



Flora and Phytochorology of Lahij Governorate of Yemen: 2-Taxonomic Revision of *Corchorus* L. (Grewioideae - Malvaceae *sensu lato*) in Toor Al-Baha District



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THIS STUDY presents a taxonomic revision of the genus *Corchorus* L. (tribe Grewioideae, subfamily Grewioideae, Malvaceae *s.l.*) in Toor Al-Baha district, Lahij Governorate, Yemen. The revision is based on about 33 specimens collected from different locations and habitats in the study area. Four species of *Corchorus* were recognized and identified; three were native to the study area (*C. depressus*, *C. tridens*, *C. trilocularis*), and one was cultivated for its edible leaves (*C. olitorius*). The morphological characteristics of the vegetative and reproductive parts, such as leaf shape and size, stipule type, flower number and length of the pedicel, and seed shape, colour, and length, were proved to have high taxonomic significance in distinguishing between the four species belonging to the genus *Corchorus*. An artificial key to the four species, full species descriptions, photos, updated names, synonymy, local names, and distribution maps are provided to facilitate the identification and recognition of these species.

Keywords: *Corchorus*, Lahij, Malvaceae *s.l.*, Morphological characteristics, Toor Al-Baha, Yemen.

Introduction

The Malvaceae *sensu lato* (*s.l.*) family is a large and diverse group of plants that includes herbs, sub-shrubs, shrubs, and small trees. It has 245 genera and 4300 – 4500 species inhabiting most environments from dry to wet and low to high altitudes (Bayer & Kubitzki, 2003; Heywood et al., 2007; Utteridge & Bramley, 2015). Based on molecular studies, the family was expanded to include four former families: Bombacoaceae, Malvaceae, Sterculiaceae, and Tiliaceae (Bayer et al., 1999; APG II, 2003). Accordingly, the family has nine sub-families: Bombacoideae (17 genera and 164 species), Brownlowioideae (8 genera and 68 species), Byttnerioideae (26 genera and 650 species), Dombeyoideae (20 genera and 375 species), Grewioideae (25 genera and 770 species), Helicteroideae (8 genera and 95 species), Malvoideae (78 genera and 1,800 species), Sterculioideae (12 genera and 430 species),

and Tilioideae (3 genera, 50 species) (Stevens, 2001 onwards). In Yemen, the Malvaceae *s.l.* is considered very important and widely distributed. It includes 25 genera and 112 species (Al-Khulaidi, 2013; Al-Hawshabi et al., 2017b). In Toor Al-Baha district, Lahij Governorate, Al-Hawshabi et al. (2017a) recorded 11 genera and 30 taxa from this family.

The genus *Corchorus* L. (Grewioideae) consists of about 75 species of plants native to tropical and subtropical regions of the world (POWO 2023). Many of these species produce natural fibers that have various uses. For example, *C. capsularis* L. is a fiber crop cultivated for industrial purposes, while *C. olitorius* L. is a food crop that provides fibers grown in Asia, the Middle East, and parts of Africa (Islam, 2013). In Yemen, Wood (1997) reported seven species of *Corchorus* native to the country.

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The species of the genus *Corchorus* are morphologically similar and complex to distinguish using vegetative characteristics only (Benor, 2018). Therefore, several studies have investigated the morphological diagnostic features of *Corchorus* species at different levels, such as the whole genus (Sinha et al., 2011), national floras (Osawaru et al., 2012; Fawzi, 2018), or local floras (Paithane & Bhuktar, 2012; Dar, 2019). These studies have examined various aspects of plants, such as the shape, size, number, and color of the leaves, flowers, stamens, capsules, and seeds. The results have shown some similarities and differences among the species. For instance, *C. depressus* (L.) Peterm. had the smallest leaves and fruits, while *C. trilocularis* L. had numerous stamens and the most giant seeds (Sinha et al., 2011). In contrast, *C. olitorius* and *C. tridens* L. have serrated leaf margins and leafy stipules at the base of the leaves (Osawaru et al., 2012). The capsules of *C. tridens* and *C. olitorius* open into different numbers of valves and have different shapes at the apex (Paithane & Bhuktar, 2012). Similarly, the seeds of *C. tridens* and *C. trilocularis* have different shapes and colors (Fawzi, 2018). The seeds of *C. depressus* and *C. tridens* were very similar (Fawzi, 2018). Moreover, the vegetative and reproductive characteristics were also valuable for distinguishing the species, especially between *C. olitorius* and *C. trilocularis* (Dar, 2019). These studies have highlighted the greater importance of the morphological characteristics of capsules and

seeds in distinguishing between the closely related species of *Corchorus*.

