

## **General View of Malvaceae Juss. S.L. and Taxonomic Revision of Genus *Abutilon* Mill. in Saudi Arabia**

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*Abstract.* This work deals with the recent opinions about the new classification of the core Malvales with special reference to the family Malvaceae s.l. and the morphological description and variations in the species of the genus *Abutilon* Mill. Taxonomical features of the family as shown in the recent classification systems, with full description of the main divisions of the family. Position of Malvaceae s.l. in the different modern taxonomical systems is clarified. General features of the genus *Abutilon* stated according to the careful examination of the specimens. Taxonomic position of *Abutilon* in the Malvaceae is given. Artificial key based on vegetative morphological characters is provided.

*Keywords:* *Abutilon*, Core Malvales, Eumalvaceae, Morpholog, Systematic Position, Taxonomy.

### **General Features of Family Malvaceae**

According to Heywood<sup>[1]</sup> and Watson and Dallwitz<sup>[2]</sup> the plants of the family Malvaceae s.s. are herbs, shrubs or trees with stipulate, simple, non-sheathing alternate or spiral, petiolate leaves usually with palmate venation (often three principal veins arising from the base of the leaf blade). Plants are hermaphrodite, rarely dioecious or poly-gamonoecious with floral nectarines and entomophilous pollination. Flowers are solitary or aggregating in compound cymes, varying in size from small to large, regular or somewhat irregular, cyclic with distinct calyx and corolla. Sepals connate valvate, polysepalous or gamosepalous. Epicalyx present or absent and corolla is polypetalous, asymmetric,

contorted or imbricate. Androecium varies from 5 to many fertile stamens, branched, adnate to petals with coherent filaments forming monadelphous staminal tube. Anther wall with one middle layer with amoeboid tapetum, dehiscing via longitudinal slits, introrse unilocular and bisporangiate. Spore tetrads are tetrahedral or decussate with polysiphonous pollen grains which shed as single grains. Pollen apertures differ in number and type, from 3 to even 100, colporate or foraminate with either rugate or spinulose exine. Gynaecium is superior, syncarpous, synovarious to synstyleovarious from one to many carpelled and ovary from one to many locules. Locules, are sometimes, secondary divided by false septa resulting in one-ovules segments. Styles apical, free or partially joined ended with dry papillate or non-papillate stigmas. Ovules are in axial placentation, ascending or pendulous, anatropous or campylotropous, bitegmic, crassinucellate, embryo-sac development from the *Polygonum*-type. Polar nuclei fuse prior to fertilization and three antipodal cells are formed. Synergids are pear-shaped or hooked with nuclear endosperm formation and asterad embryogeny.

Fruit loculicidal capsules or berry, are non-fleshy or fleshy, dehiscent or indehiscent or schizocarp comprising follicles or nutlets. Seeds hairy or not hairy, are with oily endosperm and curved embryo with zigzag micropyle.

Secretory cavities present with mucilage canals within the tissues, and stellate (star-shaped) hairs present on both of the vegetative parts and stipules. The bark is often very fibrous and tough because of the stratified phloem. Seeds have specific structure and chemical composition.

### **Taxonomic Position of the Family**

The systematic position of the family Malvaceae, according to different systems of classifications is illustrated in Table 1. Malvaceae s.s., consists of about 111-119 genera. It is a homogeneous family, so subfamilies are not applicable and only divided into tribes. The family Malvaceae s.s. is most closely to Bombacaceae, and the two are separated primarily on the basis of pollen characters (smooth or rugose in Bombacaceae, spiny in Malvaceae). Molecular phylogenies have demonstrated that Malvaceae s.s. is monophyletic whereas Bombacaceae is paraphyletic. Edlin<sup>[3]</sup> restricted Malvaceae s.s. even more by

transferring the genera with capsular fruits, including *Gossypium* and *Hibiscus*, into a more broadly defined Bombacaceae.

