'17"35–38.29'42"53  |
|     |                                       | East of Sabya (east of | 23 September 2018   | 20.93'17"13–52.32'42"48  |
| 5   | Commiphora quadricincta Schweinf. in  | Akwa Mountain)      | 20 January 2019     | 36.74'317–12.03'42"55    |
|     | Bull. Herb. Boiss. 7. App. 2: 283 (1899). | East of Abu-arish | 18 June 2019        | 35.30'317–4.99'42"55     |
The ethno-botanical field trips were carried out in different localities of the Kingdom. Ethnobotanical data were obtained using a semi-structured questionnaire method. The target groups for this study were people from different ages and cultures, traditional midwives, housewives, farmers, and other people who had practiced and used medicinal plants.

A descriptive statistical method using frequencies and percentages was used to analyze the socio-demographic data of the respondents, and the results of the ethnobotanical survey were analyzed using the relative frequency of citation (RFC). This measure was calculated to determine the relative importance of a particular species. This value was determined using the relation $RFC = \frac{Fc}{N}$ [51], where $Fc$ is the number of respondents who cited a particular species, and $N$ is the total number of respondents.

3. Results

3.1. Morphological Study

Table 2 shows the recorded morphological characters of the *Commiphora* species under investigation, from which five were quantitative and seven were qualitative. By recording the characters, it is clear that: only two species, i.e.; *C. myrrha* and *C. quadricincta* (Figures 2 and 3), were armed (with conspicuous spines), whereas the remaining three species were spineless. *C. quadricincta* was characterized by simple leaf with single blade, whereas *C. erythraea*, *C. kataf*, and *C. myrrha* appeared with trifoliate leaf; on the other hand, *C. gileadensis* is characterized by heteromorphic leaves. Leaf margin is recorded dentate in *C. myrrha* and *C. kataf*, whereas the remaining species had an entire leaf margin. Leaf was characterized by an acute apex in *C. myrrha*, but the apex was aristate in *C. quadricincta*.

| Characters                  | No. | Character States               |
|-----------------------------|-----|--------------------------------|
| Plant height (m)            | 1   | >5                             |
|                             | 2   | <5                             |
| Spine                       | 3   | present                        |
|                             | 4   | absent                         |
| Leaf blade                  | 5   | simple                         |
|                             | 6   | trifoliate                     |
|                             | 7   | heteromorphic (3–5)            |
| Leaf margin                 | 8   | entire                         |
|                             | 9   | dentate                        |
| Leaf apex                   | 10  | acute                          |
|                             | 11  | aristate                       |
| Leaf texture                | 12  | leathery                       |
|                             | 13  | papery                         |
|                             | 14  | hairy                          |
| Petiole length (mm)         | 15  | >15                            |
|                             | 16  | <15                            |
| Blade length (mm) L         | 17  | >15                            |
|                             | 18  | <15                            |
| Blade width (mm) W          | 19  | $4.5 \pm (4–5)$                |
|                             | 20  | $7.5 \pm (6–9)$                |
|                             | 21  | $12 \pm (10–14)$               |
| L/W ratio                   | 22  | >2                             |
|                             | 23  | <2                             |
| Blade size/leaf             | 24  | equal                          |
|                             | 25  | unequal                        |
| Flower color                | 26  | yellowish green                |
|                             | 27  | creamy-pinkish                 |
|                             | 28  | red                            |
Leaf texture character was represented by three states: (1) leathery in *C. kataf*; (2) papyry in *C. gileadensis, C. quadricincta,* and *C. myrrha*; and (3) hairy in *C. erythraea*. Leaf blades were in equal size in only one species, i.e., *C. quadricincta*, whereas the remaining species were characterized by unequal blades. Red flowers were recorded in *C. myrrha* and *C. quadricincta*, whereas yellowish green flowers were recorded in *C. kataf* and *C. erythraea*, but *C. gileadensis* was characterized by creamy-pinkish flowers (Figures 4–6).

