

AN ACCOUNT

OF THE

SOUTH AFRICAN SPECIES OF *TRIBULUS*

Tourn. ex Linn.

BY

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In Southern Africa, the genus *Tribulus* L. is of considerable economic importance, since several species have been found to be the cause of a troublesome disease in sheep, known as "geeldikkop."

Preliminary experiments and investigations carried out during the past few years by veterinary and agricultural officers in connection with this disease, have resulted in the accumulation of much material in certain South African herbaria. Increasing difficulties were encountered in naming such material forwarded for identification from various sources to the National Herbarium, Pretoria. These difficulties were due to the fact that the species appeared to be ill-defined and the writer was consequently encouraged to undertake a study with a view of defining more clearly the limits of these species.

During the course of this investigation the material in the South African and that from Southern Africa in several of the larger European herbaria was studied. [Royal Botanic Gardens, Kew; Brit. Museum (Natural History); Berlin-Dahlem; German Univ., Prague; Mus., Stockholm; Univ., Zürich.]

The conclusions arrived at in this paper have thus been based almost entirely on the study of dried material. As will be pointed out, the results have proved to be somewhat inadequate and unsatisfactory, i.e. the limits of several species as yet remain uncertain.

Recourse to field work and breeding experiments seems desirable, in order that a clear concept of the limits of such species be obtained which appear to exhibit an extremely wide range of variation in vegetative, flowering and fruiting characters.

The first record of the genus *Tribulus* in a work relating to South African plants appears to be that of *Thunb. Prodr.* 79 (1794) where the Mediterranean species *T. terrestris* L. is enumerated. *Harvey* in his *Genera of S. Afr. Pl.* 46 (1838) likewise only mentions this species, and remarks that it is "a very common weed in cult. ground in the months of Nov. and Dec. It is perhaps merely naturalised from the South of Europe." *Presl, Bot. Bemerk.* 29-30 (1844) enumerated five species from the (present-day) limits of the Cape Province. He considered these five species to be distinct from *T. terrestris* L. In how far his views are justified will be dealt with under the species concerned. *Harvey* apparently overlooked *Presl's* paper, as only two species are enumerated in the second edition of his *Genera of S. Afr. Pl.* 36 (1868), although the first volume of the *Fl. Cap.* (1859-60) had by then been published. In the latter *Sonder* mentions four species, accepting and rejecting some of *Presl's* species. During the time between the appearance of *Fl. Cap. I.* and the present day, relatively few references to South African *Tribuli* are to be found in literature. Apart from *Engler's* account in *Veg. der Erde*, no comprehensive

enumeration of the species exists. In *Fedde Rep.* XXIV (1927) *Dinter* enumerates the species which had been recorded from South West Africa up to the year 1917 and *Range* did very much the same thing, on the basis of his own collections, in *Fedde Rep.* XXXVI (1934).

The following pages are thus intended to be of a revisional character as well as a critical exposition of the conclusions drawn from the study of a wide range of herbarium material from southern Africa.

In the list of localities given under each species only such specimens as were actually seen and examined are quoted.

TRIBULUS Tourn. ex. Linn. Syst. ed. I (1735); Linn. Sp. Pl. ed. I. 386 (1753):—

Sepals 5, deciduous or semi-persistent. *Petals* 5, spreading, shorter to longer than the sepals, deciduous. *Stamens* 10, those opposite the petals somewhat longer than those alternating with the petals; filaments subulate, those opposite the sepals with both an extra and intrastaminal basal gland; anthers cordate or oblong-cordate; intrastaminal glands free or connate to form a shallow cup at the base of the ovary. *Ovary* sessile, covered with erect bristle-like hairs, 5-lobed, consisting of 5 intergrown carpels; each carpel with 3-5 ovules; style short or absent; stigma conspicuous, 5-angled, pyramidal or hemispheric, formed by intergrowth of the 5 stigmatic lobes. *Fruit* 5-angled, at length breaking up into 5 indehiscent cocci; cocci dorsally tuberculated, unarmed, spinous, winged, or winged and spinous, 1-5 seeded. *Seeds* exalbuminous.

Xerophilous, mostly annual or perennial herbs, more rarely perennial shrubs; branches prostrate or ascending, more rarely erect. *Leaves* opposite, one usually larger than the other, more rarely alternate, bistipulate, abruptly pinnate; leaflets opposite, entire, somewhat oblique. *Pedicels* axillary, one-flowered. *Petals* usually yellow.

TAXONOMICALLY IMPORTANT CHARACTERS.

The habit of the plant is of some importance. The erect shrubby perennial nature of *T. excrucians* Wawra is a constant and unique character among the African species known up to the present day and by means of which it may readily be distinguished from the other species. The remaining members are all very much alike in habit, i.e. usually prostrate or semi-prostrate annuals or perennials.

In purely vegetative characters each of these species shows a marked degree of variation, being very plastic with regard to the size, shape, indumentum, etc., of the vegetative parts. Such variation is frequently met with in plants inhabiting arid or semi-arid regions and may probably be accounted for by the edaphic and climatic conditions under which the plants develop.

The length of the pedicel appears to be of some taxonomic value. In the *large-flowered prostrate* species it always exceeds the subtending leaf, and even in extreme cases still attains the length of the leaf, whereas in the small-flowered species the pedicel is usually exceeded by the leaf.

The size of the flower and hence the petals is of some value, since species such as *T. terrestris* L. may be excluded from the "large-flowered" species on basis of this character. The ratio of length of petals to sepals is of very little and in the writer's opinion probably of no taxonomic value. Many measurements carried out with a view to detecting whether that ratio is a character of some constancy proved it to be of little value; the flowers on even one and the same individual show such strong variation that allied species (distinguishable by other characters) were found to overlap.

The nature of the intrastaminal glands situated at the base of the ovary has been found to be of great taxonomic value, and two forms may be recognised: (a) glands free,

distinct, and not connate (fig. I.), (b) glands connate to form a shallow cup at the base of the ovary (fig. II.). At times the region of intergrowth of the glands is not readily visible in herbarium specimens, and in such cases soaking and careful dissection is essential.

The shape and size of the stigma appears to be correlated with the nature of the intrastaminal glands. A hemispheric somewhat asymmetric stigma (fig. I.) is found in species with free glands and small flowers, whereas a very much larger pyramidal almost symmetric stigma (fig. II.) is correlated with intergrown glands. The length of the style appears to be variable and for this reason was discarded as a taxonomically useless character.

Taxonomically the fruits are of the greatest importance. In their absence several closely allied species, resembling each other in vegetative and floral characters, are readily confused; in order to identify large-flowered species with certainty the presence of fruits is indispensable. Whereas the fruits of species such as *T. cristatus* Presl exhibit characters which have proved to be fairly constant and thus taxonomically of the utmost importance, other species exhibit but little constancy in this respect. *T. excrucians* Wawra may serve as an example of the species in which the fruits exhibit great variation both in regard to size and degree of spinosity of the individual cocci. Owing greatly to the limited amount of material available for study to the older authors, too much value was attached to the nature of the fruits. Study of a wide range of material has shown that fruit characters of several species are to be used with some discretion. This remark brings forward the question of natural hybrids about which *Dinter* states that he has never observed any plant possessing "Bastardeigenschaften." As will be shown later, there appears to be evidence in favour of the occurrence of natural hybrids among the species of *Tribulus* from Southern Africa.

KEY TO THE SPECIES.

- I. Intrastaminal glands connate to form a shallow cup at the base of the ovary; stigma slender, usually pyramidal (fig. II.):—
- A. Plant an erect shrubby perennial attaining a height of 1 metre or more; main stem woody with corky bark; fruits (cocci) unarmed or armed with one or two pairs of short lateral spines; spines at times somewhat flattened and almost winglike.....1. *excrucians*.
 - AA. Plant annual or perennial, *prostrate* or at length with the extremities of the branches somewhat ascending:
 - B. Cocci winged; wings armed with spines or wholly devoid of spines:
 - C. Wings of cocci with numerous pungent slender marginal spines and very often a long spine arising from the centre of each wing near the dorsal crest of the coccus.....2. *cristatus*.
 - CC. Wings of cocci without or with several marginal blunt teeth but never with a spine arising from the surface of the wing, leathery and subrigid, or thin papery and brittle in texture extremely variable in shape.....3. *pterophorus*.
 - BB. Cocci never winged but armed with 2 or more pairs of spines; spines variable in length, arising from the sides of the dorsal crest or near the base of the coccus.....4. *Zeyheri*.
- II. Intrastaminal glands free, never connate to form a shallow cup; stigma hemispheric, never slender (fig. I); petals 2-12 mm. long; sepals 2-6 mm. long.....5. *terrestris*.

ENUMERATION OF THE SPECIES.

1. *T. excrucians* Wawra, in Sitzb. Akad. Wien. Math.—Nat. XXXVIII. 557 (1860).

Syn.: *T. micans* Welw. Apont. 566 (1858), nomen subnudum.