**Table 1. Systematic position of Malvaceae according to different systems of classifications.**

System	Cronquist	Dahlgren	Reveal	Takhtajan	Thorne	APGI	APGII
Year	1981-1988 [13 & 14]	1981-1983 [15]	1997-1999 [16]	1997 [17]	1992-2001 [11&18]	1998 [19]	2003 [20]
Class	Magnoliopsida		Rosopsida	Magnoliopsida		Eudicots	
Sub class	Dilleniidae	Magnoliidae	Dilleniidae		Mognoliidae	Eurosids II	
Super order	—	Malvanae				—	—
Order	Malvales						
Family	Malvaceae Juss.						

In the broader APG circumscription, Malvaceae s.l. corresponds to the four traditional plant families Malvaceae s.s., Bombacaceae, Sterculiaceae and Tiliaceae (Table 2). Thus, the family has expanded to include 250 genera and has been divided into nine subfamilies, one of which is Malvaceae s.s.<sup>[4&5]</sup>. These families are closely related to Malvaceae s.s. but they are not monophyletic groups as shown by numerous researchers on the Malvales *e.g.*<sup>[6-8]</sup>. The nine subfamilies:

1. Bombacoideae, traditionally in family Bombacaceae
2. Brownlowioideae, traditionally in family Tiliaceae
3. Byttnerioideae, traditionally in family Sterculiaceae
4. Dombeyoideae, traditionally in family Sterculiaceae
5. Grewioideae, traditionally in family Tiliaceae
6. Helicteroideae, traditionally in families Sterculiaceae (tribe Helictereae) and Bombacaceae (tribe Durioneae)
7. Malvoideae, traditionally family Malvaceae s.s.
8. Sterculioideae, traditionally in family Sterculiaceae
9. Tilioideae, traditionally in family Tiliaceae

The broad circumscription of the family, as mentioned above, is defined as core Malvales in the Cronquist system. This classification has been adopted by<sup>[5-9&10]</sup>. But the most recent version of the Thorne system<sup>[11]</sup> takes an intermediate approach in combining Bombacaceae

and Sterculiaceae under Malvaceae s.l., but retaining Byttneriaceae (containing traditional Sterculiaceae and Tiliaceae) and a considerably restricted Tiliaceae as separate families. Hinsley<sup>[12]</sup> has put several alternatives for a new classification of Malvaceae s.l. (core Malvales). These alternatives are: 1. to keep all the four families (core Malvales) as a single family (Mavaceae s.l.), 2. to keep each of the nine holophyletic clades as a separate family, 3. to gather the seven subfamilies consisting the clades Malvadendrina in a separate family Malvaceae, while the two later subfamilies in another family, and 4. if paraphyletic groupings are accepted a five family classification is possible with the transfer of some species and genera. The contents of the nine subfamilies are as follows as indicated by Hinsley<sup>[12]</sup>:

**Table 2. Families combined with the Malvaceae s.s. in the different systems of classification.**

System	Cronquist 1981-1988 [13&14]	Dahlgren 1981-1983 [15]	Thorne 1992-2001 [11&18]	Takhtajan 1997 [17]	APGI 1998[19] And APGII 2003[20]
Families	Malvaceae Bombacaceae Sterculiaceae Tiliaceae Elaeocarpaceae Lecythidaceae	Malvaceae Bombacaceae Sterculiaceae Tiliaceae Bixaceae Cistaceae Cochlospermaceae Dipterocarpaceae Huaceae Plagiopteraceae Sphaerosepalaceae Sacrolaenaceae	Malvaceae Bombacaceae Sterculiaceae Tiliaceae Diegodendraceae Dipterocarpaceae Huaceae Monotaceae Plagiopteraceae Sarcolaenaceae Sphaerosepalaceae Thymelaeaceae Gonystylaceae Bixaceae Cistaceae Cochlospermaceae	As Thorne 1992, with the exception of the last 5 families  ← ← ← ←	Malvaceae Bombacaceae Sterculiaceae Tiliaceae

### 1. *Malvoideae*

Malvoideae is defined cladistically as a stem group, which is composed of those species to *Malva sylvestris* (Common Mallow, High Mallow) and *Bombax ceiba* (Kapok).

This subfamily is composed of several tribes; Abutileae, Decaschistieae, Gossypieae, Hibisceae, Kydieae, Malopeae, Malva-

visceae, Malveae, and Ureneae; that make up the Malvaceae s.s., plus Matisiae (formerly classified in Bombacaceae) and Fremontodendreae (formerly classified either in Bombacaceae or Sterculiaceae).

