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A revision of the genus *Xanthostemon* (Myrtaceae) in Australia

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Abstract

Wilson, Peter G. (National Herbarium of N.S.W., Royal Botanic Gardens, Sydney 2000) 1990. A review of the genus Xanthostemon *(Myrtaceae) in Australia.* Telopea *3(4): 451–476.* — The Australian species of *Xanthostemon* are examined in the light of morphological and anatomical evidence and their relationships are discussed. Thirteen species are recognised, three of them new: *X. formosus*, *X. xerophilus* and *X. graniticus*. Also, the new combinations *X. petiolatus* (based on *Nania petiolata* Valeton) and *X. verus* (based on *Metrosideros vera* Roxb.) are made for two Malesian species.

Introduction

Xanthostemon is a genus of at least 45 species, most of which are arborescent, with a range extending from the Philippines to the Solomon Islands, New Caledonia and Australia. In Australia, the distribution is predominantly tropical with the only extratropical species, *X. oppositifolius*, occurring not far north of Brisbane.

When Ferdinand Mueller described the genus in 1857 with one species, *X. paradoxus*, he stated that it was close to the genus *Metrosideros* but was presumably convinced of the distinctness of the taxon by its golden-yellow stamens and its almost superior capsule. In the first volume of his 'Fragmenta' (1858: 80) he added a new species, *X. eucalyptoides*, and particularly indicated three character-states that distinguished *Xanthostemon* from *Metrosideros*, viz., capsule hardly adnate to the calyx tube, endocarp becoming free, and seeds flattened. However, in a later part of the same publication (1858: 243) he reduced the genus to subgeneric status under *Metrosideros*, influenced by the affinity of his two species to *Metrosideros ciliata* (now usually considered to constitute the monotypic genus *Purpureostemon* Gugerli).

Bentham (1865, 1867) reinstated the genus *Xanthostemon* for species with alternate leaves, e.g. *X. paradoxus*, but left species with opposite leaves, e.g. *X. eucalyptoides*, in *Metrosideros*. Gugerli (1940), in his monograph of the genus *Xanthostemon*, follows Bentham in excluding those species with strictly opposite leaves, except for *X. oppositifolius* which F.M. Bailey had placed in *Xanthostemon* rather than *Metrosideros* because the fruits were quite similar to those of *X. chrysanthus*. In this case, Gugerli's reasoning was based on his interpretation of leaf arrangement which he described as 'folia subopposita vel leviter alterna'. Although he excluded them from his taxonomic treatment, Gugerli did give some consideration to the opposite-leaved species which he considered under *Metrosideros* sect. *Nania*, and concluded that the latter taxon could be combined with ('zurückgeführt') *Xanthostemon*. While his monograph was in preparation, Gugerli (1939) described a new genus, *Purpureostemon*, distinct from *Xanthostemon* in four characters, viz., quincuncial (vs. imbricate) aestivation of the corolla, extent of fruit dehiscence, reduced size of the embryo (associated with the winged seed) and placenta angle (oblique rather than horizontal).

Merrill (1952: 156), in a discussion of *X. crenulatus* C. White, a species with opposite leaves, considered that it might be better placed in the genus *Nani* Adanson (*Nania* Miq.) which had long been considered a synonym of *Metrosideros* but which Valeton (1901: 65) accepted (as *Nania*) as generically distinct from *Metrosideros* on the basis of the more or less superior fruits and the different seeds and placenta. However, although Merrill seemed to be in favour of placing opposite-leaved species in *Nani* he did not transfer *X. crenulatus* to that genus.

Dawson (1972a) compares the four genera *Xanthostemon*, *Nani*, *Pleurocalyptus* and *Purpureostemon*, and concludes that none of them have any close affinity with *Metrosideros*. The four genera have a large number of character-states in common and differ from each other in only a few respects, and so Dawson raises the possibility that a detailed revision would lead to these genera being merged. Briggs and Johnson (1979) present an informal classification of the genera of the Myrtaceae into alliances, suballiances and infra-alliances and within this scheme they place the genera *Xanthostemon* (including *Nani*), *Purpureostemon* and *Pleurocalyptus* in the *Xanthostemon* suballiance, which is part of the *Metrosideros* alliance. If all four genera are combined, or if *Nani* alone is merged into *Xanthostemon*, the name *Nani* Adanson has priority but Wilson and Dawson (1981) have proposed that *Xanthostemon* be conserved against it.

Discussion of Characters

Phyllotaxis

In the Myrtaceae, the phyllotaxis is generally opposite and decussate or alternate, i.e. disperse in the terminology of Briggs and Johnson (1979), in both juvenile and mature plants. The best known exception to this is the condition found in most species of *Eucalyptus* sens. lat., where the juvenile foliage is opposite and decussate with the adult foliage becoming alternate by the separation of the pairs of leaves through expansion of the intranode, i.e. disjunct opposite in the terminology of Briggs and Johnson (1979). Another example is the genus *Lophostemon* which also has opposite leaves in the juvenile stage and alternate (disjunct opposite) leaves in the adult; the latter is most noticeable in young plants when the phyllotaxis first changes, but it is obscured in the more mature plant by the aggregation of almost all the true leaves into a pseudoverticil at the tip of the seasonal growth unit (Wilson & Waterhouse 1982). In *Lindsayomyrtus* it has been reported (Hyland & van Steenis 1973) that the first leaves in the seedling are opposite but that the phyllotaxis very soon becomes disperse, and a similar occurrence has been observed in *Welchiodendron* seedlings (Wilson & Waterhouse 1982). This ontogenetic sequence also occurs in at least some *Melaleuca* species and in *Leptospermum* (J. Thompson, pers. comm.) and may be more widespread in the family than the literature would indicate.

In *Xanthostemon*, however, a further exception is found in three of the species with opposite adult leaves, viz., *X. eucalyptoides*, *X. umbrosus* and *X. xerophilus*. When seed of these species was germinated, the seedlings were found to bear alternate leaves for at least the first season's growth. However, the phyllotaxis was not identical; in *X. xerophilus* it was distinctly disperse but in *X. eucalyptoides* it appeared to be disjunct opposite. Disperse phyllotaxis

succeeded by opposite has recently been reported for the newly described genus *Barongia* (Wilson & Hyland 1988) which does not, however, appear to have close affinities with *Xanthostemon.*

A variation of this has been observed in *X. whitei*; this species has predominantly disperse leaves but produces occasional branchlets bearing opposite leaves. Another species, *X. verticillatus,* has its leaves in apparent whorls of (3–)4(–5) at each node, a unique phenomenon in the genus. In the related genus *Purpureostemon,* which has alternate (? disjunct opposite) leaves, it has been observed (J.W. Dawson, pers. comm.) that the seedlings of the single species, *P. ciliatus,* bear opposite leaves.

Inflorescence

A range of inflorescence types is found in the genus. Briggs and Johnson (1979) record the occurrence of monads, triads, botryoids, metabotryoids and panicles; metaxymonads were said to occur rarely. All these inflorescence types have been observed in Australian species during the present study, as well as occasional metaxytriads. Briggs and Johnson also comment that branching in the larger unit inflorescences is often subopposite or irregular and that recaulescence (adnation of a bract ("pherophyll") to the axis it is subtending) is common. All inflorescences in *Xanthostemon* are axillary, although certain species have pseudoterminal inflorescences consisting of aggregations of lateral monads, triads or botryoids, subtended by reduced phyllomes, that occur at the apex of a stem.

Hypanthium and Perianth

The perianth in *Xanthostemon* is perigynous, the sepals and petals being borne on the rim of a dished hypanthium. The hypanthium varies in shape from broad and shallow to relatively deep and cylindrical. In the latter case, the rim of the hypanthium much exceeds the ovary summit while in the former it is below or barely exceeds the ovary summit. The variations in this character were used by Gugerli (1940) as the basis for a number of the sections that he described. In at least three species (two from Australia and one from the Philippines), the broad hypanthium has concave depressions opposite the petals; this feature was the basis of Gugerli's Section *Vesicaria.* Two of these species, *X. youngii* from Queensland and *X. speciosus* from the western Philippines (Calamian-Palawan group), have red flowers. This character may be associated with bird pollination; however, there are no published observations on the pollination biology of any member of the genus.

The petals are always free and may be red, yellow or cream to white in colour. There are at least four species with deep red petals and stamens but these do not seem to have arisen in the same evolutionary line as the red-flowered *Purpureostemon ciliatus,* and may not themselves represent a monophyletic group. A number of other species, from New Caledonia, have petals that are reddish orange to red but the filaments of the stamens are not necessarily the same colour.

The sepals are free and persistent; however, in the related New Caledonian endemic genus *Pleurocalyptus* the calyx is fused to form a calyptra which tears irregularly at anthesis to reveal the petals and stamens. The single species of

this genus has very close affinities with one particular group of New Caledonian species of *Xanthostemon* (Gugerli's Sect. *Bullata*) and does not warrant generic status solely on the basis of this one character-state (Wilson 1987).

Androecium

The stamens are numerous, mostly the same colour as the petals and arranged in one to several rows. They are relatively long (at least twice as long as the petals in most cases) and are usually the most prominent feature of the flower. Bentham (1867), in his description of the genus, says "stamens indefinite, free or slightly united at the base" but there is no evidence of regular fusion in any species that I have examined, although occasionally two filaments are connate giving the impression of a single stamen with two anthers. In some species there are small gaps in the ring of stamens opposite the centre of each sepal; in other cases the stamens are in two rows in front of a petal but in a single row elsewhere.

