

## Review of the Genus *Tribulus* L. in Saudi Arabia

Fahad Al-Hemaid and Jacob Thomas

Department of Botany and Microbiology, King Saud University,  
P.O. Box 2455, Riyadh 11451, Saudi Arabia

**ABSTRACT.** *Tribulus*, a highly polymorphic genus, includes many intermediate forms. Taxonomy of these taxa, mostly found in the same population has been studied over a wide range and a number of problematical species is discussed to resolve which of these merit taxonomic recognition. Five new combinations are proposed and the reasons for dropping the status of a few specific epithets, including *amanense* Hosni, to the level of synonyms are discussed in detail. Of the taxa described, *T. rajasthanensis* Bhandari and Sharma (1977) is reported for the first time from the Arabian Peninsula.

In the taxonomy of the genus *Tribulus* L., there has been a persistent problem in distinguishing species because of erroneous literature and inadequate study of limited number of specimens. Although studies in the last two decades have given us a much better understanding of the early history of most of the species present in the Saharo-Arabian, Saharo-Sindian and Sudanian territories, a taxonomic revision was necessary to define species boundaries and to describe the variation involved. Since the time of Linnaeus divergent estimates of the number of species have been made for this genus. The earlier writers of Floras that cover this part of the world have different opinions in demarcating the variation within the species level, especially in the highly polymorphic species *T. terrestris* L. Descriptions of species by these authors (Blatter 1919-36, El-Hadidi 1972, 1974, Migahid 1988), based on non-identical characters of holotypes and isotypes lodged in various herbaria, have also added confusion to this thorny issue. Confusion may also arise from vague descriptions based on single specimens collected from areas with extreme climatic conditions or on plants evolved as a result of hybridization between morphologically

similar variants. Although caution is needed in view of limited information available at present, there appears little justification in keeping these variants or ecotypes under different specific names. Persistent differences among these groups occurring in the same population verify earlier conclusions that a taxonomic species is not a single ecological unit but is composed of numerous races which exhibit inherent differences in physiology and often in morphology as well (Daubenmire 1974). In addition to the characteristic features of its species, the phenotypic plasticity resulting from diploid to polyploid conditions which prevail in this genus also suits it for a wide range of habitats.

*Tribulus* L., a genus of over 25 species (Airy Shaw 1985), (because the taxonomic status of some of the taxa present outside the study area has yet to be decided, the exact figure is not known at present), is unique within the Zygophyllaceae owing to its opposite, pinnate leaves which are fundamentally different from those of other genera such as *Fagonia* and *Zygophyllum*. Because of this distinct character and the spiny or winged fruits which divide into separate cocci, many scientists have attempted to separate this genus from the Zygophyllaceae. But Hutchinson (1967) treated *Tribulus* under Zygophyllaceae with the view that it is a natural family. Engler (1931) divided this family for the first time on the basis of its heterogeneous characters. He created 7 subfamilies, 8 tribes, 4 subtribes and 25 genera. The subfamily Zygophylloideae which includes the tribes Tribuleae and Zygophylleae of Engler was later raised to family level by Takhtajan (1969). Porter (1974) distinguished subtribe Tribulinae of the tribe Tribuleae *sensu* Engler as a subfamily within the Zygophyllaceae while El-Hadidi (1977) gave it the status of a family. The family Tribulaceae Hadidi consists of two subfamilies, Tribuloideae comprising 4 genera including the paleotropical genus *Tribulus* and the Neoluederitzioideae, on the basis of zygophylloid versus tribuloid characters (woody versus herbaceous, alternate-exstipulate versus opposite, stipulate leaves, dehiscent carpels versus indehiscent mericarps and endospermic versus non-endospermic seeds). Bhandari (1983), who studied the morphological characters of the pollen (panporate pollen), also supported the separation of the tribe Tribuleae from the subfamily Zygophylloideae *sensu lato*. Anatomical features studied by Sheahan and Cutler (1993) agreed with many views of earlier workers except for the inclusion of the subfamily Neoluederitzioideae of El-Hadidi under the family Tribulaceae. The presence of two types of trichomes and the unusual arrangement of broad radial bands of vessels and fibres in the stem of the members of the family Tribulaceae have added further evidence for their separation from the mother family. Kranz anatomy, which was evident only in the subfamily Tribuloideae of El-Hadidi (except for *Zygophyllum simplex* all other species studied by Sheahan and Cutler (1993) including the genera *Neoluederitzia* and *Sisymbrium* are C3 plants), is another

characteristic to separate tribuloid genera (*Tribulus*, *Kallstroemia*, *Kelleronia* and *Tribulopsis*) from the zygophylloid genera, at least at subfamily level. Of these genera, *Kelleronia* Schinz is a shrub with alternate, stipulate leaves whereas *Kallstroemia* Scop. possesses opposite exstipulate leaves and 10 mericarps. *Tribulopsis* R. Br. (an Australian genus) previously thought to be congeneric with *Tribulus* L., can be separated by its persistent style, 1-seeded mericarp and pendulous seed. (Some specimens of *T. arabicus sensu* Hosni in our area also have the same features).

### Materials and Methods

More than 300 specimens (both living and dried) were examined in this study and a key is developed for their determination. Most of the herbarium specimens were borrowed from Royal Botanic Garden, Edinburgh (E) and Royal Botanic Garden, Kew (K). A considerable number of specimens was also obtained from the National Herbarium (RIY) of Saudi Arabia and from the personal collection of Mandaville of ARAMCO, Dhahran. Apart from these, specimens housed in our Herbarium (KSU) in the Department of Botany and Microbiology and the Herbarium of the College of Pharmacy, King Saud University were also critically examined.

### Historical Review

A survey of various works published in and around the Arabian Peninsula shows that there are several questionable names applied to different taxa which may be conspecific. The generic name *Tribulus* was first validated by Linnaeus in 1753 based on *T. terrestris* L. Later scientists derived many taxa at the level of species and variety from this polymorphic species. The characters they used to distinguish the variants (var. *orientalis* Beck; var. *robustus* Boiss.; var. *bicornutus* (Fisch. et Mey.) El-Hadidi) were the presence or absence and the length of spines in each mericarp. There has been much discussion in different Floras (Ghafoor 1974, 1977, Agnew 1980) in solving these of varietal status and most authors now agree that these varieties are one and the same within the variable *T. terrestris*. The present study reiterated that neither prior determinations nor any new data support the recognition of these varietal names at any rank except for the taxon with unarmed mericarps.

Forsskal (1775) recognized another taxon, *T. pentandrus*, with winged carpels. The type specimen from Egypt (*fide* El-Hadidi) is remarkably small with 5-6 stamens and pyramidal fruits. The immature fruits, which mostly lack a conspicuous wing on their mericarps, misled many workers to consider it as a new species and



unfortunately it has been questionable one among taxonomists for a long time. Later Deline in 1813 (El-Hadidi 1978) derived a new species *T. alatus* nom. *superfl.* based on Forsskal's *pentandrus*, which later became a synonym of *T. longipetalus* Viv. which in itself was another taxon constantly mistaken for species with similar characters. El-Hadidi (1978) who saw the type specimens of both *T. pentandrus* and *T. longipetalus*, stated that these taxa are same as the specimens do not differ in flower or fruit characters. The descriptions of many authors, who depicted the identity of *T. longipetalus* s.l., often confuse it with *T. macropterus* reported by Boissier in 1867, although the latter is a perennial with 10 stamens. The differences in size, length and the pubescence or glabrous nature of the wings on the carpels had led some of the early workers to split *T. longipetalus* auct. div. into species, subspecies or variety levels. *T. megistopteris* Kralik (= *T. pterocarpus*), endemic to the Nubian desert and Arabia, has close resemblance with many conserved characters of *T. pentandrus* but differs in the presence of a more or less circular wings along the lateral side of the mericarps. But this character is observed in mature fruits of many species described under different taxa. Mandaville (1990), noted it as variations within a single polymorphic species, i.e. *T. pentandrus*.

Boissier (1867) recognized 5 species (Table 1), considering *T. bimucronatus* as conspecific with *T. pentandrus* and *T. macropterus* with *T. pterocarpus* Ehrenb. Two varieties, viz. *robustus* and *inermis*, were created under *T. terrestris* based on the presence or absence of spines on the mericarps. *T. persicus*, which he treated as a variety of *T. macropterus* had later become a synonym of *T. macropterus* in all other works.

El-Hadidi (1972) reported 4 species under *Tribulus*, including *T. longipetalus* ssp. *pterophorus* and *T. terrestris* var. *bicornutus* as two new combinations. Of the four species (*T. ochroleucus*, *T. longipetalus*, *T. pentandrus* and *T. terrestris*) the specific name *pentandrus* was mistakenly given to the species *parvispinus* because of two different type specimens lodged at BM and C. Ghafoor (1974, 1977) also made the same error while writing the Flora of Pakistan and Libya. El-Hadidi (1985), in his Zygophyllaceae for the Flora of Tropical East Africa, corrected this mistake by saying that the material which he saw at BM has small, immature but clearly spinescent mericarps (a character correlated with *parvispinus*) whereas of the two type specimens deposited at C one has larger flowers and mature winged mericarps (a character of *pentandrus*) and the second has small and immature fruit but has spiny mericarps. The second specimen, collected from Yemen, is in all respects similar to the isotype at BM and the types of *T. parvispinus* and *T. bispinulosus*. *T. ochroleucus* is another species often confused with *T. pentandrus* and *T. longipetalus* ssp. *longipetalus* (*T. longipetalus* var. *mollis* sensu Zohary







(1972)) owing to the presence of small basal spinules. *T. mollis* (the first *Tribulus* species described as having fruits unarmed, alveolate-rugose, and densely hairy), another species reported in 1867, also has the same fruit character as those of *T. ochroleucus*. El-Hadidi (1978) clarified the confusion concerning these two species by stressing that the two isotypes one located one at Kew and the other at Stockholm, have different fruit characters. The isotype of *mollis* lodged in Kew has clear dentate wings which makes many workers to think that it is conspecific with *pentandrus* whereas the isotype at Stockholm has distinctly unarmed carpels and agrees perfectly with the original descriptions of *mollis* and *ochroleucus* (El-Hadidi 1978).

