

# Species delimitation in *Portulaca* sect. *Portulaca* (Portulacaceae) in East and Northeast Tropical Africa

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Twenty three species are recognised in *Portulaca* sect. *Portulaca* from East and Northeast Tropical Africa. The reliability of the characters used to distinguish them is assessed, especially with reference to the works of Peter and von Poellnitz, and with the use of examples from the area. Distribution patterns and habitat preferences are discussed. The morphology of the seed testa is described for each species, and most are illustrated by means of SEM photographs. A key to the species is provided.

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## Introduction

The genus *Portulaca* was divided by Geesink (1969) into two subgenera: subgen. *Portulacella* (F. Muell.) Legrand with glabrous nodes and flowers in dichasia, and subgen. *Portulaca* with nodal scales or hairs and flowers aggregated into terminal heads. Subgenus *Portulaca* was further subdivided into two sections: sect. *Neossia* Legrand with opposite leaves and sect. *Portulaca* with alternate leaves. Sect. *Neossia* has been addressed elsewhere (Gilbert & Phillips 2000). Sect. *Portulaca* occurs throughout the world in tropical and warm temperate areas, and includes a number of species complexes and a few widespread and variable weedy species. Species delimitation in this section in east and northeast tropical Africa is discussed in this paper.

The number of species in sect. *Portulaca* is

much disputed owing to problems in drawing specific boundaries, and collections are notoriously difficult to name. The dehisced stamens are always to be found adhering to the stigma-branches within the collapsed perianth of the calyptra, and indeed have often dehisced whilst the flower is still in bud. Hence it appears that self-pollination is the norm, explaining the multiplicity of local variants. Danin *et al.* (1978) have shown the pantropical weedy annual *P. oleracea* L. to be a polyploid complex. It is highly likely that polyploidy also plays a part in the variability of some other species. This paper arises out of the necessity to sort out the African species for the *Flora of Tropical East Africa* account. It attempts to evaluate characters that have been used in keys in the past, and set out those which have been found to be most useful.

*Portulaca* collections make very poor herbarium specimens, due to shrinkage of the succulent stems and leaves and the fugacious nature of the delicate flowers, which open only for a few hours. Unless great care is taken, all the leaves tend to fall off on drying and details of the flowers are lost. Characters, which should be recorded in the field and areas where further field work would be beneficial, are noted.

### History of *Portulaca* sect. *Portulaca* in eastern tropical Africa

The account of the family by Oliver (1868) in *Flora of Tropical Africa* included only two species from this section: the pantropical weed *P. oleracea* L. and *P. foliosa* Ker-Gawl. which is confined to Africa. The name *P. foliosa* has been widely misapplied in Africa since that time. Six more species were described by various authors over the next 60 years, but it was not until the 1930s that the number of species was suddenly increased, mainly through the publications of two German botanists, Peter and von Poellnitz.

Peter published seven more species in his *Flora von Deutsch Ost-Afrika* (1932-1938), all from Tanzania. These were based on his knowledge of the plants in the field, and are described and illustrated in detail. Poellnitz, working in Berlin on Peter's herbarium specimens, added another four species and three varieties (Poellnitz 1933, 1940a, 1940b). His descriptions, alphabetically arranged, are essentially translations into German of Peter's Latin, with the addition of seed morphology that was omitted by Peter. Thus within a decade the number of taxa in this section was almost tripled.

Poellnitz's account of *Portulacaceae* in East Africa (Poellnitz 1940a), published two years after the completion of Peter's Flora, has remained the standard work of reference for the region up to the present time. The difficulty of using this work, and doubts about the

validity of some of his new taxa, have meant that until very recently it has not been possible to determine collections of *Portulaca* from eastern Africa with any degree of confidence. This situation is now being remedied by the publication of modern Flora accounts for the *Flora of Somalia* (Gilbert 1993), and the *Flora of Ethiopia and Eritrea* (Gilbert 2000), and the account for the *Flora of Tropical East Africa* is completed and awaiting publication.

### Assessment of characters

The keys in both Peter's and Poellnitz's accounts of East African *Portulaca* are very difficult to use. Peter's key relies heavily on characters of the flower which are best suited to fresh material. His first couplet asks whether the petals are free or connate below which, whilst important, is often impossible to determine from dried material. His supporting characters of stamen number and leaf shape are not contrasting, and do not distinguish the species in the two halves of his key. He also frequently uses flower or petal length, likewise not usually determinable in herbarium material. Poellnitz's use of variable characters, and occasional faulty observation, has necessitated keying out several species more than once, *P. oleracea* and *P. somalica* no less than three times! The search for reliable characters to delimit the species, suitable for use both in the field and herbarium, has therefore been the primary concern in the preparation of recent African Flora accounts. Characters found to be useful are discussed below, using examples from eastern tropical Africa.

### Habit

Providing basal parts are present, the species are quite easily distinguishable into short-lived annuals or ephemerals, and those with a more persistent perennial habit. *P. decorticans* Gilbert, from north Kenya and Somalia, forms

a definite shrublet eventually broader than high, with much-branched stems and a base 1 cm or more thick. *P. massaica* is a common perennial herb from dry stony soils in southern Kenya and northern Tanzania. It has a wide-spreading, branching root system sometimes more extensive than the aerial parts. *P. centrali-africana* is the only species in eastern Africa to possess fleshy creeping stolons, whilst *P. somalica* has a thickened subtuberous tap root. Annual species, such as the widespread *P. kermesina* N.E. Br., arise from a single slender root.

Whether the habit is erect, ascending or decumbent appears to be fairly constant. For example, *P. fischeri*, locally common in the area around Lake Victoria, has decumbent stems radiating from a central root which, together with the close-set leaves, imparts a recognisable facies to this species. In contrast, in typical *P. kermesina* the branches are rather stiffly ascending above an erect base, and the more widely spaced leaves contribute to a more open appearance.

#### Stems

The stems are always more or less succulent, and frequently flushed red or purple. A few species exhibit distinctive stem characteristics. In *P. decorticans* the old stems are clothed in an exfoliating papery brown bark, whilst the young shoots are densely papillose. Papillose young shoots also occur in *P. conoidea* from northeast Kenya and flaking bark in *P. stuhlmannii* from north Tanzania. Both these species are known only from the type collections. *P. grandis*, a close relative of *P. massaica* and occupying the same area, has a typically smooth, light grey bark.

#### Axillary hairs

The hair-tufts in the leaf-axils may have slightly broadened bases, and are almost certainly derived by the subdivision of scales, a deriva-

tion more clearly evident in sect. *Neossia*. They are variously interpreted as either trichomes or stipules (Carolin 1993: 545).

These hair-tufts are a most useful identification aid, as their form is constant within species and they are easily visible, even in the most poorly preserved herbarium material. In a few species the hairs are very short and inconspicuous. *P. oleracea* is the commonest example of this, and in *P. foliosa* the hairs are also short and inconspicuous. *P. humilis*, known only from the type from northern Tanzania, has distinctive dense tufts of stiff white hairs only 1 mm long. The majority of species divide into those with loosely shaggy long hairs (e.g. *P. kermesina*) and those with compact woolly tufts (e.g. *P. decorticans*). In *P. massaica* and *P. grandis* the outermost hairs of each shaggy tuft are connate at the base into two conspicuous crescentic white scales. This is seen to a lesser degree in other species and reinforces the derivation of the hairs from scales. In *P. somalica* the tufts are composed of a mixture of conspicuous long slender brown scales and much shorter hairs at their base. The hairs are often brown in herbarium material, but this may be at least partly an artefact of drying. *P. olosirwa* is said to have golden hairs.