The exact nature of the androecium of *Xanthostemon* will only be determined through developmental studies. Payer (1857) was the first to investigate floral organogenesis in the Myrtaceae and described the development of the corolla primordia followed by the differentiation of each of these into a petal and a staminal primordium from which the individual stamens developed centripetally; his work implied that the family is basically obhaplostemonous. However, Johnson and Briggs (1985: 739) argue that the family is basically obdiplostemonous and give a range of examples to support this view.

In the original description of the genus, Mueller stated that the anthers were basifixed. However, Gugerli (1940:33) and Dawson (1972a, fig. 8) have shown that the anthers are, in fact, dorsifixed; the point of attachment of the filament is under a flap of the connective so that it can give the superficial impression that the anthers are basifixed. This mode of attachment is distinctive and is consistently present in *Xanthostemon*, *Pleurocalyptus* and *Purpureostemon* (Dawson 1972a). There seems to be a similar structure occurring in some species of *Metrosideros* sens. lat. (see, e.g., Dawson 1972b).

Another distinctive feature of the anther in *Xanthostemon* is the nature of the oil glands in the connective. The Myrtaceous anther typically has a conspicuous oil gland towards the apex of the connective, but in *Xanthostemon* this single large gland is often accompanied by a number of smaller glands elsewhere in the connective. This was noted by Dawson (1972a) in all the genera of the *Xanthostemon* group and has been observed in the present study in at least six species, *X. paradoxus, X. chrysanthus, X. whitei, X. umbrosus, X. psidioides* and *X. graniticus*; the extra glands may be present in other Australian species but are sometimes difficult to detect. Some species of *Metrosideros* sens. lat. also have such additional glands in the connective (Dawson 1970a,b, 1972b).

Ovary and Fruit

The ovary in *Xanthostemon* is often almost superior, although the base is always broadly attached, and it is this character-state, coupled with the subsequent fruit development, that gives the genus its distinctive appearance. The sides of the ovary are free from the hypanthium rather than adhering to it as in most other Myrtaceous genera with the exception of *Ristantia* and, perhaps, a

few other genera. The style is terminal on the ovary or, more usually, set into a slight depression in the summit; the stigma is flat or convex and is as wide as or narrower than the style.

The placentas in most species are rod-like and project into the loculi from the axis at various angles. The only exception to this is in the two closely related species *X. crenulatus* and *X. eucalyptoides* where the ovules are attached to the axis above a very slight protrusion (Fig. 1a). The placentas in these two species have been erroneously thought to be erect and, therefore, the species have been assumed to be part of the same taxon as the type of the genus *Nani* Adanson (Dawson 1972a) which is not here considered to be sufficiently distinct from *Xanthostemon* to warrant separate generic status. The condition described for *Nani* by Dawson (1972a) of placentas obliquely inserted towards the base of the axis and more or less erect, is, however, present in the two Australian endemic species *X. psidioides* and *X. graniticus* (Fig. 1b). In *X. umbrosus* and at least one species from New Guinea the placentas arise from the axis and project obliquely into the upper part of the loculus (Fig. 1c), while in the bulk of the species in the genus the placentas project horizontally into the centre of the loculus (Fig. 1d). In *Purpureostemon* the placenta is oblique but arises from the base of the axis and projects into the centre of the loculus (see Gugerli 1939: Fig. 2).

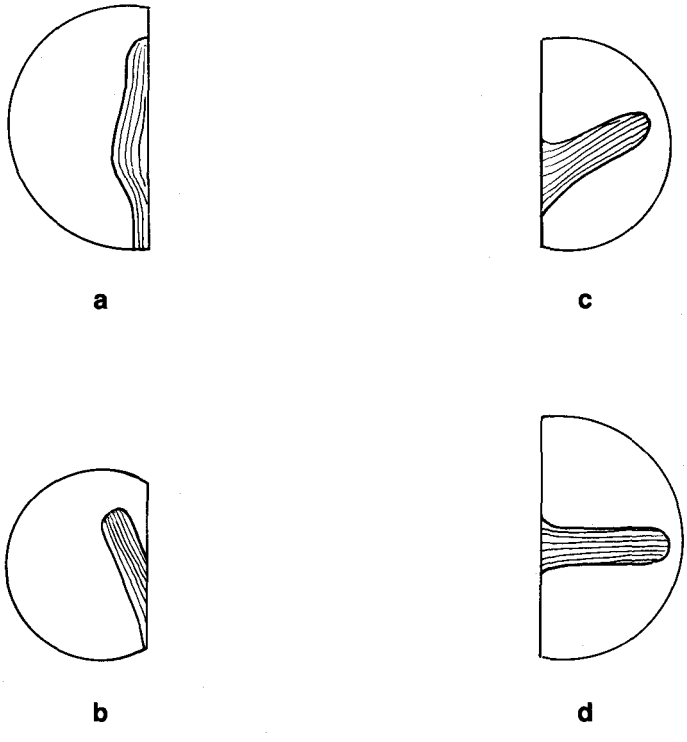

Fig. 1. Diagrammatic representation of the various placenta types found in *Xanthostemon* (see text for details).

The ovules are hemitropous (Dawson 1972a), bilaterally flattened and accumbent to the axis or the placenta. In the species with horizontal placentas the ovules form a complete ring around the placenta whereas in the species with oblique placentas the ring is almost complete, being interrupted at the top by the axis. In *X. crenulatus/eucalyptoides* and *X. psidioides/graniticus* the attachment of the ovules is such that they are borne in an arc. In *Purpureostemon* the different configuration of the placenta with respect to the loculus allows the placenta to bear a complete ring of ovules (Dawson 1972a).

As the ovary develops into the fruit, the free part expands at a much faster rate than the fruiting hypanthium so that, finally, the fruit is strongly exserted from the hypanthium. In a fruit that develops from a flower with a shallow hypanthium, the fruiting hypanthium does not enclose the base of the fruit while a cupular hypanthium will often partly enclose the base of the fruit.

Seed and Embryo

The fertile seeds of *Xanthostemon* species are bilaterally flattened and deltoid to semicircular in outline. The embryo usually fills the seed but in two species, *X. eucalyptoides* and *X. crenulatus*, the embryo is confined to one end of the seed, the other being a somewhat membranous wing. Dawson (1972a: Fig. 61) shows a winged seed in *Purpureostemon* but a closer examination of this wing reveals that it is not homologous with the wing in the two species of *Xanthostemon*; in *Purpureostemon* the major wing development is between the raphe and the embryo while in *X. eucalyptoides* and *X. crenulatus*, it is distal to the raphe. Winged seeds in *Xanthostemon* are more or less the same size as unwinged seeds but the embryo in the winged seeds is relatively small and consequently they weigh much less. For example, the average weight of the unwinged seed of *X. chrysanthus* is 3.2 mg while the average weight of the (fertile) winged seed of *X. eucalyptoides* is only 1.3 mg.

The embryo of members of the *Xanthostemon* suballiance is very distinctive. The cotyledons are relatively broad (when compared, for example, with *Metrosideros*) and flat and lie face-to-face; the hypocotyl is bent more or less at right angles to the cotyledons and is accumbent (i.e. lying along the margins of the cotyledons). No other genus of the Myrtaceae is known to have the same embryo type.

Palynology

The study by Pike (1956) of Myrtaceous pollen included three species of *Xanthostemon*, viz., *X. crenulatus*, *X. paradoxus* and *X. verdugonianus*, but apart from a general description of the grains in tabular form and a line drawing of a pollen grain of *X. crenulatus*, the only comment on the genus related to the occurrence of syncolpate or parasyncolpate grains. The more recent study by Gadek and Martin (1981) also included only three species, *X. crenulatus*, *X. chrysanthus* and *X. psidioides*, but the increased resolution of the S.E.M. has enabled a more precise description of the surface pattern of two of the grains as 'microfossulate'. These authors characterise the genus by this type of sculpture as well as by the presence of arcuate colpi and predominantly parasyncolpate grains. However, in a genus of over 40 species, this sample is far too small for any definite conclusions to be reached. The morphological diversity of the genus, and its wide geographic range, would make it a fruitful area

for a more detailed investigation. A recent survey of Myrtalean pollen (Patel et al. 1985) did not include any species of *Xanthostemon.*

Vegetative Anatomy

Earlier studies of anatomy have indicated some characters that may be useful in the taxonomy of *Xanthostemon* as well as in distinguishing that genus from other genera. The study by Ingle and Dadswell (1953) showed that it is not always possible to distinguish genera from each other on the basis of wood anatomy: from their key, *Xanthostemon* would appear to be indistinguishable from *Callistemon, Calothamnus, Lysicarpus, Melaleuca, Syncarpia,* and *Tristania* sens. lat. On the other hand, bark anatomy appears to be of considerably more value in characterising genera. Bamber (1962) found, from a survey of four species in the genus, that *Xanthostemon* is distinctive in having the following combination of character-states: alternating layers of sclerosed and suberized cells in the phellem, silica deposits in the ray parenchyma cells (except in the New Caledonian *X. aurantiacus*), fibre-sclereids, and oil glands usually present. On the basis of bark anatomy, Bamber was able to determine that a specimen sent to him labelled "*Metrosideros* sp." was probably a species of *Xanthostemon.* During the present study, observation has recorded oil glands in the bark of *X. eucalyptoides* and *X. graniticus.*

Gugerli (1940) studied vegetative anatomy in his monograph of the genus but this aspect of his work has rarely been referred to. For example, he had already noted (p. 27) that there were alternate rows of sclerosed and suberized tissue in the periderm and that sclereids were found almost always and oil glands less frequently. His findings on leaf anatomy are also quite important. He records the presence of a hypodermis in every one of the 38 species that he examined and this ranged from a single, discontinuous layer in the Australian species *X. oppositifolius* to a very substantial layer five cells deep, occupying almost half the leaf thickness, in the New Caledonian species *X. grandiflorus.*