Although studies on the genus *Tribulus* in the Arabian Peninsula have continued ever since the time of Forsskal, a concise work on this genus was started only in the late seventies. Hadidi and his student H. Hosni while preparing the latter's thesis recognized three new species from this part of the world. *T. arabicus*, obviously an endemic species in the southern and south-eastern Arabian Peninsula, differs from all other species by its conspicuous large flowers (2-4 cm). The type material collected from Yemen, Lower Wadi Najran, has flowers more than 2.5 cm wide and carpels hirsute, dorsally punctate with two dentate marginal wings. However, this is another taxon with a wide ecological amplitude, having different forms especially in vegetative characters, flower size and in the margins of the mericarp wings, which are common in plants growing in the same population (Mandaville 1990). Yet some of the plants with small flowers (1-1.5 cm across) seen in the same population (Mandaville 1990 and Collenette, in Sched.) of *T. arabicus* are difficult to separate from *T. macropterus*, a common plant in other parts of Arabian Peninsula. Since Boissier's description clearly states *T. macropterus* as a decandrous plant with crested trapeziform wings and, the specimens described from Iraq undoubtedly show that this species can also grow erect with a shrubby base, one may question the authenticity of *T. arabicus* as a separate species. As the epithet *T. macropterus* has priority, the specimens with large flowers (2-4 cm across), seen in a population of both *T. macropterus* and *T. arabicus* would be better considered as a variety of the former. Hosni (in El-Hadidi 1978) recognized another species, *T. omanense*, from populations growing in the same ecological areas. Some of the diagnostic features of this species are: "Flos magnus 2.5 cm diam., petala flava; stamina 8-10. Fructus sphaericus 6-9 (-14) mm dia.; alae 2 semicirculares, basi interruptae, glabrae, margine integrae; calyx deciduus". Deciduous sepals, a main character separating it from *T. arabicus*, is a common character in the genera *Tribulopsis* and *Tribulus* under the subfamily Tribuloideae (El-Hadidi 1977 *sensu* Porter 1974). The margins of the wings are not strictly entire in some of the fruits with deciduous sepals (cf. Mandaville Nos. 7753, 7831). Another specimen from Kuwait, identified as *T.*



*omanense* by El-Hadidi (R.M. Lawton 2570, Kew) has vegetative organs overall less pubescent, leaflets widely spaced, pedicel shorter than the small subtending leaf, calyx deciduous, and mericarp wing fused at one end (wing semicircular in type specimen). If the elimination of several specific epithets mentioned earlier is regarded as justified, the characters given for this species also appear to be too narrow to be considered as a new species. Mandaville (1990), who observed many intermediate forms of *T. arabicus sensu* Hosni, also regards the distinction of *T. omanense* doubtful and concludes it to be a variant within the former species. Two other specimens, both collected from wadi beds (Boulos *et al.* 16585 at E and Gilliland 4286 at K) have small flowers (up to 1.5 cm across) and comparatively larger vegetative parts compared to typical *T. omanense sensu* Hosni. In one of the specimens (Gilliland-4286) even the number of stamens varies from 10-12. Boulos (1988) reported the former specimen as a new variety (var. *nova ined.*) of *T. omanense* based on a determination note of Hosni. The present study, however, indicates these specimens as variations within *T. macropterus*.

Another species, *T. kaiseri*, previously treated as a variety of *T. terrestris* (var. *inermis*) is also debatable. The description given for this taxon especially of the stamens and mericarps: "stamina 5-10, fructus sphaericus, 5-lobatus, 10-15 mm diam., carpella 3-5 mm longa, 2 mm lata, inermia, sparse hirsuta, punctata, rugosa" conforms with conserved character, for *T. terrestris* in general and var. *inermis* in particular. Gradual reduction in the number of stamens is observed in many specimens associated with the reduction of spines or the size of the flowers. The number of stamens in var. *bicornutus sensu* El-Hadidi 1972 is also reported to be 5-10. Furthermore, the diagnostic features of the mericarps (Fig. 3, h) of some herbarium specimens (nos: KSU-1439, 1456, 1457, 1449) which were collected from the Central Province of Saudi Arabia do not fall within the circumscription of *T. kaiseri sensu* Hosni. Therefore, the treatment of *T. kaiseri* as a species is considered inappropriate in view of the absence of a clear cut disjunction in the range of morphology shown by *T. terrestris*. We too agree with the justification given by Akhiani (1993) and treats the taxon *kaiseri* as a synonym of *T. terrestris* var. *inermis*.

The position of *T. bimucronatus* Viv. was also problematical for a considerable time owing to its doubtful interpretation. Boissier (1867) described it as "carpellis adpresse hirtis vel canis dorso rotundius rugoso-scribiculatis quadrispinosis spinis inferioribus ad tuberculos saepe reductis", a character which fits well with the characters of *T. bicornutus* or *T. parvispinus*. This taxon was reported in the same sense by Post and Dinsmore (1932) and Zohary (1972) with detailed description including stamens number as 5, rarely 10. Hosni (1977), gives *T. bimucronatus* as a

species with winged carpels. This is perhaps due to the confusion in the identity among species such as *T. bimucronatus*, *T. mollis* and *T. pentandrus*. El-Hadidi (1978), recognized *T. bimucronatus* Viv. (= *T. bimucronatus* Kralik) as the taxon described with small, pyramidal, sparingly hairy, punctate-rugose fruits having 2 minute spinules at the base (Fig. 3, n).

It is interesting to see the similarities of fruit characters in *T. bimucronatus* and *T. mollis* (= *T. ochroleucus*), irrespective of one being annual and the other a perennial. One of the specimens (Collenette no. 3227, Makkah (RBG-E) has mericarps, up to 2 mm wide, similar to a specimen described from East Africa (El-Hadidi 1985) whereas few other specimens (Grainger-702; Miller-6010; Munton s.n.; S. Abedin and Al-Yahya-12914) have comparatively larger fruits with small, triangular wing-like spinules at the base. It seems very likely that the plants with large fruits are similar to the plants reported from Egypt, Iran, Pakistan and Libya. Small plants with small fruit have stamens up to 8 whereas plants with larger parts always have 10 stamens. The presence of spinules or small, triangular wing-like projections at the base of the mericarps, in both species, will (in most cases) be left unnoticed due to the dense villous surface and the sub-persistent sepals. These spinules in fact are prolongations of the lateral margin of the mericarps, which are sometimes highly reduced or absent in one or two mericarps of the same fruit. Many specimens of *T. pentandrus* (Trott, 146, 1668-K; Edmondson, 3056-E) with young vegetative parts have small flowers (5 mm) and unarmed fruits or mericarps with minute spinules at the base. These specimens (as reported by El-Hadidi 1978) were previously determined as *T. bimucronatus*. Two specimens, one identified as *T. ochroleucus* (Sultan and Yahya no. 12914) has stamens 10, fruits up to 1.5 cm wide and mericarps densely villous (long hairs beset with small appressed ones) with highly reduced marginal wings which project at the base as small spinules while the second specimen (Mandaville-8361) has 5 stamens and a similar type of indumentum and fruit characters but the wings more prominent than in the former. The second specimen collected from an oil field resembles the first specimen in all characters except for the number of stamens and mericarp wings. This evidence indicate the affinity of *bimucronatus* and *mollis* (= *T. ochroleucus*) with that of *T. pentandrus* and *T. macropterus*. However, controlled breeding experiments in different climates are required to determine whether these species are closely interrelated.

The species *T. rajasthanensis* validated by Bhandari and Sharma (1977) is closely related to some forms to *T. terrestris* var. *terrestris*. According to them, this species differs from var. *terrestris* by its "constantly much more densely hirsute cocci, having much more pronounced and stouter secondary spines, and complete

absence of lower pair of spines". Various intermediate forms noticed in the fruits (Fig. 3, e) of many specimens collected from Oman and Saudi Arabia have shown that there is a gradual transformation of tubercles to spine-like tuberculate hairs (Fig. 1, c and d). *T. echinops* Kers reported from West Africa and *T. hystrix* R. Br. and *T. occidentalis* R. Br. reported from Australia also have secondary spines and resemble *T. rajasthanensis* in many respects. The reference by Kers (in El-Hadidi 1978) regarding the similarity of these species, as a case of parallel evolution raises the question as to whether these changes in the fruit characters are permanent or influenced by environmental factors. However, the presence of *rajasthanensis* (*sensu* Bhandari and Sharma) in Arabia is undebatable and the characters described for this species undoubtedly match the characters of a few herbarium specimens (Collenette-5793 as *T. parvispinus*; Trott-1461 E; Miller and Nyberg-9361 E) deposited in E. Another specimen (Miller-2542 E) with small flowers (5 stamens) and small spiny fruits (mericarps 2.5 mm in diameter), has small spiny tubercles equalling the length of the median spines and mericarps covered with hairs on all sides. It is similar to *T. parvispinus sensu* Presl except for the secondary tuberculate hairs and the overall pubescent character. This specimen could have been lumped under *T. terrestris* var. *parvispinus* comb. nov. if the mericarps were without the above characters. This intermediate form between var. *parvispinus* and *T. rajasthanensis sensu* Bhandari and Sharma coupled with similar forms between var. *terrestris* and the new species prove beyond doubt that the various characters used by the authors did not appear as sufficient grounds for a species separation. Therefore *T. rajasthanensis* is treated here as a variety of *T. terrestris*.