#### Leaves

Leaves are important for identification, but unfortunately shrivel badly and often drop on drying. Nevertheless, approximate leaf-shape can be seen and was used extensively by Peter in his key. The commonest leaf-shape is linear-terete. *P. oleracea* is usually immediately recognisable by its obovate to spatulate leaves. *P. ramosa*, a species of local distribution in Tanzania, is also easily recognisable by its large, flat, oblanceolate-oblong leaves up to 3 cm long and 5 mm wide. The form of the leaf-tip, whether acute-apiculate or obtuse, has proved useful in distinguishing species with linear or narrowly oblong leaves. In *P. kermesina* it is always apiculate but

obtuse in *P. foliosa*, two species which are frequently confused. Characters lost in pressing include leaf colour, cross-section shape, and whether the nerve is impressed.

Although leaf-size and shape are usually reasonably constant, there are indications that they can vary widely in some species, especially *P. kermesina* where some forms have shorter, broader leaves than usual. An extreme variant from the Kenya/Uganda border area near Kacheliba has rather short elliptic leaves (e.g. *Thomas* 3400; *Tweedie* 3338).

### Flowers

Flowers open in succession within the head. The total number is not easy to count in the herbarium, but seems to vary within narrow limits. *P. ramosa* and *P. conoidea* are unusual in usually having solitary flowers. In contrast, *P. oleracea* and *P. kermesina* may have up to six or more flowers in each head, and *P. fischeri* has bulky clusters of up to ten.

Peter gives very precise measurements for flower size in his key, but only rarely can flowers be measured accurately from herbarium material. Clearly some species have larger flowers than others, notably *P. centrali-africana* from the type locality in the Ruzizi valley, which has showy magenta flowers almost as large as some cultivated *Portulaca*, and also *P. somalica* with large yellow flowers. However, flower size seems to be very variable in some species, and the basis for this variation requires further investigation. It may be that the first central flowers to open in the head are larger than subsequent ones. Another possibility is that polyploidy is involved. *P. kermesina* is particularly variable, some specimens from Kenya having flowers twice as large as others (e.g. *Polhill* & *Paulo* 581, petals 7 mm long; *Gillett* 20997, petals 3 mm long). The same phenomenon has been seen in *P. kermesina* in Zimbabwe, where two collections from the same population varied widely in size (*Garley* 316, flowers 1/4 in. (= 6.4

mm) wide; *Garley* 317, flowers 3/4 in. (= 19 mm) wide). Flowers in *P. fischeri* are always small, but petal length varies from 2.5-4.5 mm long. *Danin et al.* (1978: 182) reported that in *P. oleracea* flowers may sometimes be cleistogamous, varying between chasmogamy and cleistogamy even within the life cycle of an individual plant, and the cleistogamous flowers are smaller with fewer stamens. This may explain variation in flower size in other species. *Geesink* (1969: 280) reports that flower size and stamen number in *P. pilosa* vary according to growing conditions.

The time of day that the fugacious flowers open is likely to be significant, but is very seldom recorded. The sparse information available indicates that flowers open as follows: *P. oleracea*, *P. kermesina* and *P. centrali-africana* in the morning; *P. massaica* and *P. grandis* in late morning; *P. decorticans* at midday. This contrasts with the genus *Talinum* in Africa, where the few records note flowers opening in late afternoon and early evening. More field observations are needed for this character.

### Sepals

The two sepals are always more or less ovate-triangular, basally connate and concave, with broad thin margins and a crested tip. They present few useful characters, although the size of the apical crest varies slightly between species. In *P. oleracea* and *P. oblonga* the crest is extended down the midline as a narrow wing, whilst in *P. conoidea* it is narrowed into a rostrate extension 1.5 mm long.

### Petals

Details of the petals are mostly lost on drying, especially as open flowers are only rarely present in herbarium specimens. Full details of petal morphology should therefore be included in field notes.

Flowers normally have five petals in sect. *Portulaca*, in contrast to sect. *Neossia* where the flowers are 4-petalled. There are a few excep-

tions; *P. ramosa* and *P. grandis* are occasionally 6-petalled. The petals appear to be usually connate or at least adherent below, but this is very difficult to make out in collapsed dried flowers. Peter describes the petals as free in *P. ramosa*, and this does seem to be correct. Petal shape is important, but likewise very difficult to determine in the herbarium. The petals are usually ovate or ovate-oblong, with a rounded or subtruncate tip with a small central apiculum as illustrated by Peter for most of his new species. The presence of retuse petals, as in *P. foliosa*, is a significant difference.

Variation in petal colour requires more field observations, and is sometimes not even mentioned in older collections. It seems that whilst some species are stable in this character others are more variable, and even in species where flower colour is normally stable exceptions can occur. Species known only with yellow flowers include *P. foliosa*, *P. massaica*, *P. grandis* and *P. oblonga*. Species with magenta-pink flowers include *P. centrali-africana*, *P. fischeri* and *P. pilosa*. *P. kermesina* usually has red or pink flowers, but orange- and yellow-flowered variants occur occasionally. There are even pink-flowered variants of the yellow-flowered weed *P. oleracea*. Thus whilst petal colour is useful and obvious, it must always be used with caution as a character for identification, and should not be given a high priority in keys.

#### Stamens

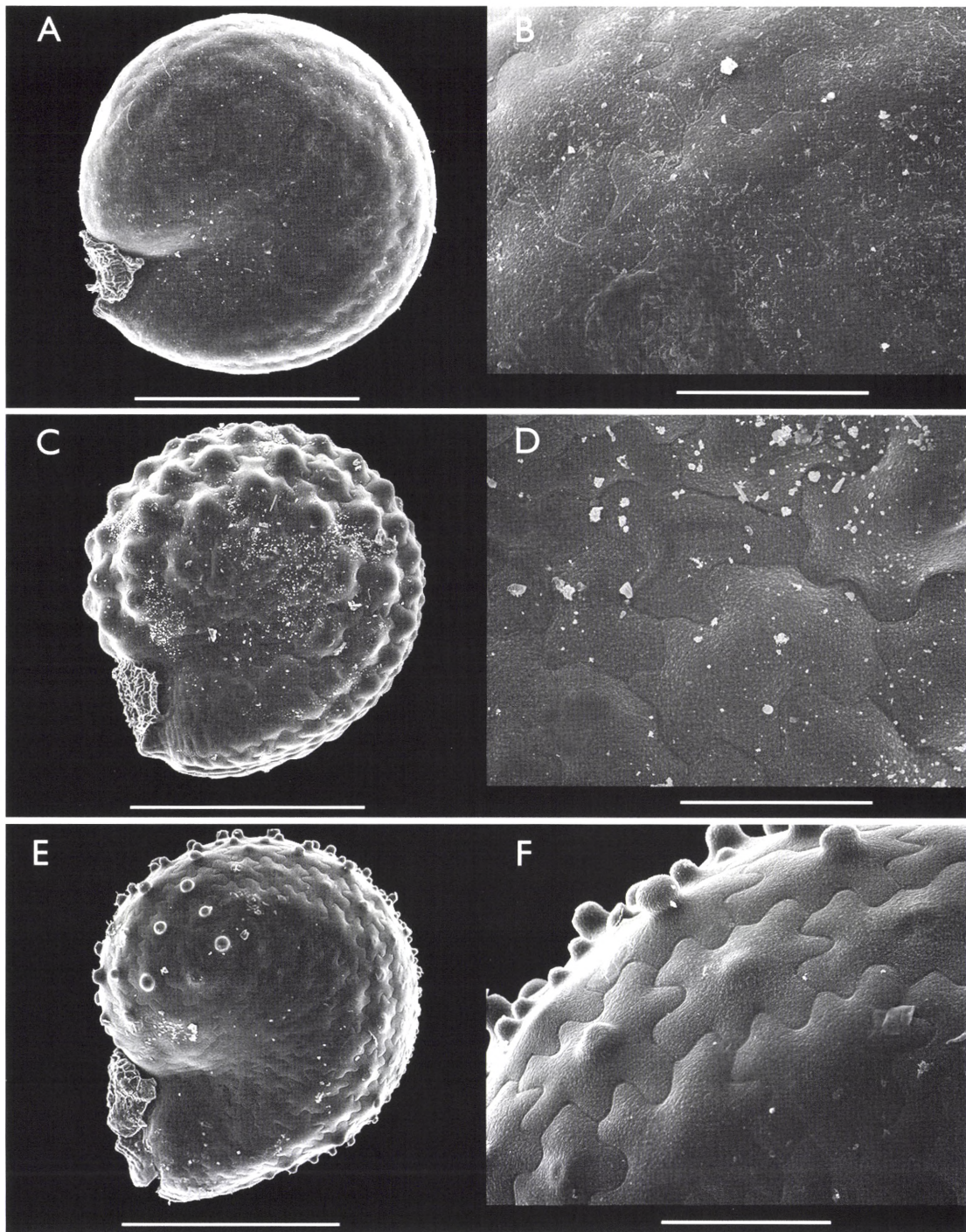
Stamen number is indeterminate, but varies within a limited range for each species. The number can vary in different flowers from the same plant. *P. fischeri* is described as having five stamens only, but may have from five to twelve. The range in *P. kermesina* is 8-13, with a few exceptional specimens having up to 20. *P. foliosa* has 10-25 stamens, whilst *P. somalica*, *P. ramosa*, *P. grandis* and *P. humilis* all have more than 30. Thus stamen number is useful in broad terms, but precise numbers cannot be given.