The measurements of some plant parts had been taken, recorded as mean values, and represented as quantitative characters such as: plant height, petiole length, and blade length. (Table 2). From the recorded data, *C. kataf* appeared with large measurements of plant height, petiole length, and blade length in comparison with other species.

**Figure 2.** *Commiphora myrrha*; (A): whole plant in leafy stage; (B): leaves; (C): floral buds and one flower is magnified at 1.2 ×; (D): fruits and leaves.

**Figure 3.** *Commiphora quadricincta*; (A): whole plant in naked stage; (B): whole plant in leafy stage; (C): fruits and leaves; (D): flowers at normal view; (E): A magnified flower at 1.2 ×.
Leaf texture character was represented by three states: (1) leathery in *C. kataf*; (2) papery in *C. gileadensis, C. quadricincta*, and *C. myrrha*; and (3) hairy in *C. erythraea*. Leaf blades were in equal size in only one species, i.e., *C. quadricincta*, whereas the remaining species were characterized by unequal blades. Red flowers were recorded in *C. myrrha* and *C. quadricincta*, whereas yellowish green flowers were recorded in *C. kataf* and *C. erythraea*, but *C. gileadensis* was characterized by creamy-pinkish flowers (Figures 4–6). The measurements of some plant parts had been taken, recorded as mean values, and represented as quantitative characters such as: plant height, petiole length, and blade length. (Table 2). From the recorded data, *C. kataf* appeared with large measurements of plant height, petiole length, and blade length in comparison with other species.

**Figure 3.** *Commiphora quadricincta*; (A): whole plant in naked stage; (B): whole plant in leafy stage; (C): fruits and leaves; (D): flowers at normal view; (E): A magnified flower at 1.2 X.

Blade width was recorded at 4.5 ± (4–5) mm in *C. myrrha* and 7.5 ± (6–9) mm in *C. erythraea* and *C. gileadensis*, whereas it was 12 ± (10–14) mm in *C. kataf* and *C. quadricincta*. L/W ratio was calculated as less than 2 in *C. erythraea, C. gileadensis*, and *C. kataf*, but more than 2 in *C. myrrha* and *C. quadricincta*.

**Figure 4.** *Commiphora erythraea*; (A): whole plant at naked stage, leaves at upper corner; (B): flowers upper view, and one flower is magnified at 1.2 ×; (C): fruits with dried twigs.
Figure 4. *Commiphora erythraea*; (A): whole plant at naked stage, leaves at upper corner; (B): flowers upper view, and one flower is magnified at 1.2 X; (C): fruits with dried twigs.

Figure 5. *Commiphora gileadensis*; (A): leaves; (B): whole plant; (C): one flower is magnified at 2 X; (E): flowers at original size; (D): fruits and leaves.

Figure 6. *Commiphora kataf*; (A): whole plant in leafy stage; (B): whole plant in naked stage; (C): A magnified flower at 2 X; (D): flowers at normal view; (E): fruits and leaves.
Figure 7 illustrates the relationships among the *Commiphora* species under investigation in terms of UPGMA (Unweighted Pair Group Method with Arithmetic mean) dendrogram. This dendrogram resulted from the data matrix, generated by coding the macro-morphological characters as “1, 0” for present and absent. *C. myrrha* is separated from the group of species in which that the plant is armed with unequal trifoliate leaves, the terminal leaflet is much longer than the lateral leaflets, and the resin is transparent with glossy appearance. *C. quadricincta* clustered close to *C. myrrha* because they shared some characteristics such as the spiny habit of the plant and red flowers, while having simple leaves and an opaque (not transparent) resin. This result is supported by the resulting identification key (Figure 8).

![UPGMA dendrogram](image)

**Figure 7.** UPGMA dendrogram shows the relationships between the *Commiphora* species using the gross morphological characters.