There are confusions about *T. cistoides* L., one of the most widely spread species in East African countries and in parts of West Asia including the Arabian Peninsula. A critical review of the literature showed that there are contradictions in separating it from *T. terrestris* and *T. zeyheri* Sond. (mainly a South African species introduced elsewhere including West Asia (El-Hadidi 1985). Chaw *et al.* (1993) described *T. cistoides* in Taiwan, with mericarps dorsally crested, tuberculate-sericeous and stigmas linear, while El-Hadidi (1985), who examined the Linnean type described the fruit as disc-shaped, glabrous and the stigmas hemispherical-asymmetrical. Further, they are either perennials or annuals and with styles 0.8-1.2 mm or 2-4 mm long respectively. Hence, the only character agreed in both cases in designating it as a species is the stylar length which, according to Hadidi (1978), is of minor systematic value.

### *Tribulus* L.

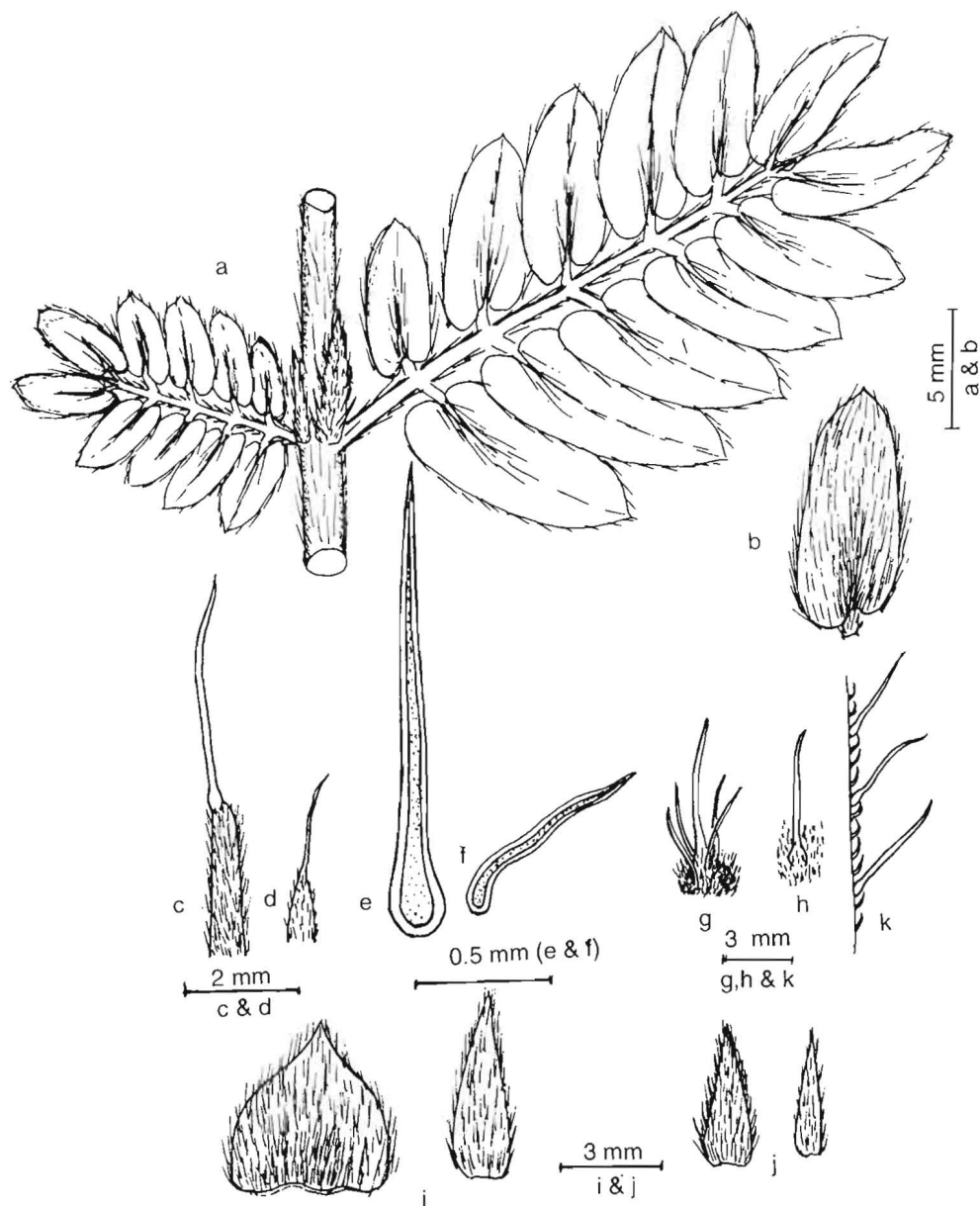
Annuals, biennials or perennials, erect, or prostrate, diffusely branched herbs or



subshrubs, common in arid, semi-arid tropics and subtropic regions of both hemispheres. Of the species, *T. terrestris* is the most widely distributed species in Saudi Arabia, being usually seen in wastelands and agricultural fields. All species in this region are trailers except var. *arabicus*, which can also grow as an erect subshrub reaching up to 1 m tall. The height or length of the plants varies according to the ecological conditions in the field. In drier conditions plants possess a thick indumentum and small imbricate leaves. Var. *arabicus*, commonly seen in the sandy deserts, has stout bases, small leaves, a thick indumentum and a very long tap root (a common feature associated with deserts and constantly moving sand substratum).

### **Vegetative Characters**

Stems in all species (except in var. *arabicus*) thin, sometimes zig-zag, finely striated, pubescent to hispid, mixed with long erect and short appressed hairs (plants growing in shady sites have only sparsely pubescent stems). Stems of some forms of *T. terrestris* are slightly reddish (including the round side of the petiole facing the substratum). Trichomes unicellular (exceptionally bicellular), cutinised at their bases; long ones erect, usually with raised bases and surrounded by a rosette of epidermal hairs (Sheahan and Cutler 1993) while in short ones appressed, arising directly from the epidermis. Leaves paripinnate, opposite or rarely alternate due to the abortion of one leaf. One leaf per node remarkably smaller; stipulate, petiolate; petioles somewhat flat on the upper side (as in *T. terrestris*) and round on the back, ending in a leafless mucronulate tip. Leaflets 6-9 pairs in large leaves and 4-5 pairs in small leaves, opposite, shortly petiolulate or apparently sessile as in var. *arabicus*. Shape and arrangement of leaflets are almost same in all the species studied but variations occur on plants influenced by environmental factors. The leaf-let shape is usually elliptic oblong (*T. terrestris*) or obovate or ovate-oblong (*T. terrestris* var. *parvispinus* var. *nov.*); basal pairs usually unequal; margin entire, slightly reddish in *T. terrestris*, base oblique, apex acute, apiculate. Indumentum appressed pubescent to hispid at the lower side and sparsely pubescent at the lower half of the midrib and side-veins to almost glabrous on the upper side (*T. terrestris*, *T. pentandrus*). *T. macropterus* var. *arabicus*, which is usually seen in the desert, has leaflets more or less sericeous on both sides. Stomata anomocytic in all the species studied; slightly sunken, surrounded by irregular epidermal cells. Stipules usually unequal in each node. As a rule larger leaf has large stipules and smaller leaves have smaller stipules. The shapes and sizes of stipules are variable from species to species: linear-lanceolate (up to 2 mm, e.g. *T. terrestris* var. *parvispinus*) to lanceolate (*T. terrestris* var. *terrestris*) to trullate-ovate (var. *arabicus*). They are pubescent in var. *terrestris* and sericeous to hispid-pilose in var. *arabicus*.



**Fig. 1.** a. Portion of stem showing opposite, unequal leaves of *T. terrestris* var. *terrestris*; b. lower side of leaflet; c. spiny-tuberculate hair of var. *rajasthanensis*; d. intermediate form of spiny-tuberculate hair; e. unicellular erect hair; f. unicellular appressed hair; g and h. two types of hairs in the *pentandrus-macropterus* complex; i. stipules of *T. macropterus* var. *arabicus*; j. stipules of *T. terrestris* var. *terrestris*; k. hairs.