## **2. *Bombacoideae***

It is remnant of the Bombacaceae, after the removal of the tribes Matisiae (to Malvoideae) and Durioneae (to Helicteroideae).

These two subfamilies are grouped together in a well supported clade named Malvatheca and considered by Thorne<sup>[11]</sup> as a separate family with three tribes, Adansonieae; Matisiae, and Durioneae.

## **3. *Brownlowioideae***

It contains elements of the former Tiliaceae, consisting of the tribes Berryeae and Brownlowieae.

## **4. *Byttnerioideae***

This subfamily contains the tribes Byttneriae, Hermannieae, Lasiopetaleae and Theobromeae (cacao and allies from family Sterculiaceae).

## **5. *Dombeyoideae***

This subfamily contains only one tribe Dombeyae from family Sterculiaceae.

## **6. *Grewioideae***

This subfamily consists of the tribes Grewieae which includes *Oceanopapaver* and Sparmannie which includes *Corchorus*.

## **7. *Helicteroideae***

Consists of both tribes Helictereae (formerly classified in Sterculiaceae) and Durioneae (formerly classified in Bombacaceae).

## **8. *Sterculioideae***

It contains only one tribe Sterculieae (*Sterculia*, *Cola* and allies).

## 9. *Tilioideae*

This subfamily is reduced to one tribe Tiliaceae which is consisting of *Tilia*, *Craigia* and *Mortoniiodendron*. It is more close to members of the former Sterculiaceae than to the remainder of the former Tiliaceae.

### **Taxonomic Opinions of Genus *Abutilon* with Special Reference to Tate *et al.*<sup>[8]</sup>**

*Abutilon* is one of the genera belonging to subfamily Malvoideae (Eumalvoideae of Baum *et al.*<sup>[6]</sup>). This subfamily has consistently emerged as a monophyletic group based on both morphological and molecular data<sup>[4,21&22]</sup>. In the most recent treatment of Malvoideae,<sup>[5]</sup> divided the subfamily into four tribes: Gossypieae, Hibisceae, Kydieae, and Malveae. *Abutilon* lies under tribe Malveae.

Traditionally, members of the Malveae have been characterized by a combination of several morphological characters: schizocarpic fruits (sometimes a capsule), number of mericarps varying from 3 to over 20 and equal to the number of free styles, antheriferous apex of the staminal column, and the absence of lysigenous cavities ("gossypol glands")<sup>[5, 23]</sup>. The members of Malveae exhibit a broad geographic distribution. They occur in both tropic and temperate areas exploiting a variety of habitats. Around 15 of the 70 Malveae genera have mostly temperate distributions, while some of the largest genera in the tribe (*Abutilon*, *Sida*, *Nototriche*) have primarily tropical distributions.

Various interpretations of the composition and subdivision of tribe Malveae have been proposed. Bentham and Hooker<sup>[24]</sup> divided Malveae into four subtribes based on carpel arrangement and ovule number and position: Abutilinae, Malopinae, Malvinae, and Sidinae (as Abutileae, Malopeae, Eumalveae, and Sideae, respectively). Schumann<sup>[25]</sup> reassigned three genera (*Malope*, *Kitaibela*, *Palaua*) to a separate tribe Malopeae based on the irregular arrangement of their carpels into superimposed verticils (*i.e.*, not in single whorl). The remaining genera of the Malveae were placed into one of three subtribes by Schumann (Abutilinae, Malvinae, or Sidinae) based on carpel morphology. This classification was followed by Edlin<sup>[3]</sup> and slightly modified by Kearney<sup>[26,27]</sup> who erected a fourth subtribe, Corynabutilinae. Hutchinson<sup>[28]</sup> further restructured the family and tribes by including the

tribes Abutileae (composed of subtribes Abutilinae and Sidinae), Malopeae, and Malveae (containing subtribes Corynabutilinae and Malvinae). *Bastardia* and *Bastardiopsis*, the two Malveae genera that have capsules rather than schizocarps, were transferred to tribe Hibisceae. Abutileae was created to accommodate genera with decurrent stigmas, while the genera with apical stigmas remained in tribe Malveae. Hutchinson<sup>[28]</sup> distinguished between the subtribes of Abutileae and Malveae by the number and position of the ovules.

