A trial key and notes on *Tribulus* (Zygophyllaceae) in Australia, including one new species and validation of *Tribulus suberosus*

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Abstract

R.M. Barker. A trial key and notes on *Tribulus* (Zygophyllaceae) in Australia, including one new species and validation of *Tribulus suberosus*. Nuytsia 12 (1): 9-35 (1998). A trial key is presented to those species of *Tribulus* L. which occur in Australia, together with notes on the taxonomy and biology of these species. Taxonomy of the native species which are not related to *T. terrestris* L. is clear cut, apart from the addition of a new species, *T. adelacanthus* R.M. Barker, most closely related to *T. hirsutus* Benth. and *T. macrocarpus* F. Muell. ex Benth. In contrast, the taxonomy of those species surrounding the *T. terrestris* complex is sorely in need of a world revision. Two taxa are informally described from within that group and there is a discussion of the taxa in the *T. terrestris* complex. *T. suberosus* H. Eichler ex R.M. Barker is validated and lectotypes are designated for several species.

Introduction

The taxonomy of *Tribulus* L. (Zygophyllaceae) is very much in need of a detailed revision world-wide, particularly of those species with spiny cocci i.e. *T. terrestris*, *T. cistoides*, *T. occidentalis*, *T. hystrix* and related species. The classification presented here is the traditional approach taken to the genus for a number of years but the author has often had difficulty in satisfactorily delimiting the taxa of the *T. terrestris* complex, and in distinguishing between *T. cistoides* and *T. eichlerianus*, *T. cistoides* and *T. occidentalis* and between *T. occidentalis* and *T. hystrix*. Most fruiting specimens can be assigned to a taxon but there are specimens which erode the differences between species, such that it is often difficult to find reliable distinguishing characters. A number of possibilities could explain this:

1. There are more or less taxa present here in Australia than the present classification suggests.
2. Hybridization is occurring between taxa which were previously geographically isolated.
3. Morphological expression is very plastic and much influenced by environment.

Until there is a better understanding of the biology of these mostly introduced species, combined with field studies, it is unlikely that a stable classification can be achieved. There is particular difficulty with specimens from the north-western areas of Western Australia where a number of species overlap in distribution and there are, as a consequence, a number of collections which cannot be satisfactorily placed at the species level. Even being able to identify those taxa which have been introduced may help considerably in understanding the taxonomy of this group. For example, at the moment it is considered that some of the taxa in the *T. terrestris* group are native, but this may not be the case. The smaller, more

or less unarmed cocci of *T. minutus* and *T. micrococcus*, both considered to be native to Australia, could well relate to *T. terrestris* var. *inermis* Boiss. or var. *bicornutus* (Fisch. & C.A. Meyer) Hadidi as depicted in the treatment of Zygophyllaceae (El Hadidi 1972) in "Flora Iranica". In contrast to the complexities within section *Terrestris*, the other native Australian species are usually easily distinguishable.

The purpose of this paper is to provide an overview of *Tribulus* in Australia, to highlight the problems and to provide an interim working key to taxa.

Generic and infrageneric considerations

All of the species of *Tribulus* (and *Tribulopis* R. Br.) in Australia were transferred to *Kallstroemia* Scop. by Engler (1890). One species, *T. platypterus*, presumably because of its bushy habit where all other species were prostrate, continued to be referred to *Kallstroemia* even after the rest had been transferred back to *Tribulus*.

Porter (1971) in his notes on the floral glands of *Tribulus* indicated that "the principal diagnostic floral characters distinguishing *Tribulus* from the closely related genus *Kallstroemia* Scop., with which it is often confused, is the presence of a whorl of five intrastaminal glands at the base of the ovary in *Tribulus*". These intrastaminal glands are unmistakably present in the species surrounding the *T. terrestris* complex and in the other spiny-fruited *Tribulus* species whose taxonomy is not clear cut as discussed above. These glands are absent in the native Australian species, *T. suberosus*, *T. platypterus*, *T. forrestii*, *T. astrocarpus*, *T. hirsutus* and *T. macrocarpus*, raising the possibility that they might be more appropriately treated as *Kallstroemia* than *Tribulus*. However, *Kallstroemia* is further characterized by a 10-lobed stigma and fruit and a 10-lobed disc upon which the 5 stamens are attached, all characters not applicable to the endemic Australian species. Thus it seems likely that the native Australian species could well form their own section within *Tribulus* based on the lack of the intrastaminal glands.

This approach would not be supported by El Hadidi's (1978) classification where he proposed three sections for *Tribulus*, based on fruit morphology. Section *Terrestris* consisted of all of the species within the *T. terrestris* complex and *T. astrocarpus*, section *Alata* of those species with winged carpels and section *Inermis* of species with unarmed and unwinged fruits. He further suggested that *T. platypterus* might represent a new genus because of its unique shrubby habit. Based on his classification the Australian species would be disposed as in Table 1.

Table 1. Placement of the Australian species of *Tribulus* in the sections recognized by El Hadidi (1978).

section *Terrestris*	section *Inermis*	section *Alata*
T. terrestris complex	?*T. forrestii* F. Muell.	*T. platypterus* Benth.
T. hystrix R. Br.		*T. suberosus* H. Eichler ex R.M. Barker
T. occidentalis R. Br.		*T. macrocarpus* F. Muell. ex Benth.
T. eichlerianus K.L. Wilson		?*T. hirsutus* Benth.
T. cistoides L.		
T. astrocarpus F. Muell.		

There are problems with this classification when applied to the Australian species. *T. forrestii* agrees closely with the fruits of *T. kaiseri* H. Hosni pictured by El Hadidi (1978) as representative of section *Inermis*, except that it does possess a pair of median spines. Similarly some of the forms of *T. terrestris* in Australia, referred to *T. micrococcus* and *T. minutus,* are almost without spines and approach section *Inermis*. *T. forrestii* would appear to differ from all species within section *Terrestris* and section *Inermis* by the lack of the intrastaminal glands. *T. astrocarpus* was placed by El Hadidi in section *Terrestris* but as stated above, it lacks the intrastaminal glands of that group.

There is also variation within the Australian species assigned to section *Alata*. While *T. platypterus* and *T. suberosus* have clearly winged fruits which agree well with the fruits of this section, their shrubby habit is at odds with the more usually prostrate species of *Tribulus*. The fruits of *T. hirsutus*, while clearly winged in the dry state, seem to be derived by a different process to the other winged fruits. In their fresh state, fruits of *T. hirsutus* appear much more like the fruits of section *Inermis* since the walls are greatly inflated. It is only on drying that these walls collapse in on each other to give a winged appearance. *T. macrocarpus*, also assigned to this section, has a pair of median spines between the wings of each carpel. *T. astrocarpus* was placed in section *Terrestris* by El Hadidi although its relationships would appear to be with *T. macrocarpus* if the author has correctly interpreted the structure of the fruit of the newly described *T. adelacanthus* (see below).

In the forthcoming treatment for the "Flora of Australia", the species have been placed in informal groupings based on a number of characters, including habit, sepal characters, presence or absence of intrastaminal glands and fruit characters. The position of the endemic Australian genus *Tribulopis,* sometimes included in *Tribulus,* also requires further study, but for the purposes of this paper it is treated as a distinct genus.

Biology

Longitudinal rolling of petals

It is quite noticeable that the petals of most, if not all, *Tribulus* species in Australia are widespread and plate-like in open flower, but when the flower closes the petals roll up longitudinally and stand erect about the centre of the flower. The reason for this characteristic is not known. It may be a signal that the flower is finished, it may be a means of surrounding the stigma by the stamens and thus ensuring pollination or alternatively, as has been observed in *T. hystrix*, the rolling of the petals may include the stamens and prevent self-pollination. There is also a possibility that allowing post-floral access time to the nectaries may encourage ant activity and thus discourage attack of the ovary by other boring insects.

Dispersal unit

Despite some observations to the contrary (see under *T. suberosus* below), the fruits of all of the *Tribulus* species in Australia do eventually dissociate into fruitlets or cocci for dispersal. All species have the potential to produce 5 cocci from each fruit, but the actual number of cocci developing to maturity ranges from 1 to 5. Enclosed within the extremely hard cocci of the mature fruit are the seeds, which this author has found to be impossible to extract without damage.

Those species which have spines on the fruit clearly belong to the dispersal syndrome known as "trample burrs" (van der Pijl 1972). Thus species of *Tribulus* section *Terrestris*, together with *T. astrocarpus* and possibly *T. forrestii* are all prostrate and all have hard fruits lying upon the ground. Any pressure applied to these fruits from above will first of all cause dissociation of the cocci and, depending on the length of the spines and the hardness of the object applying pressure, may well result in penetration of the object applying the pressure. The subsequent dispersal will presumably depend on the effect that the penetrating spines have on the object. If the penetration causes irritation, it is likely that the dispersal will not be far, but in the case of an inanimate object such as a tyre or boot, the dispersal could be much further. It is interesting to note the record of 1911 (Dill & Bryan 1912) where an expedition to Laysan Island in the Hawaiian Group recorded a spiny *Tribulus* "seed" embedded in the sides of the toes of a Laysan albatross. This was identified as *T. hystrix*, which is certainly incorrect. It is more likely to have been the coastal species, *T. cistoides*. It is probably because of this dispersability that there is a problem with the taxonomy of section *Terrestris*.

On the other hand there is less of a problem with the taxonomy of the wing-fruited *Tribulus* species in Australia, and this may relate to the short distances over which they are dispersed. This group of species belonging to section *Alata* produce 5-winged fruits which at maturity, break into five 2-winged cocci. While workers in *Tribulus* (e.g. El Hadidi 1978) comment on the unusual (for *Tribulus*) upright shrub habit of *T. platypterus* and *T. suberosus*, dispersal of these winged cocci from a height would seem to be more efficient than dispersal from ground level, and it has to be asked what function a wing could have for a fruit which is already on the ground. The only time wings would seem to be advantageous in this situation would be if there were no competing vegetation and wind was a factor in the environment. *T. macrocarpus* is one such prostrate species producing winged fruits although the wings are much more thickened and not as wide as those in *T. platypterus*. It is found in mulga areas on red sand and under these conditions it is quite easy to envisage the circular fruit with its 5 wings as the primary dispersal agent. Subsequent dissociation of the fruit into its 2-winged cocci gives a secondary means of dispersal.

For a discussion of the particular dispersal characteristics of *T. suberosus* and *T. platypterus*, see under *T. suberosus* below.