**Figure 8.** Identification key of *Commiphora* species based on gross morphology.

A. Armed (spiny) plant
   B: Leaf simple, resin not transparent (opaque) .................................................. *C. quadricincta*
   BB: Leaves unequal trifoliate, resin glassy transparent ....................................... *C. myrrha*

Aa. Spineless plant
   C: Plant height more than 5 m, trifoliate leaves with long petiole, and leathery blade.............*C. kataf*
   CC: Plant height less than 5 m, with black resin
   D: Whole plant has no smell, with trifoliate hairy blades and yellow flowers ............... *C. erythraea*
   DD: Whole plant has strong smell, leaflets from 3-5, with hairless blades, flowers pinkish...*C. gileadensis*

Although *C. quadricincta* appeared at the same assemblage as the remaining four species, relatively, it clustered separately from the remaining three species. The three species *C. erythraea*, *C. gileadensis*, and *C. kataf* are clustered together at the same group at the similarity level 0.49; this is due to the spineless nature of the plant and unequal size of leaflets’ blade per leaf. *C. erythraea* and *C. gileadensis* are the only species that are found
Although *C. quadricincta* appeared at the same assemblage as the remaining four species, the cortex appeared differentiated into outer and inner cortex, with collenchyma and parenchyma, respectively. Endodermis is found as a layer/multiple layers of schlerenchymatous cells surrounding the vascular cylinder.

*C. kataf* is arranged with *C. erythraea* and *C. gileadensis* at the same group in the dendrogram (Figure 7) due to sharing the characteristic spineless nature of the plant, whereas it is distinguished from them by the maximum height of the plant (may reach more than 5 m) and trifoliate leaflets with longer petioles, as well as the leathery texture of the blade. This result is supported and confirmed in the identification key (Figure 8).

### 3.2. Anatomical Variations in *Commiphora* sp. Stem

The anatomical characters of the stem in *Commiphora* species are structurally similar (Figure 9). The transverse sections of the stem of most species show the epidermis covered by the periderm, differentiated into cork layer with relatively large barrel cells followed by a conspicuous layer of cork cambium with different thickness. Epidermal trichomes extend from the epidermis densely in the form of a multi-cellular hairs in *C. qudricincta*, whereas they appear as uni-cellular hairs in *C. kataf* and *C. erythraea*, and are absent in both *C. myrrha* and *C. gileadensis*. Sometimes, the epidermal layer was covered by a lignified layer of cuticle; lenticels are formed clearly in old stems of some species such as *C. myrrha*. The cortex is found next to the periderm and appeared narrow in the majority of species (Table 3) because of the presence of periderm, which occupies a large proportion of the stem diameter, including the bundles of fibers. In many stems of *Commiphora* species, the cortex appeared differentiated into outer and inner cortex, with collenchyma and parenchyma, respectively. Endodermis is found as a layer/multiple layers of schlerenchymatous cells surrounding the vascular cylinder.

![Figure 9. Cont.](image-url)
The vascular cylinder appeared with phloem, xylem, and vascular cambium in between; together, they form a continuous ring in most species. The width of xylem and phloem varied according to the studied species (Table 3). Phloem is located outside, including scattered resin canals through it, which take a ring appearance; the majority of canals are of circle shape in cross section, and the average number of them reaches 14–50 (Table 3). Xylem layer is found inside the cambium; it appeared, in most species, with the structure of metaxylem, protoxylem, and xylem vessels, in addition to the medullary rays, which cut this layer longitudinally. Pith is the innermost layer; it consists of parenchymatous tissue, and it extends to different diameters. Due to the structural similarity in the stem anatomy of most studied species of Commiphora, only the quantitative variations in the measurements of anatomical layers are illustrated comparatively in Table 3.