#### Capsule

Capsules and seeds are usually present, and provide some of the most easily observed and useful characters for species delimitation. Strangely, these characters were almost entirely ignored by Peter in his key and he does not even mention the seeds or their distinctive surface sculpture in his descriptions. In contrast, Poellnitz recognised the importance of seed surface morphology and made frequent use of it in his key.

The most striking distinction in capsule structure is between *P. oleracea* and *P. oblonga* on the one hand and the rest of the species on the other. In these two species the capsule lid is papery in texture, with a constriction about two-thirds up. The nipple-like apical portion is thinner walled with obvious veins, and retains one or more seeds within it when the capsule lid falls. The capsule in *P. nogalensis* is also thin with obvious veins, but without an apical constriction. In all the other species the capsule is coriaceous without a constriction, and glossy yellow or infrequently whitish in colour.

The capsule in all *Portulaca* species is circumscissile, opening by a circular split into base and lid. Poellnitz placed great emphasis on the position of this split, whether at the midpoint or above or below it. This probably has some validity, but is not easily observed in complete capsules before dehiscence as they are usually immersed in dense hairs. Capsule lids and bases fall separately, but their relative shape will give some guide. In *P. conoidea* dehiscence is very low, and the capsule base is almost disc-like. The most usual situation is a dehiscence line between 1/3-1/2 up the capsule, as in *P. foliosa*, *P. kermesina*, *P. massaica* and *P. decorticans*. Dehiscence is at the midpoint in *P. centrali-africana* and *P. fischeri*. In *P. ramosa* dehiscence is above the middle, resulting in a deeply infundibular capsule base and a shallowly domed lid. Capsule size is variable, even within individual plants, most likely mirroring variation in flower size.



**Fig. 1.** Seeds and details of testa morphology (SEM). *Portulaca grandiflora*. **A-B:** Miers 408 (Argentina). **C-D:** Reed s.n. (Argentina); **E-F:** Matthew RHT 53107 (cult. India). A, C, E: scale bar equals 500  $\mu\text{m}$ ; B, D, F: scale bar equals 100  $\mu\text{m}$ .

The style disarticulates from the capsule lid at maturity, but remains inside the marcescent flower with the anthers adhering to the recurved stigma-branches. The number of stigma-branches varies within the range 3-5 in most species (sometimes increasing to 8 in *P. grandis*), and may vary between flowers on the same plant. The most common number of stigma-branches is four.

### Seeds

Seeds in *Portulaca* are reniform, sometimes broadly so and almost circular in outline, with a small aril. The testa-cells are arranged more or less concentrically on the flanks, and usually in regular rows on the peripheral rim. Seeds are always plentifully produced, and are often iridescent and ornamented. It is curious that Peter completely ignored seeds both in his keys and descriptions, as they are both useful and obvious. Poellnitz recognised the importance of seed characters, but unfortunately some faulty observations have led to mistakes in his key. Descriptions of testa cell shape refer to the cells on the flanks.

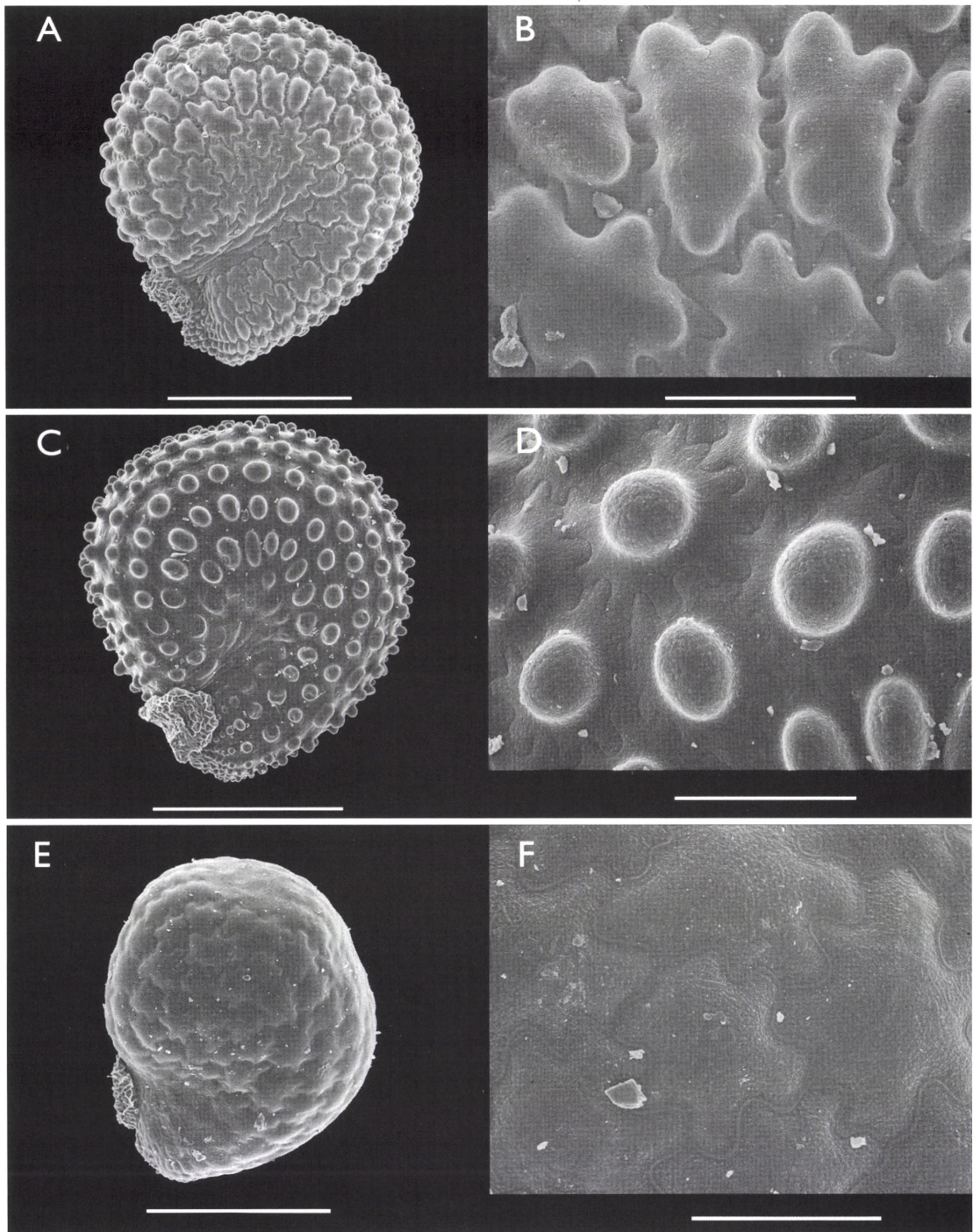
The testa cells are usually sinuous in outline, and the anticlinal walls interlock irregularly in jigsaw-fashion. The cells are thus slightly to conspicuously jigsaw- to stellate-shaped depending on the degree of interlocking. *P. olosirwa* (Fig. 4C-F), *P. conoidea* (Fig. 5E, 5F) and *P. cifferii* (Fig. 7E, 7F) have only slightly sinuous walls. Seeds vary in size between species from about 0.5 mm up to 1 mm long, but size is usually fairly constant within a species. Particularly small seeds occur in *P. coralloides* (Fig. 6A, 6B) and *P. humilis* (0.45 mm). Most species have seeds 0.6-0.8 mm long, whilst large seeds over 0.8 mm long are found in *P. massaica* (Fig. 5A, 5B), *P. grandis*, *P. ramosa* (Fig. 2E, 2F) and *P. conoidea* (Fig. 5E, 5F). Danin *et al.* (1978: 180) found seed size to be related to ploidy level in *P. oleracea*.