T. terrestris Oliv., in Fl. Trop. Afr. I, 283 (1868) *pro parte*, non Linn.; Hiern., Welw., Cat. Afr. Pl., 105 (1896).

T. Pechullii O. Kuntze in Jahrb. Bot. Gart. Berl. IV, 262 (1886); Engler, Jahrb. X, 31 (1888); Schinz in Bull. Herb. Boiss. II, 187 (1894); Heering and Grimme, Untersuch. Weideverh. Deutsch-Südwest afr., 27 (1911); Engler, Veget. der Erde. 9, III, i, 738 (1915), cum fig. 343 P-R et Pflzfam. ed. II, 19a, 176 (1931), cum fig. 84 P-R.

T. Zeyheri Sond. var. *Pechuelii* Schinz, in Verh. Bot. Ver. Prov. Brandenb. XXIX, 54 (1887).

T. inermis Engl., Bot. Jahrb. X, 32 (1888), non Kralik.; Heering and Grimme, Untersuch. Weideverh. Deutsch-Südwestafr., 27 (1911).

T. erectus Engl., Bot. Jahrb. X, 32 (1888); Dinter, Deutsch-Südwest-Afrika, 86 (1909); Engl., Veget. der Erde 9, III, i, 738 (1915); Dinter, in Fedde Rep. XXIV, 14 (1927).

An erect or suberect perennial *shrub* up to 1.5 m. high, with a short stem, up to 5 cm. thick near the base. *Branches* erect, robust, longitudinally striate, terete, pubescent-glabrous in age; internodes up to 6 cm. long, but usually much shorter. *Leaves* unequal; the larger up to 7 cm. long, 6-10-jugate; the smaller up to 3 cm. long, 3-6-jugate; stipules up to 7 mm. long, linear-lanceolate to obliquely lanceolate, acute, silky pubescent on the outer surface, less so on the inner surface; petiole silky pubescent, slightly winged towards the apex; leaflets obliquely oblong to lanceolate, acute, up to 25 mm. long and 8 mm. broad, but usually much smaller, densely silky pubescent on the lower surface. *Pedicele* fairly short, 1.5-2 cm. long, terete, silky pubescent, markedly striate in age. *Flower-buds* ovate, markedly acuminate. *Sepals* linear-lanceolate, up to 11 mm. long and 3 mm. broad, silky pubescent on the outer surface. *Petals* broadly cuneate, up to 25 mm. long, often much smaller. *Filaments* 3.5 mm. long; anthers 2.5 mm. long. *Intrastaminal glands* connate to form a very shallow cup at the base of the ovary. *Stigma* pyramidal, about 2.5 mm. long. *Mature fruit* at length breaking up into several (usually less than 5) cocci; cocci unarmed or armed, some without any signs of spines, merely tubercled laterally and dorsally, densely but very minutely pubescent, others again armed with 1-3 pairs of lateral spines, which at times are much flattened and almost wing-like (fig. III).

ANGOLA.—Loanda: July, *Menyhart*, 228. Lobito Bay: Aug., *Obermeyer*, in Herb. Tvl. Mus. 32816. Benguela: Jan., *Wawra*, 299 (types in Herb. Mus. Nat. Hist. Vindob).

Between Mossamedes and Rio Bero: Apr., *Hopfner*, 5. Mossamedes: July, *Welwitsch*, 1579, 1580. Oct., *Brühl*, 5, 6. *Jessen*, 329. March, *Fritzsche*, 2.

SOUTH WEST AFRICA.—Swakopmund: *Dinter* 22. *Belck*, 63a; upright perennial in bed of river, *Bradfield*, 550. 580. Swakoprivier: May, *Marloth*, 1457. Nov. *Rewsch*, 63a. Walfish Bay: Okahandja: Oct., *Luderitz*, 147. Husab: June, *Fleck*, 727. March, *Dinter*, 8446. Kuwosis: Oct., *Schenck*, 433. Haigamchab: Jan., *Galpin et Pearson*, 7607, 7637; shrub along banks of Swakoprivier, June, *Gurich*, 129, 147. Khanthal: Apr., *Engler*, 6058. Ukuib: Dec., *Pogge*, 9. Gamkoischas: May, *Dinter*, 207. Usakos: June, *Marloth*, 1457a; Nov., *Schinz*, 1120. Otjimbingue: May, *Marloth*, 1300, 1390. Okahandja, cult.: Nov., *Dinter*, 207.

Without precise locality: *Luderitz*, 208. *Schenck*, 452. *Nels*, 16. *Francois*, 38. *Pechuel Lösche*, 36.

In the description of *T. excrucians*, Wawra l.c. cites the type as being his 290. The specimen in the Vienna Herbarium and a duplicate of same in the Zurich Herbarium both bear the number 299. The number *Wawra* 290 is thus probably a typographic error for 299.

The shrubby nature, together with the peculiar ashy-grey silky appearance of the plant, are the most reliable characters by which this can be distinguished from other related species. Apparently *T. excrucians* has been overlooked by all authors cited below since they do not refer to this species in their work relating to *Tribulus*.

O. Kuntze (1886) l.c. in describing *T. pechuelii* apparently did not know that he was dealing with a shrubby species (the label on the type specimen gives no information with regard to the habit of the plant). He consequently made use of the number of leaflets per leaf, the nature of the fruit and other characters to distinguish his species from allied plants such as *T. Zeyheri* and *T. cistoides*. Both the latter, however, are prostrate in habit, the branches only rarely ascending to a few centimetres above the level of the substratum, whereas *T. excrucians* (*T. Pechuelii* of various collectors) is a perennial undershrub or shrub attaining a height of up to 1.5 metres. It also possesses a short main stem which may equal a "man's wrist" in thickness.

The colour of the flowers may either be pale yellow (*Dinter*) or yellow with a dark claw (*Marloth*). The size of the petals is variable and may be anything from 15–24 mm. long; the petals are ± 2.5 times the length of the sepals.

Schinz (1887) l.c. pointed out that contrary to *Kuntze's* statement regarding the unarmed nature of the fruits, the cocci showed the presence of small spines. As a consequence of the armed nature of the cocci, *Schinz* lowered the rank of this plant and considered it to be a variety, viz. *T. Zeyheri* Sond. var. *Pechuelii* Schinz. *Schinz* at this time was unaware of the shrubby nature of the species.

Engler (1888) l.c. independently described a shrubby species (*T. erectus*) from South West Africa. He also hinted at the presence of a second erect species in the form of *T. inermis* since he described the habit of this plant as "procumbens?". *Engler* had overlooked *T. excrucians* Wawra but had naturally consulted *Kuntze's* type in drawing up his descriptions; being a hypercritical worker he considered *T. erectus* and *T. inermis* to be distinct from *Kuntze's* species (the latter is a very fragmentary specimen only possessing young fruits). His views which were naturally based on the material available for study at the time appear to have been by no means unreasonable.

As a result of *Engler's* work as well as the study of further material *Schinz* (1894) l.c. subsequently somewhat modified his earlier views regarding the taxonomic position of *T. Zeyheri* Sond var. *Pechuelii* Schinz. He revived *T. Pechuelii* Kuntze, and considered it a valid species still closely allied to *T. Zeyheri* Sond. *Engler's* species *T. inermis* and *T. erectus* had also come to his notice and realising the great variability of the fruits he correctly considered them to be conspecific with *T. Pechuelii* Kuntze. Attention may be drawn to the fact that *T. micans* Welw. from Angola had apparently been overlooked and perhaps wilfully excluded in the absence of a description by all three authors mentioned above. [Since *Welwitsch* did not draw up a valid diagnosis *T. micans* Welw. is a *nomen subnudum*.] The type of this plant in Herb. Mus. Brit. undoubtedly is conspecific with *T. excrucians* Wawra, which is the oldest validly published name for this species. *Dinter* (1927) l.c. also considers *T. erectus*, *T. inermis* and *T. Pechuelii* to be conspecific, but adopts the name *T. erectus* to designate the species which, however, is not in accordance with the International Rules of Nomenclature.

As a result of my own studies of dried material I have arrived at the conclusion that all the species in question are conspecific. The fruits of many specimens seen showed either the presence or absence of spines; at times the spines were so weakly developed that they could easily have been overlooked. The fruits of even one and the same plant

show a fair degree of variation. *Dinter* (1927) l.c. says of *T. erectus* that this species "ist in jeder Beziehung konstant, wenn auch höchst wahrscheinlich aus *T. Zeyheri* hervorgegangen," furthermore that the fruits may either be spineless or weakly thorny.

Marloth 1457 and 1457b from Swakop, S.W.A. and *Pocock* 975 from Benguella, Angola belong to *T. excrucians*. These sheets, however, have elliptic acute leaflets which are much larger (25 mm. l.) and broader (up to 9 mm.) and more markedly veined than those of the typical species. *Engler* (1888) l.c. places *Marloth* 1457 and 1457b under *T. Pechuelii* but mentions that *Marloth* collected "diese Art. . . . in zwei Formen." The cocci of *Marloth* 1457 and 1457b are glabrous in age except for a few bristly hairs, whereas in *Pocock* 975 they are densely minutely pubescent. In all these specimens the cocci are armed with 1-2 pairs of short lateral spines and the whole appearance of these fruits is somewhat different from those of typical *T. excrucians*. But having studied a wide range of material I am of opinion that all the sheets cited above probably only represent *one variable* species.