Table 3. Quantitative anatomical characters of stem in Commiphora sp.

| Commiphora Species | Anatomical Parts in the Stem |  |  |  |  |  |
|--------------------|----------------------------|---|---|---|---|---|
|                    | Cortex Width (mm)          | Phloem Width (mm) | Xylem Width (mm) | Pith Diameter (mm) | Resin Channels |
| C. erythraea       | 0.03                       | 0.02                  | 0.04                  | 0.08                  | 28             |
| C. gileadensis     | 0.004                      | 0.02                  | 0.04                  | 0.06                  | 14             |
| C. kataf           | 0.04                       | 0.05                  | 0.02                  | 0.08                  | 43             |
| C. myrrha          | 0.01                       | 0.02                  | 0.04                  | 0.09                  | 30             |
| C. quadricincta    | 0.01                       | 0.03                  | 0.06                  | 0.08                  | 50             |
3.3. Anatomical Variations in the Petiole of Commiphora Species

From the investigation of the internal structure of *Commiphora* petioles through the transverse sections (Figure 10), it was clear that the outermost layer is the epidermis, sometimes covered by a waxy, thick cuticle. The epidermal trichomes arise from the epidermis of all studied species except *C. quadricincta*. These trichomes are of many types: uni-, multicellular or glandular (Table 4).

The cortex is of variable sizes, and it consists of collenchymatous layers outside and parenchymatous layers inside in the majority of species. Vascular cylinders formed from separate bundles are separated by the medullary rays, which extend from the pith, and every bundle is covered by a thick layer of sclerenchymatous cells called the bundle cap. Phloem is found directly inside to the bundle cap, including 4–11 resin canals with different diameters (Table 4).

Vascular cambium is arranged in a single layer between phloem and xylem. Xylem is formed internally, including the xylem vessels with varied diameters. Pith is located centrally; it consists of parenchyma with crystals deposits in many medullary cells in some species.

The anatomical structure of the petiole had shown a large degree of similarity between the studied species. The qualitative variations appeared only in the trichomes presence/type, whereas the quantitative variations were recorded as average measurements and illustrated in Table 4.

![Figure 10. Cont.](image)
3.4. Seed Macro- and Microstructure

The recorded macro- and micro-morphological features of seeds that were seen under light microscope and scanning electron microscope are illustrated in Tables 5 and 6, described with details as shown later and supported by figures.

Table 5. Seed micro-morphological variations of Commiphora species using SEM.

| Seed Microstructure | C. erythraea | C. gileadensis | C. kataf | C. myrrha | C. quadricincta |
|---------------------|--------------|----------------|----------|-----------|-----------------|
| Overall pattern of ornamentation | irregular | reticulate | reticulate | reticulate | reticulate |
| Anticlinal wall shape | irregular | angled | angled | irregular | irregular |
| Anticlinal wall thickness (µm) | 5 | 1.66 | 3.33 | 1.66 | 1.66 |
| Preclinal level | raised | sunken | sunken | sunken | sunken |
| Cuticular deposits | absent | present | present | absent | absent |
| Hilum level | raised | raised | sunken | sunken | raised |
| Hilum area width (mm) | 3.19 | 0.006 | 2.21 | 1.97 | 1.65 |
Table 6. Seed macro-morphological variations of Commiphora species using L.M.

| Characters          | C. erythrya | C. gileadensis | C. kataf | C. myrrha | C. quadricincta |
|---------------------|-------------|----------------|---------|-----------|-----------------|
| Weight of 10 seeds (g) | 0.73        | 0.25           | 1.17    | 0.65      | 1.9             |
| Outline Seed shape  | circle      | ovate          | ovate   | elongated | elongated ovate |
| Color of mature seed| Black with brown base | Brown with black base | Black with brown base | Black | Brown |
| Length (mm) L       | 16          | 11             | 26      | 15        | 16              |
| Width (mm) W        | 12.5        | 8              | 16      | 8.5       | 10              |
| L/W ratio           | 1.28        | 1.4            | 1.62    | 1.7       | 1.6             |

Figure 11 and Table 6 show that the seed outline is circular in *C. erythrya* but is ovate in *C. gileadensis* and *C. kataf*, whereas it was elongated ovate in both *C. myrrha* and *C. quadricincta*. The color of mature seed was black with a conspicuous brown base in *C. erythrya*, *C. gileadensis*, and *C. kataf*, whereas it was black and brown in both *C. myrrha* and *C. quadricincta*, respectively. The recorded seed length and width for all species’ seeds ranged between 11 and 26 mm and 8 and 16 mm, respectively, and the L/W ratio ranged between 1.2 and 1.7. The maximum weight of 10 seeds reached 1.9 g in *C. quadricincta*, whereas the lighter one was recorded in *C. gileadensis* (0.25 g).