Immature seeds are always brown, but as

they mature the colour usually changes either to a glossy black, or shades of metallic grey or silver. The iridescent metallic sheen appears quite late, and it is not unusual for the tips of tubercles of otherwise silvery seeds to remain black. Most seeds of *P. coralloides* are still brown when shed, but a silvery sheen may eventually develop. The seeds of *P. foliosa* are normally black, but may rarely be metallic-grey *e.g.* Hepper 3781 from Mali. *P. kermesina* seeds are mostly metallic-grey, but may occasionally be silvery as in *P. fischeri*. Hence whilst seed colour is usually diagnostic for a species, it cannot be relied on absolutely as exceptions sometimes occur.

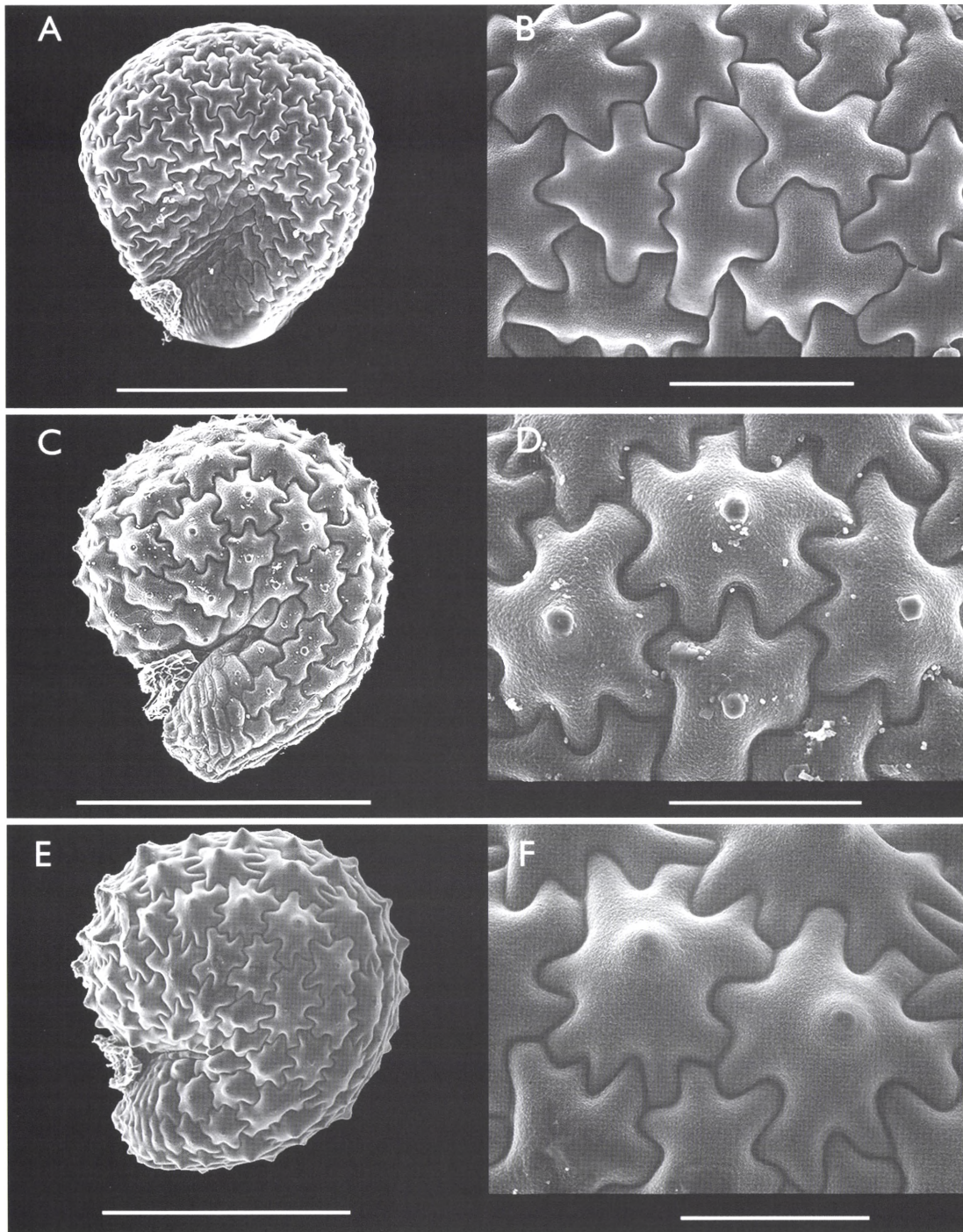
The thickness of the anticlinal (usually sinuous) cell walls varies between species. For example, they are thin and rather obscure in *P. grandiflora* (Fig. 1A-F), sunken in *P. kermesina* (Fig. 6C-F), raised in *P. ramosa* (Fig. 2E, 2F), and thick and obvious in *P. olosirwa* (Fig. 4C-F). Thus seed size and colour, and the outline and wall thickness of the testa cells are all reasonably constant within species, and appear to be good characters for use in species delimitation.

The surface of the testa cells may be flat or convex to domed, and is often raised into a conical tubercle or a central peg. When present, this is a very striking feature of the seed surface morphology, but unfortunately is sometimes variable and can only be used with caution for the delimitation of species. In most species the surface relief is stable, for example *P. ramosa* (Fig. 2E, 2F) has flat cells, *P. fischeri* (Fig. 3E, 3F) tuberculate cells, and *P. massaica* (Fig. 5A, 5B) flat cells with a central peg. However, infraspecific variability in this character can be demonstrated in *P. grandiflora*, a native of Argentina now widely cultivated and known from gardens in Africa. Seeds may be completely smooth with flat cells (Fig. 1A, 1B), raised into conical tubercles (Fig. 1C, 1D), or with central pegs (Fig. 1E, 1F). Pegs may be present in some cells and not in others of the