Study of this interesting species together with breeding experiments will undoubtedly be necessary in order to prove whether in the foregoing only a single or perhaps more than one closely related species is involved.

T. excrucians Wawra appears to have a very limited geographic distribution. It is only known to occur in the western regions of the Mandate of South West Africa and Angola, where it is mainly found growing in or near the dry sandy beds of desert rivers.

2. *T. cristatus* Presl, Bot. Bemerk., in Abh. Böhm. Ges. Wiss. V. 3.29 (1844); Sond., in Fl. Cap. I. 354 (1859-1860); Glover, in Ann. S. Afr. Mus. IX. iii. 170 (1913); Engl., Veg. der Erde 9. III. i. 738 (1915), cum fig. 343 V; *Dinter*, in Fedde Rep. XXIV. 15 (1927); Engl., Pflzfam. ed. II. 19a. 177 (1931), cum fig. 84 V; Range, in Fedde Rep. XXXVI. 249 (1934).

As *Presl's* description is somewhat incomplete and that of *Sonder* in the *Fl. Cap.* was based on the same gathering and consequently does not add much to it, it was thought necessary to draw up an amended description based on the material now represented in the South African and European herbaria consulted.

An annual, or possibly a biennial or perennial plant. *Branches* prostrate, radiating from the much branched rootstock, 12-100 cm. long, usually again branched but not conspicuously so. *Branches*, stipules, leaves, peduncles and calyx, in fact all vegetative parts of the plant usually hirsute with bulbous-based bristly hairs; internodes terete, striate, 0.5-6.0 cm. long. *Leaves* unequal, the larger 1.5-6.5 cm. long with 3-8 pairs of leaflets; the smaller (subtending a branch or flower) with 2-4 pairs of leaflets and much shorter than the first internode of the subtended branch, or the peduncle; stipules 2.5-8 mm. long, obliquely lanceolate, acuminate, upper and lower surface hirsute or almost glabrous, with marginal bulbous-based hairs; petiole hirsute or minutely pubescent, at times somewhat winged; leaflets hirsute or glabrous except along the midrib above, hirsute and paler beneath, obliquely oblong, obtuse or acute, with marginal bulbous-based hairs, up to 14 mm. long and 6 mm. broad but usually much smaller. *Pedicel* 2.5-4 cm. long, usually 2 to 3 times the length of the subtending leaf, striate, terete, set with tubercle-based hairs interspersed between a finer indumentum. *Flower-buds* abruptly acuminate. *Sepals* persistent, acuminate, 8-12 mm. long. *Petals* broadly cuneate, up to 25 mm. long, apparently always pale yellow in colour, twice or slightly more than twice as long as the sepals. *Filaments* up to 4 mm. long, bearing anthers about 2 mm. long. *Style* one-third to two-thirds as long as the stigma; stigma conical-oblong, slender and 2-3.5 mm. long. *Disc* at base of ovary a shallow cup formed by the intergrowth of the *intrastaminal glands*. *Mature fruits* variable in size, glabrous except for a few bristle-like hairs, 6-25 mm. long, 12-30 mm. in diameter including the wings, finally breaking up into 5 cocci; cocci with lateral oblong rounded wings, dorsally ridged and set with tuberculate bristly hairs; wings rounded, transversely markedly striate with marginal subrigid acute spines of unequal length often

bearing an analogous spine dorsally from the centre of each wing near the body of the coccus, a character which appears to be unique and by which this species may readily be distinguished from all the other South African species. This spine may sometimes be intergrown with the wing and in such cases is less conspicuous (Fig. IV).

SOUTH WEST AFRICA.—Great Namaqualand: Elephantenfluss: *Range*, 1483; Eirup; nr. Marienthal: March, *Steyn*, 22533. Gouchassib R.: Aug., *Range* 727. Nabaos nr. Keetmanshoop: Apr., *Range*, 1313. Kuibis: Sandstein plateau: Jan., *Dinter*, 1166 and Tafelbergsandstein: Jan., *Dinter*, 1248. Seeheim, sandy bed of Fish river: Apr., *Engler*, 6633 and Apr., *Dinter*, 2967. Klein Karas: October, *Dinter*, 5055 and Apr., *Örtendahl*, 95. Satansplatz: March, *Dinter*, 2041. Wasserfall: Jan., *Pearson*, 3154. Between Dabai-gabis and Gründoorn: Febr., *Pearson*, 3154.

CAPE PROVINCE.—Little Namaqualand: Verleptpram, stony hills on the Orange river: *Drege*, 7160 (type deposited in Herb. Univ. Germ. Prag.). Herbert: Douglas, *Orpen in Mus. Austr. Afr.*, 14494. Prieska: Prieska, on sand dunes north of Orange river: March, *Wilman*, 3039 and 3040; in sand near Prieska, March, *Bryant*, 880 and J. 251.

Examination of many herbarium specimens has led me to believe that the above species is an annual. Specimens such as *Dinter* 5055 and *Pearson* 7863, however, suggest that the plants may be biennial and even perennial since these sheets possess a moderately branched rootstock bearing the remains of dry withered branches at the apex. *Bryant* 880 in Herb. Kew. bears a note to the effect that the species is annual.

T. cristatus Presl appears to be consistently prostrate in habit with the branches radiating from the crown of the rootstock. The length of the internodes of the branches is a very variable one; robust specimens usually have longer internodes than weaker specimens. This character appears to be correlated with the size of leaf, leaflets, flower and fruit, i.e. a weak specimen usually is smaller in all vegetative and reproductive characters than a luxuriant specimen. There does not appear to be a great deal of variation in the degree of hairiness in the vegetative parts of the species.

Bryant 880 bears a remark to the effect that this species does not "vary in flower or shape of fruit." From my own observations of herbarium material I cannot agree with the first part of this statement. The smallest flowers so far seen had sepals 8 mm. long and petals about 18 mm. long, the largest sepals up to 12 mm. long and petals up to 25 mm. long. The colour of the petals appears to be consistently pale yellow in colour and according to *Bryant* the "flowers open for an hour or two in the morning" and are "very fugacious." The shape and consistency of the fruits undoubtedly form the best diagnostic characters of the species. Whereas the size of the fruits is variable, the shape and texture, however, is fairly consistent. The largest fruits seen had wings about 25 mm. long and up to 10 mm. broad, but on an average the fruits are much smaller. The species flowers during the months of November and April.

The plants appear to prefer a sandy substratum and the species therefore is primarily psammophytic and according to *Bryant* is "very rarely found on hills."

The distribution is fairly restricted and the species appears to be limited to the sandy regions of Griqualand West, Little and Great Namaqualand. It has not yet been recorded further north than the Mandate of South West Africa and its southern limit appears to be approximately the Orange River basin.

Bryant has observed that this species "often grows alongside *T. terrestris* L. but never hybridises apparently." *Dinter* regards *T. cristatus* Presl as being a very good species having nothing in common with *T. pterophorus* Presl, an opinion which I am inclined to endorse.

If accompanied by young or preferably mature fruits, *T. cristatus* Presl may always be readily indentified. It is one of the most clearly defined species in the whole genus and owing to its characteristic fruits, taxonomically occupies a somewhat isolated position.

Among the material examined none was observed to exhibit intermediate characters, an indication that this species does not tend towards natural hybridisation.

3. *T. pterophorus* Presl, Bot. Bemerk. in Abh. Böhm. Ges. Wiss. V. 3. 29 (1844); Sonder, in Fl. Cap. I. 353 (1859–1860); Dinter, Deutsch-Südwest-Afrika, 86 (1909); Glover, in Ann. S. Afr. Mus. IX. iii. 170 (1913); Engl., Veg. der Erde, 9. III. i. 738 (1915), cum fig. 343 U; Burt Davy, Flow. Pl. & Ferns I. 187 (1926); Dinter, in Fedde Rep. XXIV. 15 (1927) et Fedde Rep. Beih. LIII. 50 (1928); Engl., Pflzfam. ed. II. 19a. 176 (1931), cum fig. 84 U; Range, in Fedde Rep. XXXVI. 249 (1934).

Syn.:—

T. alatus Drège, Zwei Pflzgeogr. Docum. 227 (1843), non Del.

T. securidocarpus Engl., Veg. der Erde, 9. III. i. 738 (1915) in obs., cum. fig. 343 S. a, b, c; Dinter, in Fedde Rep. XXIV. 15 (1927); Engl., Pflzfam. ed. II. 19a. 176 (1931), cum fig. 84 S. a, b, c; Range, in Fedde Rep. XXXVI. 249 (1934).