In the present study, the leaf anatomy of 12 species (10 from Australia, 2 from New Guinea) was examined and a hypodermis was found to be always present; this varies from being a single, discontinuous layer to a layer three cells thick that takes up 5–18% of the leaf thickness. Another notable anatomical feature observed was the nature of the support tissue associated with the secondary leaf traces; in every species examined there is an adaxial column of sclerenchyma reaching through the palisade mesophyll up to or almost to the hypodermis while on the abaxial side there is usually a smaller group of sclerenchyma cells and, below that, a short column of lightly thickened collenchyma reaching to the lower epidermis. There appears to be a correlation between the degree of sclerophylly, as shown anatomically by the amount of sclerenchyma and the thickness of the hypodermis, and the usual habitat of the species; those from woodlands on poorer soils, e.g. *X. paradoxus* and *X. xerophilus,* are more sclerophyllous than those from moist riparian or rainforest situations, e.g. *X. chrysanthus* and *X. whitei.*

Gugerli (1940) reported the occurrence of sclereids or idioblasts in the midveins of many species but not in any of the four Australian species that he studied: in the present investigation only one species, the extra-Australian *X. novoguineensis,* displayed this character-state. Gugerli also noted various kinds of sclereids in the pith of young stems; in this study small groups of sclereids were found to be commonly present in the pith but large, angular sclereids were

observed only in the pith of *X. novoguineensis*. Gugerli did not remark on the presence of oil glands in the medulla of the petiole or in the pith; in this study oil glands were observed in the medulla of the petiole in seven species, and an examination of the stem revealed oil glands in the pith in each of these species and also in four other species that had not shown oil glands in their petioles. It seems likely that oil glands occur in all species but may be infrequent in some and thus overlooked.

Oil glands in the leaf lamina were in the size range 55–120 μm in diameter which is almost identical to that recorded by Gugerli for the four Australian species he examined, although the usual range for the extra-Australian species he studied was 100–220 μm. In only one species, *X. psidioides*, were the oil glands consistently located below the palisade in the leaf and this accounts for the difficulty in observing oil glands in fresh leaves of this species.

Discussion of relationships

The species of *Xanthostemon*, as accepted here, fall into a number of distinct groups. The first of these is the group containing *X. eucalyptoides* and *X. crenulatus*; Dawson (1972a) has suggested, following a number of earlier authors, that these two species are closely related to the type species of the genus *Nani* Adanson. These two species are each other's closest relatives as shown by their shared, unique derived character-states (synapomorphies), particularly the narrow perianth segments, the placentation and the winged seeds; there are no obvious synapomorphies linking them to *Nani*.

A second distinctive group of species is made up of *X. psidioides* and *X. graniticus*. The fruits of these two species are superficially similar to that illustrated by Dawson (1972a) for the type species of the genus *Nani*, but there are some differences between these species and *Nani*. In *Nani* the leaves are regularly opposite and mesophyllous while in *X. psidioides* and *X. graniticus* they are alternate and stiffly coriaceous. These differences in leaf arrangement are not necessarily significant since phyllotaxis seems to have become fixed as either opposite or alternate a number of times in the genus (Wilson, unpublished analysis).

A third group of species consists of *X. youngii* and *X. speciosus* Merr. from the Philippines which both have red flowers and vesiculate hypanthium; *X. formosus* shares the vesiculate hypanthium of these species but lacks the derived character-state 'red flowers' and differs markedly in leaf shape and texture, and fruit morphology.

Other species that appear to be closely related are 1) *X. oppositifolius*, *X. xerophilus* (and possibly *X. verticillatus*), and 2) *X. umbrosus* and *X. petiolatus*; these groups of species both have opposite leaves but are not closely related to each other as shown by the difference in placentation (see discussion above). The three remaining Australian species, *X. paradoxus*, *X. chrysanthus* and *X. whitei*, seem to form a group but this may only be due to the sharing of unspecialized (plesiomorphous) rather than specialised (apomorphous) character-states, and may not indicate common evolutionary descent; their affinities may lie with the *X. oppositifolius* group which shares the same placentation.

In this paper, *Xanthostemon* (including *Nani* Adanson) is treated as a single genus. A phylogenetic analysis of the genus and the genera *Purpureostemon* and

Pleurocalyptus (i.e. the *Xanthostemon* suballiance of Briggs and Johnson 1979) is in preparation (see Wilson 1987) and this will examine the evolutionary relationships between the species in these taxa.

In accordance with the conclusions reached so far, new combinations are made here for two Malesian species.

Xanthostemon petiolatus (*Valeton*) *Peter G. Wilson*, **comb. nov.**

BASIONYM: *Nania petiolata* Valeton, Meded. Lands Plantentuin 40: 172 (1900); Ic. Bogor. 1 (4): t. 99 (1901).

Xanthostemon verus (*Roxb.*) *Peter G. Wilson*, **comb. nov.**

BASIONYM: *Metrosideros vera* Roxb., Hort. Bengal.: 37 (1814); Fl. Ind. ed 2, 2: 477 (1832).

Xanthostemon

Xanthostemon *F. Muell.*, Hooker's J. Bot. Kew Gard. Misc. 9: 17 (1857) *nom. cons.*
TYPE: *Xanthostemon paradoxus* F. Muell.

Nani Adans., Fam. Pl. 2: 88, 581 (1763) *nom. rejic.*
TYPE: *Metrosideros vera* Roxb.

Nania Miq., Fl. Ind. Batav. 1: 399 (1855) *nom. illeg.*

Draparnandia Montr., Mem. Acad. Lyon 10: 205 (1860)
TYPE: *Draparnandia multiflora* Montr.

Metrosideros subg. *Xanthostemon* (F. Muell.) F. Muell., Fragm. 1: 243 (1859).

Metrosideros sect. *Nani* (Adans.) Niedenzu, Nat. Pflanzenfam. 3(7): 88 (1898), as 'Nania Miq.'

Nani sect. *Xanthostemon* (F.Muell.) O. Kuntze in Post & Kuntze, Lexicon Gen. Pl.: 382 (1904), as 'Nania'

Fremya Brongn. & Gris, Bull. Soc. Bot. France 10: 372 (1863); Ann. Sci. Nat. Bot., sér. 5, 2: 131 (1864).
TYPE: F. rubra Brongn. & Gris

DISTRIBUTION: Northern Australia, New Caledonia, New Guinea, Solomon Islands, eastern Indonesia, Philippines.

Low shrubs to tall trees, bud scales lacking. *Leaves* of all species alternate in the juvenile stages, some species becoming opposite. *Inflorescences* of axillary monads, triads, botryoids, metabotryoids, thyrsoids or panicles. *Petals* 4 or 5, yellow, white or red. *Sepals* 4 or 5, persistent. *Stamens* longer than the petals, numerous, free, usually in a single whorl, sometimes in two whorls, rarely more; sometimes interrupted opposite each calyx lobe. *Anthers* with a broad connective, gland-tipped, often with smaller glands elsewhere in the connective; filaments dorsifixed, the point of attachment enclosed by the connective. *Ovary* almost superior to half inferior, 2–6-locular (mostly 3–5), surrounded by or included in a saucer- or cup-shaped hypanthium. *Stigma* small, flat or slightly convex, narrower than the style. *Placentation* axile, the ovules attached to the centre of the axis or to a rod- or bracket-like placenta upright in the basal angle of, or projecting from, the axis horizontally or obliquely into the loculus. *Ovules* numerous, hemitropous, bilaterally flattened and accumbent to the axis or placenta and adhering to it along their edges. *Capsule* woody, globular, loculicidal, with the hypanthium partly enclosing, or flattened under, the fruit;

sepals persistent. *Seeds* flattened, semicircular to deltoid, occasionally winged at the chalazal end. *Embryo* with broad cotyledons lying face to face; hypocotyl accumbent.

LEAF ANATOMY: Hypodermis present, 1–3 cells deep. Secondary leaf veins supported adaxially by a column of sclerenchyma reaching through the palisade mesophyll to the hypodermis, and abaxially by collenchyma or sclerenchyma plus collenchyma. Petiole trace V- to very broadly U-shaped with oil glands very often present within the arc of the xylem.

A genus of over forty species. The name is derived from the Greek *xanthos*, 'yellow', and *stemon*, 'stamen', a reference to the yellow stamens of the type species, although red- and white-stamened species are not uncommon in the genus.

The genus *Nani* was described by Adanson (1763) who took the name from the Ambonese word given by Rumphius (Herbarium Amboinense 3: 16, t.7, 1743) for the species that he called 'Metrosideros vera'. This volume of Rumphius' work was published before the starting date for valid publication of names but his illustration constitutes the type of Adanson's genus.

The validity of the names in Adanson's publication under the present rules of nomenclature has recently been questioned by Parkinson (1987). The questions raised by Parkinson are still unanswered; however, Adanson's generic names have been treated as validly published for at least the past 50 years and this seems likely to remain the case (Nicolson, pers. comm.). In this paper, Adanson's name is treated as validly published; in the event of the rejection of his names, the following discussion and the synonymy given above would need amendment.

The first valid publication of Rumphius' species is *Metrosideros vera* Roxb. (Hort. Beng.: 37, 1814) based solely on Rumphius' illustration. Lindley's later publication of the same name (Collectanea Botanica t.18, 1821) also cited Rumphius' illustration (the type) and must, therefore, be considered to be an isonym (Nicolson 1975) and superfluous. Neither Roxburgh nor Lindley acknowledged Adanson's publication.