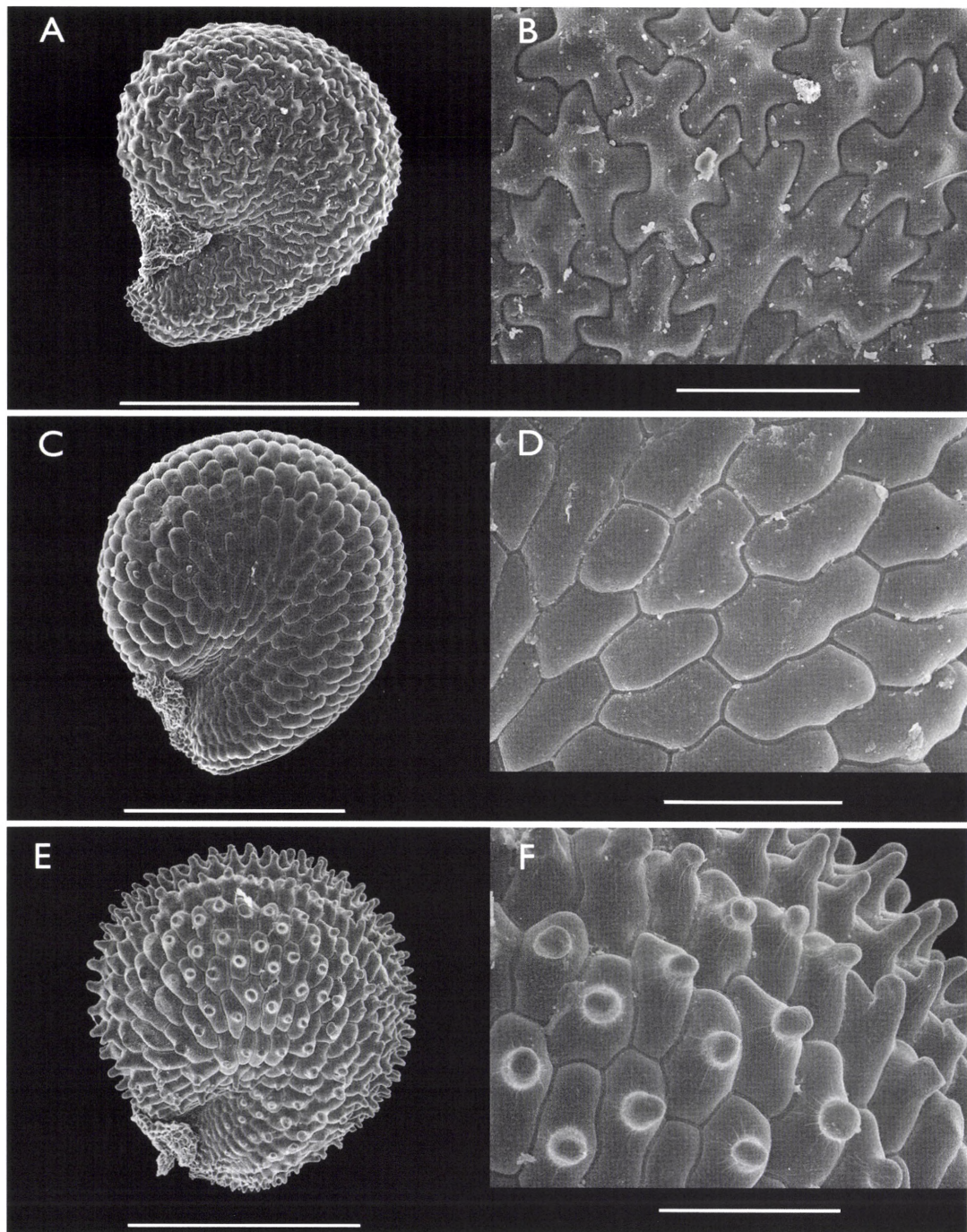


**Fig. 2.** Seeds and details of testa morphology (SEM). **A-B:** *Portulaca oblonga*; Greenway 2154 (Tanzania). **C-D:** *P. oblonga*; Polhill & Paulo 640 (Kenya). **E-F:** *P. ramosa*; Williams 27 (Tanzania). A, C, E: scale bar equals 500 µm; B, D, F: scale bar equals 100 µm.





**Fig. 3.** Seeds and details of testa morphology (SEM). **A-B:** *Portulaca foliosa*; *McClintock* 71 (Nigeria). **C-D:** *P. centrali-africana*; *Reekmans* 5791 (Burundi). **E-F:** *P. fischeri*; *Tanner* 4164 (Tanzania). A, C, E: scale bar equals 500  $\mu\text{m}$ ; B, D, F: scale bar equals 100  $\mu\text{m}$ .



**Fig. 4.** Seeds and details of testa morphology (SEM). **A-B:** *Portulaca decorticans*; Bally & Smith 14454 (Kenya). **C-D:** *P. olosirwa*; Harger 35 (Kenya). **E-F:** *P. olosirwa*; Glover et al. 2234 (Kenya). A, C, E: scale bar equals 500  $\mu\text{m}$ ; B, D, F: scale bar equals 100  $\mu\text{m}$ .

same seed. *P. olosirwa* has distinctive black seeds with non-sinuate cells, but likewise may be smooth (Fig. 4C, 4D) or tuberculate (Fig. 4E, 4F). In *P. kermesina* the cells are usually lightly convex, but occasionally some cells may develop a tubercle (Fig. 6E, 6F). Thus the ability to develop a tubercle or peg seems to be latent in perhaps most species, but is only sometimes expressed.

#### *A review of seed morphology*

*P. anceps*: Seed unknown.

*P. centrali-africana*: Seeds 0.6-0.7 mm long, metallic-grey or silvery; cells stellate-conical with short arms and black tips, the walls fairly thick (Fig. 3C, 3D).

*P. cijferii*: Seeds 0.65-0.7 mm long, iridescent grey-black; cells slightly domed, only slightly jigsaw-shaped, the walls shallowly sinuous (Fig. 7E, 7F).

*P. conoidea*: Seeds 1 mm long, dull grey; cells slightly domed, not jigsaw-shaped or stellate, the walls only slightly interlocking (Fig. 5E, 5F).

*P. coralloides*: Seeds 0.45 mm long, brown, finally with a silvery-grey iridescent sheen; cells jigsaw-shaped, almost flat (Fig. 6A, 6B).

*P. decorticans*: Seeds 0.6 mm long, dark brown; cells with jigsaw-shaped to stellate, domed to conical, sometimes with a central tubercle (Fig. 4A, 4B).

*P. erythraeae*: Seeds 1 mm long, glossy black; cells stellate, gently domed.

*P. fischeri*: Seeds 0.6-0.7 mm long, iridescent silvery-grey; cells stellate, conical-tuberculate with black tips (Fig. 3E, 3F).

*P. foliosa*: Seeds 0.7-0.8 mm long, black (rarely metallic-grey); cells slightly convex to domed (Fig. 3A, 3B).

*P. grandiflora*: Seeds 0.8 mm long, iridescent grey; cells stellate with narrow obscure walls, flat to conical, often tipped with a peg especially round the periphery (Fig. 1A-F).

*P. grandis*: Seeds 0.85-0.95 mm long, light grey

with a dull lustre; cells small, flat, jigsaw-shaped with broad cell walls, usually with a black central peg (identical with seeds of *P. massaica*).

*P. heterophylla*: Seeds 0.5-0.6 mm long, iridescent grey; cells stellate, domed to conical-tuberculate.

*P. humilis*: Seeds 0.45 mm long, iridescent silvery-grey; cells stellate, domed, tuberculate round the periphery.

*P. kermesina*: Seeds 0.5-0.75 mm long, metallic-grey or occasionally silvery; cells jigsaw-shaped to stellate, usually convex to slightly conical, rarely with a few tubercles (Fig. 6C-F).

*P. massaica*: Seeds 0.8-0.9 mm long, light grey with a dull lustre; cells small, flat, jigsaw-shaped with broad cell walls, usually with a black central peg (Fig. 5A, 5B).

*P. nogalensis*: Seeds 0.75 mm long, dark brown; cells small, jigsaw-shaped to stellate with a central peg (Fig. 7C, 7D).