T. securidocarpus Engl. forma *vulgaris* Engl., l.c., cum fig. 343, S. a, b.

T. securidocarpus Engl. var. *subtruncatus* Engl., l.c., cum fig. 343. S. c.

T. albescens Schltr. ex Dinter, in Fedde Rep. XXIV, 14 (1927), nomen tantum; Engler, Pflzfam. ed. II. 19a, 176 (1931).

An *annual*. *Branches* prostrate, radiating from the much branched crown of the rootstock, up to 100 cm. long and usually somewhat branched again, in all vegetative parts more or less densely hirsute with a fine indumentum scattered between which are much longer bulbous-based hairs; internodes up to 10 cm. long, usually much shorter, striate, terete. *Leaves* unequal; the larger up to 6 cm. long, 6–9-jugate; the smaller (subtending a branch or pedicel) up to 3.5 cm. long, 3–6-jugate; stipules 3.5–6 mm. long, obliquely lanceolate, acute, upper and lower surface pubescent, with marginal tubercle-based hairs; petiole not winged; leaflets obliquely oblong, sub-acute or oblique, up to 12 mm. long and 6 mm. broad, densely silky beneath, less so on the upper surface. *Pedicel* 1–3 times as long as the subtending leaf, up to 3.5 cm long. *Flower-buds* ovate in outline, hardly acuminate. *Sepals* linear-lanceolate, up to 10 mm. long and 2.5 mm. broad, acute, silky pubescent without. *Petals* broadly cuneate, 1.5 to 2 times the length of the sepals, up to 20 mm. long and apparently bright yellow to orange in colour. *Filaments* up to 4 mm. long, bearing anthers up to 3.0 mm. long. *Style* short; stigma broadly pyramidal, 1.25–2.5 mm. long. *Intrastaminal glands* united to form a shallow cup at the base of the ovary. *Carpels* and *young fruit* minutely pubescent. *Mature fruit* winged, glabrous or minutely pubescent, at length breaking up into 5 cocci; cocci winged, with several spines on the dorsal crest, each terminating in a tubercle-based hair; wings extremely variable in shape, size and texture, often rounded, oblong, narrowed and triangular or subtruncate, transversely striate and with one or several teeth on the margins, more rarely irregularly dentate, never spiny, papery, brittle or coriaceous and tough, minutely pubescent or glabrous, up to 18 mm. long and 10 mm. broad, but often very much smaller and showing mere traces of wings (Fig. V).

SOUTH WEST AFRICA.—Gt. Namaqualand: Marienthal: March, *Dinter*, 2022; March, *Steyn*, 22555 and 22546. Haribes: 40 km. S.W. of Marienthal, Apr., *Engler*, 6578, 6579, 6592. Garis: Oct., *Hartman*, 155, 155b. Between Packrien and Leberfluss: *Trotha*, 43. Sandverhaar: sand dunes, Febr., *Pearson*, 4693; tiefer sand, Jan. *Dinter*, 1187. Kubub-Fläche: March, *Range*, 232. Seeheim: Apr., *Dinter*, 2956; sandy bed of Fisch river, Apr., *Engler*, 663. Holog: dry river bed, *Pearson*, 4120. Klein Karas: *Dinter*, 5101. Great Karasberge: Noachabeb, 1918, *Blank*, s.n. Keetmanshoop: *Fenchel*, 29. Sandfontein: *Wilman*, 2177. Satansplatz: *Dinter*, 2042; Ariamsvlei, farm Walsbrunn, *Ortendahl*, 316. Orange River: Gaidib, Dec., *Dinter*, 5138. Without precise locality, Afr.: *Fleck*, 26a.

CAPE PROVINCE.—Little Namaqualand : Orange River, Verleptpram, *Drège*. Wortel : Dec., *Pearson*, 3631 ; without precise locality : *Marloth*, 7809. Kenhardt : Upington, *Moss*, 10730 ; *Smith*, 2369. Gordonia : without precise locality, *Pole Evans*, 2180. Prieska : Prieska, March, *Bryant*, J. 39. Barkly West : Danielskuil, *Lawson*, in *McGregor Mus.*, 2121.

TRANSVAAL PROVINCE.—Zoutpansberg : Messina, nr. the town, *Young*, in *Hb. Moss.*, 14675.

From the large range of material studied it appears that this species is an annual or at the very most a biennial. The indumentum of the vegetative parts is more pronounced than in other species, especially with regard to the bulbous-based hairs, but this character is inadequate to identify the species in the absence of fruits.

The size of the flowers is extremely variable. *Engler* 6579 has flowers with petals about 8 mm. long whereas *Pearson* 4693 has such of over 15 mm. in length ; in fact they may reach a length up to 20 mm. The colour, however, appears to be consistently a pure though a somewhat pale yellow.

In fruiting characters the species, however, is extremely variable, especially with regard to the shape, size and texture, and degree of indumentum of the wings of the individual cocci. The colour of the wings appears to be brown, whereas in *T. cristatus* Presl they are apparently always pale olive-green in colour. The latter character is remarked upon by *Dinter*, who also states that he has never observed a transition from the one to the other. In sheets such as *Dinter* 1187 and *Bryant* J. 39 the extreme variation in the size and shape of the wings may be clearly seen. The texture of the wings is also of a very variable nature ; it may be papery and brittle showing all intermediate stages to rigidly coriaceous and tough. This great variation undoubtedly led *Engler* (1915) l.c. to figure and describe (inadequately?) *T. securidocarpus* which he considered to be specifically distinct from our species in question. Under his species he also distinguished forma *vulgaris* and var. *subtruncatus*. Examination of the material of this species and its forms deposited in Herb. Mus. Bot. Bérol. has convinced me that neither the forms nor this species created by *Engler* can be upheld, as they fall within the limits of variation of *T. pterophorus*. A further argument in favour of this view is the following : the type number of *T. pterophorus* Presl in Herb. Mus. Brit. bears fruits which appear to be almost mature and comparison of these with such of typical *T. securidocarpus* Engl. have led me to believe that both these species are conspecific. *E. Meyer* when working through *Drège's* gatherings of *Tribulus* labelled certain sheets *Tribulus alatus* Delile? thus (inadvertently?) drawing attention to the similarity between the Cape plant and the true but distinct Indian and north-east African *Tribulus alatus* Del. As *Presl's* type of *T. pterophorus* cannot be traced in the *Herb. Un. Germ. Prag.* we have no evidence that this species is distinct from *T. securidocarpus* Engl., but the fact that the type numbers of *T. pterophorus* in both Herb. Kew and Herb. Mus. Brit. agree perfectly with the latter species and also with *Engler's* figure of *T. securidocarpus* is sufficient evidence to regard them as being conspecific.

T. albescens Schlechter ex *Dinter* l.c. is only more densely hispid than typical *T. pterophorus* Presl. It agrees in fruiting characters with, and therefore is also conspecific with the latter.

T. alatus Del., *T. macropterus* Boiss. and *T. pterocarpus* Ehrenb. are the nearest allies of *T. pterophorus*. *T. alatus* Del. and *T. macropterus*, however, both have smaller flowers, intrastaminal glands which are not joined to form a shallow cup at the base of the ovary and fruits with smaller and shorter wings. *T. pterocarpus* Ehrenb. has extremely small flowers with petals about 5 mm. long and the fruits, including wings, do not exceed 10 mm. in both length and diameter, characters by which it is readily distinguishable from *T. pterophorus*.

Dinter (1927) l.c. states that *T. pterophorus* and *T. securidocarpus* are undoubtedly closely related species, but never show transitions between each other. I have had the privilege of studying a wide range of material, my observations have led me to the following conclusions. The extreme forms included under the two species can definitely be distinguished but since every degree of variation and in many cases great variation in the shapes of the fruits on one and the same plant can be observed, the question arises whether we are dealing with two distinct species and their numerous intermediates due to hybridisation. It is possible that *T. securidocarpus* may prove to be a hybrid of the parentage *T. pterophorus* on the one hand and *T. Zeyheri* or an allied species on the other, but this can only be proved by breeding experiments. The figure in Engler l.c. of *T. pterophorus* does not agree in shape with the fruits of the type numbers I have studied; should *T. pterophorus* Engl. (*non* Presl.) eventually be recognised as a distinct species, it will have to receive another name.

In order to decide with absolute certainty whether *T. pterophorus* Presl is an extremely variable species or includes more than one closely allied species with tendencies towards hybridisation, careful breeding experiments will be necessary. As I have had neither the opportunity of studying these plants in the field nor undertaking breeding experiments, my deductions are based on the study of herbarium material, and such conclusions I have reached and the views which are being forwarded here may later prove to be quite erroneous.

The distribution of the species is a fairly limited one. It is fairly frequent in the sandy parts of the Mandate of South West Africa and its southernmost limit appears to be approximately the Orange River basin. It has not yet been recorded from as far north as Angola.