Scavengers of seed

In the mature fruit it is extremely difficult to remove seed from the hardened area of the coccus which surrounds it. *T. eichlerianus* is known to be a favoured food source of the Red-tailed Black Cockatoo (D. Albrecht, pers. comm. 1996), and it would not be surprising if *T. forrestii* and *T. macrocarpus* were also subject to attack in a similar fashion. In one specimen of *T. suberosus* at least (*Eichler* 23606 *p.p.*), the hardened area about the seed has been neatly opened and the seed removed, and it is presumed, because of the strength needed, that this was also done by a cockatoo.

Little evidence of insect attack was found on the mature fruits of *Tribulus*, but it would be surprising if there was not some interest shown by borers and/or weevils.

Possible ant attractants

In *T. platypterus*, the area exposed when the fruitlets separate, particularly the area covering the seed, is covered with tiny gland-like excrescences which are here postulated to be food reward for ants. These glands are also to be found in *T. suberosus* but do not appear to be as numerous, and they have also, somewhat surprisingly, been seen in some members of the *T. terrestris* complex. The gland-like excrescences appear identical with those found on *Sida* L. (Malvaceae) cocci which are dispersed by

ants, but such glands appear never to have been investigated for an insight into the reward they might be offering. Given the size of the *T. suberosus* fruitlet, any movement by ants would have to be by the larger representatives of the community.

Tentative key to *Tribulus* in Australia

It is unlikely that a vegetative key to *Tribulus* would be very satisfactory since there is overlap in most leaf characters, but the number of leaflets has been included as a subsidiary character for each of the species, along with the distribution. The key does rely on the presence of flowers or fruits. Relative style and stigma lengths are also important, but these can be judged from the flower or the fruit since the style and stigma invariably persist for some time and their relative lengths are unchanged.

1 Upright bushes. [Fruits winged, lacking any spines]

2 Stems with corky bark. Sepals sparsely sericeous or patchily villous adaxially. Fruits tardily dissociating, densely pubescent between wings. [Hamersley Region, WA. Leaflet pairs (1)2-4(5)] ..... **2. T. suberosus**

2: Stems usually lacking corky bark. Sepals densely villous adaxially. Fruits quickly dissociating, sparsely pubescent between wings. [Hamersley Region, WA. Leaflet pairs (4)5-7] ..... **1. T. platypterus**

1: Prostrate herbs

3 Fruits star-shaped when viewed from above. [Mulga woodlands from Carnarvon to Warburton in WA, southern NT, northern SA and SW Qld. Leaflet pairs (3)4(5)] ..... **7. T. astrocarpus**

3: Fruits 5-lobed, or 5-winged, irregular or symmetrical, but not star-shaped

4 Fruits winged, at maturity splitting into five 2-winged cocci

5 Plants glabrescent. Fruits sparsely appressed pubescent, with a pair of median spines between the wings. [Cape Range to Geraldton and inland to southern NT and northern SA, usually in red sand. Leaflet pairs 5-7] ..... **5. T. macrocarpus**

5: Plants villous. Fruits densely pubescent between wings, lacking spines

6 Fruits 20-32 mm high, 20-45 mm wide; wings lacking any hardening or spines, very inflated in fresh state. Style and stigma 3.5 mm long. [Hamersley region through to Rudall River and Great Sandy Desert in WA to southern NT. Leaflet pairs (3)5-6(8)] ..... **3. T. hirsutus**

6: Fruits 10-14 mm high, 18-25 mm wide; wings with hardened structures equivalent to spines just below middle in dried condition, in fresh state unknown. Style and stigma 1.8-2.3 mm long. [Mount Magnet, Newman, Leonora area, possibly extending through to Gibson Desert. Leaflet pairs (3)4-5(6)] ..... **4. T. adelacanthus**

4: Fruits not winged

7 Plants subglabrous. Intrastaminal glands lacking. Fruits 5-lobed, glabrous or sparsely pubescent; cocci dorsally ± smooth, reticulately marked, rounded and with a pair of median spines. [Carnarvon/Shark Bay area of WA. Leaflet pairs 6-7] ..... **6. T. forrestii**

7: Plants villous. Intrastaminal glands present. Fruits irregular or 5-lobed, sparsely to densely pubescent; cocci dorsally spiny or tuberculate, rarely rounded, usually with more than median pair of dorsal spines

8 Fruits with many spines distributed randomly all over; cocci not bilaterally symmetrical

9 Fruits with spines 10-17 mm long; petals 15-30 mm long. Style 4-5 mm long. [Fruits up to 30 mm high and 50 mm wide. Red sand dunes of central interior of Australia. Leaflet pairs (4)7-9] ..... **9. T. hystrix**

9: Fruits with spines less than 8 mm long. Petals 6-17 mm long. Style less than 2 mm long

10 Flowers with petals 10-17 mm long. Fruit 10-20 mm high, 20-30 mm wide, spines 4-6(8) mm long. [Coastal areas of WA from Broome to Carnarvon. Leaflet pairs 7-10] ..... **8. T. occidentalis**

10: Flowers with petals 6-7 mm long. Fruit 7-10 mm high, 12-15 mm wide, spines 0.5-4 mm long. [Saline soils on edges of salt pans, central Australia. Leaflet pairs 6-7] ..... **10. T.** sp. **saline flats**

8: Fruits sometimes tuberculate and often with a pair of median and basal spines, but lacking spines distributed all over; cocci bilaterally symmetrical

11 Flowers with petals more than 15 mm long. [Stigma shorter than style]

12 Style 4 mm long or more; petals 15-35 mm long. Leaves with 8-10 pairs of leaflets; leaflets less than 2.5 mm wide. [Kununurra and Victoria River area. Leaflet pairs 8-10] ..... **11. T. ranunculiflorus**

12: Style less than 4 mm long; petals 15-18 mm long. Leaves with 5-8 pairs of leaflets; leaflets 3-5 mm wide

13 Fruit pubescent with relatively dense short hairs overtopped by sparser long strigose hairs; median pair of spines present or absent. [Tanami in NT to Rudall River, Giles and Hamersley region in WA. Leaflet pairs 6-8] ..... **14. T.** sp. **long-styled eichlerianus**

13: Fruit subglabrous, very sparsely strigose; median pair of spines always present. [Coastal sands of tropical Australia. Leaflet pairs 5-7] ..... **12. T. cistoides**

11: Flowers with petals less than 15 mm long

14 Fruits 7-13 mm high, 10-20 mm wide, densely pubescent all over. Intrastaminal glands forming a ring. [Stigma 1.3-2.5 mm long, longer than style. Drier areas of all states except Victoria and Tasmania. Leaflet pairs 6-10] ..... **13. T. eichlerianus**

14: Fruits 4–7.5 mm high, 5-13 mm wide, subglabrous to moderately pubescent only. Intrastaminal glands 5, distinct [*T. terrestris* complex]

15 Cocci with distinct divergent, median spines 3-8 mm long

16 Style 0-0.3 mm long, shorter than stigma. [Southern Australia in waste places, also about Broome, WA. Leaflet pairs 4-7] ..... **15a. T. terrestris (short style)**

16: Style 0.6-1.4 mm long, longer than or equal to stigma. [Northern Australia in waste places. Leaflet pairs 4-7] ..... **15b. T. terrestris (long style)**

15: Cocci either lacking median spines or these less than 3 mm long

17 Style 0.2-0.7 mm long, shorter than or equal to stigma. Petals 2.5-7 mm long. Fruits 5-7.5 mm high. [Mostly southern Australia, with larger fruited specimens through to Alice Springs area. Leaflet pairs 5-7] ..... **16. T. minutus**

17: Style 0.7-1.4 mm long, longer than or equal to stigma. Petals 5-15 mm long. Fruits 4-5 mm high. [Central Australia & Qld. Leaflet pairs 4-7] ..... **17. T. micrococcus**

Endemic Australian species not included in Section *Terrestris* Hadidi

1. Tribulus platypterus Benth., Fl. Austral. 1: 289 (1863). *Type:* For citation of types see Barker (1996).

Distinguishing features. Distinguished from all other *Tribulus* species except *T. suberosus* by its shrubby habit. *T. platypterus* differs from *T. suberosus* by the lack of development of corkiness on the stems, by its fruits more or less glabrous between the wings, by its longer styles (4-6.5 mm long) and by the higher number of leaflet pairs on a mature leaf (5-7).

Notes. The record of this species for the Kimberley region by Lawrence (1992) is erroneous. The cited collection from 17 miles north of Christmas Creek on the Rabbit Proof Fence represents the Christmas Creek just north of Roy Hill and not the Christmas Creek in the southern Kimberley. Thus *T. platypterus* occurs from the Hamersley Pilbara region across to Rudall River in Western Australia. It does not extend as far south as *T. suberosus*.

2. Tribulus suberosus H. Eichler ex R.M. Barker, *sp. nov.*

Tribulus suberosus H. Eichler ex R.M. Barker, J. Adelaide Bot. Gard. 17: 171 (1996) *nom. inval.*, type not cited.

Typus: At the base of Mt Bruce, Hamersley Range National Park, Western Australia, 1 May 1977, *Hj. Eichler* 22569 (*holo:* CANB 255582; *iso*: PERTH 04182464, NSW).

Specimens examined. WESTERN AUSTRALIA: Opposite Fortescue roadhouse, 30 Aug. 1985, *Hj. Eichler* 23606 (CANB, MEL, NSW, PERTH - mixture of *T. platypterus* and *T. suberosus*); Karratha, Sep. 1982, *P. Glennon* 64B (PERTH).

Distinguishing features. Distinguished from all other *Tribulus* species except *T. platypterus* by its shrubby habit. *T. suberosus* differs from *T. platypterus* by the development of corkiness on the stems, by its fruits with dense pubescence between the wings, by its shorter styles (2-4 mm long) and by the lower number of leaflet pairs on a mature leaf (2-4).

Comments on the type collection. The type collection displays the very characteristic corky stems of the species, although it should be noted that occasional *T. platypterus* specimens also develop some corkiness (e.g. *Eichler* 23606). A number of fruits are also present on the holotype and these display another characteristic of the species which distinguish it from *T. platypterus*, *viz.* the dense pubescence to be found in the area between the wings. No flowers are present.

Notes. The name *T. suberosus* H. Eichler ex R.M. Barker, published by the author (Barker 1996), was invalid since the type was inadvertently omitted. The name is validated here by the citation of the type with reference to the previously published description and diagnosis (Article 32.3, International Code of Botanical Nomenclature, Greuter 1994). As well as the description and Latin diagnosis, all other details of distribution, ecology, synonymy and specimens examined are to be found in the earlier publication.