The morphological studies of the Grewioideae in Yemen are scarce. The previous works on this sub-family dealt with it as an independent family Tiliaceae (Wood, 1997; Al-Hawshabi et al., 2017a). In addition, they were either simple lists of genera and species (Gabali & Al-Gifri, 1990; Wood, 1997; Al-Khulaidi, 2013; Al-Hawshabi et al., 2017a) or botanical notes from foreign botanists who visited Yemen in different years (Boulos, 1988; Gabali, 1992). Moreover, the genus *Corchorus* has not yet been revised in Yemen. The study area has four species (57% of *Corchorus* species in Yemen): *C. depressus*, *C. tridens*, *C. trilocularis*, and *C. olitorius*. The current study aims to update the identification key for all *Corchorus* species found in Toor Al-Baha District, add distinctive morphological traits that distinguish between closely related species of *Corchorus*, and give a distribution map of these species in the study area.

Materials and Methods

Study area

Toor Al-Baha district, Lahij Governorate, in southwest Yemen, was selected as the study area for the genus *Corchorus*'s morphology. The area extends between 12°58' and 13°20'N and 44°11' and 44°39'E (Fig. 1).

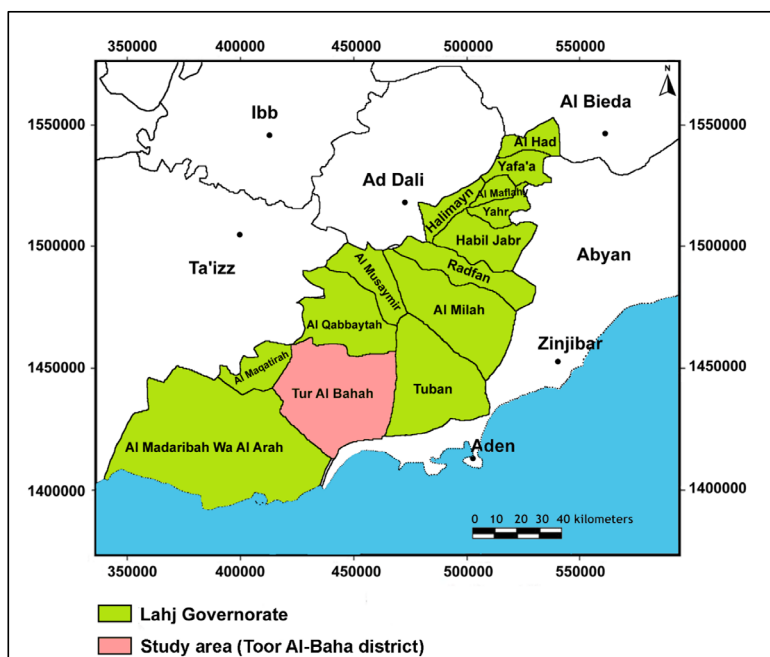


Fig. 1. Map of Lahij Governorate showing the study area of Toor Al-Baha

Plant collection and species identification

Corchorus specimens were collected from the field by the second author (Al-Hawshabi) through several trips (four trips per month, increased to eight during the rainy months, September– mid-November, and the flowering season, January– April) in the study area from August 2020 to January 2022. The study area has mosaic habitats, such as mountains, intermountain basins (Wadis), alluvial plains, hills, slopes, and sandy dunes. The number of field visits varied according to plants' abundance, density, and topographical diversity (Fig. 2).

The collected species were identified and named according to the available literature (Edwards & Hedberg, 1995; Wood, 1997; Thulin, 1999; Boulos, 2000; Bayer & Kubitzki, 2003) and were updated according to POWO (2023). The morphological characters studied included stems, leaves, petioles, inflorescences, floral parts, and fruits, and these were investigated using a stereo microscope (Olympus VE-3, with eyepiece G20XT). Voucher specimens were deposited in the Herbarium of Biology Department Faculty of Education, Aden University, Yemen.

Results

A total of 33 plant samples from four species were collected in the study area: *C. depressus* (8

specimens), *C. olitorius* (one specimen), *C. tridens* (5 specimens), and *C. trilocularis* (19 specimens).

Subfamily: Grewioideae

***Corchorus* L. (1753)**

The genus is represented in the study area by three native species widely distributed in the study area and one cultivated species; the key below distinguishes between them:

- 1a. Stems prostrate; leaves < 2cm long1. *C. depressus*
- 1b. Stems erect to ascending; leaves 4–8cm long 2
- 2a. Stamens numerous; capsule terminated by undivided beak at the apex 3
- 2b. Stamens 10; capsule terminated by 3 spreading bifid tips at the apex 3. *C. tridens*
- 3a. Stem glabrous; capsule 5-valved2. *C. olitorius*
- 3b. Stem with short crisped hairs; capsule 3-valved 4. *C. trilocularis*

1. *Corchorus depressus* (L.) Peterm., Pflanzenreich: 924 (1845) (Fig. 3A)

Syns.: *Antichorus depressus* L. (1767); *Corchorus microphyllus* Fresen. (1837); *Corchorus prostratus* Royle (1834); *Jussiaea edulis* Forssk (1775)