A note on *Blank* s.n. (*leg. anno* 1918) in *Herb. Mus. Bot. Berol.* says "Aufschlag, das erste nach dem Sommerregen spriessende Grün, wächst überall und wird, besonders im jungen Zustande, von allem Vich gern gefressen. Wenn die Samenkapseln gelb werden, sollen sie Schuld an der 'Geelsiekte' der Schafe sein. Das Fett der an dieser Krankheit verendeten Schafe ist durchweg gelb . . .", an indication that this species is suspected of causing "geeldikkop"? in sheep.

4. *T. Zeyheri* Sond., in *Fl. Cap.* I. 353 (1859-1860); Dinter, *Deutsch-Südwest-Afrika*, 85 (1909); Heering & Grimme, *Unters. Weideverh. Deutsch-Südwestafri.* 27 (1911); Glover, in *Ann. S. Afr. Mus.* IX. iii. 170 (1913); Engler, *Veg. der Erde* 9. III. i. 736 (1915), cum fig. 343Y; Burt Davy, *Flow. Pl. & Ferns* I. 187 (1926); Dinter, in *Fedde Rep.* XXIV. 15 (1927); Engler, *Pflzfam. ed. II.* 19a. 176 (1931), cum fig. 84 Y; Bremekamp, in *Karsten u. Walter: Vegetationsbilder*, XXII. 3. 3 (1932), cum fig. 13; Range, in *Fedde Rep.* XXXVI. 250 (1934).

Syn.: *T. Zeyheri* Sond., var. *hirtus* Schinz, in *Verh. Bot. Ver. Brandenb.* XXIX, 54 (1887).

T. Zeyheri Sond., var. *hirsutissimus* Schinz, l.c.

T. terrestris L., var. *Zeyheri* Schinz, in *Bull. Herb. Boiss.* II, 187 (1894).

T. Zeyheri Sond., var. *aurantiacus* Dinter, in *Fedde Rep.* XXIV, 15 (1927).

T. murex Schlechter ex Dinter, in *Fedde Rep.* XXIV, 14 (1927), nomen subnudum, non Presl, pro parte; Range, in *Fedde Rep.* XXXVI, 249 (1934).

A prostrate *perennial*. Branches prostrate or at length somewhat ascending, radiating from the much branched crown of the rootstock, up to 1 metre long (sometimes even exceeding this length but usually very much shorter) and branched again, more or less hirsute in all vegetative parts with a fine indumentum, with scattered bristle-like bulbous-based hairs; internodes very variable in length, depending on the robustness of the plant, up to 9 cm. long, usually much shorter, striate, terete. *Leaves* unequal; the larger up to 9 cm. long, up to 9-jugate; the smaller up to 5 cm. long, up to 4-jugate; stipules up to

10 mm. long, usually much shorter, narrowly linear-lanceolate to obliquely ovate, acute, ciliate with tubercle-based hairs, more or less pubescent on both surfaces; petiole not winged; leaflets obliquely oblong, acute or ovate acute to slightly obovate abruptly acute, very variable in size and shape, from 4–20 mm. long and 2–11 mm. broad, more or less densely pubescent on both surfaces sometimes almost glabrous on the upper surface and very often conspicuously ciliate with bulbous-based hairs. *Pedicel* $1\frac{1}{2}$ to 2 times as long as the subtending leaf. *Flower-buds* ovate, obtuse or acuminate, up to 8 mm. long. *Sepals* narrowly linear-lanceolate, acute, up to 12 mm. long and 2 mm. broad, unusually densely pubescent without. *Petals* broadly cuneate, up to 25 mm. long, 1.7 to 2.5 times the length of the sepals. *Filaments* up to 3.5 mm. long; anthers up to 3 mm. long. *Style* usually fairly short; stigma slender, pyramidal, about $2\frac{1}{2}$ mm. long, much exceeding the style in length. *Intrastaminal glands* united to form a shallow cup at the base of the ovary. Carpels and young fruit minutely pubescent and hirsute with bristle-like hairs. *Mature fruits* armed or almost devoid of spines, extremely variable in size and shape, at length breaking up into 5 cocci; cocci usually armed with 4 (–6) well developed spines, or spines very much reduced as to give the coccus almost a warted appearance, tubercled on the dorsal crest and very often laterally compressed (Fig. VI).

DAMARALAND.—Grootfontein: Jan., *Lightfoot*, 63; Febr., *Seiner*, 674; Jan., *Schoenfelder*, 488. At Gaub: *Borle*, 50. Okahandji: *Dinter*, 143, 303; *Bradfield*, 412; *Hopfner*, 53, 52. Swakopmund: *Bradfield*, 581; *Lüderitz*, 148. bei Ukib: *Dinter*, 60; *Pogge*, 15. Onguati: *Engler*, 6191. Salem: *Dinter*, 110. Karibib, *Hartman*, 155a, 155c pro parte; *Mücke*, 7. Auasberge: *Dinter*, 1888. Windhuk: *Rogers*, 29766. Rehoboth: *Fleck*, 150, 592. Kuiseb-bed: *Fleck*, 776.

GREAT NAMAQUALAND.—Gibeon: *Pearson*, 9212. Sandverhaar: *Range*, 942. Kuibis: *Range*, 897. Aus: *Schäfer*, 156; *Schinz*, 1121. Huibplateau: *Schenck*, 207, 211. Holog: *Pearson*, 4120. Aias: *Pearson*, 8039. Klein Karas: *Örtendahl*, 250. Choaberib: *Pearson*, 9461.

CAPE PROVINCE.—Namaqualand: Rietfontein, *Pearson*, 3434. Kamabies: *Pearson*, 3780. Springbok: *Godman*, 689; *Salter*, 4577. Calvinia: Springbokkuil, *Zeyher*, 272 (type in Herb. Mus. Bot. Stockholm). Calvinia: *Marloth*, 10487. Gordonia: Upington, *Wagner*, s.n. Askkam: *Lang*, s.n. Laingsburg: Matjesfontein, *Foley*, 192. Graaff Reinet: Kruidfonteinhoogte, *Bolus*, 836. Prieska: *Bryant*, J.21, J.39, J.19. Hopetown: Orange River nr. Hopetown, *Bolus*, 1836; *Rehmann*, 3336. Herbert: St. Clair, Douglas, *Orpen*, 124. Kimberley: Witpan, *Pocock*, s.n. Barkly West: *Benim*, 607. Groot Boetsap: *Marloth*, 1133. Likat: *Wilman*, s.n. Winters Rust: *Wilman*, s.n. Kuru-man: 50 miles from Kuruman, *Lang*, s.n. Batlharos: *Silk*, 15.

ORANGE FREE STATE.—Fauresmith: *Henrici*, 2557.

TRANSVAAL PROVINCE.—Zoutpansberg: Blaauwberg: *Bremekamp* and *Schweickerdt*, 120. Mapagoni: *Breyer*, in *Hb. Transv. Mus.*, 16044. Messina: *Rogers*, 19373, 19401, 18422; *Scholtz*, 1. Zoutpan: *Obermeyer*, *Schweickerdt* and *Verdoorn*, 263, 299. Waterpoort: *Obermeyer*, *Schweickerdt* and *Verdoorn*, 325. Lydenburg: Sekukuni, *Barnard*, 186.

Sonder in *Fl. Cap.* I. l.c. based his description of the above species on one gathering only; i.e. *Zeyher* 272 from Springbokkuil, Little Namaqualand. Examination of the type numbers of this species in various herbaria suggested that it is an annual, the crown of the rootstock not being strong enough to give one the impression of a perennial species. Sheets such as *Pearson* 3780, 3015, 9212 and 3434, and *Marloth* 1133 which are good matches with the type, however, have rootstocks in which the crown exhibits the presence of remains of dry shoots from an earlier season. Observations of this species in the field in the sandy areas of the northern Transvaal (during the month of November) showed the presence of persistent rootstocks (with the remains of withered and dried branches) giving rise to young flowering shoots. This species is thus undoubtedly perennial but very probably may reach the flowering stage within a year.

Sonder's type is undoubtedly a specimen which grew under unfavourable circumstances. In endeavouring to find a match with this type among more recently gathered material it was found that stunted and dwarfed plants such as *Pearson* 3780 and *Marloth* 1133 approached the type most closely, whereas more robust gatherings such as *Dinter* 303 and *Pole Evans* 1, at first sight, did not appear to belong to this species. Furthermore, luxuriant specimens such as *Schweickerdt* and *Verdoorn* 650, and *Obermeyer*, *Schweickerdt* and *Verdoorn* 299 at first sight appeared wholly out of place in this species. Careful examination of vegetative, floral and fruit characters, however, have subsequently shown, that all these exhibit such a wide range of variation that a sub-division based on these characters would amount to the description of individual plants as species. It therefore became obvious that owing to the great variation in the specimens examined, the adoption of a broad view of the species seemed the only one possible.

From the appearance of the specimens examined, the notes made by different collectors and from my own observations of plants in the field, it appears that the habit of this species is a fairly constant one: the primary branches arising from the crown of the rootstock are prostrate and towards their extremity may be ascending, but the species never tends to become shrubby as in *T. excrucians* Wawra. It is by this character (supported by others less conspicuous) that these two species may be distinguished.