Dispersal of *T. suberosus* and its close relative, *T. platypterus*, has not been documented but the following observations have been made. It has been reported that the larger fruit of *T. suberosus* does not break as easily into its five 2-winged components as does that of *T. platypterus*. This comment was provided by Mrs P. Glennon who noted on her collection (*Glennon* 64B) of *T. platypterus*, that "fruits separate easily when ripe unlike inland wood ones [?*T. suberosus*] which are large and adhere." Mrs Glennon further credits Jack Paine, the last government nurseryman [in Karratha], as noting that the inland variety which is presumably attributable to *T. suberosus* as above "germinates best if no attempt is made to separate carpels". My own field observations do not support this. While *T. suberosus* fruits may be tardier to break up than those of *T. platypterus*, since at the green stage they show no inclination to split apart and this continues even when the fruits are dried, they do break up quite easily (on touch) provided the fruit is ripe and yellowish in colour. The dispersal unit in both species is the 2-winged fruitlet.

3. Tribulus hirsutus Benth., Fl. Austral. 1: 289 (1863). *Type citation:* Nich[k]ol Bay, *F. Gregory. Type:* Nickol Bay [Western Australia], *s.dat.* [1861], *P. Walcott s.n.* (*lecto,* here designated: MEL 79405); Nickol Bay [Western Australia], *Gregory's Expedition, s.dat.*, Herb. *Mueller s.n.,* (*isolecto:* K-herb. Hooker).

Tribulus alatus auct. non Delile: F. Muell., Trans. Bot. Soc. Edinburgh 7: 487(1863).

Distribution. Found in the Pilbara region of Western Australia through to the Rudall River area and Great Sandy Desert to southern Northern Territory.

Distinguishing features. In fresh material the fruits are deeply 5-lobed, soft-textured and without any spines. Other species, such as *T. forrestii, T. macrocarpus* and some of the *T. terrestris* group could be described as 5-lobed but they all have a much more leathery texture and have median spines. At maturity, in dried specimens, the wings of the fruit are usually much larger in *T. hirsutus* than any other species in Australia, although there are a few specimens where the wings are similar in size to those of *T. platypterus* and *T. suberosus.* However these latter species are shrubs, while *T. hirsutus* is prostrate.

Typification. The MEL sheet indicates that the collector of this species was Pemberton Walcott, a volunteer member of Francis Gregory's 1861 expedition to the Hamersley region (Birman 1979). The sheet in K does not indicate the collector but merely that it was the result of Gregory's Expedition. Mueller has annotated the MEL sheet as "T. alatus?" and just below this Bentham has annotated it as *Tribulus hirsutus*. Both collections are scrappy but there is more material on the MEL sheet and so it has been selected as the lectotype.

Bentham's erroneous protologue description of the species as "a shrub allied to T. platypterus" was presumably based on the resemblance of the fruit of *T. hirsutus* in the dried state to that of the shrubby species *T. platypterus* of the same region. There are no notes on habit with the specimen and it is impossible to determine that it is prostrate from the scrappy fragments which make up the type sheets.

Notes. This is a variable species with respect to leaflet size and pubescence. The fruits of this species are markedly different in their fresh state to those encountered on the herbarium sheet or in the dried

state. Before drying out, the walls of the five carpels are quite inflated and with brown or red coloration, resembling more the shape of the fruit in *T. forrestii*. On drying, the lateral walls collapse in on each other and then split to form the two wings of each fruitlet. The dispersal unit is the two-winged fruitlet as in *T. macrocarpus, T. suberosus* and *T. platypterus*, but it is almost certainly derived in a different fashion, since these latter species are clearly 5-winged from their earliest formation.

4. Tribulus adelacanthus R.M. Barker, *sp. nov.*

Species nova *T. macrocarpo* proxima sed differt densibus pubescentibus fructibus et destitutis paribus spinarum inter alas.

Typus: c. 22 miles [35 km] south of Wongawol Station Homestead, Western Australia, 28 July 1963, *A.S. George* 5588. Prostrate ephemeral herb; fruits orange-brown. (*holo:* PERTH 03776166; *iso:* CANB 359689).

Prostrate *herb*, stems at least 20 cm long. *Leaves* in unequal pairs or, more usually alternate, with (3)4-5(6) pairs of leaflets above 4-11 mm long petiole; leaflets elliptic or ovate, sometimes narrowly so, shortly petiolulate, rounded-oblique, shortly acuminate, ± concolorous, glabrous or sparsely white villous adaxially, denser abaxially, 5.5-11 mm long, 3-4.5 mm wide. *Fruiting pedicel* 9.5-14 mm long. *Sepals* mostly unknown, but villous externally. *Flowers* unknown. *Ovary* densely white pubescent, 5-celled; style and stigma 1.8-2.3 mm long in fruit, stigma 0.5-1.0 mm long. *Fruit* star-shaped with apical conical projection, 10-14 mm high, 18-25 mm wide, 5-winged by wings from apex of conical projection to the ends of each of the arms and then to the apex of the pedicel, densely pubescent all over with a mixture of simple, bent, shorter, softer hairs and longer, more robust hairs, lacking external spines, probably dissociating into five 2-winged cocci.

Specimens examined with typical features. WESTERN AUSTRALIA: 10 km from Mount Magnet on Geraldton Road, 9 Mar. 1963, *Y. Chadwick* 1979 (PERTH); Leonora district, July 1963, *S.B. Dimer per A.C. Linto s.n.* (PERTH); Bulloo Downs Station, 3 Oct. 1978, *A.A. Mitchell* 640 (PERTH); Ashburton, Sep. 1971, *M. Wittwer* S1775 (PERTH).

Specimens examined with affinities to T. macrocarpus. WESTERN AUSTRALIA: Eagle Bore Study area, Gibson Desert Nature Reserve, burnt site 3 km N of camp, 2 Sep. 1991, *A. Chapman & S. Fraser* 89 (PERTH); Young Range, Gibson Desert, Sep. 1992, *Desert Dreaming Expedition* 9 (PERTH); Exburn, N of Camp Zone 3, Gibson Desert Eagle Camp, Sep. 1992, *Desert Dreaming Expedition* 144 (PERTH).

Distribution. Known only by four collections in Western Australia, one from Bulloo Downs, south of Newman, one from the Mount Magnet area, one from the Leonora district and one from the Wongawol area near Lake Carnegie. Specimens from the Gibson Desert may also belong here. Ecology and flowering time of the species is unknown.

Etymology. The specific epithet comes from *adelos*, Greek for unseen or obscure and *acantha,* Greek for spine or thorn, in reference to the spines which in this species are apparently hidden within the wings.

Distinguishing features. As with most *Tribulus* species it is the fruit shape which is diagnostic for *T. adelacanthus.* As stated below the fruits appear to be based on the same framework as the fruit of *T. astrocarpus* but with an added wing from the apex to each of the legs and then to the apex of the pedicel. The fruits are densely pubescent all over.

Notes. Tribulus adelacanthus is described from limited material. The author would appreciate further collections so that its variability and relationships can be properly investigated and its description completed.

It has sometimes been confused with *T. hirsutus* in the past although Lawrence (on PERTH specimens) suggested that it was "intermediate between *Tribulus* sp. B [*T. ?suberosus*] and *T. hirsutus*". *T. hirsutus* has very inflated cocci in its fresh state and there is no underlying hardened framework within the walls of these cocci, as there is in *T. adelacanthus*.

Based on the fruit alone, *T. adelacanthus* seems to be closely related to *T. macrocarpus* and *T. astrocarpus*. The spines usually present between the wings of *T. macrocarpus* appear to have become longer and amalgamated with the wing. Another way of viewing the fruit is as a *T. astrocarpus* fruit with wings from the apex to the end of each of the five spines, these wings then continuing from the spines to the pedicel apex and base of the fruit.

The presence of spines within the wing is not unknown since material of *Tribulus cristatus* from South Africa, seen in AD, has numerous spines projecting from the ends of its wings.

T. macrocarpus and *T. adelacanthus* can be distinguished by the subglabrous fruits with only a sparse appressed pubescence and external spines between the wings for *T. macrocarpus* compared with the pubescent fruits and internal spines of the new species. There may also be a distinct difference in the lengths of the style and stigma between the two taxa, with those of *T. macrocarpus* being longer, but there is insufficient flowering material of the new taxon to be sure about this. The new taxon may also have a more southerly and inland distribution than *T. macrocarpus*.

The Gibson Desert collections have the spines more or less amalgamated with the wing but the fruits are not as densely pubescent as those of collections from further south. They also appear to have the shorter styles and stigmas associated with the new taxon, but the lengths also apply to *T. macrocarpus* with which these collections also have affinities.

5. Tribulus macrocarpus F. Muell. ex Benth., Fl. Austral. 1: 289 (1863). *Type citation:* N. Australia. In the interior, from Nichol Bay, *F. Gregory. Type:* Nickol Bay [Western Australia], *s.dat.*, *Anon.* [Unknown. Brought in from interior by Party] (probable *holo:* MEL 79423).

Tribulus sp. F. Muell., Trans. Bot. Soc. Edinburgh 7: 487 (1863).

Specimens examined. WESTERN AUSTRALIA: 125 km S of Barradale, *Hj. Eichler* 23611B (CANB, PERTH); *c.* 0.5 km N of No. 18 Bore, Hamelin Station, *Hj. Eichler* 23646 (CANB); Cape Range, *Grealy* 10 (PERTH).
NORTHERN TERRITORY: South Lake Hopkins, *P.K. Latz* 7998 (CANB, DNA).

Distribution and ecology. Found in dry areas of Western Australia, from Cape Range to Geraldton and inland to southern Northern Territory, and north of Oodnadatta in South Australia. Found in red sand, usually in mulga with *Aristida, Plectrachne* or *Triodia*, sometimes the sand over limestone.

Phenology. Flowering predominantly April through to September, occasionally also outside these months.

Distinguishing features. Fruits in this species resemble small balls with 5 narrow longitudinal wings. Between the wings there are usually two median downward pointing spines, although these are not always obvious.

Typification. The type in MEL consists merely of 13 dissociated cocci with quite narrow wings. There is nothing on the labels to indicate that the collector was Gregory, indeed it is unlikely that it was him since it was brought in by the "Party". The material is annotated with the name by Mueller and has been seen by Bentham. In the same year as the protologue Mueller mentioned this species in an account of the specimens collected on the Gregory expedition (Mueller 1863) but did not use the epithet he had coined.

Notes. A single specimen from the Cape Range (*Grealy* 10) has much larger flowers and a longer style and stigma than is usually found in this species. Whether this is of any taxonomic significance is unknown since there is only the one collection from the area, but the Cape Range is known to support plants which show divergence from the rest of their species or are in fact different taxa e.g. *Calophanoides* (Acanthaceae), *Abutilon* (Malvaceae), *Stackhousia* (Stackhousiaceae).