Recently, Bayer and Kubitzki<sup>[5]</sup> provided a comprehensive treatment for the tribe, as well as for the entire subfamily and family. Fourteen Malveae alliances were maintained, but their generic compositions were altered somewhat. The genera previously segregated into the *Herrisantia*, *Robinsonella*, and *Sida* alliances by Fryxell<sup>[23]</sup> were subsumed into the *Abutilon* alliance. La Duke and Doebley's<sup>[29]</sup> on the basis of molecular analysis study gathered the two genera *Abutilon* and *Sida* in one alliance and the other genera of tribe Malveae in another alliances. Tate *et al.*<sup>[8]</sup> used the ITS sequence data and they found that tribe Malveae comprised of two main clades. One of the main clades consists of *Abutilon*, *Anoda*, *Batesimalva*, *Gaya*, and *Malacothamnus* (in part), *Plagianthus*, and *Sphaeralcea* (in part) alliances. The second large clade (cladeB) contains *Anisodontea*, *Kearnemalvastrum*, *Malacothamnus*, *Malope*, *Malva*, *Malvastrum*, *Modiola*, *Sidalcea*, and *Sphaeralcea* alliances.

From the above mentioned opinions and investigations the *Abutilon* and *Sida* are the most closely related genera. They are well segregated from the other Malveae. The genus *Sida* is perennial erect herb, with similar morphological characters to the genus *Abutilon*, since both have simple broadly ovate leaves, with yellow flowers and absent epicalyx. Thus, specimens of fresh plants of the five Saudian *Abutilon* and *Sida* species have been carefully examined to recognize the main differences between them and to facilitate their recognition. The genus *Sida* can be recognized by having one seed only in the carpel while species of genus *Abutilon* have 2, 3 or 4 seeds in their carpels.

In Saudi Arabia, the genus *Malva* has five species present mainly in Hijaz and Southern and Eastern regions. They inhabit the sandy disturbed places and can resist drought. of *Abutilon pannosum* used by Bedouins in folk medicine for the treatment of dysentery and gonorrhoea, other species can be eaten by goats and camels. The five Saudian species, according to

Migahid<sup>[30]</sup>, are *A. bidentatum* Hoch, *A. figarium* Webb, *A. fruticosum* Guill & Perr., *A. hirtum* Don and *A. pannosum* Schlecht. These species are morphologically similar and their identifications need careful examinations. Specimens of these species gathered from Jeddah and Makkah regions and allocated in College of Education for girls in Jeddah, and reexamined to facilitate their identifications (Table 3).

**Table 3. List of specimens examined from Saudi Arabia.**

Specimen	Collector – Year	Locality
<i>A. bidentatum</i>	1. Badr, Rokaya –2004	Makkah, Al-Azizya
	2. Taia, W. – 2002	Makkah, Jabal El-kaaba
	3. Taia, W. – 2001	Jeddah, El-Senaeya
	4. El-Mazrouee, M. –1999	Jeddah, in front El-Estad
	5. Fawzy, M. – 1998	Jeddah, Eljamaa region
	6. Al-Amoudy, M. – 1998	Jeddah, Al-Rehab
	7. Al-Ghanem, W. – 1998	Jeddah, Al-Hamra
<i>A. figarium</i>	1. Al-Aglan, R. – 2006	Makkah, Al Shamsan region
	2. Al-kazan, M. – 2004	Jeddah, Al-Estad region
	3. Al-Amry, L. – 2003	Beginning of Jeddah-Makkah Road
	4. Al-Zahrany, K. – 2003	Makkah, Al-Aziziya
	5. Al-Harby, R. – 2003	Makkah, near Al-Haram
	6. Al-Amoudy, M. – 2002	Makkah, near Al-Haram
<i>A. fruticosum</i>	1. Al-Amoudy, M. – 2007	Makkah, Al-Azizya
	2. Taia, W. – 2007	Beginning of Jeddah-Makkah Road
	3. Taia, W. – 2005	Jeddah, Al-Rouwas region
	4. Taia, W. – 2003	Jeddah, Al-Hamra region
<i>A. hirtum</i>	1. Al-Gamdy, T. – 2006	Jeddah, Al-Bughdadeya
	2. Al-Solamy, M. – 2006	Jeddah, Al-Rehab
	3. Al-Oteby, M. – 2002	Makkah, near Al-Harram
	4. Al-Ghanem, W. – 2002	Jeddah, Al-Bughdadeya
<i>A. pannosum</i>	Taia, W. – 2007	Jeddah, Al-Bughdadeya
	Taia, W. – 2007	Jeddah, Al-Estad region
	Kotby, A. – 2006	Jeddah, Al-Eskan region
	Abdel-Gleel, S. – 2004	Jeddah, Al-Bughdadeya
	Al-Amoudy, N. – 2004	Beginning of Jeddah-Makkah Road
	Al-Harby, L. – 2003	Makkah, Al-Shamsan
	Al-Solamy, T. – 2003	Jeddah, Al-Estad region
	Taia, W. – 2002	Jeddah, Al-Jamaa
	Al-Magrabi, R. – 2002	Makkah, Al-Shamsan
	Al-Meteri, A. – 2002	South Jeddah