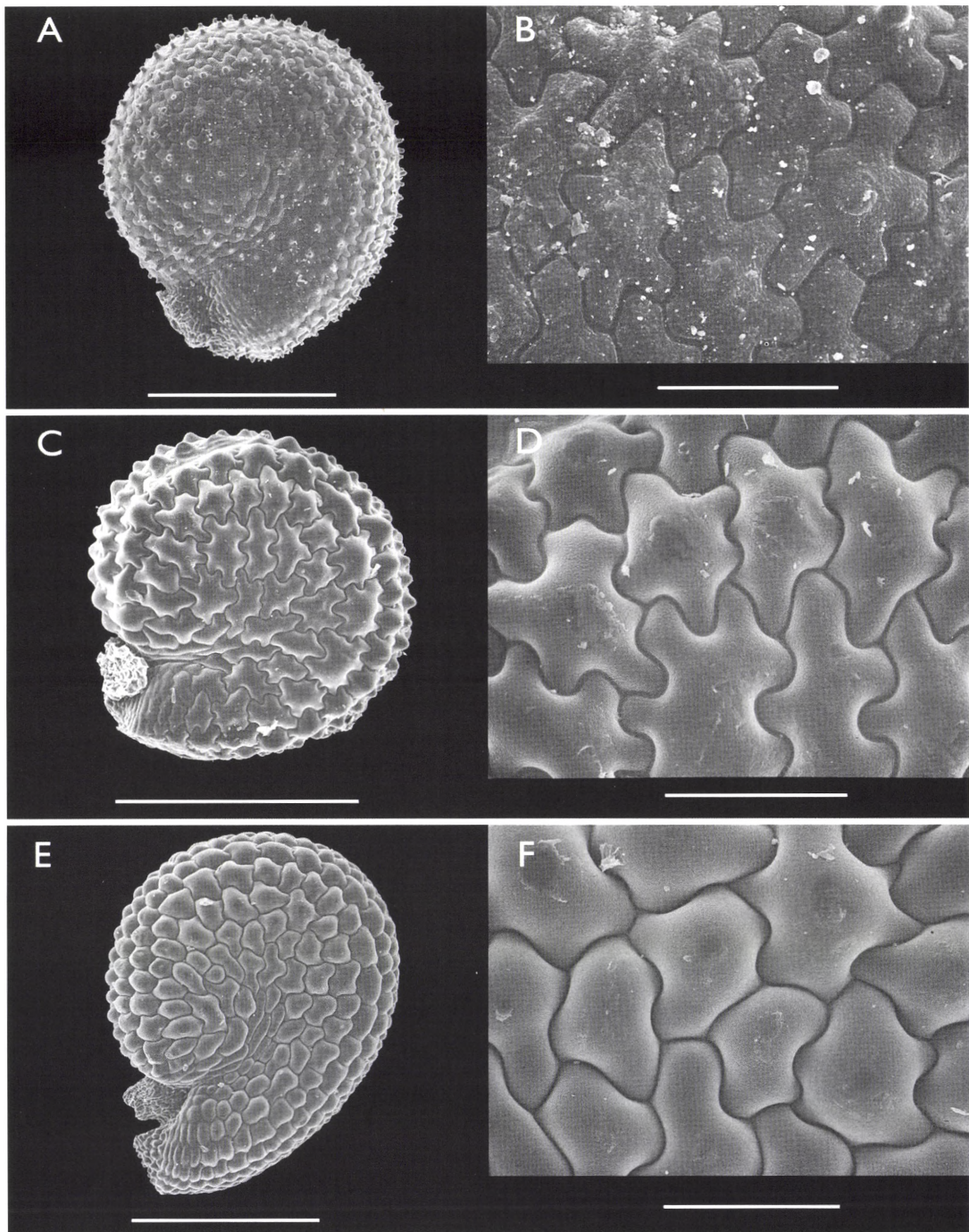
*P. oblonga*: Seeds 0.85-1 mm long, black; cells stellate with short arms, the body raised as a broad irregular tubercle with low papillae on its surface (Fig. 2A, 2B), or sometimes peg-like (Fig. 2C, 2D). This same variation is found in subspecies of *P. oleracea*, illustrated by Danin *et al.* (1978).

*P. oleracea*: Seeds 0.65-1 mm long, black; cells stellate, often also tuberculate and/or papillose (Danin *et al.* 1978).

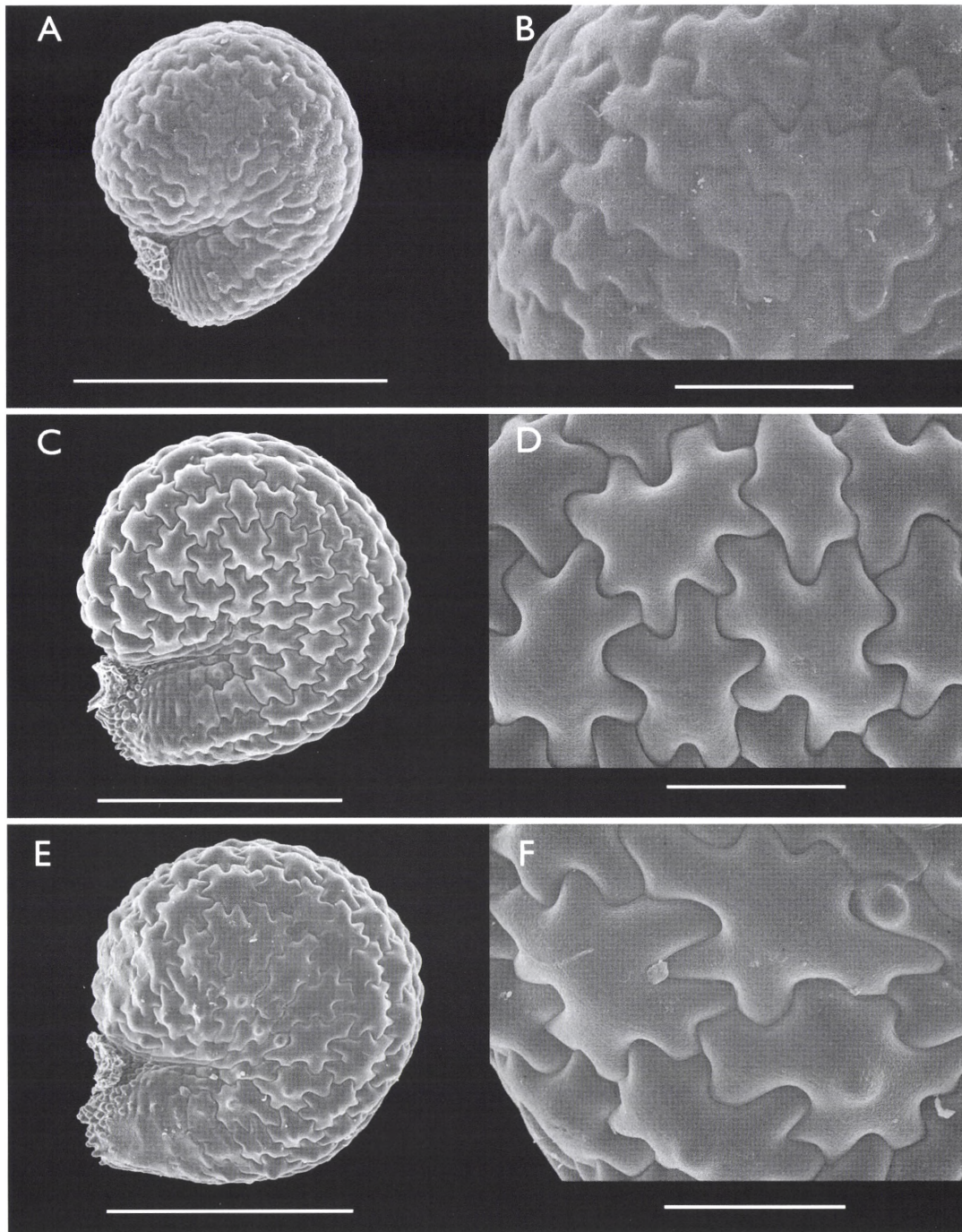
*P. olosirwa*: Seeds 0.75 mm long, black, glossy; cells small, elliptic, convex to domed, with thick almost straight walls, sometimes with a central tubercle (Fig. 4C-F).

*P. pilosa*: Seeds 0.6-0.7 mm long, black or dark metallic-grey; cells jigsaw-shaped to stellate, conical, tuberculate round the periphery (Fig. 5C, 5D).

*P. ramosa*: Seeds 0.8 mm long, metallic-grey, smooth in outline; cells stellate with short arms, almost flat, the walls prominent (Fig. 2E, 2F).



**Fig. 5.** Seeds and details of testa morphology (SEM). **A-B:** *Portulaca massaica*; Faden & Evans 74/595 (Kenya). **C-D:** *P. pilosa*; Bidgood & Vollesen 3092 (Tanzania). **E-F:** *P. conoidea*; Gillett & Gachathi 20624 (Kenya). A, C, E: scale bar equals 500  $\mu\text{m}$ ; B, D, F: scale bar equals 100  $\mu\text{m}$ .