### Reproductive characters

Flowers solitary, pedicellate at the axils of smaller leaves, ebracteate, hypogynous, pentamerous and actinomorphic. Flowers of *T. pentandrus* with 5 stamens are the smallest (up to 6 mm across) reported from this region whereas in var. *arabicus* they are showy, reaching up to 3.5-4 cm in diameter. The size of the flowers are not always constant within a species, especially in var. *arabicus*. Mandaville (1990) and Collenette (on a herbarium label) reported smaller flowers (1.5 cm across) of this species from the same population. Pedicels hairy-pubescent, shorter than the subtending leaves (except in var. *arabicus* which sometimes reaches up to 2 cm). *T. zeyheri* Sond., a taxon present in East Africa, also has pedicels longer than the subtending leaf. Sepals 5, linear-lanceolate, equal, acute, sericeous, entire, imbricate; inner sepals membranous at the margins. Petals 5, separate, widely spreading, obovate to oblong, truncate or uneven at apex, pale yellow to yellowish with dark brown veins at the base (var. *arabicus*), contorted. Stamens 5-10 (rarely 12), inserted between the lobes of the disc. The outer whorl consists of 5 stamens with nectaries at the base on both sides, somewhat bilobed (var. *terrestris*); stamens opposite the petals are without nectaries. Inner nectaries free in *T. terrestris* and fused in *T. cistoides* (Chaw *et al.* 1993), triangular to trilobed (Fig. 2,a). But our study of some specimens of var. *terrestris* revealed both free and fused nectaries in the same flower. Tri-lobed nectaries always have slight fusion with the right and left nectaries while triangular nectaries have a free (at least on one) side. In *T. pentandrus* and *T. macropterus* var. *arabicus*, inner nectaries fuse to form a cup-like structure. Anthers unequal, dorsifixed, 0.4-2.5 mm long, oblong (var. *arabicus*) or sagittate (var. *terrestris*). Pollen grains sub-globose, tectum reticulate (var. *terrestris*, Chaw *et al.* 1993). Ovary sessile, strigose, 5-lobed, 5-celled with 1-5 ovules per cell; styles short, 1-1.5 mm long or absent (var. *terrestris*), terete, glabrous or pubescent in some specimens of var. *parvispinus*; stigmas 5-lobed, linear or capitate, surfaced with small papillate hairs.

Fruits are the basic source of information for identifying and classifying *Tribulus*. Their size (0.5-1.75 cm across) depends upon the plant maturity. They are indurate, separating into 5 indehiscent, equal or unequal winged, spined or tubercled mericarps. Pubescence (sparse to dense) is affected by environmental factors. In some forms of var. *terrestris* (KSU-1502) the mericarps are totally glabrous except for a few tubercles on their back whereas in some other forms, and also in all other varieties and species, the mericarps are pubescent (including spines and wings). In var. *rajasthanensis* comb. nov., the base of the tubercles on the surface of the mericarps are as long as the spines, giving the appearance of many spined mericarps. Margin and width of the wings also vary within the species. Among the species with winged carpels, *T. pentandrus* has a wide range of wing shapes from triangular to



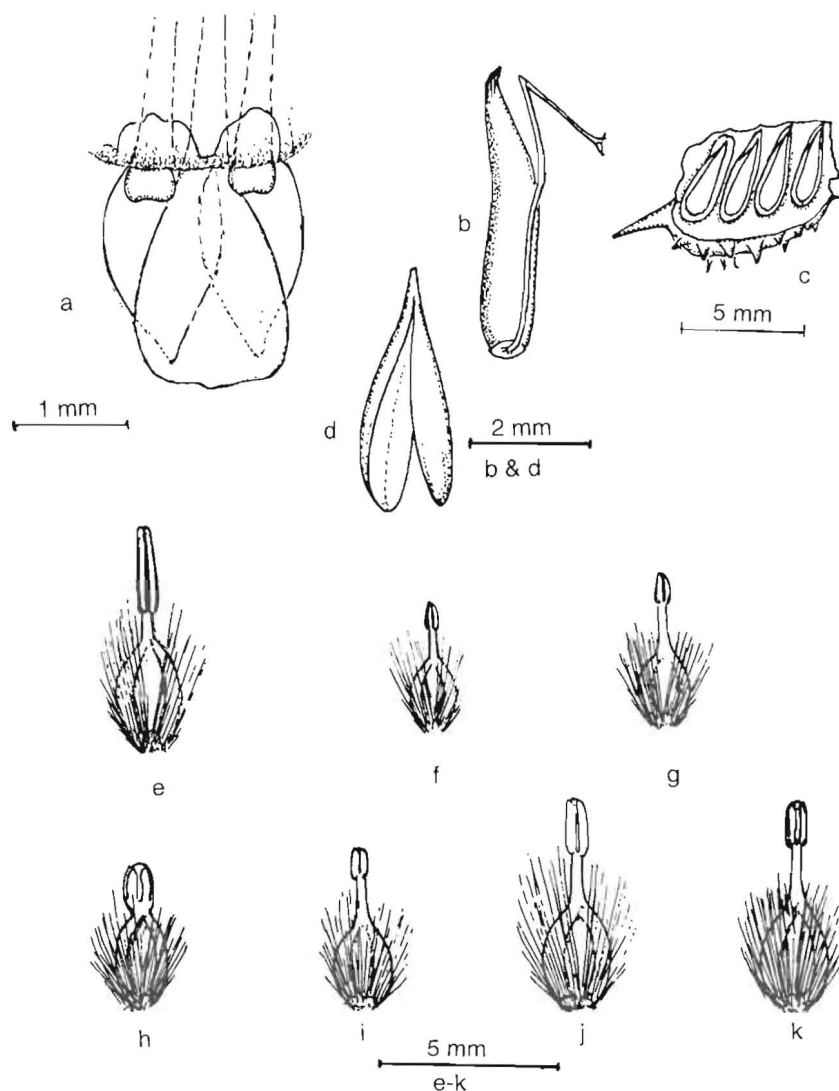


Fig. 2. a. Diagrammatic representation of a flower showing the shape of the (n) nectaries; b. seed of *T. pentandrus* var. *pentandrus*; c. L.S. of a mericarp (*T. terrestris* var. *terrestris*) showing the arrangement of seeds; d. cotyledons; e-k pistils, e. *T. macropterus* var. *arabicus*; f. *T. terrestris* var. *parvispinus*; g. *T. pentandrus* var. *bimucronatus*; h. *T. terrestris* var. *terrestris*; i. *T. pentandrus* var. *pentandrus*; j. *T. macropterus* var. *mollis*; k. *T. terrestris* var. *rajasthanensis*.

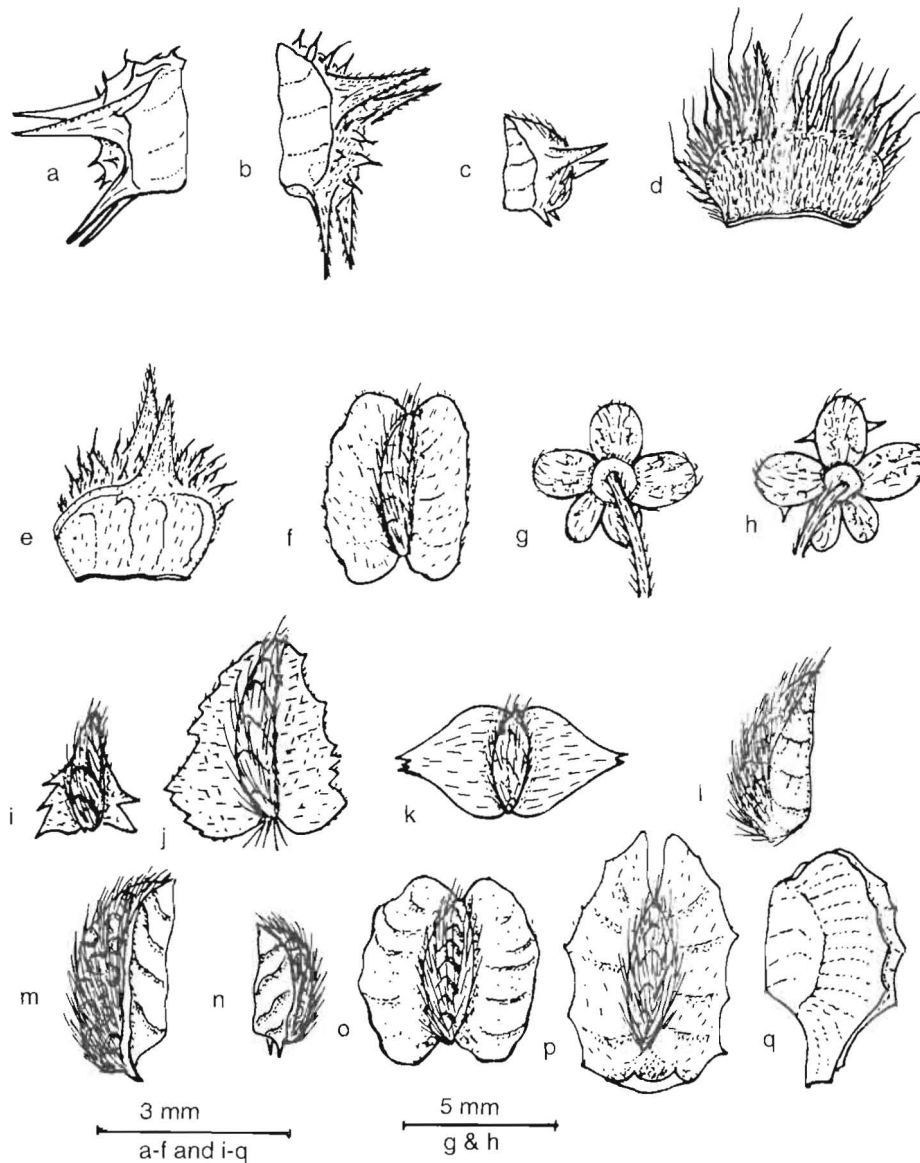


Fig. 3. Mericarps of *Tribulus* spp.: a & b. *T. terrestris* var. *terrestris*; c. var. *parvispinus*; d. var. *rajasthanensis*; e. intermediate form of var. *rajasthanensis*; f, i and k. *T. pentandrus* var. *pentandrus*; j. *T. macropterus* var. *macropterus*; l. var. *mollis* (typical); m. intermediate form of var. *mollis*; n. *T. pentandrus* var. *bimucronatus*; o, p and q. *T. macropterus* var. *arabicus* (q. lateral view). Fruits of: g. *T. terrestris* var. *inermis*; h. intermediate form of var. *inermis*.

wings extending over the whole mericarp. Taxonomic arguments concerning these wing shapes have centered around this group as to whether these characters are significant enough to be used in placing some specimens in different categories. Wings in some specimens of *T. pentandrus* are wider than their carpel width (up to 10 mm) whereas in a few other specimens the two wings on the mericarp are fused, at least the lower portion.