Miquel (1855) published the genus *Nania*, latinising the Ambonese 'Nani', independently of Adanson; the name is therefore new rather than an orthographic variant. Miquel's species, *Nania vera*, has been taken by some as a new combination of Adanson's and Roxburgh's names but Miquel gives no indication that he was aware of either publication. However, Miquel's species citation includes Rumphius' illustration so his genus is illegitimate since it includes the type of a previously published name (*Nani* Adanson) which ought to have been used.

The combination from Adanson's generic name and Roxburgh's specific epithet has never been made, but some combinations in *Nani* were made by Kuntze (1891). Kuntze took up Adanson's name, although he preferred the latinised form *Nania* (this *was* an orthographic variant), and applied it to the extremely broad concept of the genus *Metrosideros* favoured by Mueller in his Systematic Census of Australian Plants. This broad treatment was not accepted by any later botanist although Valeton (1901) did accept *Nania* Miq. as a genus distinct from *Metrosideros* and Merrill (1952: 156) supported this view, at least in principle.

The lack of any widespread usage of the name *Nani*, coupled with the conclusion that the genus had affinities with *Xanthostemon* rather than *Metrosideros*,

prompted Wilson and Dawson (1981) to propose that *Xanthostemon* be conserved against it. The Committee for Spermatophyta of the IAPT has voted to recommend conservation of the name *Xanthostemon* F. Muell. (Taxon 33: 298, 1984); this recommendation was ratified at the International Botanical Congress in Berlin.

Key to the Species of *Xanthostemon* in Australia

1. Flowers with distinct depressions ('vesicles') in the hypanthium opposite the petals 2

   Flowers lacking vesicles in the hypanthium 3

2. Flowers red; ovary densely pubescent ..... **1. X. youngii**

   Flowers greenish yellow; ovary glabrous ..... **2. X. formosus**

3. Placenta projecting more or less horizontally into the loculus; ovules forming a complete ring 4

   Placenta oblique to erect; ovules not forming a complete ring 9

4. Adult leaves opposite or in apparent whorls 5

   Adult leaves alternate (sometimes, in *X. whitei*, with some branchlets bearing opposite leaves) 7

5. Leaves opposite 6

   Leaves in apparent whorls of four ..... **3. X. verticillatus**

6. Flowers white; ovary hairy; bark scaly ..... **4. X. oppositifolius**

   Flowers yellow; ovary glabrous; bark persistent, rugose .. **5. X. xerophilus**

7. Hypanthium not enclosing the fruit at the base 8

   Hypanthium partly enclosing the fruit ..... **6. X. chrysanthus**

8. Calyx, corolla, stems and leaves glabrous or covered with a white tomentum; leaves obtuse, shortly petiolate ..... **7. X. paradoxus**

   Calyx, corolla, stems and leaves covered with a dense yellow-brown tomentum; leaves occasionally opposite, acute, distinctly petiolate ..... **8. X. whitei**

9. Petals ovate or elliptical; ovules attached at the apex of the placenta; seeds not winged 10

   Petals narrowly spathulate; ovules attached part-way up the axis; seeds winged 12

10. Adult leaves alternate 11

    Adult leaves opposite ..... **9. X. umbrosus**

11. Indumentum on young shoots golden brown; leaves 5.5–9.0 cm long, 2.5–4.0 cm wide ..... **10. X. psidioides**

    Indumentum on young shoots reddish brown; leaves 7.0–18.0 cm long, 4.0–10.0 cm wide ..... **11. X. graniticus**

12. Leaves sessile or nearly so ..... **12. X. eucalyptoides**

    Leaves petiolate ..... **13. X. crenulatus**

1. Xanthostemon youngii *C. White & Francis*, Proc. Roy. Soc. Queensland 37:159 (1926) Plate vi; Gugerli, Repert. Spec. Nov. Regni Veg., Beih. 120: 54 (1940).

HOLOTYPE: QUEENSLAND: Temple Bay, Cape York Peninsula, *J.E. Young AQ 316316*, vii.1923 (BRI).

Shrub (in heath communities) or tree with reddish brown, rough bark; young leaves and stems, floral parts and fruit white-pubescent. *Leaves* alternate in both juvenile and adult plants; petiole short, c. 0.5 cm long; lamina obovate to elliptical, 5–8 cm long and 1.5–3.5 cm broad, obtuse, glabrous, coriaceous with prominent venation. *Inflorescence* axillary, a monad or triad, borne at the apex of the seasonal growth unit. *Hypanthium* 17–18 mm broad, extending as a saucer around the ovary, with (4–) 5 distinct depressions (vesicles) opposite the petals. *Petals* 5, red, 7–10.5 mm long and up to 8 mm wide, finely pubescent, the margins ciliate. *Sepals* broadly triangular, 3–3.5 mm long. *Stamens* up to 25 mm long, in a continuous whorl around the rim of the hypanthium but drawn in towards the base of the ovary at the sides of the vesicles. *Ovary* almost superior, 3- to 5-locular, densely covered with hairs about 1 mm long. *Style* 15–20 mm long, terminal on the ovary; stigma not dilated, flat to convex. *Placentas* horizontal, bilaterally flattened. *Fruit* c. 15 mm in diameter; hypanthium everted under the capsule. *Seeds* not winged.

DISTRIBUTION: East coast of Cape York Peninsula, heath and low forest on sand dunes.

SELECTED SPECIMENS (2/9): QUEENSLAND: Cook District: Olive River, 12°10' S, 143°05' E, *Hyland 7440, 7450 & 7474*, 13.ix.1974 (QRS, UNSW); 3 km NW of Bolt Head, *Hind 4562*, 26.vii.1986 (NSW).

This is the only red-flowered species of *Xanthostemon* known in Australia. It has obvious affinities with *X. speciosus* Merr. from the Philippines (restricted to the continental Calamian-Palawan group) which also has a vesiculate hypanthium; the other red-flowered species, e.g. *X. ruber* from New Caledonia, *X. verdugonianus* from the Philippines, *X. novoguineensis* from New Guinea, and *X. confertiflorus* from Sulawesi, are not necessarily closely related either to *X. youngii* or to each other.

There have been occasional references to this species as '*X. youngiae*' (see, e.g., Lavarack & Godwin, 1987). There is no justification for this since the person after whom the species was named, J.E. Young, was a male.

Fruiting specimens of a plant resembling this species have been collected in similar communities near Cape Flattery; however, there are unconfirmed reports that this entity has yellow flowers.

2. Xanthostemon formosus *Peter G. Wilson*, **sp. nov.**

Arbor media, cortice squamoso. Folia juniora adultaque alterna, glabra, laminis plerumque 12–22 cm longis et 2–4.5 cm latis, chartaceis, acuminatis. Flores flavovirentes, petalis suborbicularis 1.5–1.8 cm latis, hypanthio vesiculato, ovario glabro, placentis horizontalibus. Capsula minute verrucosa; semina non alata.

HOLOTYPE: QUEENSLAND: Cook District: Portion 49V, Portion of Alexandra, Cooper Creek, 16°10' S, 145°25' E, *Gray 3366*, 26.iv.1984 (NSW). ISOTYPES: QRS, BRI.

Tree to 18 m tall and 30 cm d.b.h., with grey flaky bark. *Leaves* alternate in both juvenile and adult plants; petiole 0.5–1.5 cm long, becoming swollen at the base; lamina narrowly elliptical to oblanceolate, (9–)12–22 cm long and

2–4.5 cm broad, acuminate, glabrous, discolorous, chartaceous, midvein sunken above, prominent below, lateral veins and intramarginal vein conspicuous; oil glands numerous. *Inflorescence* an aggregation of monads at the apex of the shoot, subtended by reduced foliage leaves. *Hypanthium* 1.5–2 cm broad, saucer-like but with 5 distinct depressions (vesicles) opposite the petals. *Petals* 5, greenish yellow, suborbicular, 1.5–1.8 cm in diameter, glabrous, the margin irregular. *Sepals* yellowish, triangular to oblong, 0.7–1.0 cm long and 0.4–0.7 cm broad. *Stamens* c. 25, in a single series around the rim of the hypanthium, filaments 2–2.5 cm long. *Ovary* almost superior, (2- to) 3-locular, glabrous. *Style* 1.5–2.5 cm long, terminal on the ovary, persistent; stigma not dilated, flat to slightly convex. *Placentas* horizontal, bilaterally flattened. *Fruit* 1.5–2 cm in diameter, the surface minutely verrucose; hypanthium everted under the capsule. *Seeds* not winged. (Fig. 2)

DISTRIBUTION: Known only from the area around Cooper Creek (between Noah Creek and the Daintree River) where it occurs in rainforest along the creek.

SELECTED SPECIMENS (2/8): QUEENSLAND: Cook District: Cooper Creek, *Gray 3345*, 14.iii.1984 (QRS); *Sankowsky 574*, 16.xii.1986 (NSW).

This remarkable species is the first one known to have both a vesiculate hypanthium and yellow flowers. Apart from the vesiculate hypanthium it does not particularly resemble *X. youngii*; the leaves are chartaceous rather than coriaceous, acuminate rather than acute to obtuse, the ovary is glabrous rather than densely pubescent, the capsule minutely verrucose rather than ± smooth and the style is markedly persistent. It can easily be distinguished from all other Australian yellow- or white-flowered species by the vesiculate hypanthium and the much larger perianth segments.