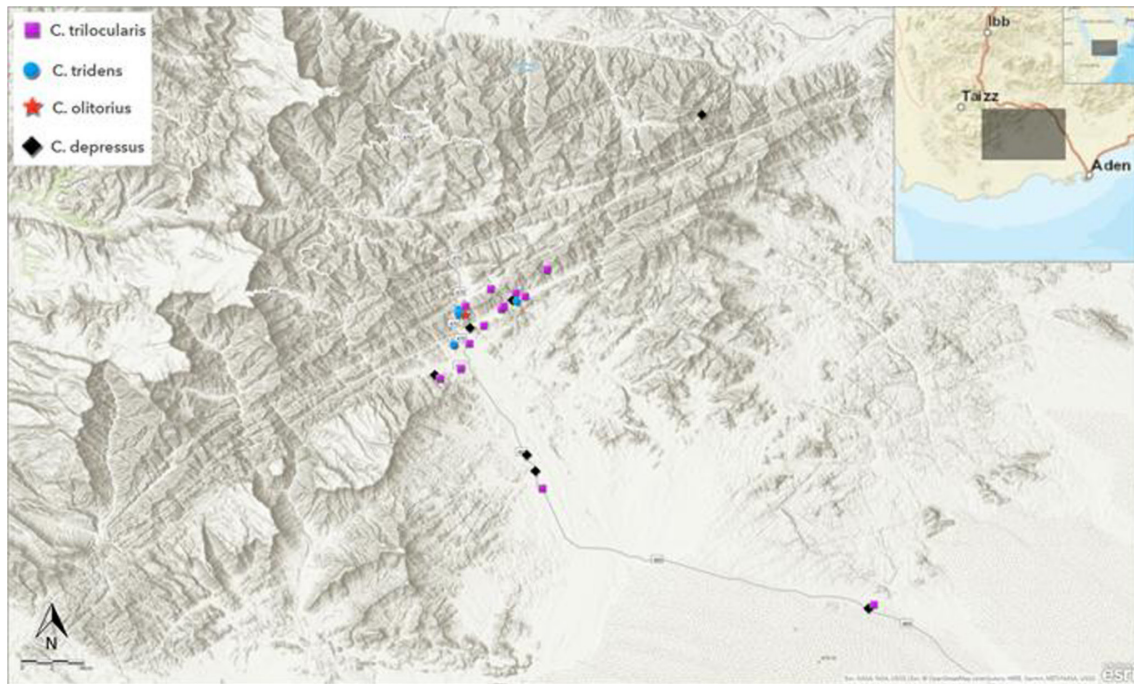


Fig. 2. Occurrence map of *Corchorus* L. species in the study area. Reproduced by ArcGIS Online (Esri, "Topography")

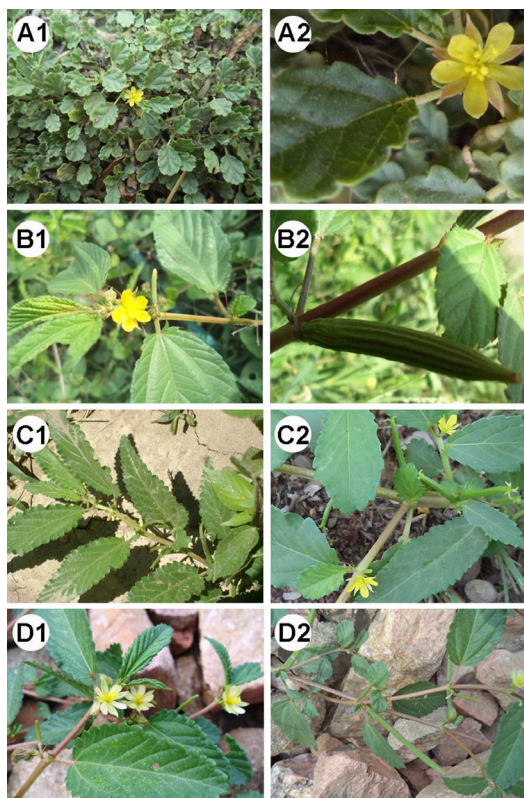


Fig. 3. *Corchorus* L. species in the study area. 1. Vegetative part of the plant with flowering and fruiting buds. 2. Close-up view of an open flower and/or fruit. A. *Corchorus depressus*; B. *Corchorus oltorius*; C. *Corchorus tridens*; D. *Corchorus trilocularis*.

Perennial herb. Stem prostrate, mat-forming, much-branched, woody at the base, young branches sparsely hairy, older ones glabrous. Stipules subulate, glabrous, ca. 1mm long. Leaves green to greyish, simple, 1–1.4cm long, alternate. Petioles 5–6mm long, with short crisped hairs. Blade elliptic to broadly elliptic, 6–8mm × 5–6mm, glabrous, margins irregularly crenate, absence of auricles, apex acute – obtuse. Flowers axillary, usually 1- to 2, opposite the leaves. Peduncle glabrous, up to 2mm long; pedicel glabrous, up to 4mm long. Calyx of 5 sepals, 3–4mm × 2 mm, yellowish-green, linear-oblong, acute, spreading. Corolla of five petals, free, yellow, with clear veins, 3–4 mm × 2 mm, obovate-spathulate, obtuse apex. Androgynophore 1mm long, glabrous. Stamens 10 free, filaments 3mm long; anther 2mm × 1mm. Carpels 4; ovary 2mm × 1.5mm, oblong-cylindric, 4-loculed, covered with short hairs; style equaling the ovary; stigma 4-lobed, glabrous. Capsule 4-valved, 11–14mm height × 2mm diameter, glabrous, narrowly cylindrical, curved or straight,

ending with three beaks, usually buried in the soil. Seeds 32–36, 1mm × 0.5mm, oblong in outline with truncate ends, brown, glabrous.