A study of the characters of the vegetative and reproductive organs, i.e. length of internodes, size of leaflets, degree of indumentum, relative and actual size of calyx and corolla, nature of the fruit, etc., showed *T. Zeyheri* to be an extremely variable species, the limits of which are not at all clearly defined. In fact it is only with great difficulty and uncertainty that it may be distinguished from *T. cistoides* L. *Sonder* l.c. states that *T. cistoides* is "much more robust and has larger leaves, flowers and fruits, besides a style 2 lines long and a short terminal stigma, by which character as already stated by *Schlechtendal Bot. Zeit.* 1851, p. 844, it is known from other *Tribuli*." This statement holds good for *Sonder's* type and a few modern gatherings of stunted plants which are in no way truly representative of the species. As soon as a broader view of the species is adopted it is a matter of difficulty to distinguish our South African species from the American *T. cistoides* L. Examination of material of the latter from America, Cape Verde Islands and Tropical Africa, etc., has shown that in many cases the style is extremely well-developed and the stigma very much reduced; in other cases, however, a pyramidal well-developed stigma and consequent reduction in the length of the style is exhibited by the American plants. The character of relative size and length of style and stigma thus does not hold good as a means of distinction between *T. Zeyheri* and *T. cistoides*. The shape of the leaflets, however, appears to be more satisfactory, viz. in *T. cistoides* they tend to be oblong to obovate-oblong apiculate, whereas in *T. Zeyheri* they tend to be more or less oblong or ovate-oblong. The fruits of these two species do not exhibit any constant differences.

From the foregoing observations it is assumed that these two species are closely related. Whereas extreme forms of these species may be readily distinguished, occasions arise when one is rather somewhat in doubt as to the identity of a plant especially when it has come from an area where both species overlap, i.e. some parts of Tropical Africa.

To take a restricted view of the above species would not further the position in any way. It would merely mean that certain individuals would have to remain unclassified. To regard *T. Zeyheri* and *T. cistoides* as being conspecific would amount to extending the limits of the species too considerably. *Oliver* in *Fl. Trop. Afr.* I. 283 (1868) considers *T. cistoides* L. to be a variety of *T. terrestris* L. This is very unlikely to be true for the following reasons. The flowers of *T. terrestris* L. (from Southern Europe) possess intrastaminal glands which are free and not joined to form a definite cup around the base of the ovary, whereas *T. cistoides* L. shows the presence of this cup. This characteristic appears to be of great taxonomic importance as in the many sheets examined I have always been able to distinguish *T. terrestris* L. (including *T. parvispinus* Presl and *T. murex* Presl) from the other South African members of this genus.

Schinz l.c. after having studied a large number of specimens from the Mandate of South West Africa, arrives at the conclusion that *T. Zeyheri* is to be regarded as a variety of *T. terrestris* L. I cannot agree to this view on the grounds that *T. Zeyheri* has intergrown intrastaminal glands whereas in *T. terrestris* these are free. *Schinz* furthermore states that he had not yet seen *T. cistoides* from Africa, but regards all plants so-named from that continent to be *T. Zeyheri*. In *Herb. Kew.*, however, several sheets from Tropical Africa undoubtedly belong to *T. cistoides* L., in fact they resemble the typical South American form of that species.

Dinter, in *Deutsch-Südwest-Afrika* l.c. states that *T. Zeyheri* differs from *T. terrestris* only in the very large flowers and which are extremely variable in colour. This fine collector evidently overlooked the nature of the intrastaminal glands.

Engler, *Veg. der Erde* l.c. considers *T. cistoides*, *T. terrestris* and *T. Zeyheri* to be distinct and from a phylogenetic point of view equivalent species. He distinguishes *T. Zeyheri* from *T. cistoides* in the following characters: *T. cistoides* has smaller flowers, broader sepals and larger fruits than our plant. These characters appear to be of little or no taxonomic value since I have examined many sheets of *T. Zeyheri* with flowers smaller and fruits larger than those of the American species.

Dinter, in *Fedde Rep. XXIV* l.c. again stresses the variation in colour of the flowers which can be either uniformly yellow, cream with a saffron claw or more rarely, uniformly cream, and in the region of the Aviser Pforte nr. Windhoek very frequently orange-yellow to orange-red. On the basis of the latter colour he distinguishes var. *aurantiacus* Dtr. l.c. from the typical plant. I very much doubt whether this represents a distinct variety and for the present am inclined to consider it synonymous with *T. Zeyheri* Sond.

Schinz's varieties *hirtus* and *hirsutissimus* of *T. Zeyheri* are in my opinion only extremely hairy individuals of the typical plant. I do not consider degree of indumentum to be of any taxonomic importance.

T. murex Schlechter l.c. definitely falls within the range of *T. Zeyheri*. *Dinter* 110 which bears "typ. auct." in *Schlechter's* hand has extremely spiny fruits and it was no doubt on the basis of this character that *Schlechter* had intended to separate it from *T. Zeyheri*.

The fruits of *T. Zeyheri* appear to vary markedly in their degree of spinosity. *Bradfield* 581 and *Dinter* 303, both from South West Africa, exhibit fruits which are extremely spiny and in this respect are not unlike immature fruits of the Australian *T. hystrix* R. Br. The fruits of *Bryant* J. 21, *Mücke* 52, *Schoenfelder* 488 and *Steyn* 22566 again present the other extreme in which the cocci are laterally much compressed and warted on the dorsal crest; the spines are short and rigid. In fact the fruits of the specimens just mentioned appear so typical, that may be on the basis of this character it would be possible to regard them as a species distinct from *T. Zeyheri*. It will be necessary, however, to grow plants from such seed before any conclusions are arrived at. Another most interesting gathering is that of *Bryant* J. 39 (see also under *T. pterophorus*) which has fruits partly devoid of spines and in which the cocci are sharply tubercled as well as having two slender downward turned spines arising from near the base of each coccus. These fruits are not unlike the figure representing *T. Zeyheri* in *Engl. l.c.* (True *T. Zeyheri* Sond. possesses fruits in which each coccus is armed with four well-developed spines.)

Until an intensive study of the various variations outlined above has been made in the field in conjunction with breeding experiments, it will be impossible to say whether several varieties or even species are involved under the present concept of *T. Zeyheri* Sond., or whether this species is only one extremely variable species. The distribution is a much wider one than that of any of the large-flowered South African species. It is found mainly in the sandy arid and sub-arid regions of Southern Africa and occurs further north through South Tropical Africa, finally overlapping with *T. cistoides* L. in the Tropics proper.

5. *T. terrestris* Linn., Sp. Pl. 387 (1753); Thunb. Prodr. 79 (1794); Thunb. Fl. Cap. ed. Schult. 543 (1823); DC. Prodr. I. 703 (1824); Eckl. & Zeyh. Enum. Pl. 95 (1835); Harvey, Gen. S. Afr. Pl. 46 (1838); Drège Zwei Pflzgeogr. -Doc. 58, 73, 131 (1843); Krauss in Flora 1844, p. 301; Sonder, Fl. Cap. I. 352 (1859-1860); Harvey, Gen. S. Afr. Pl. ed. II. 36 (1868); Engl. et Gilg., in Warburg Kunene-Samb.-Exped. Baum: 269 (1903); Dinter, Deutsch-Südwest-Afr. 85 (1909); N. E. Brown in Kew Bull. 1909, p. 97; Heering & Grimme, Untersuch. Weideverh. Deutsch-Südwestafr. 26, 74 (1911); Glover, in Ann. S. Afr. Mus. IX, iii, 170 (1913); Engler, Veget. der Erde 9. III. i. 736 (1915), cum fig. 343, E-L; Juel, Plant. Thunberg. 309 (1918); Burt Davy, Flow. Pl. & Ferns I. 187 (1926); Dinter, in Fedde Rep. XXIV. 15 (1927); Engler, Pflzfam. ed. 2. 19a. 176 (1931), cum fig. 84 E-L; Range, in Fedde Rep. XXXVI. 250 (1934).

Syn.: *T. terrestris* β . *desertorum* Eckl. and Zeyher, Enum. Plant., 95 (1835).

T. hispidus Presl, Bot. Bemerk., 29 (1844).

T. murex Presl, l.c.

T. parvispinus Presl, l.c.

T. terrestris L., var. δ . *desertorum* Sond., Fl. Cap. I, 353 (1859-60).

T. terrestris L., var. β . *hispidissimus* Sond., Fl. Cap. I, 353 (1859-60); Burt Davy, Flow. Pl. and Ferns I, 187 (1926).

T. parviflorus Schlechter ex Engler, Pflzfam. ed. II, 19a, 176 (1931), nomen tantum.

T. murex Schlechter ex Dinter, in Fedde Rep. XXIV, 14 (1927) pro parte, nomen subnudum, non Presl; Range, in Fedde Rep. XXXVI, 249 (1934).

