

## Taxonomic Status of Some of the *Tribulus* Species in the Indian Subcontinent

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**Abstract.** *Tribulus* L. is considered as the most complex genus in Zygophyllaceae because of enormous number of invalid specific epithets and also of the variations present in various populations. A comparative study has been carried out on specimens of a number of species in the Arabian Peninsula and India to find out whether the species with identical characters reported from above regions are indeed same or different. Distribution range of a few species reported from India has also been extended in the light of the present study. Nomenclature status of certain species' names widely used in India, such as *T. lanuginosus* L. and *T. longipetalus* Viv have been verified, while the subspecies status of *T. lanuginosus* ssp. *macropterus* (Boiss.) Maire ex Ozenda & Quezel has been elevated to species level. The reasons explained by other authors for lowering the species status of *T. rajasthanensis* Bhandari & Sharma to a variety level; and a detailed comparative study on *T. subramanyamii* P. Singh, Giri et V. Singh with similar species reported from West Asia are included in the text. A provisional key to the species of *Tribulus* in India is also provided for easy determinations.

**Key words:** Distribution, Taxonomy, *Tribulus*, Validity, West Asia, Zygophyllaceae.

### Introduction

*Tribulus* L., a highly polymorphic genus in Zygophyllaceae, has about 25 species in the arid and semi arid countries of the paleotropic region. Among these majority of them are in the Saharo-Sindian Phytogeographical zone. Exact determinations of its species are still considered difficult primarily due to the publications of a considerable number of specific epithets that spread over wide a range of variations. Although the overall vegetative and reproductive features of this genus are widely used in the classification of species, mature carpels are considered to be the most reliable character for determinations (Hadidi, 1978). Nevertheless, intrastaminal glands are also, sometimes, considered important for the delimitation of species in this genus, at least in the group level (Launert, 1963; Porter, 1971).

The characters of typical specimens with mature fruits are generally constant in a species growing in a relatively stable environment. However, in unstable environment, or species growing in extra arid climate, the characters often tend to change, particularly in the

shape and ornamentation of the mericarps (spines and wings). During the course of development of fruits, the spines or wings on the mericarps show significant variations. Determinations of plant specimens, which were collected at various stages of development of fruits often confuse taxonomists and force them to take their own judgments. This will eventually result in several confusions and false interpretations of names of the same species growing in different geographical locations. Close examinations of specimens of certain taxa in the floras of India and in certain countries in the West Asia, particularly of Arabian Peninsula showed that the variations in considering the species status of certain sections are much more than the existing accounts indicate.

Hadidi (1978) recognized three sections, each with a specific diagnostic character. Section *Terrestris* L. consists of species with spiny mericarps while Section *Alata* Hadidi with winged mericarps and Section *Inermis* Hadidi with spineless or wingless mericarps. He also merged a fourth group, (mericarps covered with several spines) proposed by Engler (1931) with

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Section *Terrestris*. Though a specific classification to segregate the species of *Tribulus* in the arid region is yet to be finalized, some of the guidelines proposed by taxonomists such as Engler (1931), Hadidi (1972; 1978), etc. could be considered as a platform for all future demarcations.

The species of *Tribulus* are annual or perennial, decumbent herbs with pinnately compound leaves. Leaves usually contain 3-10, sessile leaflet pairs with unequal or oblique or round bases. Flowers are solitary and pentamerous. Number of stamens varies from 5 to 10 and ovary 5-chambered. Fruits are the most significant part of this genus that divide at maturity into 5 indehiscent mericarps, each containing 2-5 seeds in a horizontal row.

### Materials and Methods

This study is based on both fresh and dried specimens of *Tribulus* spp. Considerable number of specimens housed in a number of Herbaria in Britain (E, K, BM), Arabian Peninsula (KSU, RIY, KACST, KSUP) and India (Herbarium, Dept. of Botany, Jai Hind College, Dhule) were studied for the preparation of this paper. Herbarium abbreviations are based on Holmgren *et al.*, (1990).