6. Tribulus forrestii F. Muell., Southern Science Record 1 (New Series) (Nov. 1885), apparently distributed only as page proofs to Kew and Germany, but also published by Mueller in Bot. Centralbl. 24: 373 (1885). *Type citation:* Near the Gascoyne-River, Hon. J. Forrest; also sent from thence by Mr. Jones, but as yet only fruiting specimens obtained. *Type*: Gascoyne River [Western Australia], 1880, *Jones s.n.* (*lecto,* here designated: MEL 79403); Gascoyne River [Western Australia], 1882, *J. Forrest s.n.* (*syn:* MEL 79404).

Distribution and ecology. T. forrestii is confined to the Carnarvon area of Western Australia, particularly in the Shark Bay area. It is recorded from sand, calcareous clay, red-brown clay and red sandy clay, usually from within shrubland, but sometimes from disturbed areas.

Phenology. Flowering between April and September.

Distinguishing features. Fruits in *T. forrestii* are circular, 5-lobed and regular (except when not all carpels develop) with a smooth, reticulately marked surface (similar to the shell of a peanut) and a pair of median dorsal spines on each of the developed cocci.

Typification. The Jones material is the more copious and has a number of mature fruits whereas the Forrest material has only immature fruits present. Mueller has annotated both sheets but the Jones specimen has further notes on the shape of the fruit in comparison with that of *T. macrocarpus.* For this reason it has been selected as the lectotype of *T. forrestii.* Despite his statement to the contrary, Mueller did have flowering material available to him in the form of earlier collections by Forrest and Carey in 1878, but neither of these had fruits and so he did not recognize them as *T. forrestii.* It is not entirely clear where *T. forrestii* was first published. The particular issue of Southern Science Record was apparently never published and the paper containing the description of *T. forrestii* only ever distributed as an Extra Print to Kew and Germany (see Churchill *et al.* 1978). However, Article 29 of the International Code of Botanical Nomenclature (Greuter *et al.* 1994) states that publication is effected by "distribution of printed matter (through sale, exchange, or gift)....to botanical institutions with libraries accessible to botanists generally" and so these conditions would seem to have been met by the distribution to Kew Gardens. Mueller did publish the same name in the same year in Bot. Centralbl. and so it is only the place of publication which might be questioned.

7. Tribulus astrocarpus F. Muell., Fragmenta Phytographiae Australiae 12: 4 (1882). *Type citation:* Prope flumen Gascoyne River; J. Forrest. *Type:* Menilyalya River north of Shark Bay [Western Australia], 1882, *J. Forrest s.n.* (*lecto,* here designated: MEL 79395); Gascoyne River [Western Australia], 1882, *J. Forrest s.n.* (*isolecto:* K).

Representative specimens examined. WESTERN AUSTRALIA: Great Northern Hwy, 45.6 km S of Kumarina, 27 Aug. 1995, *R.M. Barker* 1067 (AD); No 1 Well, Canning Stock Route, *L.A. Craven* 5044 (CANB, PERTH); Warburton Community, between shop and river bed, *F.A. Zich* 76 (CANB, NSW, PERTH, PRE).
NORTHERN TERRITORY: Plenty Highway, 22 km NE of Stuart Highway, *K.L. Wilson* 4641 (DNA, NSW).
SOUTH AUSTRALIA: Timber Camp Bore, Hamilton Station, 100 km N of Oodnadatta, *F. Badman* 309 (AD, BRI, C, CANB, MEL, NSW).
QUEENSLAND: 72 km S of Winton, Mar. 1971, *P. Knowles s.n.* (BRI).

Distribution and ecology. Occurs in Western Australia from Carnarvon to Warburton, extending into southern Northern Territory, south-west Queensland and northern South Australia, invariably within mulga woodland. Soils vary from red sand to pebbly brown clay.

Phenology. Flowering has been recorded in most months of the year but predominantly March to May and August to September.

Distinguishing features. The star-shaped fruits of this species are very distinctive.

Typification. Both sheets have been annotated by Mueller as "Tribulus astrocarpus", although the lectotype is annotated as "asterocarpus" with the "e" crossed out. The MEL sheet consists of three fragments and contains flowers and young and mature fruits. In contrast, the sheet in K has only a single fragment with one mature fruit present. Both specimens were seen as photographs in the Eichler manuscripts.

Notes. There seem to be two flower sizes amongst the material studied. The few specimens with larger flowers, i.e. petals up to 10 mm long (e.g. *Knowles s.n., Craven* 5044), were more robust plants and tended to be flowering in the earlier months, but there does not appear to be any pattern to their distribution since they came from all states except South Australia. These larger flowers tend to have at least 2 or 3 stamens with longer anthers; these are possibly staminodal. Also associated with the larger flower size, as might be expected, was a longer style.

Section *Terrestris* Hadidi, Taeckholmia 9: 60 (1978)

The taxonomy of this whole group is very unsatisfactory and much in need of world-wide revision. Many specimens exist which possess characteristics of more than one species and there is an urgent need, particularly in view of efforts to find a biological control for *T. terrestris*, of an understanding of the biology of the whole group before a satisfactory classification can be achieved. It is likely that some of these species are much more closely related than the present taxonomy suggests, and it is also likely that barriers to crosses between species are not well developed. Even some basic experimental work to establish whether such crosses are possible and the characteristics of any progeny may help to place the taxonomy on a firmer footing.

8. Tribulus occidentalis R. Br. in Sturt, Expedition into Central Australia 2 App. 69 (1849). *Type:* For a discussion of the typification of this species see Wilson (1992a).

Representative specimens examined. WESTERN AUSTRALIA: Karratha Beach, on first sand dune back from beach, next to road, *R.M. Barker* 1145 (AD, dupl. to be distributed); Dampier, at Dampier Clinic (Marine Biological Station), *Hj. Eichler* 23602 (CANB, NSW, PERTH); Point Sampson, 28 Mar. 1921, *C.A. Gardner* 1634 (PERTH); 116 km S of Barradale, Carnarvon Road, 8 June 1988, *S. Jacobs* 5846 & *P. Wilson* (NSW); *c.* 14 km SE of Carnarvon along the NW Coastal Hwy, *P.S. Short* 1574 (CANB, MEL); Beside road near parking area at lagoon 1 km from Port Smith camping area, Port Smith, *F. Zich* 155 (CANB, DNA, NSW, PERTH, PRE, US).

Specimens examined showing some approach to T. hystrix. WESTERN AUSTRALIA: 35 miles [56 km] N of Winning Station, *D.E. Symon* 5424 (AD, CANB, PERTH); 64 miles [102 km] S of Onslow, *H. van Dam* 136 (AD, 2 sheets).

Distribution. Confined to the west coast of Western Australia from Broome to Carnarvon.

Phenology. Flowering April to September.

Distinguishing features. When fruits are present, *T. occidentalis* is easily distinguished by the presence of spines all over the fruit. Spines are shorter than those found in *T. hystrix* (up to 8 mm long compared with up to 17 mm long in *T. hystrix*). Flowers are large (petals 10-17 mm long) but the style and stigma are more or less equal in length and 1-2 mm long.

Notes. T. occidentalis is usually distinguishable from *T. hystrix* by the smaller fruits and flowers and by the style and stigma of similar length. The nectary glands in *T. hystrix* appear to form a complete ring whereas in *T. occidentalis* they are distinct from each other. Some specimens of *T. occidentalis* which approach *T. hystrix* are listed above and discussed in the notes under *T. hystrix.*

T. occidentalis occupies a similar coastal locality to *T. cistoides*, although also occurring further inland, and without fruits these two are difficult, if not impossible, to distinguish. When fruits are present, *T. cistoides* has only 2 pairs of spines, one median and one basal, compared with the all over distribution of spines, some of which may be branched, in *T. occidentalis.* See notes under *T. cistoides.*

A specimen from Barradale (*Jacobs* 5846) in Western Australia has the flower size (petals *c.* 12 mm long) and developing fruits of *T. occidentalis,* but the style (*c.* 1.6 mm) is longer than the stigma (*c.* 1 mm), whereas it is usual for the stigma to be longer than the style in this species.

Bentham (1863) treated *T. occidentalis* as a synonym of *T. hystrix* apparently based on the diagnosis only since he was unable to locate the specimens seen by Robert Brown. Mueller (in Mueller & Tate 1896) claimed that it was he who was responsible for making this decision in his account of the plants of the Babbage Expedition. If it was Mueller who first suggested this, then it was not in this account of the Babbage collection (Mueller 1859), since *T. occidentalis* is not mentioned there. However, it may have been the account of the Gregory Expedition that Mueller meant, since he certainly treated plants collected by Walcott and Brown as *T. hystrix* (Mueller 1863). Bailey (1899) possibly confused the situation even further by choosing to call the only specimen of *T. hystrix* that he saw from the Diamantina in Queensland (*Bancroft s.n.* in BRI), *T. occidentalis.*

9. Tribulus hystrix R. Br. in Sturt, Expedition into Central Australia 2 App. 69 (Jan.-Feb. 1849). *Type citation:* in collinis arenosis. Lat 26°, D. Sturt. *Type:* Sand Hills in Lat about 26°, *s.dat.*, *Captain Sturt* 109 (*holo:* BM *n.v.*, seen as photograph in Eichler manuscripts).

Representative specimens examined. NORTHERN TERRITORY: Camel Lake, Simpson Desert, *D.F. Gibson* 61 (DNA).
SOUTH AUSTRALIA: Priscilla Creek, 30 km NW of Finniss Creek on Oodnadatta road, *K.L. Wilson* 4601 & *R.M. Barker* (AD, CANB, NSW); 5 km N of Stuart Creek Homestead, *F.J. Badman* 1587 (AD, HO, MEL).
QUEENSLAND: *c.* 27 km SW of Betoota, *K.P. Nicolson* 291 & *P.E. Novelly* (BRI).

Distribution. Found in northern South Australia, south eastern Northern Territory and south west Queensland. It has been recorded from Western Australia in the past (Hnatiuk 1990) and is in the WAHERB Census, but most of the material identified as such is probably *T. occidentalis* (but see notes below).

Distinguishing features. If fruits are present, this species cannot be confused with any other *Tribulus* species in Australia. Their size (up to 30 mm high and 50 mm wide) far exceeds that of any other species, and the length of the narrow spines (10-17 mm) is also diagnostic. In the absence of fruits, the large size of the flowers and length of the style (4-5 mm), coupled with a known distribution, should be sufficient to identify *T. hystrix*.

Typification. The holotype sheet consists of a single branch with a flower and a single fruit. It has been annotated by Brown as "Tribulus hystrix Br."