In seed microstructure, which is investigated using SEM (Table 5 and Figure 11), it was clear that, the overall pattern of ornamentation was irregular only in *C. erythrya*, whereas it was reticulate in the other species. The anticlinal walls shape appeared irregular in *C. erythrya*, *C. myrrha*, and *C. quadricincta*, whereas it had an angled shape in both *C. gileadensis* and *C. kataf*. Anticlinal walls were recorded with the same thickness of 1.66 µm in *C. gileadensis*, *C. myrrha*, and *C. quadricincta*, whereas it was measured as 5 µm in *C. erythrya* and 3.33 µm *C. kataf*. Periclinal area had a raised level in only *C. erythrya* but appeared sunken in the other species. No testa remains or cuticular deposits appeared in *C. erythrya*, *C. myrrha*, and *C. quadricincta*. Hilum was sunken in both *C. kataf* and *C. myrrha*, whereas it was raised in the remaining three species. The hilum area recorded the greatest width (3.19 mm) in *C. erythrya*, and the smallest one (0.006 mm) in *C. gileadensis*.

Figure 11. Cont.
Figure 11. Seeds of Commiphora sp.: (A) *C. erythraea*, (B) *C. gileadensis*, (C) *C. kataf*, (D) *C. myrrha*, and (E) *C. quadricincta*; I: LM figure magnified at X1.7, II: SEM figure shows the whole seed, III: hilum area, as seen by SEM, IV: overall pattern of ornamentation, as seen by SEM.

4. Phytochemical Results

4.1. Determination of Total Phenolic Contents

A chemotaxonomic study of the five species of *Commiphora* was achieved by preparing the aqueous solutions of the different extracts from each species. From Table 7, it is clear that the measured gallic acid (as phenolic contents) in the specimens ranged from 3.95 to 44.25 µg per 1 mg of dry plant. The highest concentration was recorded in *C. kataf* (44.25 µg/mg dry plant), followed by *C. quadricincta* (43.37 µg/mg dry plant). The concentration was approximately at the same range in *C. gileadensis*, and *C. myrrha* showed very close concentrations of gallic acid (23.54 and 23.99 µg/mg dry plant), whereas the lowest concentration was measured in *C. erythraea* (3.95 µg/mg dry plant) (see Table 7).
Table 7. Total of phenols and flavonoid contents of Commiphora species.

| No. | Species          | µg G A/mg Dry Plant * | µg R/mg Dry Plant ** |
|-----|------------------|------------------------|----------------------|
| 1   | *C. erythraea*   | 3.95                   | 1.63                 |
| 2   | *C. gileadensis* | 23.54                  | 1.67                 |
| 3   | *C. kataf*       | 44.25                  | 1.21                 |
| 4   | *C. myrrha*      | 23.99                  | 1.10                 |
| 5   | *C. quadricincta* | 43.37                  | 2.04                 |

*Microgram of gallic acid (as total phenolic contents)/milligram of dry plant. **Microgram of flavonoid contents (as Rutin)/milligram of dry plant.

4.2. Determination of Total Flavonoid Contents

Table 7 also shows the flavonoid contents (as Rutin) recorded in the studied species. *C. quadricincta* showed the highest concentration of flavonoids (2.04 µg Rutin/mg of dry plant), whereas flavonoid contents were recorded at approximately the same concentrations in *C. erythraea* and *C. gileadensis*. The remaining two species, i.e., *C. kataf* and *C. myrrha*, showed the lowest concentrations (1.21 and 1.10 µg Rutin/mg of dry plant, respectively).