### Results and Discussion

One of the authors (Thomas, J.) had an opportunity to study several specimens collected from Arabian Peninsula over a period of three years. A preliminary survey on the species of *Tribulus* L. belonging to the Arabian Peninsula revealed that there are disparities in the nomenclature on a number of species that have a wider distribution in Saharo-Sindian phytogeographical zone. The species' statuses of typical specimens are easy to determine while atypical ones (hybrid and intermediate forms) often confuse taxonomists to reach a conclusion. There are a number of binomial names created for the recognition of these atypical specimens growing in arid areas by various authors. Although there are sufficient explanations to support the evidences to create new species or to raise the lower taxa to the specific status, various intermediate forms seen in the field often confuse taxonomists/botanists to lump such variants in the right lot. The status of several *Tribulus*

spp. belonging to South Asia and West Asia needs to be clarified. The present study, however, selected only three species; namely *T. rajasthanensis* Bhandari & Sharma; *T. subramanyamii* P. Singh, Giri *et* V. Singh and *T. longipetalus* Viv for evaluation. Among these *T. rajasthanensis* is reported as endemic to Western India (Nayar, 1996). Some of the specimens deposited in the herbaria (KSU, RIY, KACST, E and K) are similar to *T. rajasthanensis* reported from Rajasthan and other arid regions of Western India and therefore the distribution of this species is apparently much wider than expected. New collections of this species from Arabian Peninsula or the West Asia in general show that it is a Saharo-Sindian phytogeographical element with high polymorphism in the morphological characters, particularly in fruits. Nevertheless, the distribution of *T. rajasthanensis* in West Asia is highly restricted. According to Bhandari and Sharma (1977), the species is closely allied to *T. terrestris* L. but can be easily distinguished by its constantly much more densely hirsute mericarps, stouter secondary spines and the complete absence of lower pair of spines. Typical specimens with mature mericarps can be easily told apart while the intermediate forms that show the characters of both *T. rajasthanensis* and *T. terrestris* are difficult to separate. Hemaïd and Thomas (1996) regarded the typical forms of *T. rajasthanensis* Bhandari & Sharma as a variety of *T. terrestris*. Intermediate-forms [e.g. Saudi Arabia: Collette, S. 3805 (E); Oman: Miller, A.G. 2542 (E); Miller, A.G. and Nyberg, J.A.M. 9066 (E)] collected from Oman and Saudi Arabia have shown that there is a gradual transformation of tubercles on the mericarps to spine-like tuberculate hairs. According to the rules of International Code of Botanical Nomenclature, species that show intermediate characters should be regarded as a variety or a subspecies of its closest relative; and hence the present study also agrees to the proposal made by Hemaïd and Thomas (1996) to consider *T. rajasthanensis* Bhandari & Sharma as a variety of *T. terrestris* (*T. terrestris* var. *rajasthanensis* (Bhandari & Sharma) Hemaïd & Thomas). The present study also revealed that the above taxon is no longer endemic to the western region of India. Three other species, namely *T. echinops* Kers from West Africa and *T. hystrix* R. Br. and *T. occidentalis* R.Br.

both from Australia also have morphological features similar to that of *T. rajasthanensis*. The similarities of these species, although located in three different geographical regions, often confuse taxonomists and sometimes forced to believe that all four taxa, to a certain extent, are conspecific. Kers (1971), compared the morphological characters of similar species from Africa and Australia while studying the flora of Angola, also expressed a similar view and commented that it was a case of parallel evolution. The possible explanations for these intermediate forms are several. Hairiness or tuberculate hairs on the surface of mericarps are always associated with the extreme climates of the arid zones. There may be a gradual transformation of hairs to develop into tuberculate hairs or to spine-like hairs as part of an evolutionary trend to withstand extreme climates or to develop an additional mechanism to aid the dispersal of its disseminules. The phenotypic characters on typical forms of *T. rajasthanensis* may be genetically stable for several generations, but the characters displayed on the intermediate forms need to be genetically proved whether or not they are stable or fluctuate between generations. As it is difficult for one to lump the intermediate forms either in *T. terrestris* or in *T. rajasthanensis*, the present investigation also agree to the combination proposed by Hemaïd and Thomas (1996).