Notes. Mueller annotated a number of specimens of *T. hystrix* as "var. grandiflorus" including that of McDouall Stuart's from Attack Creek (MEL 79414) which was seen by Bentham, but the name has never been published.

T. hystrix can be distinguished from *T. occidentalis* by the much longer style than stigma, by the larger flowers and fruits and possibly by the intrastaminal gland being a complete ring rather than 5 distinct lobes. Distribution also often helps in distinguishing the two species, with *T. hystrix* coming from central Australia and *T. occidentalis* from the west coast of Western Australia between Broome and Carnarvon. However, there are some specimens from the west coast of Western Australia and the intervening area which appear to break down the distinctions by approaching *T. hystrix* in some characters rather than *T. occidentalis*, raising the possibility that the two species are merely ends of a cline. The intervening specimens tend to have larger flowers than is usual for *T. occidentalis* (petals up to 28 mm long) and the styles are longer than the stigmas, but not as long as the 4-5 mm found in *T. hystrix*. Spines on the Symon collection are less than 8 mm long, which is characteristic of *T. occidentalis*. The disc may be a continuous ring rather than distinct glands but this character is not always reliable or easy to interpret. Bentham treated *T. occidentalis* as a variety of *T. hystrix* and his concept may eventually prove to reflect the relationship better than the maintenance of the two as species. However, complete specimens are needed of both species as well as more specimens from the area between their present known distributions, before a decision can be made on their taxonomic status.

10. Tribulus sp. **saline flats** (*P.K. Latz* 4530)

?*Tribulus occidentalis* (smaller flowers and fruits) K.L. Wilson, *Telopea* 5(1): 28(1992).

Prostrate, villous *herb*, stems up to 30 cm long. *Leaves* in unequal pairs, more rarely alternate, with 6-7 pairs of leaflets above 1-5 mm long petiole; leaflets narrowly elliptic, shortly petiolulate, base oblique, acute, discolorous, villous adaxially, more densely villous abaxially, 4-6.5 mm long, 1.5-2.5mm wide. *Flowering pedicel* 5-8 mm long, upright, fruiting pedicel 10-16 mm long. *Sepals c.* 4 mm long, glabrous adaxially except for apical pubescence and densely villous abaxially except on hyaline margin. *Petals* yellow, obovate, glabrous, *c.* 6-7 mm long, longer than sepals. *Intrastaminal glands* 5. *Stamens* 10, at maturity equal to stigma; filaments *c.* 2 mm long; anthers 1.2 mm long. *Ovary* densely white pubescent, 5-celled; style 0.5-1 mm long in flower; stigma 0.9 mm long. *Fruit* 7-10 mm high, 12-15 mm wide, dissociating into 3-5 asymmetrical, moderately pubescent, woody cocci, with more or less equal, 0.5-4 mm long, spines all over dorsal surface.

Specimens examined. WESTERN AUSTRALIA: 2.7 km along Point Quobba Road from NW Coastal Hwy, 6 Sep. 1995, *R.M. Barker* 1209 (AD, dupl. to be distributed); Cavanagh Range, 7 July 1963, *A.S. George* 4780 (CANB, PERTH).
NORTHERN TERRITORY: Newhaven Station, *P.K. Latz* 2172 or 2127 (AD, CANB, DNA, PERTH); 2 miles [3.2 km] W Quartz Blow Rockhole, *N. Henry* 402 (CANB, DNA); 14 miles [23 km] S Rabbit Flat, *P.K. Latz* 4530 (DNA, PERTH).
NEW SOUTH WALES: Salisbury Downs Station, *P. Martensz* 2758 (CANB).

Distribution and ecology. Occurs in Northern Territory and Western Australia, with an outlier in New South Wales. Usually recorded as being found in sandy saline soils or on the edges of salt pans, but there are other records of it from sandy soil over limestone, or merely from a sandhill (*Martensz* 2758).

Phenology. Flowering January to May, presumably in response to rains.

Distinguishing features. This taxon possesses the small flower size and style and stigma lengths of *T. eichlerianus*, but the fruits are more like miniature *T. hystrix* fruits.

Notes. Occasional specimens (e.g. *Dunlop* 2107) bearing fruits similar to those of this species have been found with the much larger flowers and longer styles of *T.* sp. *long-styled eichlerianus* or *T. cistoides* (see notes under that taxon).

The Martensz collection agrees with this material in all respects except that its distribution is considerably removed from the rest of the collections and it is recorded as coming from a sandhill. Similarly the Barker collection from the west coast of Western Australia is also considerably removed from the other collections listed, although it was made from a red sand area adjacent to a salt lake. Such a widely disjunct distribution, even though it may merely reflect inadequate collecting, casts some doubt on the validity of this taxon, and is another reason why it has not been formalized here.

11. Tribulus ranunculiflorus F. Muell. (possibly *nom. nud.*) in Hooker's Journal of Botany & Kew Garden Miscellany 8: 323 (1856); F. Muell., Fragm. 1: 48 (1858). - *Kallstroemia ranunculiflora* (F. Muell.) Engl. in Engl. & Prantl, Nat. Pflanzenfam. 3(4): 88 (Dec. 1890). *Type:* Upper Victoria River, Northern Territory, January 1856, *F. Mueller s.n.* (*syn:* MEL 79472); Wickham's Creek, Northern Territory, April 1856, *F. Mueller s.n.* (*syn:* K).

Tribulus sp. A, Lawrence, Fl. Kimberley Region 681, f. 210F (1992).

Specimens examined. WESTERN AUSTRALIA: main road opposite gate of Kimberley Experimental Farm, Dept of Agriculture, Kununurra, 11 Mar. 1978, *T.E.H. Aplin* 6301 (CANB, PERTH); Kununurra,

29 Feb. 1972, *D. Bedbrook* 10B (PERTH); Kununurra area, *T.F. Black* 10 (PERTH); bitumen road verge, black clays near OPRS, Jan. 1981, *C. Glover* 1-7 (PERTH); opposite Kununurra airport, *E.C. Glover* 56 (PERTH); Kimberley Research Station, Ord Sandy Loam, *E. Langfield* 58 (PERTH); ?9 km N of Kununurra at Mocks Dairy on E side of Ivanhoe Crossing road adjacent to milking parlour, 6 May 1993, *A.A. Mitchell* 3085 (BROOME, NSW *n.v.*, PERTH); Airport entrance, Kununurra, *R.W. Purdie* 3303 (DNA); Kununurra, street edges near swimming area, 4 June 1975, *D.E. Symon* 10331 (AD, CANB, K, PERTH).

Specimen examined with affinities to T. ranunculiflorus. WESTERN AUSTRALIA: Mackay Creek, 31 July 1977, *Anon. s.n.* (PERTH 03776085).

Distribution. Apart from the type, known only from the Kununurra region of Western Australia.

Distinguishing features. This species has the large flowers of *T. hystrix*, but does not develop the extremely large spiny fruit of that species; instead it has fruits more like those of *T. terrestris*, with only a median and basal pair of spines. Mature leaves have 8-10 pairs of leaflets, with these leaflets being narrowly elliptic and no more than 2.5 mm wide. The style is 4-7 mm long, considerably longer than the stigma, and longer than any other of the sect. *Tribulus* species in Australia, apart from *T. hystrix* (which has a style length of 4-5 mm).

Typification. Both syntype collections have been labelled as *Tribulus ranunculiflorus* by Mueller, but both have petals *c.* 15 mm long and styles 4-5 mm long i.e. at the lower end of the range of measurements for this taxon. However, in the crucial measurements of petal and style length, the protologue gives a length of "7-10 lin." [15-22.5 mm] for the petals and "3-4 lineas" [6.75-9 mm] for the style. These petal measurements place the types with the taxon recognized here, but the style length is longer than that recorded for any specimens (see Table 2). Both types have only been seen as photographs in the Eichler collection of protologues and need to be checked further before a decision as to the application of the name *T. ranunculiflorus* to this taxon is made.

Notes. Since the type collection of *T. ranunculiflorus* has petals *c.* 15 mm long and a style length of *c.* 4.5 mm it was initially thought that *T. ranunculiflorus* might prove to be synonymous with *T. cistoides*. This was reinforced by a further three collections from Kununurra (*Langfield, Purdie* and *Symon,* referred to as small-flowered in Table 2) apparently sharing these attributes. However, other collections (*Aplin, Black, Glover* and *Mitchell*) from Kununurra have flowers with longer petals and styles, making them very distinct from any other species in Australia. A comparison of these entities is given in Table 2 and from that it can be seen that all of the specimens separated as *T. ranunculiflorus*, despite their variation, can be distinguished from *T. cistoides* by their style length, their leaflet number, their leaflet width and their fruit width. Fruits of *T. cistoides* are similar to those of *T. terrestris* in shape but much more robust; fruits of *T. ranunculiflorus* bear a remarkable resemblance to those of *T. terrestris* except for the presence of the very long style. *T. terrestris* and *T. ranunculiflorus* do apparently occur together since the collections *Mitchell* 3085 and 3086 are both given the same locality details.

El Hadidi has annotated a duplicate of the Symon collection in K as *T. zeyheri* Sond., another species which is only doubtfully distinct from *T. cistoides*, but this is clearly erroneous since *T. zeyheri* lacks an elongated style (see under *T. cistoides* notes below).

Differences in flower size probably relate to soil type since the larger-flowered specimens of *T. ranunculiflorus* are all recorded as coming from black clay areas while the smaller-flowered specimens are from sand and loams.

Table 2. Comparison of the type specimens of *T. ranunculiflorus* with small-flowered Kununurra specimens of *T. ranunculiflorus*, all *T. ranunculiflorus* and *T. cistoides*.

Characters	*Tribulus ranunculiflorus*			*T. cistoides*
	all specimens	type specimens	small-flowered specimens	all specimens
petal length (mm)	(15)25-35	*c.* 15	15-20	15-16
style length (mm)	4-7	*c.* 4.5	4	1.8-3
stigma length (mm)	0.5-0.7	–	0.5	0.3-1.5
leaflet number	8-10	8-10	8-10	5-7(8)
leaflet width (mm)	1-3	*c.* 2	1-3	3-5
fruit width (mm)	up to 10	-	-	up to 15

A specimen from Mackay Creek (PERTH 03776085), whose location in Western Australia is unknown, possibly belongs here, although the style is much longer (10 mm) than the usual range for the taxon (this length of style is unrecorded for any *Tribulus* species in Australia) and the leaflet number (7-8) and width (4-5 mm) are at odds with that recorded for *T. ranunculiflorus*.

12. Tribulus cistoides L. Species Plantarum 387 (1 May 1753). *Type citation:* Habitat in America calidiore. *Type:* Hermann 1698: 236, t. 236 (*lecto, fide* Wijnands 1983: 203).