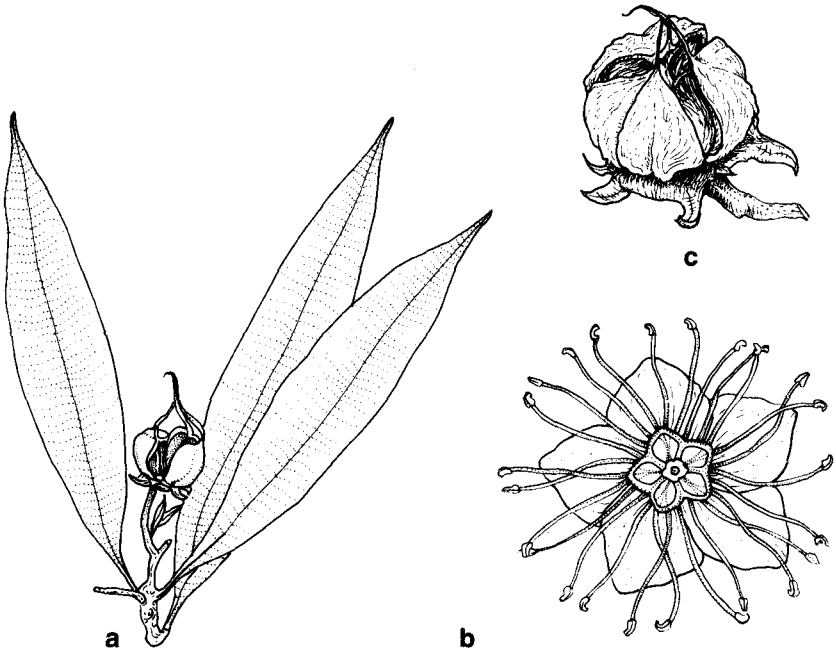

Fig. 2. *Xanthostemon formosus* Peter G. Wilson. **a** habit (x 0.4). **b** flower (x 0.8). **c** fruit (x 1.2). (**a, c** from *Gray 4340*; **b** from *Gray 3366*).

3. Xanthostemon verticillatus *(C. White & Francis) L.S. Smith*, Proc. Roy. Soc. Queensland 67: 38 (1955).

BASIONYM: *Metrosideros verticillata* C. White & Francis, Queensland Dept. Agric. Bot. Bull. 22: 24 (1920).

HOLOTYPE: QUEENSLAND: 'Bloomfield River', *W. Poland AQ 342056*, xi.1902 (BRI 36326, 36327).

Tree with tessellated, flaky bark; branchlets show sympodial growth, apparently due to regular abortion of the apical buds after flowering. *Leaves* mostly in apparent whorls of (3–)4(–5); petiole 0.5–0.8 cm long; lamina narrowly oblanceolate 4–9 cm long and (0.5–)0.8–1.3 cm broad, obtuse or sometimes mucronate at the apex, decurrent to the rather short petiole; oil glands numerous, oil yellow to orange. *Inflorescence* axillary triads, glabrous except for a faint pubescence on the sepals and petals; peduncles flattened or angular, 8–16 mm long; pedicels slender, 8–14 mm long. *Hypanthium* cup-shaped, contracted at the orifice, 5–7 mm in diameter, exceeding the top of the ovary. *Petals* 5, cream, ovate-orbicular, 5–7 mm long. *Sepals* triangular, 2–3.5 mm long. Stamens numerous, 2–2.5 cm long. *Ovary* almost superior, 3- to 4-locular, glabrous. *Style* longer than the stamens, 2.5–3.5 cm long, inserted in a depression in the ovary summit; stigma not dilated. *Placentas* horizontal with the ovules arranged in a complete ring. *Fruit* woody, 10–11 mm in diameter, with a distinct depression in the centre, hypanthium enclosing the basal part of the fruit and somewhat constricting it. *Seeds* not winged.

DISTRIBUTION: The only precisely known locality is the Daintree Logging Area where the species is a rheophyte in rainforest.

SPECIMEN EXAMINED: QUEENSLAND: Cook District: T.R. 165, Daintree L.A., 16°09' S, 145°17' E, *Hyland 3920 RFK*, 29.x.1978 (NSW, QRS).

The type collection consists of four elements, now mounted on two sheets at BRI. The protologue was accompanied by a photograph of one element (left hand specimen on sheet BRI 36327). Since these specimens are clearly all from one gathering and all were in the possession of the authors when the description was drawn up, I have treated the entire collection as holotype.

B. Hyland (pers. comm.) has not found this species in the Bloomfield River area; the type 'locality' given is probably a reference only to the Rev. W. Poland's address.

The collector's notes on the recent collection state that the flowers have 'a distinct odour of freshly cut purple passionfruit skin'. The species is the only *Xanthostemon* known to have verticillate leaves.

4. Xanthostemon oppositifolius *F.M. Bailey*, Cat. Indig. Nat. Pl. Queensland: 109 (1890), Queensland Fl. 2: 642 (1900); Gugerli, Repert. Spec. Nov. Regni Veg., Beih. 120: 58 (1940); W.D. Francis, Australian Rain-Forest Trees, edn 2: 329 (1951).

HOLOTYPE: QUEENSLAND: Noosa, *A. F. Luya AQ 316328* (BRI).

Tall tree, to c. 40 m with scaly bark that is shed in flakes; young shoots and inflorescences very finely hairy. *Leaves* opposite (occasionally subopposite) in the adult; petiole 0.5–1.5 cm long; lamina ovate to elliptical or broadly lanceolate, 4–9(–11) cm long and (1.5–)2.5–5.5 cm broad, often shortly attenuate at the base, obtuse to rounded at the apex, coriaceous, veins prominent in dried specimens. *Inflorescence* an axillary triad, botryoid or metabotryoid;

flowers 3–9(–11) per inflorescence, white; peduncles 2–4 cm long; pedicels 1–2 cm long. *Hypanthium* 5–7 mm in diameter, dish-shaped with its rim approximately at the level of the ovary summit. *Petals* (4–)5, orbicular, 4–6 mm long. *Sepals* deltoid to oblong, 2–5 mm long, 2.5–3.5 mm broad. *Stamens* numerous, 8–10 mm long. Ovary more than half superior, 3- or 4- (rarely 2-) locular, densely covered with very short, pale hairs. *Style* about 10 mm long, inserted in a depression on the ovary summit; stigma narrower than the style. *Placentas* sub-central, arms slightly ascending, projecting into the centre of the loculus; the ovules forming a complete ring. *Fruit* woody, broadly ovoid, 10–13 mm in diameter; hypanthium enclosing the base of the fruit. *Seeds* not winged.

DISTRIBUTION: South-eastern Queensland, between Maryborough and Nambour, in rainforest.

SELECTED SPECIMENS (2/16): QUEENSLAND: Wide Bay District: Kaurivale, *Hyland 6675,* 23.i.1973 (QRS); 1.9 km along Bates Road from the Kin Kin road, *Beesley 955A & Ollerenshaw,* 10.xii.1986 (CBG, MEL, NSW).

5. Xanthostemon xerophilus *Peter G. Wilson,* **sp. nov.**

Arbor cortice cinereo, rugosissimo. Folia juvenilia alterna, adulta opposita et decussata, laminis 6–11 cm longis et 2.5–5.5 cm latis, coriaceis, punctis glandulosis aurantiacis. Inflorescentia axillaris, botryoidalis. Flores luteoli, hypanthio late cupulato, staminibus numerosis, uniseriatis sed ante petala biseriatis, ovario glabro, placenta horizontali. Capsula globosa, brunneola-armeniaca, 1.0–1.4 cm diametro, 3–4-locularis; semina non alata.

HOLOTYPE: QUEENSLAND: Cook District: ca 45 miles S of Cape York, 11°19'S, 142°25'E, *Pedley 2737,* 27.vi.1968 (NSW). ISOTYPE: BRI.

Tree to 16 m tall with grey, hard, very rugose, somewhat tessellated bark; the young stems angular and yellowish tomentose. *Leaves* of juvenile plants alternate, of adults opposite and decussate, rarely subopposite; petiole 0.5–1.8 cm long; lamina broadly obovate to oblong-elliptical (4.5–)6–9(–11) cm long, 2.5–5.5 cm broad, margin undulate and the apex obtuse or shortly acuminate, discolorous, coriaceous, glabrous; midvein concave above, prominent below, venation reticulate, prominent below; oil glands numerous, oil orange. *Inflorescence* axillary, a 7–11-flowered botryoid, pedicels 1.2–1.7 cm long, peduncles covered in a fine, golden-brown tomentum. *Hypanthium* broad-cupulate, 5–7 mm in diameter, the rim extending beyond the top of the ovary. *Petals* 5, pale yellow, ovate, 4–5 mm long, 4–6 mm broad. *Sepals* 5, 2–2.5 mm long, deltoid to oblong, sparsely pubescent. *Stamens* numerous, 1.5–2 cm long, uniseriate (biseriate opposite the petals). *Ovary* 3–4-locular, half inferior, glabrous. Style 2–2.5 cm long, inserted in a depression on the ovary summit. *Placentas* rod-like, terete, horizontal, reaching the ovary wall and bearing numerous ovules in an uninterrupted whorl on the margin of the slightly dilated apex. *Fruit* brownish orange when ripe, globose, 1.0–1.4 cm in diameter; hypanthium everted or partly enclosing the base of the fruit. *Seeds* not winged, 4–5 mm long. (Fig. 3)

DISTRIBUTION: Cape York Peninsula, north and south of the Jardine River in layered open forest with *Eucalyptus tetrodonta* and *E. nesophila* (community 2b of Pedley & Isbell (1971); 5b of Lavarack & Stanton (1977)).