Local name: Wayki

Habitat and distribution in the study area: It grows on fields in clay, silt soils, wadis, and soils mixed with gravel and waste ground. It is found at 314–704m (Fig. 2).

Specimens examined: Yemen, Lahij Governorate, Toor Al-Baha district, alts. 509m, 13° 06' 543" N, 44° 21' 059" E, 25. 5. 2009, Al-Hawshabi 706; 524 m, 13° 07' 507" N, 44° 19' 904" E, 6. 7. 2009, Al-Hawshabi 1110; 653m, 13° 11' 284" N, 44° 18' 170" E, 22. 11. 2009, Al-Hawshabi 3370; 524 m, 13° 07' 349" N, 44° 20' 902" E, 20. 12. 2009, Al-Hawshabi 3453; 314 m, 13° 01' 943" N, 44° 33' 441" E, 31.1. 2010, Al-Hawshabi 3915; 648 m, 13° 10' 465" N, 44° 17' 979" E, 3.11. 2010, Al-Hawshabi 4985; 704m, 13° 12' 328" N, 44° 19' 463" E, 31.8. 2020, Al-Hawshabi 5735; 13.9. 2021, Al-Hawshabi 6054.

2. *Corchorus oltorius* L., Sp.Pl. ed.1: 529 (1753) (Fig. 3B)

Syns: *Corchorus catharticus* (1837); *Corchorus decemangularis* Roxb. ex G.Don (1831); *Corchorus lanceolatus* G.Don (1831); *Corchorus longicarpus* G.Don (1831); *Corchorus malchairii* De Wild. (1911); *Corchorus oltorius* var. *australiensis* Domin (1927); *Corchorus oltorius* var. *grandifolius* De Wild. (1908); *Corchorus oltorius* var. *incisifolius* Asch. & Schweinf. (1887); *Corchorus oltorius* var. *malchairii* (De Wild.) R.Wilczek (1963); *Corchorus quinquelocularis* Moench (1794).

Annual herb, up to 41–55 cm high (up to 3 m in cultivation). Stems woody at the base, branched, erect or ascending, glabrous, young branches somewhat angular or sulcate. Stipules 7–8 mm × 1 mm, subulate, glabrous. Leaves green, simple, 7.3–8.1cm long, alternate, 3-5-costate. Petiole 11–16 mm long, covered with short hispid hairs. Blade ovate-lanceolate, elliptic or oblong-ovate, 63–67 mm × 26–29 mm, glabrous, margin serrate with the two lowest serrations prolonged into setaceous deflexed auricles 6–10 mm long, base obtuse, apex acute to acuminate. Inflorescences of small 1–2-flowered cymes opposite the upper leaves. Peduncle glabrous, 2–3mm long; pedicel glabrous, 3–4mm long. Calyx of 5 sepals, 7–8mm × 3mm,

green, ensiform, caudate at the apex, glabrous. Corolla of five petals, free, yellow, 6–8mm × 2.5–3mm, obovate, with a short ciliate claw at the base, apex obtuse. Androgynophore 1–2 mm long, glabrous. Stamens numerous, filaments 4–6mm long, ± united at the base, anthers 2mm × 1mm, subglobose. Carpels 5; ovary 3.5–4mm × 2mm, cylindrical, subsulcate, 5-loculed, many-ovuled, minutely setulose; style linear, covered with short hispid hairs, 2mm long; stigma 5-lobed, 1–2mm × 2–2.5mm, minutely papillate. Capsules 5-valved, 1 or 2 together, 27–56 mm height × 0.4–0.6 mm width, glabrous, cylindrical, 10-ribbed. Seeds 115–120, 4mm × 3mm, triangular, greenish black.

Local name: Mulukhiyah

Habitat and distribution in the study area:

The plant is cultivated in clay soils 717m above Sea level (Fig. 2).

Specimens examined: Yemen, Lahij Governorate, Toor Al-Baha district, alt. 717 m, 13° 12' 694" N, 44° 18' 193" E, 21. 1. 2021, Al-Hawshabi 5867.

3. *Corchorus tridens* L., *Mant. Pl.*, 2: 566 (1771) (Fig. 3C).