Representative specimens examined: WESTERN AUSTRALIA: One Arm Point township, N Dampierland, *B.J. Carter* 537 (BROOME, CANB, PERTH).
NORTHERN TERRITORY: 3.5 km NE Victoria River Downs Homestead, 18 Apr. 1996, *D.E. Albrecht* 7434 (AD, DNA, NT); Blue Mud Bay: Yee to Wappah Island, *J. Egan* 2385 (DNA); South West Island, Sir Edward Pellew Group, *G. Wightman* 1581 (CANB, DNA).
QUEENSLAND: without locality, 1770, *Banks & Solander s.n.* (BM) - specimen seen as photograph in Eichler manuscripts; National Parks Station, Pallarenda, Townsville, 15 Dec. 1980, *B. Jackes s.n.* (CANB).
PAPUA NEW GUINEA: Cape Suckling, 18 May 1984, *D. Symon* 13807 (AD).

Distribution and ecology. T. cistoides is mainly confined to coastal localities in northern Australia in Northern Territory and Cape York, with some collections from islands off the Western Australian coast. It is found in deep, sometimes coralline, sand.

Phenology. It flowers most months of the year but particularly April to July.

Distinguishing features. Usually most easily recognized by its large flowers (petals 15-18 mm long), style (*c.* 2-3 mm long) longer than stigma and subglabrous fruits, similar in shape to those of *T. terrestris*, but considerably larger. Its restriction to coastal habitats is also a useful distinguishing feature.

Notes. Banks and Solander collected this species in 1770, presumably from north-eastern Queensland, where the species persists today. The identification of *T. cistoides* is confirmed by Porter, who worked on the American species of *Tribulus*.

A recent collection from the Victoria River Downs Homestead (*D.E. Albrecht* 7434) agrees entirely with *T. cistoides* specimens from coastal areas and probably indicates that the species is capable of being transported inland and sustaining itself.

T. cistoides of south-eastern United States (Porter 1971) and tropical Africa (Launert 1963) is described as having the intrastaminal glands united into a 5-lobed ring. Squires (1969) also suggested that *T. cistoides* has the glands in a ring. This is not in agreement with specimens in Australia here referred to *T. cistoides* since intrastaminal glands have been found to be quite separate. However, Porter also noted that this character breaks down in the Galapagos Islands. From his measurements, style and stigma length of *T. cistoides* in south-eastern United States also appear to be much shorter than those in Australian specimens. *T. cistoides* is predominantly maritime in its locations in the Americas and Africa, in agreement with what has been documented here.

Distinction between the two species *T. cistoides* and *T. zeyheri* apparently rests on the relative length of the style and stigma, with *T. cistoides* having a distinct style, whereas the style in *T. zeyheri* is more or less absent (Launert 1963). Schweickerdt (1937) recognized the two species as distinct but referred to the difficulty in distinguishing them in Africa while Porter (1971), after an examination of specimens from both America and subtropical southern Africa, considered *T. zeyheri* to be a synonym of *T. cistoides*. El Hadidi (1985) separated the two on the style and stigma lengths and also on the pubescence of the plants and the length of the floral peduncle with respect to the subtending leaf; he commented on the difficulty in allocating some inland forms. From notes in Eichler's manuscripts, El Hadidi's annotation on specimens (see under *T. ranunculiflorus* above), and a mention by Wilson (1992a), there has been some thought that *T. zeyheri* might occur in Australia, but there seems to be no material which would support this hypothesis.

T. cistoides may well introgress with other species in Australia and Africa and the following notes document its relationship to other members of the *T. terrestris* group in Australia. However, variation in characteristics documented in overseas material (see above) indicates that it is in need of review throughout its range.

T. cistoides and ***T.*** sp. ***long-styled eichlerianus***

Specimens examined. WESTERN AUSTRALIA: Pier Creek, Warralong Station, *N.T. Burbidge* 826 (PERTH, 2 sheets); 5 km NE of De Grey River crossing on road to Broome, *D.E. Symon* 10100 (AD, PERTH).

Notes. Some collections of *T.* sp. *long-styled eichlerianus*, e.g. *Burbidge* 826 and *Symon* 10100, have fruits more like those of *T. cistoides* with respect to their shape and distribution and number of spines, but they are invariably more pubescent than coastal populations. It may be that *T.* sp. *long-styled eichlerianus* should be thought of as an inland form of *T. cistoides*, but this needs to be investigated further.

T. cistoides and ***T. occidentalis***

Specimens examined. WESTERN AUSTRALIA: North West Cape-lighthouse hill, 31 Aug. 1960, *A.S. George* 1393 (PERTH).

Notes. A collection from North West Cape (*George* 1393) has the majority of fruits of a similar shape to those in *T. cistoides* (and some forms of *T. terrestris* and *T. eichlerianus*). However, these fruits are pubescent whereas those of *T. cistoides* are subglabrous. One other young fruit on this collection appears to be developing spines more characteristic of the fruits of *T. occidentalis.* The specimen serves to illustrate the plasticity in the development of the fruit shape in *Tribulus* species of the *T. terrestris* complex.

T. cistoides and ***T. terrestris*** *s.lat.*

Specimens examined. WESTERN AUSTRALIA: CSIRO Kimberley Research Station, Kununurra, *W. Leutert* 2 (CANB).
NORTHERN TERRITORY: Beside Stuart Hwy, *c.* 10 km N of Katherine, *E.N.S. Jackson* 1047 (AD, CANB).
QUEENSLAND: Sandhurst Bore, Millungera Station, *N.H. Speck* 4784 (BRI, CANB).

Notes. A number of specimens from inland northern Australia possess characteristics of both *T. terrestris* and *T. cistoides* while not really belonging with either species. Their flower size is somewhat intermediate between the species, the style length is too short for *T. cistoides* but longer than that for *T. terrestris* - while the fruits are typical of *T. terrestris* but with a short pubescence all over. They are not *T. zeyheri* as proposed on one of the specimens, since they have styles considerably longer than the stigma (see above), and they are not *T. eichlerianus* since the style is longer than the stigma, the fruits not as densely pubescent as in that species and the spines are as in *T. terrestris*. They might well be treated as the longer styled taxon of *T. terrestris* (*q.v.*) since this is variable with respect to hair covering on the fruit. However, it should also be noted that Porter (1971) indicated that introgression between *T. cistoides* and *T. terrestris* does occur in Hawaii, facilitated by the endemic carpenter bee, *Xylocopa darwini* Cockerell, and leading to the production of smaller flowers in *T. cistoides*. If a pollinator can be found to be visiting both species in Australia, then the same explanation may well apply here.

13. Tribulus eichlerianus K.L. Wilson, Telopea 5 (1): 21 (1992). *Type:* Central North: Sandover Highway, 5 km south-west of Utopia turn-off, Northern Territory, 17 April 1983, *K.L. Wilson* 4646 & *R. Barker* (*holo:* NSW; *iso*: CANB, NT).

Specimens examined. WESTERN AUSTRALIA: Barrow Island, Oct. 1980, *R. Buckley* 7066 (PERTH); Police Pool Camp, Lennard River, 19 Apr. 1988, *R.J. Cranfield* 6453 (PERTH); near Roebourne, Oct. 1941, *C.A. Gardner s.n.* (PERTH); Horse paddock, Gogo, 12 Apr. 1957, *C.A. Gardner* 10023 (PERTH); S side of Breaden Valley, Southesk Tablelands, *A.S. George* 15520 (CANB, PERTH); Callawa Creek, upper De Grey River, 26 May 1947, *R.D. Royce* 1943 (PERTH).
OTHER STATES: see Wilson (1992a).

Distinguishing features. T. eichlerianus is recognized by the short dense, almost velvety, pubescence on the fruits, the cocci longer than high and each with short median dorsal spines and the stigma longer than the almost absent style.

Notes. The fruits of *T. eichlerianus* are a favourite food of the Red-tailed Black Cockatoos (D. Albrecht, pers. comm. 1996).

In describing *T. eichlerianus*, Wilson (1992a) listed selected specimens from Queensland, New South Wales, Northern Territory and South Australia. The species also occurs in Western Australia and extra

specimens are listed here. Across its range the fruits are not always as large as recorded by Wilson, nor are they always as densely pubescent. There is a great deal of variability in the species with respect to the size of the median pair of spines, ranging from almost absent to almost as large as those in *T. cistoides*. A collection from the rocky coasts of Barrow Island (*R. Buckley* 7066) agrees with *T. eichlerianus* in all respects except that the cocci are only sparsely pubescent, while a collection from Southesk Tablelands (*George* 15520, CANB duplicate) has the style on one of the fruits longer than usual for this species.

14. Tribulus sp. **long-styled eichlerianus** (*A.S. George* 10666)

?*Tribulus hystrix* (short-spined, smaller fruits) K.L. Wilson, Telopea 5 (1): 28(1992).

Prostrate, villous *herb*, stems up to 40 cm long. *Leaves* in unequal pairs, more rarely alternate, with 6-8(10) pairs of leaflets above 4-10 mm long petiole; leaflets narrowly elliptic, shortly petiolulate, base oblique, acute, discolorous, villous adaxially, more densely villous abaxially, 6.5-13 mm long, 3-4.5 mm wide. *Flowering pedicel* 9-28 mm long, upright, fruiting pedicel 14-35 mm long. *Sepals* 7-10 mm long, glabrous adaxially except for apical pubescence, densely villous abaxially except on hyaline margin. *Petals* yellow, obovate, glabrous, 15-18 mm long, longer than sepals. *Intrastaminal glands* 5, indistinct. *Stamens* 10, at maturity held just below stigma; filaments 3.7-4 mm long; anthers 1.5-1.8 mm long. *Ovary* densely white pubescent, 5-celled; style 2-4 mm long in flower; stigma 0.6-1.7 mm long. *Fruit* 8-15 mm high, 11-20 mm wide, dissociating into (3)-5 symmetrical, moderately pubescent, woody cocci, with short tubercles all over, sometimes also with a longer pair of median spines 1.5-4 mm long.