### Systematic Treatment of *Abutilon* Maill. According to the Examined Specimens

Morphological characters of the five Saudian species of *Abutilon* are listed in Table 3. Twenty five specimens were examined. The minimum and maximum measurements as well as the mean of the whole readings are listed in cm. The species are yellowish green, pale green or grayish in colour perennial plants with long erect hairy stem and simple petiolate leaves. The petioles are hairy varying in length from 1.0 cm to 7.5 cm. (Table 4). The leaves are either ovate or broadly ovate or even rounded with long petioles and dentate or slightly crenate or dentate margins. Leaf apices are rounded, acute or acuminate and venation is reticulate with five to seven large veins all united at the base of the leaf blade, each ramify in a reticulate patterns. Flowers are yellow, yellow tinged with purple or violet with yellow margins, pedicellate, solitary or in pairs and sometimes in short panicles, lacking epicalyx, with five united sepals and five contorted petals. Sepals are longer or equal to the petals, with acuminate apices. Stamens are numerous with short connate epipetalous filaments and small yellow anthers. Carpels are from five to numerous, united with 2-3 seeds in axial placentation. Fruit schizocarpic with permanent sepals.

**Table 4. Morphological characters of *Abutilon* species.**




Species characters  	<i>A. bidentatum</i>	<i>A. figarium</i>	<i>A. fruticosum</i>	<i>A. hirtum</i>	<i>A. pannosum</i>
Plant colour	Grayish	Pale green	Pale green	Pale green	Yellowish green
Petiole length (cm) (mean)	1.0-2.5 (2.2)	1.8-3.0 (2.5)	4.8-7.5 (6.8)	0.6-1.2 (0.8)	3.5-4.5 (4.2)
Leaf length (cm) (mean)	4.0-5.2 (4.8)	2.5-3.8 (3.2)	3.2-5.8 (5.2)	2.2-4.1 (3.2)	3.8-5.0 (4.2)
Leaf width (cm) (mean)	3.0-4.4 (3.8)	2.5-3.9 (3.3)	3.5-6.2 (5.8)	1.3-2.5 (2.1)	3.8-5.2 (4.2)
Length/Width	1.3	1.0	0.8	1.6	1.0
Leaf shape	Ovate	Broadly ovate	Rounded	Ovate	Broadly-ovate
Leaf hairiness	Hairy	Hairy	Hairy	Hairy	Woolly
Leaf margin	Dentate	Dentate	Dentate	Dentate	Slightly dentate
Leaf apex	Acuminate	Acute	Rounded	Acuminate	Acute
No. veins	5	5	7	5	7

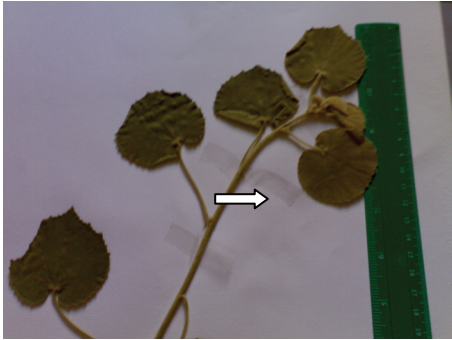
Table 4. Contd.