A spreading prostrate usually decumbent *annual*. Branches radiating from the much-branched crown of the rootstock, up to 1.5 metres long and usually branched again, in all vegetative parts pubescent, villous or hispid or glabrescent, extremely variable as to degree of hairiness; internodes up to 6 cm. long, usually much shorter, terete, striate. Leaves unequal; the larger up to 6 cm. long, usually somewhat smaller, with up to 8 pairs of leaflets; the smaller up to 3.5 cm. long, usually much smaller, with up to 6 pairs of leaflets; leaflets obliquely oblong-lanceolate, or lanceolate-ovate, acute or subobtuse, villous on both surfaces, often more or less glabrescent above, up to 15 mm. long and 5 mm. broad, usually much smaller; stipules linear or linear-lanceolate, acute, up to 10 mm. long, often much shorter. Pedicel shorter, as long as or more rarely slightly longer than the subtending leaf. Flower buds ovate-acuminate or acute. Sepals 3-6 mm. long, linear-lanceolate, acute, villous without. Petals broadly cuneate, clear yellow, 3-12 mm. long, shorter than or up to 2.3 times the length of the sepals. Filaments 3 mm. long or somewhat longer. Style short, much reduced; stigma hemispherical and almost sessile on the ovary; ovary hirsute with bristly bulbous-based hairs. Intrastaminal glands not intergrown to form a cup around the base of the ovary. Mature fruit pubescent or almost glabrous, at length breaking up into 5 cocci; cocci usually with 2 lateral divergent acute spines inserted above the middle, and two shorter spines directed downwards and inserted near the base of the coccus; dorsal crest tubercled and usually set with bristly hairs; the size and degree of spinosity of the cocci is extremely variable (Fig. VII).

ANGOLA.—Mossamedes: Höpfner, s.n. On the Kubango at Kalolo: Baum, 441.

AMBOLAND.—Ondonga: Liljebblad, 188; Rautanen, s.n. Olukonda: Schinz, 1022, 1023, 1025.

DAMARALAND.—Okahandja: Dinter, 143; Seiner, 150. Windhuk-Walfishbay: Rogers, 15179. Salem: Dinter, 102. Windhuk: Trotha, 81a. Karabib: Hartman, 155b, 155c pro parte, 155d. Lichtenstein: Dinter, 4489. Rehoboth: Fleck, 4, 65.

GT. NAMAQÜALAND.—Kubub: Range, 226; Schinz, 1024. Schakalskuppe: Pearson, 4784. Sandvehaar: Pearson, 4675. Seeheim: Pearson, 3723. Naruda-süd: Pearson, 7862, 8218.

CAPE PROVINCE.—Little Namaqualand: Steinkopf, *Schlechter*, s.n. Stinkfontein: *Pearson*, 5521. Calvinia: Springbokkuil, *Zeyher*, 273. Clanwilliam: *Bachmann*, 332. Nr. Wupperthal: *Drège*. Cape: Claremont, *Schlechter*, 553. Nr. Salt River stn.: *Salter*, 240/11. Nr. Lakeside stn.: *Andraea*, 229. Robertson: Montagu, *Moss*, 5593. Riversdale: Gauritz River: *Ecklon* and *Zeyher*, 751B. Mossel Bay: *Moss*, 5593. Knysna: *Burchell*, 1841; *Fourcade*, 1993. Uitenhage: *Ecklon* and *Zeyher*, 751. Bathurst: Fish River, *Burke*. Komgha: *Flanagan*, 82. Willowvale: Bashee, river mouth and in gardens, *Drège*. Queenstown: Shiloh, *Baur*, 973. Graaff Reinet: *Bolus*, 261. Prieska: *Bryant*, J. 39 pro parte. Hay: Asbestos Hills, *Wilman*, 3041. Herbert: Belmont, *Wilman*, *Orpen*, 125, 126. Kimberley: *Wilman*, 2124. Riverton: *Wilman*, 3041.

NATAL PROVINCE.—Ladysmith: Wagon Hill, *Wood*, 18781. Zululand: *Gerrard*, 214.

ORANGE FREE STATE PROVINCE.—Fauersmith: *Henrici*, 1873, 2461, 2462, 2532–2534, 2559–2561, 2676, 2678, 2704–2706, 2708, 2710–2712, 2718–2719; *Verdoorn*, 1561–1563; *Goossens*, 654; *Steyn*, 22565. Bloemfontein: Bestersput, *Welts*, 22. Modderrivierdrift: *Rehmann*, 3586. Kroonstad: Bothville, *Schweickerdt*, 1075, 1080. Vredefort: *Obermeyer*, in *Tvl. Mus.*, 31665.

TRANSVAAL PROVINCE.—Potchefstroom: *Burt Davy*, 854. Vereeniging, *Leendertz*, 5862. Witwatersrand: Johannesburg, *Moss*, 7469, 9557, 13779, 16146, 16171. Pretoria: Wonderboompoort, *Smith*, 6192; *Schweickerdt*, 1049, 1050. Rooikop: *Smuts* and *Gillett*, 2029. Meintjes Kop: *Mogg*, 12307; *Schweickerdt*, 1202. Rustenburg: *Nation*, 42 *Watt* and *Brandwyk*, 1813. Waterberg: Nylstroom, *Mogg*, 12535. Zoutpansberg: *Messina*, *Turner*, 18.

BASUTOLAND.—Leribe: *Dieterlen*, 127. White Hill: *Jacottet*, 236.

BECHUANALAND PROTECTORATE.—Mafeking: *Bolus*, 6402. Mochudi: *Rogers*, 6443. Kwebe (Ngamiland): *Lugard*, 105, 117, 123.

PORTUGUESE EAST AFRICA.—Ressano Garcia: *Schlechter*, 11896. Rikatla: *Junod*, 440. Lourenco Marques: *Moss*, 11806, 6947; *Thoday*, 176; *Monteiro*, 56. Inhambane: *Lawrence*, 31.

For reasons of space it has been impossible to cite all the specimens seen. Consequently gatherings for citation were selected mainly with a view to indicate the wide distribution of this species in South Africa. As a result of studying a very wide range of material from almost all parts of Southern Africa, the writer has come to the conclusion that among the various species of *Tribulus* found in the area under consideration, *T. terrestris* Linn. show the widest range of variation both in vegetative and reproductive characters.

T. murex Presl, *T. parvispinus* Presl and *T. hispidus* Presl based on scanty material are very probably only forms of the cosmopolitan *T. terrestris* L.

T. parvispinus Presl has petals and sepals 2–5 mm. long and in many cases the sepals exceed the petals in length. The ratio of length of petals to sepals may thus be represented by the factor 1.0 or a value less than 1.0.

In *T. murex* Presl the petals vary between 5–12 mm. and sepals 4–6 mm. in length. The ratio of the length of petals to sepals here has a value of 1.25–2.3 and appears to be always greater than 1.0. The flowers appear to be somewhat larger than those of *T. parvispinus*, but specimens have been examined in which the flowers approached in size those of the species just mentioned.

In the type and type numbers of *T. hispidus* Presl the petals have been eaten by insects (probably already at the time of gathering) but judging from the remains they appear to exceed the sepals in length. The very hispid nature of the plant to my mind is merely due to habitat, it does not appear to be of any taxonomic value, since it is not correlated with other distinctive characters.

An attempt to distinguish *Presl's* species from each other on basis of the relative ratios of length of petals to sepals has proved unsuccessful especially as the Linnean type of *T. terrestris* in some respects appears to be intermediate between these species.

The Linnean type of *T. terrestris* is a complete plant having about 5 branches each of which is more or less 8 cm. long. The petals are about 3 mm. long and the sepals being hidden by the former are somewhat shorter than the petals. The leaves are 4-6 jugate, and the pedicels are as long as or slightly shorter than the subtending leaves; the leaflets are up to 7 mm. long and 3 mm. broad. The young fruits are minutely puberulous (apart from the bristly hairs on the dorsal crests) and each coccus is armed with two pairs of lateral spines of which one pair is shorter than the other.

[As a note of interest the following may be mentioned: *Linnaeus* wrote up his type (sheet 4 in the cover of *Tribulus*) as *Tribulus* ∇ which actually means *T. aquaticus*. In the manuscript of the Sp. Pl., however, he correctly wrote *Tribulus* ∇ the latter sign being used by him to denote "earth," i.e. *terrestris*. By mistake the sheet was thus actually written up wrongly, but this has no bearing on *Tribulus aquaticus* C. Bauh. which is quite a different plant, namely *Trapa natans* (see Richter's Index)].

Taking various standard works on the Floras of Central Europe, North America and Australia into account, one finds that the limits by which these various authors define *T. terrestris* L. show wide discrepancy. Some define the petals as being "3-4 mm. long," some state "6 mm. long" and others again "up to 10 mm. long," the length of the sepals also exhibits this wide range of variation. There is thus very little doubt with regard to the extreme variability of this species.