Seeds, do not have any importance in delimiting the species of *Tribulus*, and are usually seen in individual chambers (Fig. 2c) formed after fertilization. The number of seeds per mericarp is 2-5 (El-Hadidi 1972, Ghafoor 1977) but single seeds were also observed in some specimens of var. *arabicus*. Seeds conical; funiculus long, as long as the length of the seed, sometimes connate on one side (Fig. 2b).

**Table 2.** Number of Seeds in each mericarp and list of published chromosome counts

Name of the Plant	Number of seeds / mericarps	Chromosome number and source
<i>T. alatus</i>		2n = 24 (Hilu 1981)
<i>T. arabicus</i> (sensu Hosni)	1-2	
<i>T. bimucronatus</i> (sensu Viv.)	2	
<i>T. kaiseri</i> (sensu Hosni)	3	
<i>T. longipetalus</i> (sensu Viv.)		n = 12 (Hussain 1986)
<i>T. macropterus</i> (sensu Boiss.)	2-3	
<i>T. omanense</i> (sensu Hosni)	1-2	
<i>T. parvispinus</i> (sensu Presl)	2	
<i>T. pentandrus</i>	2-4	n = 10, 12 (Hussain 1986)
<i>T. rajasthanensis</i> (sensu Bhandari and Sharma)	4	n = 6 (Bhandari and Sharma 1977)
<i>T. terrestris</i>	3-5	n = 18, 24 (Hussain 1986)
<i>T. terrestris</i>		n = 24 (Koul <i>et al.</i> 1976)
<i>T. terrestris</i>		2n = 48 (Bir and Sidhu 1980)
<i>T. terrestris</i> var. <i>bicornutus</i> (sensu Boiss.)	4	2n = 36 (Hilu 1981)

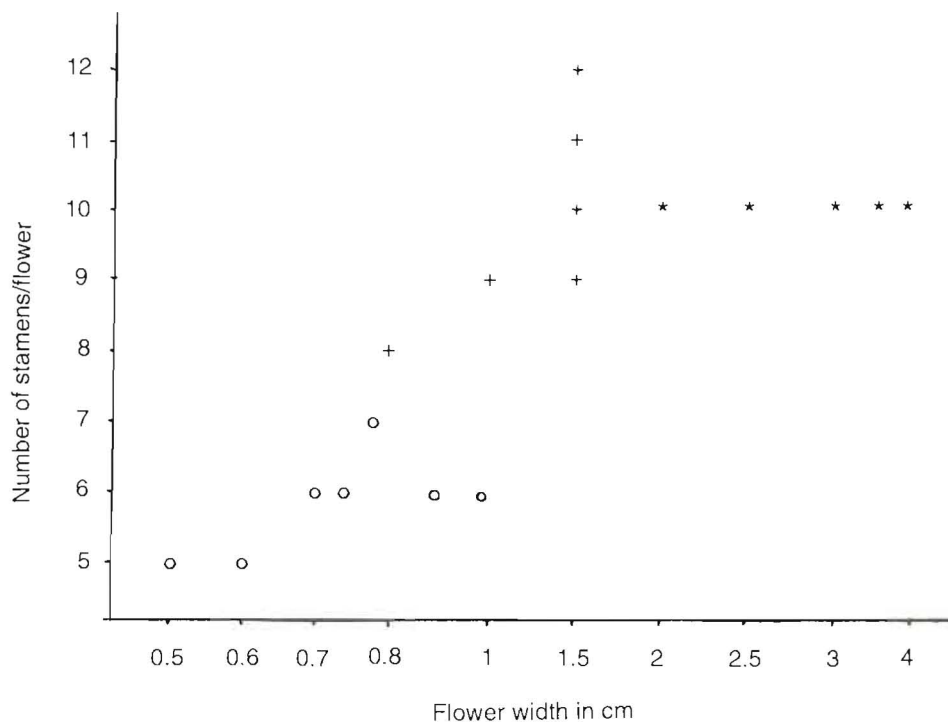


Some of the chemical components present in *Tribulus* spp., and particularly *T. terrestris*, are well known in preparing herbal medicines. Though all parts of the plant are used in medicines, certain drugs present in the dried fruits are more popular and are used as a diuretic, tonic, aphrodisiac and often in painful micturition (Zafar 1994). This plant is also used for the treatment of piles, cough and leprosy. Ghatak (1933) reported the presence of a semi-drying oil, peroxides, diastase, traces of glucosides, proteins and resins in dried fruits of *T. terrestris*. Chemical analysis of the whole plant also shows proteins and calcium in large amounts.

### **Taxonomic Treatment**

El-Hadidi (1978) classified *Tribulus* L. into three sections based on the characters of mature mericarps and the presence or absence of sepals on mature fruits. The section *Terrestris*, consisting of 7 species, is characterised by spiny carpels and deciduous sepals whereas section *Alata* (includes 8 species) contains species with winged carpels and persistent or deciduous sepals. Section *Inermis*, as the name implies, includes all species with wingless or spineless carpels and caducous sepals. There are 4 species under this section including the new species, *T. kaiseri sensu* Hosni. Though the section *Inermis* has been given an equal status with the other two sections, its members resemble the species of the other sections. None of these species has completely unarmed mericarps but have spinules (*T. bimucronatus* Viv.) or small basal dentate wings (as in an isotype of *T. mollis* lodged in Kew, *fide* El-Hadidi). Another species, *T. excrucians* Warwa (= *T. pechuelli* O. Ktze.), also belonging to this section and a native of SW Africa, has intermediate forms which were regarded as conspecific with *T. zeyheri*. However, according to El-Hadidi (1978) the typical form of *T. excrucians* is different from *T. zeyheri* in its mericarp structure and habit (being unarmed and erect). Although typical forms of these species do occur in a population, the intermediate forms give grounds for taxonomists to include these taxa either in section *Terrestris* or *Alatus*.

**Table 3.** Affinity of flower characters in the *pentandrus-macropterus* complex  
o *T. pentandrus*; + *T. macropterus* var. *macropterus*; \* *T. macropterus* var. *arabicus*.



### Key to the Species in Saudi Arabia

1. Fruit unarmed: .....2
- 1+ Fruit spiny or winged: .....4
2. Mericarps with few long, appressed white hairs; rarely with one or two small spines (half the width of mericarps) on the median side .....  
3d *T. terrestris* var. *inermis*
- 2+ Mericarps densely pubescent, with long erect hairs mixed with short appressed hairs; sometimes with small spinules at the base hidden in thick indumentum and sub-persistent sepals: ..... 3
3. Stamens usually 5, rarely 8; mericarps c. 1.5 mm wide .....  
1b *T. pentandrus* var. *bimucronatus*
- 3+ Stamens usually 10; mericarps 2.5-5 mm wide, hispid-pilose.....  
2b. *T. macropterus* var. *mollis*

4. Mericarps spiny: ..... 5  
 4+ Mericarps winged: ..... 7
5. Stamens 10, fruit 1-1.5 cm wide including spines: ..... 6  
 5+ Stamens 5-8; fruit disc shaped, less than 8 mm wide: .....  
     3b. *T. terrestris* var. *parvispinus*
6. Mericarps with 4 spines; sometimes the basal 2 or the median 2 spines highly reduced or absent; side of the mericarps glabrous.....  
     3a. *T. terrestris* var. *terrestris*
- 6+ Mericarps with many spines or spine-like tubercles; side of the mericarps pubescent: .....  
     3c. *T. terrestris* var. *rajasthanensis*
7. Annuals; flowers 5-6 mm wide; stamens 5-6: .....  
     1a. *T. pentandrus* var. *pentandrus*
- 7+ Perennials: flowers 0.8-4 cm wide; stamens usually 10, sometimes 8 or 9: ..... 8
8. Flowers 2-4 cm wide: .....  
     2c. *T. macropterus* var. *arabicus*
- 8+ Flowers 0.8-1.5 cm wide: .....  
     2a. *T. macropterus* var. *macropterus*

1. *T. pentandrus* Forssk., Fl. Aegypt. -Arab. :88 (1775)

Procumbent or prostrate, annual or biennial herb; branches up to 50 cm. Leaves pubescent to tomentose; longer one 2.5-5 cm long with 5-7 pairs of leaflets, shorter one 1-3.5 cm long with 3-4 pairs of leaflets. Leaflets elliptic-oblong 7-10 (12) x 3-6 mm, acute at apex, oblique at base. Stipules ovate-lanceolate 4-6 x 2.5-3 mm. Flowers 0.5-0.7 cm wide. Sepals linear-lanceolate, 6-9 mm long. Petals as long as or slightly longer than the sepals, deciduous. Stamens 5-6 (-8). Ovary 1-1.5 mm, angular, style short, half the length of the ovary, stigma linear to oblong 0.75-2 mm long, slightly exceeding the strigose hairs. Fruit 7-10 mm in diameter, pyramidal to spheroidal, mericarps 3-7 mm long, unarmed or winged; wing 1-9 mm wide, pubescent, extending the whole length of the mericarp, or restricted to its base; margins entire, sinuate to spiny.

a. var. *pentandrus*

Type: Fl. Aegypt. -Arab.: 88 (1775)

Syn: - *T. longipetalus* Viv., Pl. Aegypt. Dec. 4:10 (1830); *T. alatus* acut. Vix Del., Desc. de! 'Egypte, Hist. Nat. 2:62 (1813); *T. alatus* Del. var. *odontopteris* Kralik in

Ann. Sci. Nat., ser. 3, 11:30 (1849) *nom. illeg.*; *T. pentandrus* var. *micropteris* (Kralik) Hosni, Fl. Trop. E. Afr., Zygo. 3 (1985); *T. longipetalus* var. *mollis* (Ehreb. ex Schweinf.) Zoh., Fl. Pal., 2:255 (1972) *non* Ehrenb. ex Schweinf.