SELECTED SPECIMENS (3/12): QUEENSLAND: Cook District: Jardine River, *Brass 18901,* 21.v.1948 (CANB); 16 km S. Jardine R., *Wilson & Waterhouse UNSW 2734, 2735,* 5.x.1973 (NSW, UNSW).

Early specimens of this species were distributed as *Metrosideros* sp. aff. *tetrapetala* (i.e. *X. umbrosus*) to which it is superficially similar. Lavarack and Stanton (1977) erroneously refer this species to *X. paradoxus.*

The epithet refers to the preference shown by this species for the drier, open forest in contrast to the other Cape York species which usually occur in moister coastal or riparian situations.

6. Xanthostemon chrysanthus *(F. Muell.) Benth.*, Fl. Austral. 3: 268 (1867); F.M.Bailey, Queensland Flora 2: 641 (1900); Gugerli, Repert. Spec. Nov. Regni Veg., Beih. 120: 79 (1940).

BASIONYM: *Metrosideros chrysantha* F. Muell., Fragm. 4: 159 (1864).

LECTOTYPE (here designated): QUEENSLAND: Rockingham Bay, *Dallachy*, 12.iv.1864 (MEL 63325).

SYNONYM: *Nani chrysantha* (F. Muell.) O. Kuntze, Rev. Gen. Pl. 1: 242 (1891) as 'Nania'.

Tall tree with fairly smooth, hard, grey bark, decorticating in hard scales or strips; twigs and shoots usually sparingly pubescent or glabrous. *Leaves* alternate in both juvenile and adult plants; petiole short, up to 1 cm long; lamina lanceolate to oblanceolate, (7–)10–15(–20) cm long and (2–)3–4.5(–7) cm broad, acute, chartaceous to coriaceous; oil glands sometimes containing red oil. *Inflorescence* axillary, a monad, triad or, sometimes, a metabotryoid, borne at the apex of the seasonal growth unit. *Hypanthium* cup-shaped, c. 5 mm broad, extending well beyond the ovary summit. *Petals* 4–5, yellow, ovate to orbicular, 7–9 mm long. *Sepals* yellowish, triangular, 3–3.5 mm long. *Stamens* numerous,

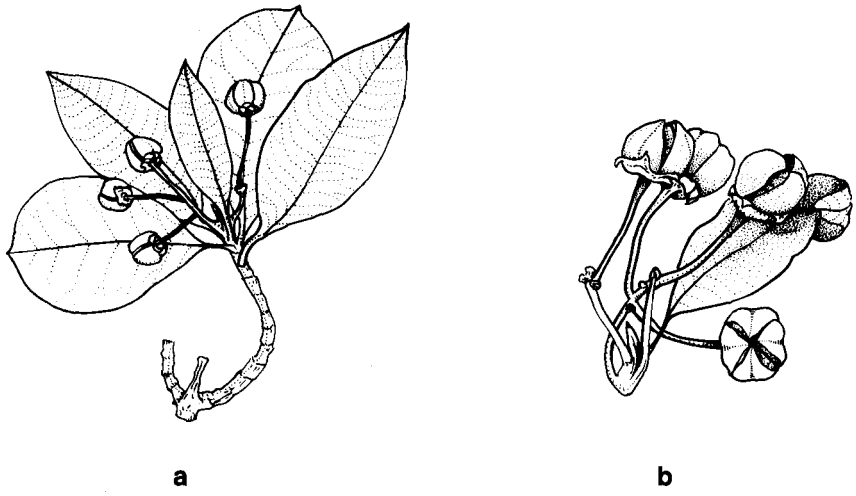

Fig. 3. *Xanthostemon xerophilus* Peter G. Wilson. **a** habit (x 0.4). **b** fruit (x 0.8). (**a** from *Benson 576*; **b** from *UNSW 2735*).

in one whorl, (15–)20–30 mm long. *Ovary* nearly superior, (2–)3(–4)-locular. *Style* (25–)30–40 mm long as long as or longer than the stamens, terminal or inserted in a shallow depression on the ovary summit, the base persistent; stigma small, convex. *Placentas* horizontal. *Fruit* 9–15 mm in diameter; hypanthium usually enclosing basal ⅓–½ of the fruit. *Seeds* not winged.

DISTRIBUTION: Coastal Queensland, between 12° S and 19° S, mostly in riparian forest.

SELECTED SPECIMENS (6/56): QUEENSLAND: Cook District: Junie Ck, *Dockrill 571*, 14.x.1972 (BRI, QRS); Shiptons Flat, *Brass 20202*, 12.ix.1948 (BRI, CANB); Cooper Ck, *Hyland 5995*, 11.iv.1972 (BRI, QRS); S.F.R. 756, Downey Ck, *Hyland 5603*, 1.xi. 1971 (BRI, QRS, UNSW). North Kennedy District: Murray Falls, c. 23 km SW Euramo, *Boyland & Gillieat 637*, 29.xi.1967 (BRI); Wallaman Falls, *Vessey 154*, 14.ix.1963 (BRI).

7. Xanthostemon paradoxus *F. Muell.*, Hooker's J. Bot. Kew Gard. Misc. 9: 17 (1857), Fragm. 1: 80 (1859); Bentham, Fl. Austral. 3: 269 (1867); Gugerli, Repert. Spec. Nov. Regni Veg., Beih. 120: 81(1940).

LECTOTYPE (here designated): NORTHERN TERRITORY: Sea Range, Victoria River, *F. Mueller* xii.1855 (MEL 63369).

SYNONYMS: *Metrosideros paradoxa* (F. Muell.) F. Muell., Fragm. 1: 243 (1859).

Nani paradoxa (F. Muell.) O. Kuntze, Rev. Gen. Pl. 1: 242 (1891) as 'Nania'.

Tree with thick, grey, persistent, rugose bark; branchlets and twigs pubescent to glabrous. *Leaves* alternate in both juvenile and adult plants; lamina elliptical, 5–16(–18) cm long and 3–6(–7) cm broad, obtuse, pubescent or glabrescent. *Inflorescence* axillary, a triad or metabotryoid, borne at the end of the seasonal growth unit, often aggregated as a pseudoterminal conflorescence. *Hypanthium* cup-shaped, 4–6 mm in diameter, exceeding the top of the ovary. *Petals* 5, elliptical, c. 5 mm long, yellow. *Stamens* in one whorl, yellow, rigid, 17–25 mm long. *Ovary* almost superior, 2–3- (rarely 4-) locular. *Style* 20–40 mm long, extending approximately as far as the ends of the stamens, inserted in a shallow depression on the ovary summit; stigma narrower than the style, convex. *Placentas* horizontal. *Fruit* 8–14 mm in diameter; hypanthium flattened under the fruit. *Seeds* not winged.

DISTRIBUTION: Kimberley Division of Western Australia and the Northern Territory; in savannah woodland or on rocky hills.

SELECTED SPECIMENS (9/116): WESTERN AUSTRALIA: Kimberley Division: Kalumburu, *Maconochie 1253*, 30.v.1971 (BRI, CANB, NT, PERTH); Marigui Promontary, *Kenneally 2164*, 27.viii.1974 (PERTH); 26 km E. Kununurra, *Beard 4296*, 3.vi.1965 (NSW, PERTH). NORTHERN TERRITORY: 47 miles (c. 76 km) N. Oenpelli, *Chippendale*, 16.vii.1961 (AD, BRI, CANB, MEL, NSW, NT); Nourlangie Rock, *Schodde AE24*, 3.v.1972 (CANB, DNA, NT); 6 miles (c. 9.7 km) S. Adelaide River, *Lazarides 6967*, 6.xii.1963 (BRI, CANB, NSW, NT); 23 miles (c. 37 km) NE. 'Tipperary', *Lazarides 6690*, 28.vii.1961 (AD, BRI, CANB, NSW, NT); Silver Mine Ck, Daly R. road, *Byrnes 11*, 3.xi.1966 (AD, NT); near Alligator Springs, 70 miles (c. 113 km) E. 'Carlton Hill', *Perry 2614*, 27.vii.1949 (AD, BRI, CANB, NSW, NT).

Herbarium specimens show a wide range of variation but detailed field observations, particularly in the Northern Territory, are required before a satisfactory taxonomic resolution can be achieved. Amongst the Australian populations, at least three distinct groups are discernible: (1) specimens collected on or around rocky outcrops have pubescent leaves 5–11 cm long, thin-walled pale brown fruits 0.8–1 cm in diameter with the style usually set slightly into the top, and pale yellow semi-persistent stamens; (2) specimens collected

in savannah woodland have glabrous to pubescent leaves 8–16 cm long, red-brown fruits 1.1–1.4 cm in diameter with the style terminal on the summit, and dark yellow deciduous stamens; and (3) specimens from low open woodland are similar to form 2 but always have tomentose leaves and fruit with a tardily dehiscent, heavily thickened pericarp markedly adnate to the remnants of the hypanthium. The limits of these 'forms' are unknown and there are still other specimens, from scattered localities, which are different again from any of these (e.g. *Webb & Tracey 13194* from Melville Island, *Webb & Tracey 12480A* from Katherine River, and *Barnett & Azzopardi 4* from Mt Brockman); these also need to be investigated.

In choosing a lectotype I have followed Merrill (1952: 155) who accepted the only collection available to him as typical but did not formally designate a specimen as type. The protologue was based on two different collections and Merrill had access to only one of these, a plant with "distinctly pubescent leaves, and densely cinereous-pubescent inflorescences" (specimens at K and G). Merrill described the savannah woodland populations from New Guinea, previously identified as *X. paradoxus*, as the new species *X. brassii* ; this taxon is closely related to *X. paradoxus* but is specifically distinct in habit, flowering phenology and indumentum.