**Fig. 6.** Seeds and details of testa morphology (SEM). **A-B:** *Portulaca coralloides*; Greenway & Rawlins 9423 (Kenya). **C-D:** *Pkermesina*; Richards 14617 (Botswana). **E-F:** *P. kermesina*; Smith 2158 (Botswana). A, C, E: scale bar equals 500 µm; B, D, F: scale bar equals 100 µm.

*P. somalica*: Seeds 0.85-1 mm long, iridescent dark grey or silvery; cells elongate-stellate with short arms, flat (Fig. 7A, 7B).

*P. stuhlmannii*: Seeds 0.9 mm long, grey with a dull lustre; cells stellate, slightly convex.

### Distribution and habitat

All *Portulaca* species in Africa occur in dry, often semi-arid places. Whilst a few species are widespread, more are of local distribution and often restricted to particular habitats. For example, *P. massaica* and the closely related *P. grandis* occur on dry stony hillsides, rock crevices and volcanic ash in the area of southern Kenya and northern Tanzania formerly known as Masailand. *P. ramosa* is known only from inselbergs in northeastern Tanzania, whilst *P. decorticans* grows in rocky places in the *Acacia-Commiphora* bushland of northeastern Kenya and neighbouring Somalia. *P. somalica* and *P. nogalensis* are endemic in N Somalia. *P. cifferii* and *P. coralloides* are both restricted to coastal sand.

*P. foliosa* and *P. kermesina* are both more widespread and have been very much confused, although they are actually quite different. They can be distinguished as follows:

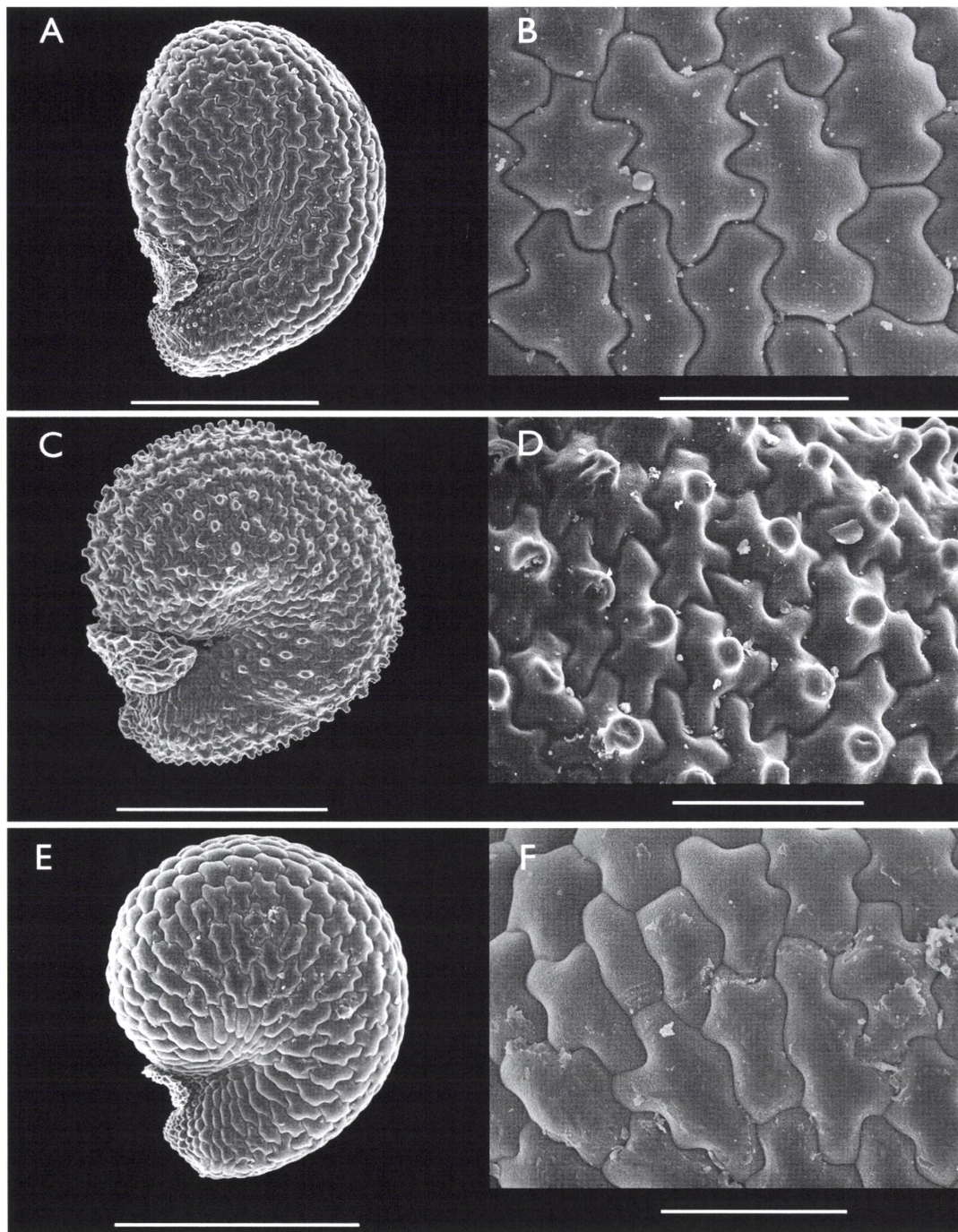
1. Leaves obtuse; axillary hairs inconspicuous; petals yellow, retuse; seeds black. *P. foliosa*
- Leaves acute; axillary hairs long and shaggy; petals red, acute; seeds metallic-grey. *P. kermesina*

These two names have also been widely misapplied to other species in the area. *P. kermesina* occurs from South Africa northwards to Eritrea on dry sandy soils, but is absent from W Africa. In contrast, *P. foliosa* is commonest in W Africa, and occurs only sporadically elsewhere in Africa. It is particularly associated with seasonally dry sandy river beds and sandbanks in

ivers. In eastern Africa it is known from the Baro river in Ethiopia, the Ruaha in Tanzania, and also from the Zambezi valley. It is to be expected in other river valleys in East Africa.

### Key to sect. *Portulaca* in East and Northeast tropical Africa

1. Petals up to 15 mm long; flowers with 5(-6) petals. 2
  - Petals 15-30 mm long; flowers often with more than 5 petals, sometimes double (garden escape). *P. grandiflora*
2. Axillary hairs 1 mm long or less; capsule lid usually with an apical nipple-like constriction of different texture containing a few seeds. 3
  - Axillary hairs almost always over 1 mm long; capsule lid without an apical constriction. 5
3. Leaves up to 20 mm wide; capsule lid uniformly textured with obvious veins, lacking a constriction and not retaining any seeds. *P. erythraeae* 4
  - Leaves up to 10 mm wide; capsule lid with a prominent constriction, smooth and opaque below, thinner with obvious veins above. 4
4. Flowers up to 1.5 cm diam.; stamens 7-12; leaves obovate or spatulate. *P. oleracea*
  - Flowers 2-3 cm diam.; stamens over 20; leaves narrowly oblong. *P. oblonga*
5. Shrublets; basal stems up to 1 cm thick, sometimes with exfoliating papery bark; young shoots often papillose. 6
  - Annual or perennial herbs; basal stems less than 0.5 cm thick, toughened but usually without flaking bark; young shoots not papillose (except *P. conoidea*). 8
6. Leaves narrowly oblong-spatulate, up to 8 mm long, obtuse; axillary hairs brown, accompanied by longer scales; petals purple. *P. nogalensis*
  - Leaves linear, up to 25 mm long, acute; axil-



**Fig. 7.** Seeds and details of testa morphology (SEM). **A-B:** *Portulaca somalica*; *Godding* 169 (Somalia); **C-D** *P. nogalensis* (Somalia, *McKinnon* 5/157); **E-F:** *P. cifferii*; *Früs et al.* 5036 (Somalia). A, C, E: scale bar equals 500  $\mu\text{m}$ ; B, D, F: scale bar equals 100  $\mu\text{m}$ .