Species characters 	<i>A.bidentatum</i>	<i>A. figarium</i>	<i>A.fruticosum</i>	<i>A. hirtum</i>	<i>A. pannosum</i>
Pedical length (cm) (mean)	0.8-1.4 (1.2)	2.2-3.0 (2.8)	4.8-7.8 (6.8)	2.5-3.8 (3.5)	3.2-3.8 (3.5)
Inflorescence	Panicle	Solitary	Solitary	Solitary	Solitary
No. of flowers	3-5	One	One	One	One
Flower size (cm) range	Small 1.5-2.0	Big 4.0-6.5	Small 1.2-2.5	Big 5.0-7.5	Big 5.0-8.5
Flower colour	Violet with yellow margins	Violet with yellow margins	Yellow tinged with purple	Yellow	Yellow
No.of carpels	More than 10	More than 10	More than 10	More than 10	7-10
Type of fruit	Schizocarpic	Schizocarpic	Connate	Schizocarpic	Schizocarpic
Length of fruit (cm)	0.6	1.2	0.5	1.2	1.0
No. ovules/carpel	3	2	2	2	2
Seed colour	Black	Brown	Brown	Black	Black
Seed shape	Kidney-shape	ovate	ovate	Bended	Kidney-shape
Seed length (mm)	1.0	1.2	1.0	1.5	2

Key of the five *Abutilon* species according to their morphological characters

1. Leave broadly ovate; acute or rounded apices
  2. Number of main veins 7
    3. Petioles very long exceeding the blades (4.8-8 cm)---- *A. fruticosum*
    3. Petioles short never exceed the blades (3-4.5cm) ---jjj--*A. pannosum*
  2. Number of main veins 5 -----jjjjj---*A.figarium*
    1. Leaves Ovate; acuminate apices
      2. Number of main veins 5
        3. Petioles short (1-2.5cm), flowers 3-5----- --*A. bidentatum*
        3. Petioles very short (0.6-1cm), flower solitary ----- *A. hirtum*

Species of *A. fruticosum*, *A. figarium* and *A. pannosum* are very similar, as the three have broadly ovate or rounded leaf blades, with either rounded or acute apices (Plate 1; 1,2 and 3). Meanwhile, the two species *A. bidentatum* and *A. hirtum* have similar morphological characters as shown in Table 3 (Plate 1; 4 and 5). From the key it becomes easy to distinguish the five species in the field as each species has its own characteristic morphological features as shown in the Table 3.



1. *Abutilon fruticosum* Guill & Perr.



2. *Abutilon figarium* Webb.



3. *Abutilon pannosum* Schlecht.

**Plate 1.** Photographs of the five Saudian *Abutilon* species, illustrating the different leaf shapes, petiole and pedicel lengths.



#### 4. *Abutilon bidentatum* Hochst



#### 5. *Abutilon hirtum* Don.

### Plate 1. Contd.

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## الفصيلة الخبازية ومراجعة تصنيفية لجنس الأبيوتيلون (القطيفة) النامي في المملكة العربية السعودية

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المستخلص. شملت هذه الدراسة مراجعه شاملة للفصيلة ألبازية وتوضيح العلاقة بين أفراد هذه الفصيلة والفصائل المجاورة على أساس الدلائل المتحصل عليها من تحليلات الحامض النووي والبروتينات المختلفة. ومن خلال هذه الدراسة والآراء المختلفة، تم سرد التقسيمات المختلفة للأجناس النباتية التابعة لهذه الفصيلة مع توضيح وضعها التصنيفي تبعاً للنظم الحديثة. كما تناولت الدراسة توضيح الوضع التصنيفي لجنس الأبيوتيلون المعروف في المملكة العربية السعودية باسم القطيفة، أو كرشة الغراب، ودراسة الشكل الظاهري للأنواع الخمس المختلفة النامية بالفلورا السعودية. تم عمل مفتاح اصطناعي لهذه الأنواع يسهل التفرقة بينها.