8. Xanthostemon whitei *Gugerli*, Repert. Spec. Nov. Regni Veg., Beih. 120: 83 (1940) as 'whitii'; Merrill, J. Arnold Arbor. 33: 154 (1952).

SYNONYM: *Xanthostemon pubescens* C. White, Proc. Roy. Soc. Queensland 29: 57 (1917), *nom. illeg.*, *non* Pampaloni, Nuovo Giorn. Bot. Ital. II, 13: 128 (1906).

HOLOTYPE: QUEENSLAND: Mazlins Creek, Herberton District, *J.F. Bailey AQ 316314* (BRI). ISOTYPE: MEL.

Tree up to 40 m tall with grey scaly bark; branchlets, inflorescences and under-surfaces of the leaves covered with a dense yellow-brown indumentum. *Leaves* alternate in the juvenile, alternate or sometimes opposite on some branchlets in the adult; petiole 1–2 cm long; lamina lanceolate, 7–16(–19) cm long and 3–5(–7.5) cm wide. *Inflorescence* an axillary triad, botryoid or metabotryoid. *Hypanthium* cup-shaped, 5–7 mm in diameter, extending beyond the top of the ovary. *Petals* (4–)5, elliptical, 4–5 mm long, creamy yellow. *Sepals* (4–)5, triangular to oblong, 3–4 mm long. *Stamens* yellow, numerous, in one whorl, 15–25 mm long. *Ovary* half inferior, 3- to 4-locular, glabrescent. *Style* 20–30 mm long, inserted in a depression on the ovary summit; stigma small, much narrower than the style. *Placenta* horizontal. *Fruit* 1–1.5 cm in diameter; hypanthium enclosing the base of the fruit. *Seeds* not winged.

DISTRIBUTION: North Queensland, Atherton Tableland region, in closed forest communities on basaltic red earths, on brown and yellow earths or on volcanic alluvium (Tracey 1982).

SELECTED SPECIMENS (2/22): QUEENSLAND: Cook District: S.F.R. 191, Barron L.A., *Hyland 6002*, 18.iv.1972 (BRI, QRS); Mena Creek, Paronella Park, *Smith 3711A*, 5.viii.1948 (BRI).

9. Xanthostemon umbrosus *(A. Cunn. ex Lindl.) Peter G. Wilson & Waterhouse*, Austral. J. Bot. 30: 444 (1982).

BASIONYM: *Tristania umbrosa* A. Cunn. ex Lindl., Bot. Reg. *sub* t.1839 (1836); Bentham, Fl. Austral. 3: 265 (1867).

HOLOTYPE: WESTERN AUSTRALIA: Shores of York Sound, *A. Cunningham* 16.ix.1820 (CGE). ISOTYPES: BM, K.

SYNONYMS: *Metrosideros tetrapetala* F. Muell., Fragm. 7: 41 (1869).

LECTOTYPE (here designated): QUEENSLAND: Cave Creek, Gilbert River, Daintree. (MEL 63313, left hand element).

Nani tetrapetala (F. Muell.) O. Kuntze, Rev. Gen. Pl. 1: 242 (1891) as 'Nania'.

Tree with grey, scaly bark. *Leaves* alternate in juvenile plants, opposite in adults; petiole 0.8–1.5 cm long; lamina elliptical, 5–8 cm long and 2–4.5 cm broad, obtuse, emarginate or mucronate. *Inflorescence* axillary, a cyme or botryoid; flowers usually 3–7 per inflorescence. *Hypanthium* 5.5–7 mm in diameter, a shallow dish with its rim at, or slightly below, the level of the ovary summit. *Petals* 4, rarely 5, cream, elliptical, 4–6 mm long and 3–4 mm broad. *Sepals* triangular, 2–4 mm long. *Stamens* numerous, 10–13 mm long, in 1–2 whorls (1 whorl opposite the sepals, 2 opposite the petals), filaments 2.5–6.0 mm long. *Ovary* half inferior, 3–4-locular. *Style* equal to or longer than the stamens, inserted in a depression on the ovary summit; stigma small, convex. *Placentas* axile, oblique, laterally flattened, bearing c. 14 ovules in an incomplete ring. *Fruit* globular, woody, 8–12 mm in diameter, dehiscence lines much paler than the red-brown fruit; hypanthium flat to everted under the fruit; sepals persistent, prominent. *Seeds* not winged.

DISTRIBUTION: Northern Australia, from Cape York Peninsula across to the Kimberley region of Western Australia.

SELECTED SPECIMENS (6/34): WESTERN AUSTRALIA: Kimberley Division: Upper reaches of Hunter R., *Kenneally 8966*, 9.vi.1984 (NSW, PERTH). NORTHERN TERRITORY: 8 miles (c. 13 km) SE. East Alligator R. crossing, *Byrnes 1953*, 29.vii.1970 (DNA, NT); Groote Eylandt, *Levitt*, 10.iii.1973, iv.1973 (BRI, DNA). QUEENSLAND: Cook District: Olive River, *Hyland 3070 RFK*, 13.ix.1975 (NSW, QRS); Tozers Gap, Tozer Range, *Brass 19416*, 2.vii.1948 (BRI, CANB, K); Gugu Yulangi main camp, *Hyland 8082*, 8.iii.1975 (NSW, QRS, UNSW).

The species has only recently been re-collected (vegetative material only) from the region where Cunningham collected the type. It is still poorly known throughout its range, and very few flowering specimens exist. The specimens show a great deal of variation, particularly in leaf shape, fruit size and habitat, and may represent more than one taxon. I am maintaining it as a single variable taxon until a fuller range of material is available.

This species (or species complex) is not closely related to any other Australian species; it is clearly distinct in having the obliquely inserted placenta. The nearest allies to this taxon are *Xanthostemon* sp. ("kasi kasi") from New Guinea and *X. petiolatus* from Sulawesi (described from a tree being grown at Bogor from seed supposedly originating in Java, but the species is not known from there).

10. Xanthostemon psidioides *(A.Cunn. ex Lindl.) Peter G. Wilson & Waterhouse*, Austral. J. Bot. 30: 444 (1982).

BASIONYM: *Tristania psidioides* A. Cunn. ex Lindl., Bot. Reg. *sub* t.1839 (1836); Bentham, Fl. Austral. 3: 264 (1867).

HOLOTYPE: WESTERN AUSTRALIA: Ravines of Regent River, Brunswick Bay, *A. Cunningham*, 10.x.1820 (CGE; not seen). ?ISOTYPE: K (dated ix.1820).

Small tree, up to 8 (rarely to 15) m tall, with dark, grey-black, tessellated bark; young stems and leaves covered with a golden brown indumentum, becoming

grey with age. *Leaves* alternate in both juvenile and adult plants; petiole (0.7–) 1.0–1.8 cm long; lamina elliptical, (3.5–)4.5–9.0(–11.5) cm long by (1.5–) 2.0–4.0(–5.8) cm broad, apex obtuse and rounded to acute; oil glands obscure. *Inflorescence* an axillary panicle or metabotryoid, branching disjunct opposite; peduncle 2–3 cm long; pedicels and floral parts finely pubescent. *Hypanthium* broad and shallow, 5–6 mm in diameter, extending like a saucer around the ovary. *Petals* 5, cream, ovate to orbicular, 3–4 mm long. *Sepals* (narrowly) triangular, 2–3 mm long, persistent. *Stamens* numerous, in one whorl, slightly interrupted in front of each sepal, 8–12 mm long. *Ovary* almost superior, 3-locular, tomentose. *Style* approximately as long as the stamens; stigma convex. *Placentas* upright, ovules attached near the apex. *Fruit* small, grey-tomentose, 6–7 mm in diameter; hypanthium enclosing basal ¼ of the fruit. *Seeds* not winged.

DISTRIBUTION: Disjunct between the Kimberley region of Western Australia and the Arnhem Land escarpment of the Northern Territory.

SELECTED SPECIMENS (6/22): WESTERN AUSTRALIA: Kimberley Division: Marigui Promontory, Brunswick Bay, *Kenneally 2148*, 27.viii.1974 (PERTH); Sale R., *Kenneally 9675*, 16.v.1986 (NSW, PERTH). NORTHERN TERRITORY: Wessell Islands, *Latz 3474*, 12.x.1972 (BRI, CANB, NT); c. 9 km NE. Jabiru, *Adams & Richardson 3037*, 19.ii.1973 (CANB, NSW); Deaf Adder Gorge, *Fox 2522*, 22.ii.1977 (DNA, CANB, MEL, NSW, NT); Koolpin Creek, *Dunlop 4278*, 29.ix.1976 (DNA, NSW).

11. Xanthostemon graniticus *Peter G. Wilson*, **sp. nov.**

Arbor parva vel media, cortice tessellato. Folia juniora indumento cinnamomeo mox supra glabrescentia, adulta alterna, laminis plerumque 7–18 cm longis et 4–10 cm latis, rigido-coriaceis, rugosis. Inflorescentia axillaris, metabotryoidalis. Flores cremei, hypanthio 7.8–8.0 mm diametro, ovario indumento cinnamomeo, placenta plus minusve erecta. Capsula 7–9 mm diametro; semina non alata.

HOLOTYPE: QUEENSLAND: Cook District: head of Roaring Meg Creek, 16°07' S, 145°24' E, *M. Godwin C2826*, 2.iii.1985 (NSW). ISOTYPES: BRI, QRS.