Annual or biennial herb; flowers usually 5 mm wide; stamens 5-6; mericarps winged, wings extending laterally or seen at the lower half of the mericarps.

Dist.: Middle East, Africa, Afghanistan, Pakistan and India.

This variety has a wide range of wing shapes and sizes (Fig. 3, f,i and k). Some of the specimens (from Afghanistan and Pakistan) with 10 stamens and wings wider than the mericarps were attributed to *T. pterophorus* Presl (= *T. longipetalus* ssp. *pterophorus* (Presl) El-Hadidi, 1972). Wings of these mericarps sometimes acute with few teeth, giving the shape of two broad, somewhat triangular wings (Fig. 3k) on both sides. Although El-Hadidi (1978) reported *T. pterophorus* Presl as a species endemic to South Africa it is now widespread in West Asia including the Arabian Peninsula. Some of the specimens reported from the *Flora Iranica* area and Pakistan have 10 stamens and mericarp wings 8-15 mm broad, straw-yellow colored and sparsely pubescent but few of our specimens collected from Wadi Dawasir have both types of wings in their mericarps (Fig. 3f and k) and flowers small (5 mm wide) with 5 stamens. Engler (1931) assigned the name *T. pterophorus* Presl to another group of plants having wings almost semicircular, much broader than the body of the mericarp and wing-margin crenate whereas plants with mericarp wings noticed as in our specimens (KSU no. 1659, Fig. 3k) were ascribed to *T. securidocarpus* Engl. (in Engl. u. Drude, Veg. d. Erde IX Pflanzenwelt Afrikas iii. 1. 737 (1915)). The first group of plants that Engler mentioned are not observed in our area but reported only from Africa.

b. var. *bimucronatus* (Viv.) Hemaïd and Jacob comb. et *stat. nov.*

Basionym: *T. bimucronatus* Viv. Pl. Aegypt. Dec. 4:9 (1830).

Type: Egypt near Cairo Viviani (M, iso!) *fide* El-Hadidi.

Syn.: *T. bimucronatus* ssp. *inermis* (Kralik) H. Hosni, Fl. Trop. E. Afr. 3 (1985); *T. inermis* Kralik, Ann. Sci. Nat. Ser. 3, 11:25 (1849).

Fruit pyramidal, mericarps small, alveolate-rugose, with or without small spinules at the base.

Dist.: Saudi Arabia, Oman, Egypt, Ethiopia.

Mandaville No. 8361 and 8363, both collected from an oil field in southern



Dahna, have 5 stamens and comparatively bigger fruits (c. 1 cm across). Wings on these mericarps are highly reduced leaving a triangular-like spinule at the base. These specimens can be considered as one of the variations within *T. pentandrus*.

The status of ssp. *inermis* (Kralik) H. Hosni, based on material collected from Jeddah, is doubtful because one of the specimens deposited in Kew, bearing a determination note in Hosni's handwriting (as *T. bimucronatus* ssp. *inermis*), has clear but small, triangular winged mericarps in one of the fruits! Apparently Kralik's determination of this subspecific rank is based on a very young *T. pentandrus* plant.

2. *T. macropterus* Boiss. Diagn. Ser. 1, 1:61 (1842).

Prostrate or decumbent, woody-based subshrub. Stem and leaves villous with short appressed and long erect hairs. Larger leaves 2.5-5 cm long; smaller leaves 0.8-1.2 cm long; leaflets 4-6 x 2-3 mm, oblong-elliptic, widely-spaced or imbricate, apiculate; stipules 2-4 mm long, ovate to broadly-ovate, sub-caducous. Pedicel equal to or longer than the subtending leaf. Sepals sericeous, 5-8 x 1.5-2 mm, lanceolate, acute. Petals 1-1.75 x 0.5-1 cm, obovate, pale to bright yellow. Stamens 10, sometimes 8 or 9. Ovary densely hairy, with straight hairs; style 0.5-1.25 mm long; stigma 1-3 mm long, linear-cylindrical. Fruit 1-1.5 cm wide, densely hairy between the wings; wings 7-10 x 3-5 mm, subentire, or dentate or greatly divided. Seeds 1-3 (in our material), 3-6 x 0.75-1 mm.

a. var. *macropterus*

Type: Aucher-Eloy 803 - bis., G. ! *vide* El-Hadidi.

Syn.: *T. longipetalus* Viv. ssp. *macropterus* (Boiss.) Maire ex Ozenda and Quezel, El-Hadidi in Fl. Iran, 98:13 (1972); St. Fl. Egypt, ed. 2:311 (1974); *T. longipetalus* var. *macropterus* (Boiss.) Zoh., Fl. Pal. 2:255 (1972); *T. pterocarpus* Ehrenb. ex C. Muell. in Walp. Ann. iv. 404 (1846).

Flowers 8-13 (-15) mm wide, stamens 8-10; stigma shorter than style; wings along the carpel side, dentate, trapeziform or squarish, sometimes exceeding the apex of the carpel to form a continuous wing around the carpel.

Dist.: Middle East, Africa.

b. var. *mollis* (Ehrenb. ex Schweinf.) Hemaid and Jacob *comb. nov.*

Basionym: *T. mollis* Ehrenb. in Schweinf., Beitr. Fl. Aethio. 1: 29 (1867).

Syn.: *T. ochroleucus* (Maire) Ozenda and Quezel, Trav. l'Inst. Recherches Sahariennes 14:74 (1956); *T. macropterus* Boiss. var. *ochroleucus* Maire, Bull. Soc. Hist. Nat. Afr. Nord 20: 176 (1929); *T. perplexans* Maire, l.c. 34: 134 (1943).

Flowers 1-2.5 cm across. Fruit pyramidal, 0.8-1.5 cm wide, densely hairy, rugose, with or without small wing-like spinules at the base.

Dist.: Middle East, East Africa, Afghanistan, Pakistan.

c. var. *arabicus* (Hosni) Hemaïd and Jacob *comb. nov.*

Basionym: *T. arabicus* Hosni, Bot. Notiser 130: 261-262. Stockholm.

Syn.: *T. omanense* H. Hosni, in El-Hadidi, Taeckh. 9: 62-63 (1978).

Type: Oman, west of Gebel Samain, 3. 5. 1948 Thesiger s.n. (BM, holo-, CAI, iso-).

Decumbent, woody based subshrub, 50-100 cm tall. Pedicel equal to or longer than the subtending leaf. Stamens 10. Stigma linear as long as or longer than style. Wings dentate or sub entire, pubescent or sparsely pubescent.

Dist.: Saudi Arabia, U.A.E., Oman, Yemen.

### 3. *T. terrestris* L., Sp. Pl.: 387 (1753).

Annual, prostrate herb; branches 30-60 cm long. Leaves 3-7 cm long, larger ones with 6-8 pairs of leaflets and smaller one with 3-5 pairs; leaflets closely to widely spaced, 4-7 x 2.5-3.5 mm, middle pairs usually longer than the basal and terminal pairs, subsessile, elliptic-oblong, appressed pubescent at the lower side, sparsely pubescent to pubescent on the upper side, sometimes pubescent on the veins only. Flowers 0.5-1.3 cm wide. Pedicel shorter than the subtending leaf. Sepals 3-5 mm long, ovate-lanceolate, sericeous. Petals 5-7 mm long, pale yellow to yellowish, obovate. Stamens usually 10, 5-8 in one variety. Ovary strigose, grooved; style very short or absent; stigma linear to capitate. Fruits 8-15 mm across including spines; mericarps with usually 4 spines (2 long on the back and 2 small at the base), sometimes 2 or all reduced to tubercles or absent, crested, glabrous or tubercled, or furnished with spiny tuberculate hairs.

a. var. *terrestris*.

Type: Southern Europe, Linnaean Herbarium 547/4 (LINN !) *fide* El-Hadidi.

Syn.: *T. bicornutus* Fisch. and C.A. Mey., in Bull. Soc. Nat. Mosc. 391 (1838); *T. robustus* Boiss. and Noe in Boiss., Diagn. Pl. Or. Nov. Ser. 2, 1:112 (1854); *T. terrestris* var. *robustus* (Boiss. and Noe) Boiss., Fl. Or. 1: 902 (1867); *T. orientalis* Kerner, Ber. Naturwiss. med. Ver. Innsbruck 3 (1872).

Flowers 0.5-1.3 cm wide; stamens usually 10; fruit 1-1.5 cm wide including spines; tubercled, glabrous or pubescent; spines usually 4 in each mericarp (2 long median and 2 short basal); sometimes the median 2 or the basal 2 reduced to tubercles.