Syns.: *Corchorus burmanii* D.C. (1824); *Corchorus patens* Lehm. (1828); *Corchorus senegalensis* Juss. ex Steud. (1840)

Annual herb, up to 36–45cm high. Stems erect to ascending, branched, young branchlets at first somewhat compressed or angular, glabrous to sparsely pilose. Stipules 3–6mm × 1mm, subulate, glabrous. Leaves green adaxially and gray abaxially, simple, alternate, 4.6–7.6cm long, 3–4-costate. Petiole 4–13mm long, pilose on the upper side. Blade oblong-lanceolate to linear-lanceolate or somewhat elliptic-obovate, 35–70mm × 2–31mm, glabrous above, except for the glandular veins with short hispid hairs, margin serrate or serrate-crenate, some with the two lowest serrations prolonged into setaceous auricles 6–8mm long, base obtuse, apex acute. Inflorescences of 1–4(–5)-flowered cymes opposite the leaves. Peduncle glabrous, up to 2mm long; pedicel glabrous, up to 2mm long. Calyx of 5 sepals, 4–6mm × 2mm, free, yellowish-green, linear-oblong, bluntly acuminate at the apex, glabrous adaxially, and appressed hairy abaxially. Corolla of five petals, free, yellow, 4–6mm × 2–5mm, oblanceolate, tapering to a short ciliate

claw, apex obtuse. Androgynophore almost obsolete, glabrous. Stamens 10, free, filaments 2mm long. Carpels 3; ovary 3mm × 1.5mm, cylindrical, subsulcate, 5-loculed, many-ovuled, covered with short white, crisped hairs; style small, glabrous; stigma 3-lobed, sparsely papillate. Capsules 3-valved, 1 or 3 together, 30–43mm height × 3 mm diameter, glabrous to sparsely setulose, cylindrical, slightly ribbed, 3-loculed, locules aseptate, straight or slightly curved, ending with three spreading bifid tips. Seeds 54–66, 2mm × 2mm, angular, oblong, obliquely truncated at both ends, dull dark brown to black.

Local name: Wayki, Mulukhiyah

Habitat and distribution in the study area:

The plant grows in fields, in sandy soils, slopes, abundant weed of fields where sorghum plants are cultivated, and also on edges wadis. It is found at 675 – 841m (Fig. 2).

Specimens examined: Yemen, Lahij Governorate, Toor Al-Baha district, alts. 740m, 13° 12' 642" N, 44° 18' 099" E, 17. 10. 2009, Al-Hawshabi 2327; 704m, 13° 12' 328" N, 44° 19' 463" E, 31. 8. 2020, Al-Hawshabi 5734; 675m, 13° 11' 989" N, 44° 17' 735" E, 23. 9. 2020, Al-Hawshabi 5773; 717m, 13° 12' 694" N, 44° 18' 193" E, 23. 9. 2020, Al-Hawshabi 5779; 841m, 13° 13' 355" N, 44° 20' 266" E, 7.9. 2021; 783m, 13° 11' 911" N, 44° 17' 319" E, 6.11. 2021, Al-Hawshabi 6120.

4. *Corchorus trilocularis* L., *Mant. Pl.* 1: 77 (1767) (Fig. 3D)

Syns.: *Corchorus aestuans* Forssk. (1775); *Corchorus asplenifolius* E.Mey. ex Harv. & Sond. (1860); *Corchorus fruticosus* Vis. (1836); *Corchorus gracilis* R.Br. (1814); *Corchorus rigidusculus* Domin (1927); *Corchorus serrifolius* DC. (1824); *Corchorus somalicus* Gand. (1922); *Corchorus triflorus* Bojer (1842)

Annual or perennial herb, up to 35–69 cm high. Stems erect to ascending, branched mainly from the base, covered with spreading setulose pubescence when young; on older stems pubescence confined to one side of the stem, branchlets often purplish. Stipules 3–5mm × 2mm, covered with few short hispid hairs. Leaves green, simple, 5.2 – 8cm long, alternate, 5-costate. Petiole 11–21mm long, setulose, especially on the upper side. Blade oblong-lanceolate to ovate-elliptic, 40–61mm × 15–24mm, glabrous or few long, hirsute hairs on

both surfaces, especially on the veins, crenate-serrate, usually with the two lowest serrations prolonged into setaceous auricles 4–6mm long, sometimes very short or absent, base obtuse or broadly cuneate, apex acute or somewhat rounded. Inflorescences of 1–3-flowered cymes opposite the leaves. Peduncle up to 2mm long, setose-pubescent, lengthening in fruit; pedicle glabrous, up to 3mm long. Calyx of 5 sepals, 4–5mm × 2mm, free, yellowish-green, narrowly lanceolate, acute, glabrous to sparsely setulose-pubescent abaxially. Corolla of five petals, free, yellow, 5–7mm × 2–2.5mm, oblanceolate, tapering to a short ciliate claw, apex obtuse. Androgynophore ca. 0.5mm, glabrous. Stamens numerous, free filaments 4–5mm long. Carpels 3; ovary 3–5 mm × 1.5–2mm, cylindrical, 3-loculed, many-ovuled, very shortly pubescent; style 2.5mm long; stigma 3-lobed, glabrous, capitate. Capsules 3-valved, 1–3-together, 46–55mm height × 3mm diameter, stellate hairy when young, scabrid when mature, cylindrical, 3-loculed, transversely septate, straight or slightly curved, ending with undivided peak. Seeds ca. 108, 2mm × 2mm, smooth, oblong-ovoid, gray to black.