It has been pointed out that the *Linnean* type has extremely small flowers. What *Presl* has described under the name *T. parvispinus* is to my mind typical *T. terrestris* L. The fruit characters on which he distinguishes his species from the Linnean plant do not hold good. A wide range of material has shown the size, etc. of the fruits to be extremely variable. For analogous reasons *T. murex* *Presl* and *T. hispidus* *Presl* are considered to be merely large-flowered and more robust forms of *T. terrestris* L.

Dinter 102 quoted in Fedde Rep. XXIV. 14 (1928) under *T. murex* Schlechter is nothing else but *T. terrestris* L. Furthermore *T. parviflorus* Schlechter ex Engler l.c. is *T. terrestris* L.

Miss I. C. Verdoorn of the Division of Plant Industry, Pretoria, who has had occasion to study plants in the field and especially on the lands of the Grootfontein School of Agriculture, Middelburg, Cape Province, recognised three closely allied forms of *Tribulus*, (a) small plants with erect dried-up looking (greyish) inward-curling branches, (b) plants with longer branches which were inclined to be prostrate, (c) luxuriant plants with closely prostrate branches. *Miss Verdoorn* kindly prepared herbarium specimens of these forms all of which have since been identified by the writer as being *T. terrestris* Linn. These forms could not be regarded as varietally different on basis of their habitat, since the latter was not correlated with any other morphological difference. The small erect "form" was suspected of having caused "dikkop" in sheep.

Dr. M. Henrici, who has grown plants at the Veld Reserve, Fauresmith, O.F.S., states: "At least four species seem to exist according to habit of growth and flowers: (1) a widely spreading plant with a large yellow dark-centered flower, (2) a running variety with a large evenly coloured yellow flower smaller than that of (1), (3) medium sized yellow flower with calyx about half as long as petals, both running and upright forms; when the species runs, calyx may be nearly as long as the petals, (4) small yellow flower with calyx as long as or longer than the petals, running and upright forms. The two latter species have forms not only differing in their habit of growth but also in their content of green pigment. While some of the forms are excellent fattening fodder plants, those which grow upright and contain less pigment cause dikkop at times, especially in the wilted state and on certain soils (limestone and river bank soils). It seems that the species with large flowers and large amounts of pigment and with long runners are never poisonous."

The plants mentioned under (1) and (2) are definitely not *T. terrestris* L. but very probably *T. Zeyheri* Sond. or one of the species with winged fruits. Since the nature of the fruits is not mentioned it is impossible to say which of these species are involved. The plants under (3) are probably luxuriant forms of *T. terrestris* L. (= *T. murex* Presl) and those under (4) almost certainly the typical small-flowered Linnean species. It may be added that according to a note by *Blank* on a sheet of *T. pterophorus* Presl in Herb. Mus. Bot. Berol., this large-flowered prostrate species has been found to cause "geelsiekte" in sheep (see notes under *T. pterophorus*). Thus not only the small-flowered species are to be suspected of being poisonous to sheep.

T. terrestris L. makes its appearance soon after the first summer rains have fallen and often forms extensive dense carpet-like growths near the habitations of man.

Owing to the ruderal and semi-ruderal nature and the wide (almost cosmopolitan) distribution of this Linnean species it is readily conceivable that under different edaphic and climatic conditions the plants may present a very variable appearance. Careful breeding experiments would do doubt throw light on the question as to whether *T. terrestris* L. as conceived in this paper is only one extremely variable species or whether at present several closely allied species are included under this name.

CONCLUDING REMARKS.

That distinguished systematists such as *Engler*, *Schinz* and *Dinter* had failed in defining the limits of the various species clearly, in spite of the fact that each of these authors had travelled and collected extensively in Southern African regions where *Tribulus* abounds, may serve to indicate how ill the members of this genus are defined.

A successful and clear delineation of the Southern African species may be possible by taking recourse to special field studies including the growing of plants from seed and the conduction of breeding experiments. A clear conception of the range of variation exhibited by any one species may be obtained in this way.

It is furthermore a *sine qua non* that thorough gatherings be made of such mother plants in both flowering and fruiting condition of which the seed is intended to be grown. Such mother plants must be retained for future reference and as a standard for comparison with the cultivated daughter plants. The mere growing of plants from seed, without having preserved specimens of the mother plants from which the seed had been derived is not of much use, since it is absolutely essential that the nature of the original plant in its wild state be known.

The most satisfactory and profitable method of procedure appears to be the following: As many different forms of species such as for example *T. pterophorus*, *T. Zeyheri* and *T. terrestris*, including specimens of these species from their type localities (where such are known) and which have been found to resemble the type, should be gathered and their seeds should be grown under identical as well as different conditions (climatic and edaphic). Gatherings should again be made of both flowering and fruiting material of these daughter plants. By subsequent comparison of these individuals possibly an insight may be gained into what at present is considered to be an individual but very variable species.

ACKNOWLEDGEMENTS.

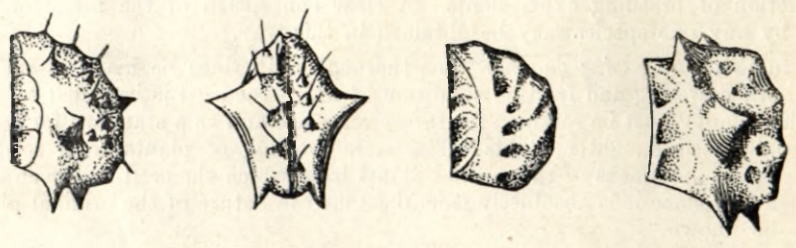
It has been my privilege to examine the material in all the South African Herbaria as well as the Southern African material in the following European Herbaria: Hort. bot. Reg. Kew., Mus. Brit., Mus. bot. Berol., Mus. bot. Stockholm, Mus. bot. Univ. Germ. Prag., Mus. bot. Univ. Zürich and Hofmuseum, Wien. I wish to tender my sincere thanks to the Directors and Curators (Keepers) of these various institutions for allowing me to consult this material. My special thanks are due to Sir Arthur Hill, Director of the Royal Botanic Gardens, Kew, for the great facilities offered during the preparation of this paper.



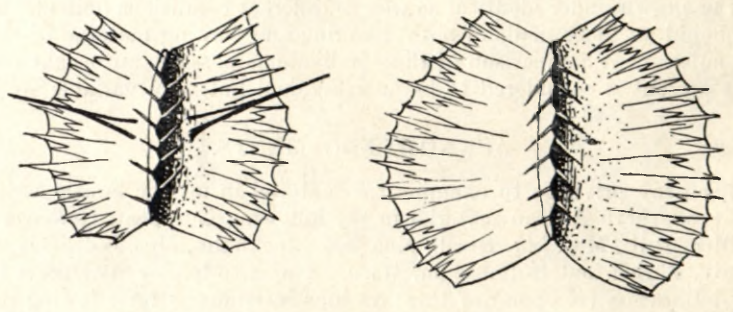
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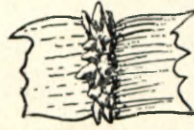
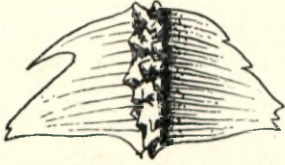
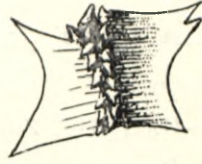
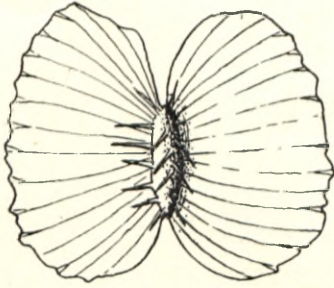
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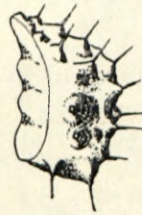
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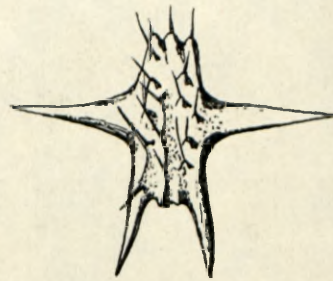
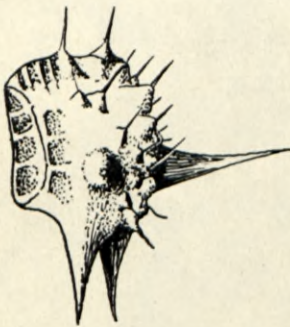
IV



V



VI



VII

EXPLANATION OF FIGURES.

- I.—Ovary of *T. terrestris* L. ($\times 10$).
- II.—Ovary of *T. Zeyheri* Sond. ($\times 10$).
- III.—Cocci of *T. excrucians* Wawra ($\times 3$).
- IV.—Cocci of *T. cristatus* Presl ($\times 2$).
- V.—Cocci of *T. pterophorus* Presl ($\times 2$).
- VI.—Cocci of *T. Zeyheri* Sond ($\times 3$).
- VII.—Cocci of *T. terrestris* L. ($\times 3$).