5. Ethno-Botanical Data

5.1. The Informants’ Data Analysis

Demographic characteristics of informants (Table 8) were documented and assessed during face-to-face meetings and discussions. In total, 167 informants were interviewed; 79 were females and 88 males, with percentages of 47% and 53%, respectively.

Table 8. Demographic characteristics of informants according to the ethno-botanical survey.

| Gender | Age       | Profession | Education Level | Place of Residence |
|--------|-----------|------------|-----------------|-------------------|
|        | Female    | Male       | More than 60    | From 30-60 | Less than 30 | No Work | Employee | Illiterate | Middle | High | City | Island | Small City | Village |
|        | 79%       | 53%        | 43%             | 76%       | 48%         | 94%     | 73%      | 64%       | 57%    | 46%  | 10%  | 15%    | 30%    | 112%   |

5.2. Ethno-Botanical Aspects Analysis

Ethno-botanical aspects of five *Commiphora* species are recorded through the ethno-botanical survey. Results of the field documentation concerning the second part of the questionnaire (plant information) are summarized in Table 9. Regarding the parts used of the plant, stem and resin are used in all species, except in *C. erythraea* and *C. myrrha*, in which only the resin is the most important part used; resin and stem were used traditionally in *C. gileadensis*, *C. quadricincta*, and *C. kataf*; whereas leaves were used only in *C. gileadensis*. The results revealed that *C. erythraea* and *C. myrrha* are used for curing skin; *C. gileadensis* and *C. myrrha* are used for chest diseases; all species were recorded to be used in abdominal diseases except *C. erythraea* and *C. quadricincta*; and all species were used for treating other organs except *C. erythraea* (Table 9). Ethno-medicinally, the process of preparation of plants was varied, as reported by the questionnaires.

All species were prepared for use by drenching, except *C. quadricincta*, whereas *C. gileadensis* was the only species whose twigs were used as a tooth-brush; at the same time, *C. myrrha*, *C. quadricincta*, and *C. kataf* were reported to be prepared for use as a powder (Table 9). Traditionally, most species are used for cosmetic purposes, except *C. erythraea* and *C. quadricincta*, whereas the therapeutic uses were recorded in all species except *C. quadricincta* and *C. kataf*, but all species were recorded to be used for household purposes except *C. erythraea* (Table 9). The survey shows many ways of using the *Commiphora* species for traditional uses, *C. erythraea* is reported to be used only as dressing, and all species were used as syrup, except *C. erythraea* and *C. quadricincta*; the other forms of uses were recorded in all species except *C. erythraea* (Table 9).
Table 9. Analysis of ethno-botanical aspects, percentage values according to the FC, where Fc is the number of respondents who cited a particular species.

| No. | Commiphora sp. | The Used Plant Part | The Target Body Organ | Preparation Process | Types of Uses | How to Use |
|-----|----------------|---------------------|-----------------------|---------------------|---------------|------------|
|     |                | Resin               | Leaves                | Stem                | Others        | Abdomen    | Chest      | Skin       | Powdered   | Both-brush | Drenched | Household | Cosmetic | Therapeutic | Others | Dosing | Syrup |
| 1   | C. erythraea   | 5                   | 0                     | 0                   | 0              | 0           | 5          | 0          | 0          | 5          | 0         | 0         | 5         | 0         | 5         | 0       |
| 2   | C. gileadensis | 5                   | 10                    | 40                  | 45             | 7           | 5          | 0          | 5          | 0          | 0         | 0         | 100       | 0         | 0         | 100      | 0 |
| 3   | C. kataf       | 9.6                 | 19.2                  | 77                  | 86.5           | 9.6         | 0          | 0          | 96         | 9.6        | 6         | 7         | 13.6      | 86.5      | 0        | 100      | 100      |
| 4   | C. myrrha      | 8.9                 | 0                     | 80                  | 80             | 8.9         | 0          | 0          | 80         | 8.9        | 26        | 80        | 0         | 80        | 0         | 8.9      |
| 5   | C. quadricincta| 98                  | 0                     | 0                   | 5              | 9.8         | 29.4       | 31         | 39         | 58         | 9.8       | 9.8       | 78        | 39        | 0         | 58       |
|     |                | 100                 | 100                   | 100                 | 100            | 3           | 0          | 3          | 0          | 3          | 0         | 0         | 3         | 0         | 0         | 0         |