Dist.: Tropical and sub-tropical regions of Asia, Europe and Africa.

Plants without 2 median spines in their mericarps were attributed to *T. bimucronatus* Kralik on the basis of the similarity to the description of *T. bicornutus* sensu Fisch. and Mey. All specimens with the above character which were examined in this study have fruits more or less 1 cm wide with prominent tuberculate hairs.

b. var. *parvispinus* (Presl) Hemaid and Jacob *comb. nov.*

Basionym: *T. parvispinus* Presl, Bot. Bemerk.: 29 [459] (1845).

Type: South Africa, Ecklon (PR, Holo. !; K, iso. !) *fide* El-Hadidi.

Syn.: *T. bispinulosus* Kralik in Ann. Sci. Nat., Ser. 3 11: 26 (1849); *T. pentandrus*, El-Hadidi in Fl. Iranica 98:14 (1972) *non* Forssk.; Ghafoor, Fl. Pak., 76: 25 (1974); Migahid, Fl. Saudi Arabia, ed. 3 vol. 1, 119 (1988) *non* Forssk.

Similar to var. *terrestris* but fruits small; flower 5-6 mm wide; stamens usually 5, sometimes up to 8; mericarps 1-1.5 mm wide, pubescent; spines narrow, small equalling or slightly longer than the width of mericarps.

Dist.: Throughout Middle East.

c. var. *rajasthanensis* (Bhandari and Sharma) Hemaid and Jacob *comb. nov.*

Basionym: *T. rajasthanensis* Bhandari and Sharma, Bot. Not. 129: 367-369 (1977).

Type: India, Rajasthan, Jodhpur dist., 3.10.1959, Bhandari 537 (CAL- holo).

Leaflets densely pubescent on both sides. Flowers 0.8-1.5 cm wide; stamens 5-10; mericarps 3-6 mm wide, hispid-pilose, 2 median spines less prominent than the tuberculate spines basal spines usually absent; secondary spines (spine-like tubercles) 20-25, unequal, each spine ending in a tuberculate bristle, longer than the spine.

Dist.: Saudi Arabia, Oman, India.

d. var. *inermis* Boiss., Fl. Or. 1: 902 (1867).

Type: Kordofan, Nubia 1841, Kotschy 38, (G!) *fide* El-Hadidi.

Syn.: *T. kaiseri* Hosni in El-Hadidi, Taeckholmia 9: 65 (1978).

Flowers 0.8-1.3 cm wide; stamens usually 10, sometimes 5 or 8; fruit spherical 6-10 mm wide.

Dist.: Middle East, Afghanistan, Pakistan, India.

One of the specimens (Collenette-1780) determined by Hosni (in Sched) has small spinules at the base of mericarps, showing its affinity towards var. *terrestris* L. The south-west African species *T. excrucians* Warwa (= *T. pechuelli* O. Ktze.), separated from *T. zeyheri* Sond. also has a similar type of intermediate forms. Though the fruits of typical *T. excrucians* are unarmed, various intermediate forms (as in *T. terrestris* var. *inermis*) fall between these two species which made many scientists consider the former species as conspecific with *T. zeyheri* Sond.

### Appendix

This list includes specimens collected from all countries in the Arabian Peninsula.

#### 1. *Tribulus pentandrus* Förssk. var. *pentandrus*

**Alder, A.M.** 29, 18 (E); **Baierle, U. and King, P.** 82-725 (E); **Bent, M.I.** ?1895 (K); **Boulos, L. et al.** 16798 (E); **Ghaudhary, S.** 8410, 5881 (RIY); **Collenette, S.** 25 (K), 6252 (RIY), 2982, 3211, 4156 (E); **Cope, T.A.** 16 (K); **Edmondson, J.R.** E. 3056 (E); **Gallagher, M.** 7963 (K), 6464, 8112/12, 6763/6 (E); **Grainger, J.** 701 (E); **Grierson, A.** 4 (E); JAS 435 (E); **Kawar, N.** (s.n.) 13569 (RIY); **Lawton, R.M.** 2570 (K); **Maconochie, J.R.** 3045, 3438, 3353 (E); **Mandaville, J.P.** 8134, 653, 8702, 7753, 8363, 8361, 8335, 517- (E); **Migahid, A.M.** 1704 (KSU); **Miller, A.G.** 6579 (E); **Miller, A.G. and Nyberg, J.A.** M. 9495, 9484 (E); **Miller, A.G. and Long, D.G.** 3514 (E); **Naylor, K. and Watkins, J.** N-70 (E); **Podzorski, A.C.** 974, 979, 1149 (E); **Popov, G.** 69/80 (E); **Sheded, M.** 6662 (E); 6861 (E); **Stanley Price, K.** 138, 172, 45 (E); **Thomas, J.** 1263 (KSU); **Trott, A.G.** 146, 1510, 1668 (K); TT/DF 416 (E); **Western, R.** 264, RW 1181, 161, 117 and 118 (E); **Whitecombe, R.** 176 (E).

#### 2. var. *bimucronatus* (Viv.) Hemaid and Jacob

**Collenette, S.** 3227 (E); **Grainger, J.** 702 (E); **Miller, A.G.** 6010 (E); **Munton, P.N.** s.n (K).

#### 3. *T. macropterus* Boiss. var. *macropterus*.

**Boulos, L. et al.** 16585 (E); **Ghaudhary, S.** e-748 (RIY); **Collenette, S.** 3131 9k0, 3131, 6609, 6610, 6287 (E); **Frey, W. and Kurschner, H.** 6544 (E); **Gallagher, M.D.** 6972/8 (E); **Gilliland** 4286 (K); **Grierson, A.** 248 (E); **Heemstra, H.H.** 7194 (RIT-6563); **Maconochie, J.R.** 3201 (E); **Mandaville, J.P.** 7446; **Migahid, A.M.** 1709, 1665, 1685 (KSU); **Ozborn, K.I.** 47 (K); **Vincet, H.** RIY-660A (E); **Western, R.** 215 (E); **Zeller, W.** B215 (E).

#### 4. var. *mollis* (Ehrenb. ex Schweinf.) Hemaid and Jacob



**Brown, J.N.B.** 789 (E); **Collenette, S.** 6609 (E); **Abedin, S.** 12914 (KSU-1710); **Wiest, G.** 588 (K).

5. var. *arabicus* (Hosni) Hemaid and Jacob

**Ghaudhary, S. et al.** 13319 (RIY); **Collenette, S.** 4140 (K), (E) and (1442-KSU); 6252, 6308 (E); **Gilliland** 4286 (K); **Mandaville, J.P.** 1955, 8312, 7670, 7686, 7686, 7017, 7857, 8036, 8443, 8032, 7686, 1955, 8831, 7495, 7881, 8025, 7831, 7833, 8138, 8807; **Miller, A.G. et al.**, M. 8137B (E); **Naylor, K.** 247 (E); **Stewart, Dr.M.** 689 (K).

6. *T. terrestris* L. var. *terrestris*.

**Bisset, E.** 107 (K); **Ghaudhary, S.** E464- (E), 5877, 6006 (RIY); **Collenette, S.** 830, 2542 (K); **Dwyer, J.D.** 13146 (E); **Fayad, A.** 1268 (E); **Mandaville, J.P.** 3161; **Migahid, A.M.** (KSU- 1705, 1684); **Migahid, A.M.** and **El-Sheikh, A.** (KSU-1683, 1450, **Thomas, J.** 1258 (KSU); **King, R.A.** 104, 251 (E); **Western, R.A.** 783 (E); **Wilcox, C.** 221 (K).

7. a. var. *rajasthanensis* (Bhandari and Sharma) Hemaid and Jacob

**Collenette, S.** 5793 (E), (10504-RIY); **Radcliffe-Smith, A.** 5559 (K); **Trott, A.C.** 1461 (E); **Miller, A.G.** and **Nyberg, J.A.** M.9066 (E).

b. Intermediate forms: **Collenette, S.** 3805 (K), (E); **Miller, A.G.** 2542 (E); **Miller, A.G.** and **Nyberg, J.A.** M.9066 (E).

8. var. *parvispinus* (Presl) Hemaid and Jacob

**Batanouny, K.H.** 2441 (K); **Collenette, S.** 1574 (K), 3210 (E); **Edmondson, J.R.** E3105 (E); **Gordon, K.J.** 561 (E); **Maconochie, J.R.** 3225 (E); **McLeish, I.** 89, 573 (E); **Miller, A.G.** 2141, 7678, M9016 (E); **Miller, A.G.** and **Long, D.G.** 3449 (E); **Radcliffe-Smith, A.** 3762, 5016 (K); **Rubens, T.G.** 103b (E); **Trott, A.C.** 1452 (K); **Virgo, K.J.** 214 (K); **Western, R.A.** RW159, 394, 69, 715, RW1180 (E); **Whitcombe, R.** 225, 456, 620, 901 (E); **Wood, J.R.I.** 3471, 3433 (K).

9. var. *inermis* Boiss.

**Ghaudhary, S.** E466 (E); 5871 (RIY); **Collenette, S.** 1780, 4764 (E-intermediate form), 5773 (K); **Frey, W. et al.** 81-166 (KSU-1449); **Migahid, A.M.** (KSU-1439, 1457, 1456).