Local name: Wayki, Mulukhiyah

Habitat and distribution in the study area

The plant grows in clay, silt, and sandy soils, slopes it abundant weed of fields where sorghum plants are cultivated, also in the Rocky Mountains, this taxon is common in the study area. It is found at 299–981m (Fig. 2).

Specimens examined: Yemen, Lahij Governorate, Toor Al-Baha district, alts. 512 m, 13° 06' 633" N, 44° 20' 828" E, 15. 6. 2009, Al-Hawshabi 0857; 642 m, 13° 10' 258" N, 44° 17' 992" E, 29. 7. 2009, Al-Hawshabi 1299; 695 m, 13° 12' 072" N, 44° 19' 295" E, 6. 8. 2009, Al-Hawshabi 1460; 658 m, 13° 10' 185" N, 44° 18' 015" E, 7. 8. 2009, Al-Hawshabi 1511; 648 m, 13° 10' 263" N, 44° 17' 894" E, 12. 8. 2009, Al-Hawshabi 1712; 798 m, 13° 12' 418" N, 44° 19' 051" E, 16. 8. 2009, Al-Hawshabi 1762; 714 m, 13° 12' 306" N, 44° 19' 577" E, 26. 9. 2009, Al-Hawshabi 2002; 718 m, 13° 12' 319" N, 44° 19' 461" E, 11. 10. 2009, Al-Hawshabi 2181; 656 m, 13° 11' 078" N, 44° 18' 152" E, 1. 11. 2009, Al-Hawshabi 2558; 653 m, 13° 11' 096" N, 44° 18' 146" E, 1. 11. 2009, Al-Hawshabi 2588; 691 m, 13° 12' 193" N, 44° 19' 308" E, 2. 11. 2009, Al-Hawshabi 2707; 753 m, 13° 12' 348" N, 44° 20' 141" E, 14. 11. 2009, Al-Hawshabi 2929; 299

m, 13° 01' 819" N, 44° 33' 695" E, 31. 1. 2010, Al-Hawshabi 3885; 981 m, 13° 12' 521" N, 44° 18' 981" E, 17. 5. 2010, Al-Hawshabi 4440; 808 m, 13° 12' 907" N, 44° 20' 204" E, 31. 10. 2010, Al-Hawshabi 4880; 955 m, 13° 11' 965" N, 44° 19' 698" E, 2. 11. 2010, Al-Hawshabi 4949; 3. 4. 2021, Al-Hawshabi 5902; 7. 9. 2021, Al-Hawshabi 6027; 841 m, 13° 13' 355" N, 44° 20' 266" E, 13. 9. 2021, Al-Hawshabi 6045.

Discussion

The current study provides a comprehensive morphological examination of four *Corchorus* species (Grewioideae) growing in Toor Al-Baha, Lahij Governorate, Yemen, belonging to the Malvaceae *s.l.* Family. *Corchorus* was formerly classified under Tiliaceae, but molecular studies have shown it is more closely related to the Grewioideae subfamily within the Malvaceae *s.l.* (Alverson et al., 1998; 1999; Bayer et al., 1999; Whitlock et al., 2001; Bayer & Kubitzki, 2003; Sinha et al. 2011). The species of this genus are morphologically similar and difficult to distinguish using vegetative characteristics.

The four species recorded in the study area were *C. depressus*, *C. tridens*, *C. trilocularis*, and *C. olitorius*. The study revealed that *C. depressus* has a prostrate habit and forms a mat with petioles 6mm long. At the same time, the other three species have erected or ascending stems with longer petioles (Fig. 3A). These results agree with Fawzi (2018) but contradict Sinha et al. (2011). All studied species have leafy stipules and serrate leaf margins, except for *C. depressus*, which has crenate leaf margins (Table 1). These results are consistent with Osawaru et al. (2012).

The blade's shape and apex are morphologically crucial in distinguishing between the four species of the genus *Corchorus* in the study area. The blade's surface is glabrous in all studied species, while the veins of the blade are glabrous in *C. depressus* and *C. olitorius* but glandular and covered with short, hispid hairs in *C. tridens*. In *C. trilocularis*, the surface of the blade veins has a few long, hirsute hairs (Table 1). These results agree with Sinha et al. (2011) and Fawzi (2018), where the blade surfaces are glabrous in *C. depressus*, *C. olitorius*, and *C. tridens* but disagree with them regarding the surfaces of the blade veins. These differences could be due to environmental variation between the studied areas.