There are confusions on the identity of *T. subramanyamii* P. Singh, Giri et V. Singh reported from Peninsular India. The validity of this species is based fundamentally on the differences in the style and intrastaminal glands with that of *T. lanuginosus* L., another species widely recognized in South Asia. There are various opinions about the use of style as a diagnostic character as far as the genus *Tribulus* is concerned. Boissier (1867) and Shukla (1971) believed that, the stylar length is significant in *T. terrestris* complex or in species belonging to the section *Terrestris* in general. According to Boissier (1867), the styles of *T. lanuginosus* L. are elongated and fruits sparsely tubercled while the styles of *T. terrestris* L. are generally short. Shukla (1971) noted these differences on fresh specimens in the field and later carried out morphological studies on specimens grown by him for up to three generations. According

to him the variations he noted on his experimental plants are genetically stable and agree well with his own observations in the natural habitat. On the other hand, Hadidi (1985) and Hosni (1988) are of the opinion that *T. lanuginosus* L. and also *T. hispidus* Presl (another cosmopolitan species similar to *T. terrestris* L.) are nothing but pubescent forms of *T. terrestris* L. Hadidi (1978) in a paper (as a preliminary to his monograph on *Tribulus*) emphatically says “the most reliable and constant morphological characters for *Tribulus* species, and hence of major systematic value are those of the mature carpels and the size of the flower. Variable characters such as habit of the plant, hairiness, size of the leaf and leaflets as well as the morphology of the style and stigma are of minor systematic value”. In majority of works, published elsewhere in the world, particularly in Europe, the intrastaminal glands of these species are not taken as a significant character. If one considers the importance of intrastaminal glands along with the long and short styles of these taxa alone are important enough for segregation, then the nomenclature status of *T. lanuginosus* L. may be considered valid. However, on the basis of observations made on a considerable number of specimens from the countries in Arabian Peninsula and India, the above characters have not shown significant weight, which may be helpful in the separation of *T. lanuginosus* L. from *T. terrestris* L. As far as the general opinion is concerned, *T. lanuginosus* L. is regarded as conspecific with *T. terrestris* L. (Index Kewensis, Version 1993) and therefore published as a synonym of the latter by several authors from West Asia (Blatter, 1978; Hadidi, 1985; Hosni, 1988; Hemaïd & Thomas, 1996; Boulos, 2000). Hadidi (1985) and Hosni (1988) who saw the type specimens of *T. terrestris* [Type: Southern Europe, Linnean Herbarium 574/4 (LINN)] and *T. lanuginosus* L. [Type: Sri Lanka, Linnean Herb. 547/2 (LINN)] believed that, there is no reason for these two taxa to be segregated because the morphology of each one will best fit with that of the other.

There is another group of species in Section *Alata* with several erroneous interpretations and combinations. These are species having winged carpels and 5-10 stamens in each flower. Two categories of species have been reported in this

category. In the first group of species, plants with small flowers (about 5 mm wide) and 5 stamens always have partially developed wing-like triangular projections at the base of the mericarps or rarely with winged mericarps. Well-developed wings (3-10 mm wide) are present in the second category. Flowers of this category are, generally, more than 8 mm wide with 6-10 (-12) stamens. Forsskal's specimen deposited at Copenhagen (Sp. No. 743, Herb-1775. Forssk. C.! *fide* Hadidi) has winged mericarps (wings 2-4 mm broad) and small flowers with 5 stamens. This is the typical *T. pentandrus* Forssk. It is believed to be the first specimen identified as a Tribulus species with winged carpels (Forsskal, 1775). *T. longipetalus* Viv. and *T. alatus* Del. *nom. nud.* are other two names, often, associated with specimens having the above characters. Hadidi (1978), after seeing the type specimens of all three species emphatically suggested that, the characters of *T. longipetalus* Viv (Pl. Egypt, Dec.10, tab. 2, fig. 5. 1831) agrees in every respect with *T. pentandrus* Forssk. Delile (*auct* Hadidi, 1978) too noticed these similarities in the above mentioned type specimens and commented that *T. pentandrus* and *T. longipetalus* are conspecific. He, therefore, did not describe his own "new species", *T. alatus* Del. *nom. nud.*, which was also similar to *T. pentandrus* and *T. longipetalus*.