*Acknowledgements*

We thankfully acknowledge the curators of the Royal Botanic Garden, Edinburgh, Royal Botanic Gardens, Kew and the National Herbarium of Saudi Arabia for providing herbarium materials. James P. Mandaville, ARAMCO, Dhahran who gave generous support in lending some of his specimens is also gratefully acknowledged. Thanks are also due to Dr. Sultanul Abedin, College of Pharmacy for reading the manuscript.

## References

- Agnew, A.D.Q. (1980) Zygophyllaceae In: **Townsend, C.C.** and **Guest, E.**, (eds.), *Flora of Iraq*, 4: 288-309
- Airy Shaw, H.K. (1985) *J.C. Willis' A Dictionary of the Flowering Plants and Ferns*, ed. 7, Cambridge Univ. Press. Cambridge, 1245 p.
- Akhiani, Kh. (1993) No. 7, Zygophyllaceae. In: **Assadi, M.**, **Khatamsaz, M.** and **Maasoumi, A.A.** (eds.) *Flora of Iran*. Research Institute of Forests and Rangelands, Tehran, 49 p.
- Al-Rawi, A. (1985) *Flora of Kuwait*, Vol. I, KPI, London in association with Kuwait University, 224 p.
- Andrews, F.W. (1950) *The Flowering Plants of the Anglo-Egyptian Sudan*, Vol. I, T. Bungle and Co., Scotland, 237 p.
- Batanouny, K.H. (1981) *Ecology and Flora of Qatar*. University of Qatar, Doha, 245 p.
- Bhandari, M.M. (1983) Palynology and systematic consideration of Zygophyllaceae. *Proc. Natl. Symp. Adv. Front. Pl. Sci. Jodhpur XVII-1*: 183-186.
- Bhandari, M.M. and Sharma, V.S. (1977) A new *Tribulus* (Zygophyllaceae) from India. *Bot. Not.* 129: 367-369.
- Bir, S.S. and Sidhu, M. (1980) Cyto-palynological Studies on Weed Flora of Cultivable lands of Patiala District (Punjab). *J. Palynology* 16: 85-105.
- Blatter, E. (1919-36) *Flora Arabica*. Records of the Botanical Survey of India, Vol. VIII, No. 1, Supt. Govt. Print., Calcutta, 519 p.
- Boissier, E. (1867) *Flora Orientalis*, Apud H. Georg, Bibliopolam, Basileae, Vol. I, 1047 p.
- Boulos, L. (1988) A Contribution to the Flora of South Yemen (PDRY). *Candollea* 43: 549-585.
- Chaw, S., Lin, S. and Wang, B. (1983) *Tribulus cistoides* L. (Zygophyllaceae): A New Record for the Flora of Taiwan, *Bot. Bull. Acad. Sin.* 34: 31-36.
- Collenette, S. (1985) *An Illust. Guide to the Flowers of Saudi Arabia*, Scorpion Publishing Ltd. London, jointly with MEPA, Jeddah, 514 p.
- Cornes, M.D. and C.D. (1989) *The Wild Flowering Plants of Bahrain*, Immel Publishing. London, 272 p.
- Daubenmire, R.F. (1974) *Plants and Environment*, Wiley Eastern Private, New Delhi, 422 p.
- El-Hadidi, M.N. (1972) Zygophyllaceae In: **Rechinger, K.H.** (ed.), *Flora Iranica*, no. 98, Ak. Druck-u verl. Graz, 32 p.
- El-Hadidi, M.N. (1974) In: **Täckholm, V.** *Students' Flora of Egypt*. Cairo University, Cairo: 300-313 pp.
- El-Hadidi, M.N. (1977) Tribulaceae as a Distinct Family, Publications from the Cairo University *Herbarium* 7-8: 103-108.
- El-Hadidi, M.N. (1978) An Introduction to the Classification of *Tribulus*, L., *Taeckholmia* 9: 59-66.
- El-Hadidi, M.N. (1985) Zygophyllaceae, In: **Polhill, R.M.** (ed.), *Flora of Tropical East Africa*: 2-8 pp.
- Engler, A. (1931) Zygophyllaceae. In: **Engler, A.** and **Prantl, K.** (eds.), *Die Natürlichen Pflanzenfamilien*. Wilhelm Engelmann, Leipzig, 470 p.

- Försskal, P. (1775) *Flora Aegyptiaco-Arabica*. ed. Neibuhr, Cophenagen, 219 p.
- Ghafoor, A. (1974) Zygophyllaceae In: Nasir, E. and Ali, S.I. (eds.) *Fl. of West Pakistan*, 35 p.
- Ghafoor, A. (1977) Zygophyllaceae In: Jafri, S.M.H. and El-Gadi, A. (eds.), *Flora of Libya*. Al Faateh University, Tripoli, **38**: 39-47.
- Ghatak, N. (1933) Chemical Examination of the Fruits of *T. terrestris* L. *Bull. Acad. Sci. United Prov., India* **2**: 163-170.
- Ghazanfar, S.A. (1992) *An Annotated Catalogue of the Vascular Plants of Oman*. National Botanic Garden, Belgium, 153 p.
- Heemstra, H., Hassan H. and Minwer, F. (1990) *Plants of Northern Saudi Arabia*. Range and Animal Dept. Res. Center, Sakaka, 357 p.
- Hilu, K.W. (1981) Cytotaxonomical Studies in *Tribulus terrestris* and *T. alatus* (Zygophyllaceae). *Nord. J. Bot.* **57**: 1694-1700.
- Hosni, H. (1977) A new *Tribulus* species with winged carpels, *Bot. Not.* **130**: 261-262.
- Husain, S.A. (1986) Cytotaxonomic studies in *Tribulus* from Pakistan. *Kromosomo*, II **42**: 1316-1329.
- Hutchinson, J. (1967) *The Genera of Flowering Plants*, **2**: Dicotyledones. Clarendon Press, Oxford, 639 p.
- Linnaeus, C. (1753) *Species Plantarum*. Vols. 1 & 2, Salvi Stockholm, 1200 p. (Reprinted in 1959 by Linnean Society, London).
- Koul, A.K., Wakhlu, A.K. and Karihaloo, J.L. (1976) Chromosome Numbers of Some Flowering Plants of Jammu (Western Himalayas). II. *Chromosome Information Service* **20**: 32-33.
- Mandaville, J.P. (1990) *Flora of Eastern Saudi Arabia*. Kegan Paul International, London, jointly with NCWCD, Riyadh, 482 p.
- Migahid, A.M. (1988) *Flora of Saudi Arabia*, Vol. I ed. 3, King Saud University Libraries, Riyadh 251 p.
- Oliver, D. (1868) *Flora of Tropical Africa*, Vol. I, Reeve and Co., Kent, 479 p.
- Porter, D.M. (1974) Disjunct distributions in the New World Zygophyllaceae. *Taxon* **23**: 339-346.
- Post, G.E. and Dinsmore, J.E. (1932) *Flora of Syria, Palestine and Sinai*, Vol. I. American Press, Beirut, 638 p.
- Richard, A. (1847-51) *Tentamen Florae Abyssinicae*, Vol. I, Apud Arthus Bertrand, Editorem, Paris, 472 p.
- Sheahan, M.C. and Cutler, D.F. (1993) Contribution of Vegetative Anatomy to the Systematics of the Zygophyllaceae R. Br., *Bot. J. Linn. Soc.* **113**: 227-262.
- Takhtajan, A. (1969) *Flowering Plants: Origin and Dispersal*. Oliver and Boyd., Edinburgh. (Translation by C. Jeffrey).
- Western, A.R. (1989) *The Flora of the United Arab Emirates*. U.A.E. University, Abudhabi, 188 p.
- Zafar, R. (1994) *Medicinal Plants of India*. CBS Publishers and Distributors, Delhi, 132 p.
- Zohary, M. (1972) *Flora Palaestina*, part 2, The Israel Academy of Sciences and Humanities, Jerusalem, 489 p.

(Received 06/11/1994;  
in revised form 14/10/1995)



## دراسة تصنيفية لجنس *Tribulus* L. في المملكة العربية السعودية

فهد الحميد و جاكوب توماس

قسم النبات والأحياء الدقيقة - كلية العلوم - جامعة الملك سعود

ص.ب (٢٤٥٥) - الرياض ١١٤٥١ - المملكة العربية السعودية

يعتبر جنس التريبولس *Tribulus* L. من الأجناس شديدة التعقيد من الناحية التصنيفية ، لكون أنواعاً منها تتخذ صوراً وسطية متباينة داخل المجتمع النباتي الواحد .

تهدف هذه الدراسة إلى تذليل تلك الصعوبات التصنيفية . تم تحليل ودراسة حوالي ٣٠٠ عينة نباتية ، وكذلك مراجعة الأسماء والمرادفات داخل هذا الجنس . أكدت هذه الدراسة أن هذا الجنس يحتوي فقط على ثلاثة أنواع في المملكة العربية السعودية من بين الأسماء والأنواع العديدة في المصادر التصنيفية ، يتبعها ثمانية أصناف خمساً منها تعتبر إضافة جديدة للباحثين . كما أن هذه الدراسة قدمت مفتاحاً تحليلياً ووصفاً شاملاً للأنواع والأصناف داخل هذا الجنس كما شملت توزيعها الجغرافي محلياً وعالمياً . وهناك العديد من الأنواع أحييت إلى أسماء مرادفة . ومن أبرز الخصائص التصنيفية المميزة للأنواع في هذا الجنس الثمار والبذيرات الناضجة وما تحمله من زوائد بالإضافة إلى عدد الاسدية والاحجام المتباينة للازهار كما هو موضح في المفتاح .