Specimens examined. WESTERN AUSTRALIA: Pier Creek, Warralong Station, *N.T. Burbidge* 826 (PERTH, 2 sheets); 19 May 1971, Rudall River, *A.S. George* 10666 (PERTH); Bloodwood Bore, near Balgo, July 1972, *C.H. Gittins* 2452 (BRI); Fanny's Peak, 85 km S of Giles Meteorological Station, 29 Aug. 1973, *B. Lay* 867 (AD); Minderoo Station, Site 28A Landsat Study 7, May 1980, *A.A. Mitchell* 704 (PERTH); Abydos Station, S of Port Hedland, Sep. 1968, *F. Richardson* 19 (PERTH); 17 May 1947, 5 miles N Christmas Creek, Rabbit Proof Fence, *R.D. Royce* 1741 (PERTH); 5 km NE of De Grey River crossing on road to Broome, *D.E. Symon* 10100 (AD, PERTH); Rudall River area, 7 Aug. 1971, *P.G. Wilson* 10297 (CANB - 2 sheets, PERTH).
NORTHERN TERRITORY: On Tanami track, *c.* 472 km NW of Alice Springs, 140 km S of Rabbit Flat, *P.A. Fryxell, L.A. Craven & J. McD. Stewart* 4505 (CANB); Rabbit Flat, 42 km SE of Tanami, *D.E. Symon* 6904 (AD).
SOUTH AUSTRALIA: plain between Tomkinson and Mann Ranges, on west face of inselberg, *c.* 15 km by road NNE of turnoff on Pipalyatjara-Putaputa road, *c.* ½ km E of Waltjatjata road, 6 Sep. 1978, *N.N. Donner* 6582 (AD, CANB).

Specimens examined of intermediates. NORTHERN TERRITORY: 46 miles [*c.* 74 km] E Mongrel Downs, 20 Apr. 1971, *C.R. Dunlop* 2107 (DNA); Alongside Tanami Creek, 306 miles [*c.* 490 km] NW of Alice Springs, 20 June 1976, *K. Hunt* 76/38 (NSW).

Distribution and ecology. Occurs in the Tanami Desert area of Northern Territory across to the Rudall River and Hamersley areas and south as far as Giles in Western Australia. Little is known of the ecology of this poorly collected taxon. It has been recorded from red clay loam with *Melaleuca glomerata, Aristida* and *Stylobasium*, from stony loam and from hummock grassland in sandstone hills.

Phenology. Flowering is recorded from April to August.

Notes. One of the reasons for not formally describing the two taxa here delineated by the phrase names *Tribulus* sp. *long-styled eichlerianus* and *T.* sp. *saline flats*, is the existence of occasional intermediate specimens like *Dunlop* 2107 and *Hunt* 76/38, both from the Tanami Desert. In these collections the fruits show a clear resemblance to those of *T.* sp. *saline flats* (i.e. small *T. hystrix* type fruits), but the flower size and style and stigma lengths are clearly those of *T.* sp. *long-styled eichlerianus* or *T. cistoides*. A better understanding is required of the biological significance of and variation in flower size and relative lengths of style and stigma, the ability of the various species of *Tribulus* to cross-pollinate and the outcomes of such crossings, if they do occur, before it can be ascertained whether these are real taxa. The paucity of collections from the inland north west region of Australia also contributes to the lack of understanding of the relationships of the taxa. The large disjunctions in distribution for both of these taxa may be real, and thus cast doubt on the validity of the taxa, or they may just reflect poor collecting in the area.

The fruits of *T.* sp. *long-styled eichlerianus* resemble those of *T. eichlerianus* but they are less densely pubescent and topped by a much longer style than that found in *T. eichlerianus*. Flower size is much larger than that of *T. eichlerianus*, resembling more the flower sizes of *T. occidentalis* and *T. hystrix,* while the style length is usually much longer than that of the stigma, as is found in *T. hystrix*, except that the style is not as long as in that species. Fruits also bear a strong resemblance to some of the larger fruited central Australian specimens assigned to *T. micrococcus* (*q.v.*), but the flowers and style length are much smaller in that taxon.

Tribulus terrestris L. complex

T. terrestris s. lat. in Australia consists of a number of taxa which overlap in distribution and imperceptibly intergrade in morphology. Three of these taxa, *T. terrestris s.str., T. micrococcus* and *T. minutus*, have already been recognized at species level within Australia and it is not proposed to change that classification here, even though it seems doubtful that this status is justified. The group is very much in need of revision both in Australia and world wide. It is a very good candidate for molecular biology study if we wish to understand relationships between the taxa in Australia and their relationship with overseas taxa. Preliminary work on burr morphology (Scott & Morrison 1996a), chromosome counts (Morrison & Scott 1996a) and isozymes (Morrison & Scott 1996b) has led to somewhat conflicting conclusions, but may lend support to the two informal taxa recognized here within *T. terrestris* s.s., based on relative lengths of the style. It is possible that all four taxa may represent long ago introductions of different forms of the species from elsewhere (see for example the varieties of *T. terrestris* recognized by El Hadidi (1972) for Iran, which show a remarkable similarity in attributes to those recognized here), but Scott & Morrison's work suggests that *T. micrococcus, T. minutus* and *T. terrestris* (long style) are native to Australia, while *T. terrestris* (short style) is introduced. Since *T. micrococcus* is an octoploid (2n = *c.* 48) according to Morrison & Scott (1996a), it would be interesting to see whether isozyme analysis would also place this taxon with Indian/Kuwaiti collections which also have a chromosome number of 48.

Table 3 gives an indication of the four taxa of the *Tribulus terrestris* complex recognized here and their relationships. Chromosome number and isozyme groups refer to the work of Scott & Morrison as quoted above. The distribution indicated is very approximate and there are many exceptions, which is another factor calling the present taxonomy into question.

Table 3. Comparison of the taxa recognized within Australia in the *T. terrestris* complex.

	approximate distribution	chromosome number	isozyme group	style length (mm)	cocci	cocci spines
T. terrestris (long style)	northern Australia	24	C	0.6-1.3	not dorsally rounded	long median spines
T. terrestris (short style)	southern Australia	24/36	A	0-0.3	not dorsally rounded	long median spines
T. micrococcus	central Australia to Qld	48	?	0.7-1.4	dorsally rounded	median spines lacking or short
T. minutus	southern Australia	?	?	0.2-0.7	dorsally rounded	median spines lacking or short

T. micrococcus and *T. minutus*, with smaller fruits in which the 5 dorsally rounded cocci are usually tuberculate all over and either lacking or with much reduced median spines, have been recognized in the past only from the eastern states of Australia. According to Wilson (1992b) they can be distinguished from *T. terrestris* by stigma characters, but these differences are often not clear cut. Instead, within specimens which have the very long median spines of true *T. terrestris*, there seem to be northern and southern forms based on style length (the longer styles usually found within the northern populations). Similarly within the smaller- and shorter-spined specimens *T. micrococcus* tends to come from more northerly areas than *T. minutus* and also has the longer style. Again, this is only a tendency and there are specimens (e.g. *Dunstan* (AD 96247073) from Adelaide has the longer style of *T. micrococcus*) which do not agree. These smaller- and shorter-spined species are not confined to the eastern states but are to be found throughout Australia, although the fruits are not always as small as in the eastern states. They can usually be distinguished from *T. eichlerianus* because the fruits are smaller and not so densely pubescent, but they resemble that species in the rounded dorsal surface of the coccus and any revision of the complex should also include that species.

There are some specimens which have the attributes of several taxa. For example, some specimens identified as *T. micrococcus*, have fruits approaching *T. eichlerianus* in pubescence, but the length of spines on the fruit are more reminiscent of *T. terrestris*, while the style and stigma lengths are similar to those of *T. micrococcus* (e.g. *P. Canty* 2486, Nullarbor Plain (AD); *M. Cole* 42 & *D. Provan*, Dugald River (BRI)). They might perhaps be better treated as a taxon distinct from the eastern states *T. micrococcus* but they might also be associated with limestone soils. The fruits are very close to those of *T.* sp. *long-styled eichlerianus* as well, but the flowers are much smaller than those of that species.

Fruits agreeing with one of the smaller-fruited species can sometimes also be found on the same plant as fruits which are closer to *T. terrestris*, e.g. *Perry s.n.*, Doodlakine (CANB).

T. acanthococcus may well coincide with *T. minutus* or *T. micrococcus* (see below) but at this stage only a photograph of the type has been seen in the Eichler manuscripts. From Mueller's description, the stigma is only half as long as the style, suggesting that it would be placed either with true *T. terrestris*

or with *T. micrococcus*. If it should prove to belong with the latter then *T. acanthococcus* predates *T. micrococcus*. If it belongs with the former then the occurrence of true *T. terrestris* in Australia was much earlier than the early 1900's indicated by Squires (1969). The type in MEL has still to be studied and lectotypified.

A study of overseas material of *T. terrestris* held at AD indicates that material from the Americas, Africa, Europe and China coincides with the southern Australian form of *T. terrestris*. However, there is a single collection from India which has the longer style of the northern form. This raises the possibility of different introductions of forms of the same species into Australia from overseas or it could possibly indicate the natural occurrence of some of these taxa over a wider area than is currently recognized.

As already mentioned above, there is a possibility that the four taxa recognized below may all relate to the varieties of *T. terrestris*, recognized by El Hadidi (1972) for Iran. Unfortunately it is not possible to discern the style and stigma lengths from the photographs of these varieties. Nor are they documented in El Hadidi descriptions of the taxa and so it is not possible to decide whether these truly coincide with the Australian taxa. If these comparisons can be made in the future then it may give an indication of which taxa can be considered to be truly native to Australia.

One further aspect which has not been addressed is the typification of *T. terrestris*. It has been assumed that the short-styled taxon which is recognized as having been introduced to Australia, coincides with the type of the species, but this could be erroneous. The microfiche of Linnaean types at AD is inadequate to determine such details as style and stigma relationships and there may well be other material which needs to be taken into account in lectotypifying the species. Of the material which is present in the Linnaean herbarium, the sheet LINN 547.2 of *T. lanuginosus* from Ceylon (Sri Lanka) has very robust fruits with long median dorsal spines, and appears very similar to the fruits of the "introduced" specimens of *T. terrestris* in Australia; *T. lanuginosus* is now usually treated as a synonym of *T. terrestris* (see for example Dassanayake 1987). The specimen which is labelled as *T. terrestris* (LINN 547.4), has been cited as the type of the species by Schweickerdt (1937) and by El Hadidi (1985). It has only a single fruit present and it is impossible to make out detail, except to say that it is considerably smaller than that on the *T. lanuginosus* sheet. However Schweickerdt describes the style of *T. terrestris* in his treatment as being "short, much reduced" and El Hadidi as "very short or absent", and since both cite this particular specimen as the type, it is assumed that the type of the name is correctly placed with *T. terrestris* (short style) recognized here.