Tree to 13 m tall with dark brown flaky bark. *Leaves* alternate in adult plants; petiole 1–2.5 cm long; lamina elliptical, 7–18(–22) cm long and (3–)4–10(–12) cm broad, stiffly coriaceous, apex acute to shortly acuminate, indumentum pale red-brown to greyish when young, soon glabrescent above, becoming greyer and sparser below; midvein and main lateral veins sunken giving the lamina a rugose appearance, margins recurved; oil glands numerous. *Inflorescence* a metabotryoid, axillary, branching opposite to disjunct opposite; peduncle 2–3 cm long. *Hypanthium* broad and shallow (dish-like), 7–8 mm in diameter, the rim exceeding the ovary summit. *Petals* 5, cream, ovate to orbicular, 4.0–4.4 mm long and 3.8–4.0 mm wide, containing numerous oil glands, pubescent on the outer surface. *Sepals* 5, triangular, 2.8–3.2 mm long and 1.9–2.7 mm wide, pubescent on the outer surface. *Stamens* numerous, (5–)7–10 mm long, uniseriate, filaments free, anthers dorsifixed, the point of attachment enclosed by the broad connective which has a large gland at the apex and 1–3 smaller glands on each side. *Ovary* half inferior, (2–)3-locular, covered with a short, dense, reddish brown indumentum. *Style* up to 12 mm long, inserted in a depression in the ovary summit; stigma narrower than the style, flat. *Placentas* upright, ovules c. 10 per loculus, attached near the apex. *Fruit* depressed-globular, 7–9 mm in diameter, grey-tomentose; hypanthium enclosing the base of the fruit. *Seeds* not winged, c. 4 mm long. (Fig. 4)

DISTRIBUTION: Known so far from only three localities in the vicinity of Mount Pieter Botte, inland from Cape Tribulation, Queensland; it grows in open areas of mossy Araucarian-notophyll vine forest on creek banks in peaty soil on granite.

This species is most closely related to *Xanthostemon psidioides* from the Northern Territory and Western Australia. It differs from that species in its cinnamon-coloured indumentum and its rugose and coriaceous leaves. These two species constitute a distinct group which has no close affinities with any other Australian species; possible links with Malesian species have yet to be investigated.

As far as can be ascertained, the species is unique in the genus in its ecology; no other is recorded as growing on granite rocks.

12. Xanthostemon eucalyptoides F. Muell., Fragm. 1: 81 (1859).

LECTOTYPE (here designated): NORTHERN TERRITORY: Fitzmaurice River, *F. Mueller*, x.1855. (MEL 63296).

SYNONYMS: *Metrosideros eucalyptoides* (F. Muell.) F.Muell., Fragm. 1: 243 (1859); Bentham, Fl. Austral. 3: 267 (1867).

Nani eucalyptoides (F. Muell.) O. Kuntze, Rev. Gen. Pl. 1: 242 (1891) as 'Nania eucalyptodes'.

Tree up to 18 m tall with persistent, grey, fine-textured bark; young stems quadrangular. *Leaves* alternate in juvenile plants; opposite in adults; sessile or subsessile, petiole up to 0.2 cm long; lamina elliptical-oblong, somewhat

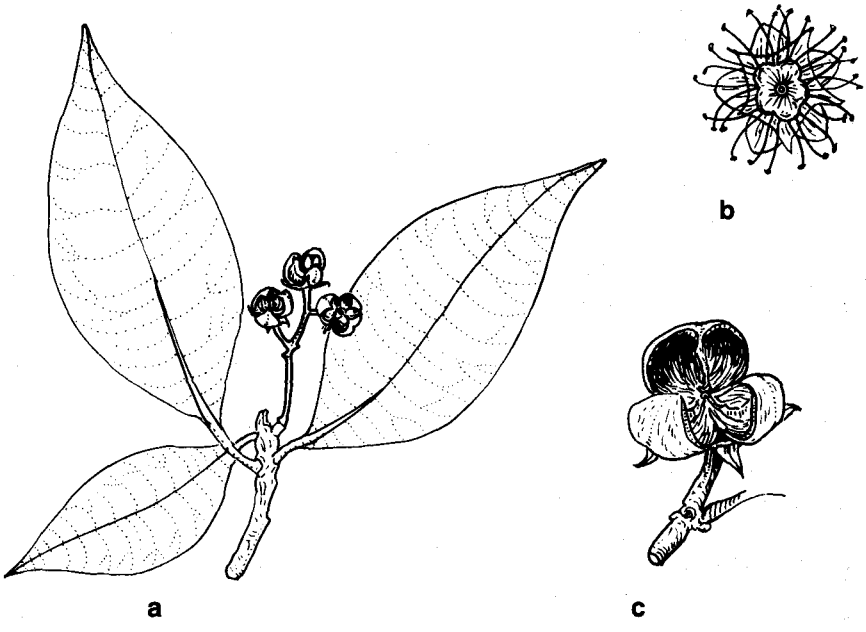

Fig. 4. *Xanthostemon graniticus* Peter G. Wilson. **a** habit (x 0.5). **b** flower (x 1). **c** fruit (x 2). (**a, c** from *Godwin C2574*; **b** from *Godwin C2826*).

cordate, mostly 5–12 cm long and 3–7 cm broad, obtuse, glabrous. *Inflorescence* an axillary panicle or metabotryoid with opposite branching, covered with a very fine indumentum; peduncles quadrangular; flowers numerous, c. 21 per inflorescence. *Hypanthium* broad and shallow, 4–5.5 mm in diameter. *Petals* 4(–5), linear to spathulate, 3–3.5 mm long and 1–1.5 mm broad, cream. *Sepals* linear, 2–2.5 mm long and 0.5 mm broad. *Stamens* numerous, in 1–2 whorls, 4.5–8.5 mm long. *Ovary* almost superior, (2–)3–4-locular. *Style* longer than the stamens, about 10 mm long, inserted in a depression on the ovary summit; stigma narrow, flat to convex. *Placentas* upright, ovules 8–10 per loculus, attached mid-way up the placenta. *Fruit* thin-walled, ovoid, about 6 mm in diameter; hypanthium everted under the fruit. *Seeds* winged; wing distal to the raphe.

DISTRIBUTION: Northern Territory and Western Australia in higher rainfall areas; almost always found near streams, on swampy ground, or on ground subject to seasonal inundation.

SELECTED SPECIMENS (4/30): WESTERN AUSTRALIA: Kimberley Division: Surveyor Falls, Mitchell Plateau, *George 13131*, 18.i.1975 (PERTH). NORTHERN TERRITORY: Oenpelli, *Specht 1244*, 22.x.1948 (AD, BRI, CANB, MEL, NSW); George Ck., Stuart Highway, *Byrnes 541*, 5.x.1967 (AD, DNA, NT); UDP Falls, *Martensz AE 533*, 24.i.1973 (BRI, CANB, NSW).

13. Xanthostemon crenulatus *C. White*, J. Arnold Arbor. 23: 82 (1942); Merrill, J. Arnold Arbor. 33: 156 (1952).

HOLOTYPE: PAPUA: Gaima, Lower Fly River, *Brass 8358*, xi.1936 (BRI).

Tree 10–20 m tall; bark grey, thick, the surface breaking up into corky flakes; young stems flattened, glabrous. *Leaves* opposite in the adult; petiole 1–1.5 cm long; lamina elliptical-oblong, 9–17 cm long and 6–11 cm broad, obtuse, emarginate or mucronate, margins crenulate. *Inflorescence* usually an axillary metabotryoid or panicle with opposite branching, covered with a fine indumentum; peduncle flattened; flowers numerous, c. 15 per inflorescence. *Hypanthium* broad and saucer-shaped, 4.5–6.5 mm in diameter. *Petals* 4(–5), cream, spathulate, 3.5–4.5 mm long and 2 mm broad. *Sepals* oblong, 2–2.5 mm long and 1–1.5 mm broad. *Stamens* numerous, 2.5–8 mm long, in (1–)2 whorls slightly interrupted opposite the sepals. *Ovary* almost superior, 3–4-locular. *Style* longer than the stamens, 8–10 mm long, inserted in a depression on the ovary summit; stigma convex. *Placentas* upright, ovules 9–11 per loculus, attached mid-way up the placenta. *Fruit* thin-walled, broadly ovate, about 7 mm in diameter; hypanthium flat to everted under the fruit. *Seeds* winged, wing distal to the raphe.

DISTRIBUTION: South-western Papua, and Cape York Peninsula as far south as the Cooktown area, common in forest adjacent to watercourses.

SELECTED SPECIMENS (4/31): PAPUA NEW GUINEA: Western District: near Morehead Patrol Post, *Pullen 7198*, 30.viii.1967 (BRI, CANB, LAE). QUEENSLAND: Cook District: Galloway Ck., Bamaga district, *Webb & Tracey 6047*, 4.v.1962 (BRI); Iron Range, *Brass 19140*, 11.vi.1948 (BRI, CANB); Muck R., Bathurst Bay, *Hyland 6304*, 27.vii.1972 (QRS).

This species is very closely related to *X. eucalyptoides* from which it differs in bark, leaf shape and petiole length. The two species are geographically isolated.

Excluded Australian binomials

X. brachyandrus C. White, Proc. Roy. Soc. Queensland 53: 219 (1942) = *Lindsayomyrtus brachyandrus* Hyland & Steen., Blumea 21: 189 (1973).

X. pachyspermus F. Muell. & F.M. Bailey, Occas. Pap. Queensland Fl. 1: 4 (1886) = *Ristantia pachysperma* Peter G. Wilson & Waterhouse, Austral. J. Bot. 30: 443 (1982).

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This index lists specimens by collector's name and collecting number (or date of collection for unnumbered collections); the numbers in parentheses refer to the species in the text.

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