5.3. Relative Frequency of Citation (RFC)

The results of the ethno-botanical survey were analyzed using the Relative Frequency of Citation (RFC). This measure was calculated to determine the relative importance of a particular species (Table 10 and Figure 12). This value was determined using the relation [51]:

\[ RFC = \frac{F_c}{N} \]

where Fc is the number of respondents who cited a particular species, and N is the total number of the respondents (167).

Figure 12. The relative importance of each species (RFC).

Table 10. The relative importance of each species (RFC).

| Species          | All Uses                                           | FC | RFC  |
|------------------|----------------------------------------------------|----|------|
| C. erythraea     | 1. Resin is traditionally used on livestock against ticks  
|                  | 2. Resin is traditionally used for humans against snake venom poisoning | 5  | 0.03 |
| C. gileadensis   | 1. Treatment of the abdomen pains by boiling leaves  
|                  | 2. Tooth brushing                              | 52 | 0.31 |
|                  | 3. Leaves used for dyeing fabrics preparations    |    |      |
|                  | 4. Crushed leaves used to treat the eye tumor     |    |      |
Table 10. Cont.

| Species     | All Uses                                      | FC | RFC |
|-------------|----------------------------------------------|----|-----|
| *C. kataf*  | 1. Laxative material (with resin drenched)   |    |     |
|             | 2. Bark is used as incense, grinded and used as a hair ornament |    |     |
|             | 3. Construction of old houses using wood     |    |     |
|             | 4. Firewood because the plank continues burning for a long time | 56 | 0.34|
|             | 5. Its smoke is insect repellent             |    |     |
|             | 6. Bee houses are made of wood               |    |     |
| *C. myrrha* | 1. Wound healing                             |    |     |
|             | 2. Antibiotic for tonsillitis                |    |     |
|             | 3. Cleaning uterus after birth               |    |     |
|             | 4. Stomachache and coughing                 |    |     |
|             | 5. Cure cancer by soaking and drinking it with honey |    |     |
|             | 6. Colds and chest pains                     |    |     |
|             | 7. Tonic for body                            |    |     |
|             | 8. Intensive hair                            |    |     |
|             | 9. Treatment for abscesses and fever in children |    |     |
|             | 10. Strengthens the head bones in children   |    |     |
|             | 11. Incense for houses                       |    |     |
| *C. quadricincta* | 1. Resin is used as glue for ancient pots in which milk is placed | 3  | 0.018|
|             | 2. Wood is used as firewood and in preparing fences for animals |    |     |

6. Discussions

Morphologically, the resulting UPGMA dendrogram and the identification key revealed that the *Commiphora* species were separated into two distinct groups: the first one includes only two species, i.e., *C. myrrha* and *C. quadricincta* were armed (with conspicuous spines). *C. erythraea* and *C. gileadensis* are the only species that are found and collected from Farasan Island; both are characterized by a short and spineless nature, in addition to a glossy, black resin, so both appeared nearly related to each other in the dendrogram. This result matches that of [28].

The anatomical results of stem and petiole through cross sections were recorded comparatively in *Commiphora* species. These results have a degree of agreement with those recorded by [28,52]. Due to the structural similarity in the stem and petiole anatomy of most studied species of *Commiphora*, only the quantitative variations in the measurements of anatomical layers are illustrated comparatively in this study.