TABLE 1. Comparison of stem and leaf morphological characteristics among the studied species of *Corchorus* (Grewioideae) in the study area

Characteristics	<i>C. depressus</i>	<i>C. olitorius</i>	<i>C. tridens</i>	<i>C. trilocularis</i>
Stems habit	Prostrate	Erect or ascending	Erect to ascending	Erect to ascending
The surface of stem and branches	Young branches sparsely hairy, older glabrous	Glabrous	Glabrous to sparsely pilose	Covered with spreading setulose pubescence
Stipules size (mm)	Ca. 1	7–8 × 1	3–6 × 1	3–5 × 2
Surface of stipules	Glabrous	Glabrous	Glabrous	Covered with few short hispid hairs
Length of leaf (cm)	1 – 1.4	7.3 – 8.1	4.6 -7.6	5.2 - 8
Length of petiole (mm)	5–6	11 – 16	4 – 13	11 – 21
Blade				
Shape	Elliptic to broadly elliptic	Ovate-lanceolate, elliptic or oblong-ovate	Oblong-lanceolate to linear-lanceolate or somewhat elliptic-obovate	Oblong-lanceolate to ovate-elliptic
Size (mm)	6–8 × 5–6	63 – 67 × 26 – 29	35 – 70 × 2 – 31	40 – 61 × 15 – 24
Surface of blade	Glabrous	Glabrous	Glabrous	Glabrous or setulose-pilose on both surfaces
Margin	Crenate	Serrate	Serrate or serrate-crenate	Crenate-serrate
Base	Obtuse	Obtuse	Obtuse	Obtuse or broadly cuneate
Apex	Acute – obtuse	Acute to acuminate	Acute	Acute or somewhat rounded
Surface of veins	Glabrous	Glabrous	Glandular with short hispid hairs	Covered with few long hirsute hairs
Length of auricles (mm)	Absent	6 – 10	6 – 8	4 – 6

One morphological feature differentiating *C. depressus* from the other three species is the leaf's lack of basal setose auricles (Table 1, Fig. 3A). Among the studied species, the cultivated *C. olitorius* has the longest auricles, up to 10mm long, while *C. tridens* and *C. trilocularis* have 6-8mm and 4-6mm, respectively (Table 1).

The number of flowers per inflorescence and the pedicle length are useful floral characteristics for distinguishing the four *Corchorus* species. *Corchorus tridens* have 1-4 flowers per inflorescence and a pedicle length of 2mm, which differs from the other species in the study area (Table 2). This result is consistent with Sinha et al. (2011) results. The position of the inflorescence also varies among the species. It is axillary in *C. depressus* and opposite to the leaves

in the other three species. This result agrees with Fawzi (2018), who reported the same variation in inflorescence position among *Corchorus* species. Moreover, the shape and apex of the calyx and corolla show significant differences among the studied species (Table 2).

The number of stamens and carpels are important distinguishing features for the four *Corchorus* species. *Corchorus depressus* and *C. tridens* have ten stamens each, while *C. olitorius* and *C. trilocularis* have numerous stamens. *Corchorus tridens* and *C. trilocularis* have three carpels each, while *C. depressus* and *C. olitorius* have four and five carpels, respectively (Table 2). These results agree with previous studies on *Corchorus* (Sinha et al., 2011; Fawzi, 2018).

TABLE 2. Comparison of flowering morphological characteristics among the studied species of *Corchorus* (Grewioideae) in the study area

Characteristics		<i>C. depressus</i>	<i>C. olitorius</i>	<i>C. tridens</i>	<i>C. trilocularis</i>
Position of the inflorescence		Axillary	Opposite to the leaves	Opposite to the leaves	Opposite to the leaves
No. of flowers		1-2	1-2	1-4 rarely 5	1-3
Length of Pedicle (mm)		4	3-4	2	3
The surface of the peduncle and pedicle		Glabrous	Glabrous	Glabrous	Peduncle setose-pubescent while pedicle glabrous
Calyx	Size of sepals (mm)	3-4 × 2	7-8 × 3	4-6 × 2	4-5 × 2
	Shape of sepals	Linear-oblong	Ensiform	Linear-oblong	Narrowly lanceolate
	Apex of sepals	Acute	Caudate	Acuminate	Acute
Corolla	Size of petals (mm)	3-4 × 2	6-8 × 2.5-3	4-6 × 2-5	5-7 × 2-2.5
	Shape of petals	Obovate-spathulate	Obovate	Oblanceolate	Oblanceolate
	Apex of petals	Obtuse	Obtuse	Obtuse	Obtuse
Androe-cium	No. of stamens	10	Numerous	10	Numerous
	Length of filaments (mm)	3	4-6	2	4-5
Gynoe-cium	No. of carpels	4	5	3	3
	Size of ovary (mm)	2 × 1.5	3.5-4 × 2	3 × 1.5	3-5 × 1.5-2
	Surface of ovary	Covered with short hairs	Covered with short hispid hairs	Covered with short white crisped hairs	Covered with very short pubescent hairs
	Surface of stigma	Glabrous	Minutely papillate	Sparsely papillate	Glabrous

Moreover, the pubescence on the surfaces of the ovary, style, and stigma are also helpful features for distinguishing the four *Corchorus* species. *Corchorus depressus* and *C. trilocularis* have ovaries with pubescent hairs and styles and stigmas with glabrous surfaces, while *C. olitorius* and *C. tridens* have ovaries with short hirsute hairs and styles and stigmas with short hispid papillae (Table 2). This result disagrees with the findings of Fawzi (2018), where *C. depressus* had a glabrous ovary.