- lary hairs in dense white woolly tufts lacking scales; petals pink, orange or yellow. 7
7. Young stems minutely papillose; petals pink and orange. *P. decorticans*  
 – Young stems smooth; petals yellow. aff. *P. grandis*
8. Leaves obtuse. 9  
 – Leaves acute to apiculate. 13
9. Axillary hairs shorter than the internodes; seeds black; petals retuse, yellow. *P. foliosa*  
 – Axillary hairs conspicuous, often longer than the internodes; seeds silvery-grey or brown; petals acute to obtuse, pink, red or purple. 10
10. Stamens 25 or more; petals 7-12 mm long; perennial with fleshy spreading stolons. *P. centrali-africana*  
 – Stamens up to 20; petals 2.5-4.5 mm long; annuals or perennials from a central root, lacking stolons. 11
11. Stamens 17-19; leaves 2.5-5 mm long; seed brown, 0.45 mm long, testa cells almost flat. *P. coralloides*  
 – Stamens 4-12; leaves 5-15 mm long; seed metallic-grey, 0.6-0.9 mm long, testa cells raised to conical. 12
12. Stems decumbent, 1.5-2 mm thick near base; leaves elliptic to oblong, 5-8.5 mm long; seed 0.6-0.7 mm long, testa cells conical-tuberculate. *P. fischeri*  
 – Stems ascending, 3 mm thick near base; leaves linear-terete, up to 15 mm long; seed 0.9 mm long, testa cells slightly raised. *P. stuhlmannii*
13. Stamens 30-50. 14  
 – Stamens less than 30. 18
14. Seeds 0.45 mm long, silvery, the testa-cells stellate-conical; axillary hairs c. 1 mm long, straight, in stiff dense tufts. *P. humilis*  
 – Seeds 0.65-1 mm long, metallic-grey (rarely silvery), the testa-cells  $\pm$  flat, sometimes with a central peg; axillary hairs and scales mostly > 1 mm long (if short not straight and stiff). 15
15. Leaves 3-5 mm wide; petals purple-pink; seeds smooth. *P. ramosa*  
 – Leaves 1.5-3 mm wide; petals yellow. 16
16. Cells of seed testa not stellate, scarcely interlocking, the walls shallowly sinuous; tufts of axillary hairs compact, densely woolly, white. *P. cifferii*  
 – Cells of seed testa stellate with interlocking walls; tufts of axillary hairs loose and shaggy, sometimes with scales (if woolly-white, plant a robust shrublet). 17
17. Root subtuberous; seeds with flat smooth testa cells; axillary tufts of slender curved scales and much shorter hairs. *P. somalica*  
 – Roots fibrous; seeds with papillate or conical testa cells; axillary tufts of hairs only, scales absent. *P. grandis*
18. Perennials with woody base and extensive branching roots; petals yellow. 19  
 – Short-lived herbs with slender base and a single main root; petals usually in shades of pink or red (infrequently yellow). 20
19. Seeds dull grey, the testa cells jigsaw-shaped to stellate, flat, mostly with a central papilla; petals 5-8 mm long. *P. massaica*  
 – Seeds black, glossy, the testa cells with straight walls; petals 3.5 mm long. *P. olosirwa*
20. Seeds black; axillary hairs densely woolly, thickly clothing the stems; stems decumbent with crowded flattened leaves; petals pink. *P. pilosa*  
 – Seeds grey, often iridescent; axillary hairs in loose shaggy tufts; stems usually erect or ascending with spaced terete leaves (if stems decumbent with flattened leaves, then petals yellow). 21
21. Sepals 8 mm long, rostrate; capsule lid conical, twice as high as wide; seeds with only slightly interlocking testa cells. *P. conoidea*  
 – Sepals 4-5 mm long, slightly crested; capsule lid domed, about as high as



- wide; seeds with interlocking jigsaw-shaped testa cells. 22
22. Leaves all linear-terete, 1-2 mm wide; petals red, pink or orange (rarely yellow).  
*P. kermesina*
- Leaves variable, some lanceolate or oblong-spathulate, up to 3 mm wide. 23
23. Petals purple; flowers surrounded by 4-5 involucre leaves. *P. anceps*
- Petals yellow; flowers surrounded by c. 8 involucre leaves. *P. heterophylla*

## Conclusion

East Africa is the centre of diversity for *Portulaca* sect. *Portulaca* in Africa, with only a few species extending beyond this area into the rest of the continent. One third of the species are endemic to southern Kenya and northern Tanzania. Most of the others are of very local distribution, often being confined to particular ecological niches. The following six species are known only from the type collections: *P. anceps*, *P. conoidea*, *P. erythraeae*, *P. heterophylla*, *P. humilis* and *P. stuhlmannii*. Some of these may prove to be extreme examples of other species. Variation in general is still very incompletely understood, and the stability of a number of characters used in keys needs further investigation.

Among the more widespread species local variants are commonplace. This is particularly true of *P. kermesina* in eastern Africa. The Kenyan coastal lowlands and the Tana River area are particularly rich in small annual forms, some of which may merit separate status when they are better known. Another outstanding problem is the separate specific status of *P. massaica* and *P. grandis*. They have an identical and distinctive seed, occupy the same habitat, and intermediates occur between them although they are readily distinguishable separately in their typical form. A chromosome survey of this complex is desirable. Plants named as *P. grandis* from northern Kenya and Ethiopia

(aff. *grandis* in the key) differ from typical *P. grandis* by their white-woolly persistent axillary hairs, tuberculate seeds and much-branched habit, all characters found in *P. decorticans* from northern Kenya.

Seed colour and ornamentation are found to be very useful for species delimitation, but are not absolutely stable. In particular, the basis for the development of tubercles and pegs on the testa-cells, and the appearance of a silvery metallic layer on the mature seed require investigation. More collecting is desirable throughout the area, and new collections should always be accompanied by full field notes. Further work is required, both in the field and experimentally, to complement the present study, which is based entirely on herbarium material. Only then will a stable classification for this group of *Portulaca* in Africa be achieved.

## Conspectus of species

- P. anceps* A. Rich. (1848)  
*P. centrali-africana* R.E. Fr. (1914)  
*P. ciferrii* Chiov. (1936)  
*P. conoidea* S.M. Phillips (2000)  
*P. coralloides* S.M. Phillips (2000)  
*P. decorticans* M.G. Gilbert (1992)  
*P. erythraeae* Schweinf. (1896)  
*P. fischeri* Pax (1893)  
*P. foliosa* Ker-Gawl. (1824); *P. fischeri* Pax var. *robusta* Poelln. (1940)  
*P. grandiflora* Hook. (1829)  
*P. grandis* Peter (1938)  
*P. heterophylla* Peter (1938); *P. mkatensis* Poelln. (1940)  
*P. humilis* Peter (1938)  
*P. kermesina* N.E. Br. (1909); *P. holosericea* Peter (1938); *P. tenera* Peter (1938); *P. rubriflora* Poelln. (1941)  
*P. kermesina* var. *lutea* (Poelln.) S.M. Phillips; *P. fischeri* Pax var. *lutea* Poelln.  
*P. massaica* S.M. Phillips (2000)

- P. nogalensis* Chiov. (1929); *P. nogalensis* var. *atricha* Chiov. (1929); *P. nogalensis* var. *homotricha* Chiov. (1929)  
*P. nogalensis* var. *heterotricha* Chiov. (1929)  
*P. oblonga* Peter (1932); *P. neumannii* Poelln. (1933); *P. neumannii* Poelln. var. *robusta* Poelln. (1940)  
*P. oleracea* L. (1753)  
*P. olosirwa* S.M. Phillips (2000)  
*P. pilosa* L. (1753)  
*P. ramosa* Peter (1938); *P. schliebenii* Poelln. (1940)  
*P. somalica* N. E. Br. (1886)  
*P. stuhlmannii* Poelln. (1933).

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