Hadidi (1972), while writing the Zygophyllaceae account for Flora Iranica did not realize these facts, wrongly interpreted the specific epithet, *T. pentandrus* Forssk. and gave this name to specimens with spinescent mericarps (mericarps with 2 median and 2 basal spines of 1.5-3 mm long), i.e. *T. parvispinus* Presl. (Fl. Iranica, 98/1.12.1972, p. 14-15). The same mistake was repeated by several authors in the region (Ghafoor, 1974; Ghafoor, 1977). Hadidi (1985), however, corrected this mistake (Fl. Trop. E. Afr. Zygo. p.4) and given the names *pentandrus* Forssk. (= *T. longipetalus* Viv; = *T. alatus* Del. *nom. nud.*) to specimens with 5 stamens and mericarps with wings; and *parvispinus* Presl. to specimens with 5-8 stamens and small, spiny mericarps. Thus as per these revelations and also based on the recent accounts on genus *Tribulus* (Hemaid & Thomas, 1996; Collenette, 1999; Boulos, 2000), specimens in India with larger flowers (10 mm wide or more), 8-10 stamens and with

well developed semicircular or trapeziform wings on mericarps should be called *T. macropterus* Boiss. (= *T. longipetalus* ssp. *macropterus* (Boiss.) Maire ex Ozenda & Quezel).

Literature citing the distribution of *T. parvispinus* indicates that, apart from Africa and Middle East, it is also present in Iran, Pakistan and India (Hosni, 1988). However, the presence of this species in India is not confirmed so far or probably the characters of these specimens from India were over looked or the specimens of this species might have lumped in *T. terrestris* L.

While coming back to discuss about the identity of *T. subramanyamii auct* P. Singh, Giri and V. Singh, it is worth pointing out the comparisons and analysis carried out on a number of specimens from West Asia with the description of the above species from the Indian Subcontinent. The taxonomic description (Singh *et al.*, 1983) of this taxon "sed stylis dense brunneo pubescentis, glandulis, intra-staminalibus connatis et ciliatis" is well fit with morphological characters of some forms of the widely distributed species, *T. terrestris* L. or rather with the hybrid forms of *T. terrestris* L. and *Tribulus kaiseri* Hosni-in El-Hadidi, *Taeckholmia* 9: 63. 1978- (= *T. terrestris* var. *inermis* Boiss.) or the hybrid forms between *T. terrestris* and *T. parvispinus*. In *T. kaiseri* Hosni, mericarps are unarmed. The characters of fruit (Singh *et al.*, 1983. p198), "mericarps 5.0-10.0 mm long, 3.5-6.0 mm broad excluding the spines, dorsally ridged, appressed silky hairy, rarely tubercled, greenish or greenish-yellow, divided by transverse septa inside; spines 4, tomentose with glabrate apex. Lateral spines 2, conical, submedian, 3.5-5.0 mm long, basal spines 2, sometimes reduced to tubercles, directed downwards at an angle" are also, to a certain extent, similar to the characters of the intermediate forms of *T. terrestris* and *T. kaiseri* (Saudi Arabia: S. Collenette-4764- E; Migahid, A.M., 1439, 1457-KSU). It is also interesting to pay an attention on the morphological description of *T. terrestris* var. *bicornutus* (Fisch. & C.A. Mey.) Hadidi, mentioned in Flora Iranica (Hadidi, 1972; p17). The description says ".....Flores 10mm diametro; petala alba vel flava; stamina 5-10. Fructus 10 mm diametro; mericarpium virescens, sparse pilosum vel canescens, lanatum, spinis binis superioribus bene evlutis, binis

interioribus ad tubercula minuta reductis vel omnino deficientibus". This description also appears to be similar to the description of *T. subramanyamii* except for the intrastaminal glands, which is not included in the text. This variety is also now regarded as a synonym of *T. terrestris* L. (Ghafoor, 1974; 1977). As the authors of this paper have not seen any authentic specimen of *T. subramanyamii* Singh *et al.*, the authenticity of this species is left unattended pending a thorough revision in this complex genus, particularly on species with spiny mericarps.