The fruit and seed traits are also helpful for identifying the four species. Benor (2018) suggested that the reproductive characteristics of the genus *Corchorus* are easy to use for distinguishing the species, especially the seeds. The seeds of the studied species differ in shape, colour, and length (Table 3). Both *C. depressus* and *C. tridens* have oblong seeds, while *C. olitorius* has triangular seeds, and *C. trilocularis*

has oblong-ovoid seeds. The seed colour also varies among the studied species (Table 3). The seed length is 1-2mm in *C. depressus*, *C. tridens*, and *C. trilocularis*, but 4mm in *C. olitorius*. These results agree with Fawzi (2018) but disagree with Paithane & Bhuktar (2012), who reported that *C. trilocularis* has black and triangular seeds.

The study identified several morphological characteristics that can help to distinguish *C. tridens* and *C. trilocularis*, two similar species that often grow together in agricultural fields. *Corchorus tridens* has a glabrous to sparsely pilose stem and branches, smooth stipules, longer auricles (6-8mm), a gray lower leaf surface, four flowers per inflorescence, ten stamens, and a capsule with three teeth (horns) at the apex (Fig. 3C). These results are consistent with Paithane & Bhuktar (2012) and Fawzi (2018). In comparison, *C. trilocularis* has numerous stamens, which agrees with Paithane & Bhuktar (2012).

TABLE 3. Comparison of fruit and seed morphological characteristics among the studied species of *Corchorus* (Grewioideae)

Characteristics		<i>C. depressus</i>	<i>C. olitorius</i>	<i>C. tridens</i>	<i>C. trilocularis</i>
Fruits	No. of valves	4	5	3	3
	Size of capsule (mm)	11–14 × 2	27–56 × 4–6	30–43 × 3	46–55 × 3
	Surface of fruit	Glabrous	Glabrous	Glabrous to sparsely setulose	Stellate hairy when young, scabrid when mature
	Apex of fruit	3-beaked	1-beaked	3-teeth	1-beaked
	Shape	Narrowly cylindrical	Cylindrical	Cylindrical	Cylindrical
Seeds	No. of seeds/valve	8–9	23–24	18–22	36
	Size (mm)	1 × 0.5	4 × 3	2 × 2	2 × 2
	Shape	Oblong	Triangular	Angular, oblong, obliquely truncate at both ends	Oblong-ovoid
	Colour	Brown	Greenish black	Dark brown to black	Gray to black

Moreover, the study assessed the distribution of four *Corchorus* species in Toor Al-Baha based on their occurrence in different regions. *Corchorus olitorius* was the only cultivated species found in a small area in Al-Awja village, while the other three were native. Among the native species, *C. trilocularis* was the most widespread, followed by *C. tridens* and *C. depressus*. *Corchorus depressus* was abundant in valleys, gravel lands, and waste ground (Fig. 2).

Conclusion

The study identified four species of the genus *Corchorus* in the study area: *C. depressus*, *C. tridens*, *C. trilocularis*, and *C. olitorius*. The shape of the blade, veins, auricles, number of flowers per inflorescence, pedicle length, number of carpels, and pubescence on the ovaries, styles, and stigmas are important distinguishing features. Moreover, the seeds of the studied species vary in shape, color, and length. The study provides useful information for distinguishing between the closely related species, *C. tridens* and *C. trilocularis*.

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S. Al-Hawshabi, S. A. Alharbi & M. O. Badry; methodology, O. S. S. Al-Hawshabi; investigation, O. S. S. Al-Hawshabi & S. A. Alharbi; resources, O. S. S. Al-Hawshabi.; data curation, O. S. S. Al-Hawshabi, S. A. Alharbi & M. O. Badry; writing—original draft preparation, O. S. S. Al-Hawshabi & S. A. Alharbi; writing—review and editing, S. A. Alharbi & M. O. Badry. All authors have read and agreed to the published version of the manuscript.

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الفلوره والتوزيع الجغرافي للنباتات في محافظة لحج اليمنية: -2 مراجعة تصنيفية لجنس الـ *Corchorus* (تحت الفصيلة النشمية) من الفصيلة الخبازية بمفهومها الواسع في مديرية طورالباحة

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تناولت الدراسة الحالية مراجعة تصنيفية لجنس الـ *Corchorus* تحت الفصيلة النشمية ضمن الفصيلة الخبازية بمفهومها الواسع في فلورة محافظة لحج، جنوب اليمن. تمت مراجعة التصنيف للعينات المدروسة بشكل منهجي وعددها 33 عينة، ميزت منها اربعة انواع تنتمي للجنس منها ثلاثة انواع تنمو برياً هي: *C. depressus*، *C. tridens* و *C. trilocularis*) ونوع واحد منزرع *C. olitorius*. الصفات المورفولوجية للأجزاء الخضرية والتكاثرية لها قيمة تصنيفية عالية في التمييز بين الأربعة الأنواع المنتمية للجنس. تم عمل مفتاح صناعي، ووصف تفصيلي للأربعة الأنواع، كما روجعت الاسماء العلمية والمرادفة والمحلية لها، وتم عمل خارطة انتشار للأنواع المدروسة في منطقة الدراسة.