15a. Tribulus terrestris (short style)

*Selected specimens examine*d. WESTERN AUSTRALIA: Vacant block, opposite Dept Agriculture, Jarrah Road, South Perth, *R.J. Cranfield* R224 (CANB, PERTH); Mt House Station on Glenroy Road at Adcock River crossing, 5 May 1983, *P.A. Fryxell & L.A. Craven* 3967 (CANB, PERTH); Broome, *K.F. Kenneally* 9864 (CANB, PERTH); Camballin, May 1970, *Y. Power* 820 (PERTH).
NEW SOUTH WALES: Northern outskirts of Jugiong, *B.J. Lepschi* 798 (CANB, NSW); Scrivener Dam, Canberra, *I.R. Telford* 10800 (AD, CANB, NSW).
NORTH AMERICA: Madison, Louisiana, 15 June 1978, *R. Dale Thomas* 58849 *& D. Rich* 972 (AD); Missouri Pacific Railroad yard south of Desiard St and E of 6th St in Monroe, Ouachita, Louisiana, 18 July 1979, *P. Pias* 4304 (AD); University Hotel, Davis, Yolo County, California, 26 May 1954, *W.D. McLellan* 95 (AD); Tarrant Co., Texas, 1 Aug. 1926, *A. Ruth* 177 (AD); Tucson, Arizona, 20 Oct. 1957, *P.O. Schallert* 1368 (AD).
SOUTH AMERICA: *c.* 1 km al norte de Patquia, rumbo a Talamuyuna, Argentinas, 7 Apr. 1959, *A.T. Hunziker* 14295 (AD).

EUROPE: Italia, 11 July 1969, *A. Charpin et al. s.n.* (AD 97030122); Yugoslavia, Macedonia L Dolina Vardarja, 24 Oct. 1964, *E. Mayer s.n.* (AD 98135009); Corsica, 12 Aug. 1932, *P. Aellen* 128 (AD); East Bulgaria, Varna, 7 Sep. 1953, *N. Vyhodcevski s.n.* (AD 98580847).
ASIA: without locality, *s.dat., R. Schomburgk s.n.* (AD 98146119); Beijing, China, 7 Sep. 1982, *B.B. Wan* 82181 (AD); near the Summer Palace, Beijing, China, 23 July 1986, *B.M. Wang* 053 (AD).
AFRICA: Farm Erfrus, Messina District, Transvaal, 21 May 1982, *E. van Hoepen* 1779 (AD).
AFGHANISTAN: Kalne, 27 May 1969, *J.E. Carter* 323 (AD).
IRAQ: Baghdad Airport, 17 Oct. 1956, *K.H. Rechinger, A.K. Khudairi & R.W. Haines s.n.* (AD).

Notes. This taxon represents the introduced component of *Tribulus terrestris.* It is distinguished by the stigma being longer than the practically non-existent (0-0.3 mm long) style and has a predominantly southern distribution except for some specimens from about the Broome-Derby area. Many of the collections are subglabrous but some are villous. *T. terrestris* (short style) appears to grade into *T. minutus.*

Specimens were seen from a number of other countries as listed above. These resembled this taxon closely, particularly those from North America. Specimens from Afghanistan and Baghdad were not so well developed with respect to the dorsal spines on the fruit and tended to be more pubescent, thus showing some approach to *T. minutus.*

15b. Tribulus terrestris (long style)

Selected specimens examined. WESTERN AUSTRALIA: Bungle Bungle National Park, Ord River at Blue Holes, *K. Menkhorst* 625 (DNA); 9 km N of Kununurra at Mocks Dairy on E side of Ivanhoe Crossing road adjacent to milking parlour, 6 May 1993, *A.A. Mitchell* 3086 (PERTH); Wittenoom Gorge, *c.* 4 km from Wittenoom, *Hj. Eichler* 22549 (CANB, PERTH).
NORTHERN TERRITORY: 9 miles [14 km] SE Katherine, 7 May 1960, *G. Chippendale s.n.* (NT 6712, PERTH); Mountain Valley Station, Gove Road at Barmguerikba Creek, *T. Henshall* 3903 (DNA); First St, Katherine, 19 June 1964, *D.J. Nelson* 1229 (NT, PERTH).
SOUTH AUSTRALIA: Olympic Dam mine area, *A. Smith per T.J. Fatchen* 391 1164 (AD).
QUEENSLAND: Bruce Hwy, *c.* 5 km W of Ayr, *J.H. Browne* 583 (CANB).
INDIA: University Campus, Delhi, Mar. 1959, *P. Masand s.n.* (AD 96033083).

Notes. This taxon presumably represents the component of *Tribulus terrestris* which is usually cited as native, although, as mentioned above, there has been some Indian material seen which resembles this taxon in its style characteristics. It is characterized by the stigma being shorter than or equal to the distinct (0.6-1.3 mm long) style and has a predominantly northern distribution.

The single Indian specimen seen has a style 1.7 mm long and stigma 1.2 mm long, making the style somewhat longer than is recorded for this taxon in Australia.

16. Tribulus minutus Leichh. ex Benth., Flora Australiensis 1: 291 (30 May 1863). - *Kallstroemia minuta* (Leichh. ex Benth.) Engl. in Engl. & Prantl, Nat. Pflanzenfam. 3(4): 88 (1890). *Type citation:* Queensland(?), Leichhardt's Expedition. *Type:* [Queensland, Leichhardt District], before Canal [pastoral run] and afterwards, *s.dat., L. Leichhardt s.n.* (*syn:* MEL *s.n., p.p.*, excluding lower LHS specimen); without locality, *Leichhardt's Expedition, s.dat., Herb. Mueller* (*syn:* K-Herb. Hooker, type seen as photographs in the Eichler manuscripts).

Specimens examined with typical fruits. WESTERN AUSTRALIA: Trayning, Gent's Farm, [near Merredin], *Hj. Eichler* 24208 (CANB).
QUEENSLAND: 17 km from Augathella on Augathella-Tambo road, *R.W. Johnson* 2200 (BRI).
NEW SOUTH WALES: "Curranyalpa", 1.5 km from Linwood gate, 61 km SW of Louth, *C.W.E. Moore* 8605 (CANB).
VICTORIA: Irymple, Armagh Court, Karradoc Ave end, between the roadside kerb and the Irymple Sports Ground fence, *J.H. Browne* 570 (CANB, MEL).

Specimens examined with larger fruits. NORTHERN TERRITORY: About halfway between Anthony Lagoon and Brunette Downs, 16 May 1947, *S.T. Blake* 17811 (BRI); Desert Grazing Area, Hamilton Downs, *G. Chippendale s.n.* (DNA 1755); Petermann Ranges area, *P.K. Latz* 2401 (DNA 34779); Derwent Station, *D. Morgan s.n.* (DNA 6674); 14 miles [22 km] S of Erldunda, 10 Mar. 1954, *R.E. Winkworth* 136 (BRI, CANB).

Typification. Both syntypes have been annotated by Bentham.

Distinguishing features. As might be expected from the name, fruits of this taxon are smaller than those found in the rest of the *T. terrestris* complex, although larger-fruited specimens, which agree in every other respect, are found in the Northern Territory. The cocci are dorsally rounded and the median pair of spines is very short or even lacking. *T. minutus* has the stigma longer than the practically non-existent style and tends to have a southern distribution.

Notes. Central Australian specimens which relate to this taxon (e.g. *D. Morgan s.n.*, *Latz* 2401 and *Chippendale s.n.*) have fruits of a similar shape to those of *T. minutus* and *T. micrococcus* but they are larger, being up to 13 mm wide. They seem only to vary from *T. minutus* in size and so have been treated as such here. The fruits superficially resemble the fruits of *T. eichlerianus* but are much less densely pubescent and usually smaller than those of that species.

Dr R.F. Parsons (pers. comm. *in litt.* 24 Sep. 1996) remarked on the fact that Victorian populations of *T. minutus* from Red Cliffs were obviously perennial because of the massive woody rootstocks compared with the clearly annual habit of *T. terrestris*. This character is in need of further investigation in the field across the range of distribution of the species since rootstocks are invariably absent from herbarium collections. S.T. Blake questioned on his collection (*Blake* 17811) whether the species was a perennial since the base of the plant was woody.

17. Tribulus micrococcus Domin, *Bibliotheca Botanica* Heft 89: 279 (Oct. 1926). *Type citation:* durftige Grasstellen bei Charters Towers, Savannenwalder bei Pentland, Grassflachen der Rolling Downs bei Nonda (*Domin* Feb.-Mar. 1910) und wohl verbreitet [Queensland]. *Type:* Rolling Downs apud opp. Nonda [Queensland], Mar. 1910, *Domin* 5493 (*syn:* PR); Charters Towers [Queensland], Mar. 1910, *Domin* 5492 (PR); apud opp. Jericho [Queensland], Mar. 1910, *Domin* 5494 (*syn:* PR). All seen as photographs in the Eichler manuscripts; photographs taken by Bruce Maslin in PR in 1978.

Specimens examined. QUEENSLAND: Minerva, *S.T. Blake s.n.* (BRI, CANB); 8 km along Leyburn road from Pittsworth-Milmerran road, *K.L. Wilson* 4198 (CANB, NSW).
NEW SOUTH WALES: Myall Creek, 18 km SW of Delungra on road to Bingara, *R. Coveny* 12582, *C. Dunn & J. Plat* (CANB, NSW).

Distribution. New South Wales and Queensland, extending into central Australia.

Distinguishing features. The fruits of *T. micrococcus* are rounded dorsally and usually lacking any dorsal spines. Unlike *T. minutus*, to which it is closely related, *T. micrococcus* usually has a globose stigma, which is considerably shorter than the short (0.7-1.4 mm long), but distinct, style.

Typification. Typification of *T. micrococcus* is impossible from the photographs since the detail of the style and stigma is not discernible. It appears from a young fruit present on the collection from Jericho that the style is distinct, thus agreeing with this taxon. However, spines present on the fruit of *Domin* 5493 are 5 mm long, much longer that the usual 2.5 mm long spines of this taxon and so it may be that the syntypes represent a mixed collection.

Notes. There is a Leichhardt specimen in MEL (*Leichhardt* 26, MEL *s.n.*) which has been annotated by him as "Tribulus parviflorus mihi" from Bokkara Flats on 3rd January 1847. It almost certainly belongs here even though only flowers are present.

The longer style with a short globose stigma as pictured in "Flora of New South Wales" (Wilson 1992b) certainly occurs in some specimens of this taxon, but there remain a number of specimens which seem to belong here which have the non-globose stigma as long as the style. It seems unlikely that *T. micrococcus* and *T. minutus* can be maintained as distinct species, although *T. micrococcus* does tend to have larger flowers. Specimens from South Australia, Northern Territory and Western Australia usually have larger and sometimes, spinier fruit than those from eastern Australia, and approach those of *T. eichlerianus* and *T.* sp. *long-styled eichlerianus,* differing from the former in the less densely pubescent fruits and the latter in the smaller flowers and shorter styles.

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