### Conclusion

A provisional key for the determination of *Tribulus* L. in India

1. Mericarps winged 2  
1+Mericarps spiny or unarmed or look-like unarmed 3
2. Stamens usually 5; wings of mericarps 2-4 mm wide or represented by small spinules at the base of the mericarps; margin of the wing much dentate 3  
*T. pentandrus*  
2+ Stamens 8-10; wings of mericarps 6-10 mm wide; margin shortly or shallowly few dentate. 3  
*T. macropterus*
3. Flowers smaller, 5-15 mm wide 4  
3+ Flowers larger, 25-40 mm wide. 4 *T. cistoides*
4. Mericarps with two lateral spines and 20-25 unequal spines spreading throughout 4 *T. terrestris*  
*var. rajasthanensis*  
4+ Mericarps with 2 lateral spines and two basal spines or the basal spines absent. 5
5. Style puberulous, intrastaminal glands connate and ciliated. 5 *T. subramanyamii*  
5+Style glabrous, intrastaminal glands free, not ciliated 6
6. Flowers 5-7 mm wide; Stamens 5-8; fruit 6-8 mm in diameter including spines; lateral spines 1.5-3 mm long; basal spines small or reduced to tubercles. 6  
*T. parvispinus*  
6+ Flowers 7-15 mm wide; Stamens usually 10; fruit 9-15 mm in diameter including spines; lateral spines 5-8 mm long; basal spines 3-5 mm long. 6  
*T. terrestris*.

1. ***Tribulus pentandrus*** Forssk. F. Aegypt. Arab., 88 (1775).

Syn.: *T. alatus* Delile, Descr. Egypte, Hist. Nat.: 62 (1813) *nom superfl.*; *T. longipetalus* Viv. Pl. Aeg. Decade (4) 1: 10, tab.2. f. 5 (1831); *T. alatus* Delile var. *odontopteris* Kralik, Ann. Sci. Nat., ser. 3, 11: 30 (1840), *nom. illeg.*

2. ***Tribulus macropterus*** Boiss., Diagn. Pl. Orient., ser. 1, 1: 61 (1843).

Syn.: *T. persicus* Kralik, Ann. Sci. Nat., ser. 3, 11: 31 (1849); *T. pterocarpus* Ehrenb. ex C. Muell. in Walp. Ann. iv. 404 (1846); *T. longipetalus* var. *macropterus* (Boiss.) Maire ex Ozenda & Quezel, trav. l'Inst. Recherches Sahariennes 14: 73 (1956).

Some of the specimens in Rajasthan State with mericarp-wings larger than 8 mm broad were attributed to *T. pentandrus* var. *pterophorus* (Presl.) Singh & Singh. Mericarp wings of typical specimens of *T. pterophorus* Presl are larger (10-15 mm) than *T. macropterus* Boiss.

3. ***Tribulus terrestris*** L. Sp. Pl., ed. 1, 387 (1753).

Syn.: *T. lanuginosus* L. Sp. Pl., ed. 1, 387 (1753); *T. bicornutus* Fisch. & Mey., in Bull. Soc. Nat. Mosc. 391 (1838); *T. robustus* Boiss. & Noe in Boiss., Diagn. Pl. Orient., ser. 2, 1: 112 (1854); *T. orientalis* Kerner, Ber. Naturwiss.-Med. Vereins Innsbruck, 3. 1872; *T. lanuginosus* var. *orientalis* (Kerner) Nayyar *et* Giri, Bull. Bot. Sur. Ind. 24 (1-4): 161 (1982). var. *rajasthanensis* (Bhandari & Sharma) Hemaïd & Thomas, Arab Gulf Jour. Sci. Res. 14(2): 437 (1996).

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

4. ***Tribulus cistoides*** L. Sp. Pl. 387 (1753).

Syn.: *T. lanuginosus* Blanco. Fl. Filip. Ed. I, 350

5. ***T. parvispinus*** Presl, Bot. Bmerk. 29 (1844).

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) *non* Forssk.

(Inclusion of this species in the flora of India is based on a remark by Hosni (1988). Authenticity of its presence in India is not yet confirmed).

6. ***Tribulus subramanyamii*** P. Singh, Giri *et* V. Singh. Bull. Bot. Surv. India, 25 (1-4): 197-198 (1983).

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