The recorded characters of seed micro- and macro-morphology were very valuable in distinguishing between the studied species of *Commiphora*, and these results match those of [28,52] with a good degree. The present study is an attempt to compile the current available knowledge of *Commiphora* species to be broadly representative of many parts of western Saudi Arabia. Investigations underline the significance of local sites for *Commiphora.* It is proposed that the explanation and classification of different species of *Commiphora* in Jazan region will facilitate understanding of the *Commiphora* life in Saudi Arabia as a whole. Our study can be usefully applied in the conservation and management of the area, as well as to focus on the ethnobotanic importance of these species.

The phytochemical results recorded high levels of phenolic and flavonoid contents in all species, especially in *C. myrrha*, *C. kataf*, and *C. gileadensis*; this result is confirmed later by an ethno-botanical survey of the these species, in which the percentages of traditional uses by respondents were recorded. At the same time, Majrashi [28] reported high levels of total of phenolic and antimicrobial activities, which reflects the importance of these species in the use of traditional medicine.

Ethno-botanical data were collected by means of a preset data capture questionnaire and open interviews. The questionnaire was designed to focus on the local names of plants, their various applications, the parts of the plant used, and the methods of preparation...
and administering. Everyone in the target population who agreed to participate was interviewed. Some people informed the researchers that they were reluctant to reveal information about certain medicinal plants, the properties of which they considered to be very powerful. They clearly wished to keep this knowledge to themselves as something belonging to their own private domain. The ability to use plants of such purported potency apparently serves as these healers’ specialty trade marks in their communities, conferring upon them the status of being the best among their peers.

From the ethno-botanic survey, the majority of informants were male, as in tribal areas of Saudi Arabia, there are restrictions on conversations and interactions of females with strangers and outside community members. This resulted in a lower contribution of females in the present study. Regarding age, about half of respondents were between 30–60 years. Kayanna [53] reported that elderly people have more skills and awareness regarding ethno-botanical uses of plants. Additionally, this experience and knowledge also declines with an upsurge in education because people with higher education experience are not attentive to the folk use of medicinal plants. This opinion has been confirmed by the result of the present study, that nearly 38% of respondents were illiterate, and they stated that vertical transfer of traditional knowledge on medicinal plants is not taking place efficiently due to a lack of interest in younger generations to learn and practice it.

Many Commiphora species were found to be of significant biological value for their cytotoxic, anti-inflammatory, antimicrobial, antimalarial, hypolipidemic, hepatoprotective, and antioxidant effects [17]. Besides its traditional usage for the treatment of sore stomach, colds, fever, and malaria, wound healing, as an antiseptic, and against skin infections, the resinous exudates of many Commiphora species may be used in incense and perfume manufacture [16,54]. In Arab countries, the Commiphora myrrha tree is commonly known as myrrh. It has been used as a traditional remedy for a long time [22].

7. Conclusions

By the end of this study, the importance of Commiphora sp. becomes clear, due to the morphological, anatomical and phytochemical unique treats. Because of the deciduous habit of the Commiphora members, the identification of species was problematic. Plants without leaves resembles each other. The identification key produced by this study based on the obvious morphological characters as well as the plant nature to provide an easy tool for the plant recognition even during its naked stage. The anatomical features of Commiphore sp., specially the quantitative ones, in addition to the micro-morphology of seeds can be used for plants determination in the case of the absence of vegetative and reproductive parts, it can be used also in the fossils recognition and paleobotanical studies. The ethno-botanical study revealed that, the most common species that are traditionally used by Saudians are C. myrrha and C. gileadensis, this surveyed result supported the phytochemical analysis of the total phenolic and flavonoid contents in these two species. The study recommends more research on Commiphora species using more advanced techniques and tries to increase public awareness on the importance of these plants. Although the current study is the first taxonomic study of Commiphora in combination with the ethnobotanic survey among the species in Saudi Arabia, it is still a preliminary one, and more work is still needed on different taxa and their relationships between other taxa of the family worldwide.

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