Cycas terryana P.I.Forst. (Cycadaceae), a new species from central Queensland

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Summary

Forster, P.I. (2011). *Cycas terryana* P.I.Forst. (Cycadaceae), a new species from central Queensland. ***Austrobaileya* 8(3): 356–363.** A new species of *Cycas* from the Broadsound and Connors Ranges in central Queensland is described, illustrated and diagnosed as *C. terryana* P.I.Forst. It is known from five populations in an area of occurrence of approximately 800 km² and does not occur in any conservation reserves. A conservation status of Vulnerable based on the IUCN criterion of D2 is recommended for the species.

Key Words: Cycadaceae, *Cycas*, *Cycas terryana*, Australia flora, Queensland flora, new species, taxonomy, identification key, conservation status

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Introduction

The genus *Cycas* L. is speciose in Australia with 28 species recognised (Hill 1998, 2004). The species generally occur in well defined, geographically discrete areas in few (in several instances one) to many populations. Botanical exploration in Queensland continues to reveal previously undocumented populations of *Cycas*; such a case pertains to several populations of plants in the area southwest of St Lawrence and northwest of Marlborough in the Broadsound and Connors Ranges.

Hill (1992) was of the opinion, albeit without supporting evidence, that this material represented a zone of hybridism (“intergrading populations”) between *Cycas media* R.Br. and *C. ophiolitica* K.D.Hill. This hypothesis was developed further (Hill 1996: 3), *viz.* “these [populations] are morphologically intermediate between the putative parent species and also show the high degree of variability to be expected from Mendelian segregation in second and later generations”. Such introgressed populations were considered to occur throughout the range of the genus in Australia (Hill 1996) and elsewhere (e.g. Hill 1994, 2008; Hill *et al.* 2004), in some instances between species that he classified in different series. This ‘multiple hybridism’ hypothesis remains to be tested using molecular markers (e.g. haplotype networks [Schaal & Olsen 2000]) and remains merely as a plausible supposition in some cases. Alternative hypotheses are that these populations are merely variations of more broadly defined species or in some instances represent discrete taxa.

Hill’s propensity for designating a large number of *Cycas* populations as hybrids or examples of introgression was probably influenced by his work on eucalypts (where this is widespread and by comparison well documented with genetic studies) and his mentoring by L.A.S.Johnson who together with Lindsay Pryor was a keen supporter of the ‘phantom’ hybrid population concept (Pryor 1951; Pryor & Johnson 1971; Parsons & Kirkpatrick 1972; Johnson 1976; Kirkpatrick & Potts 1987). Eucalypts are bisexual, often promiscuous outbreeders with non specialist pollinators and appear to be readily dispersed; hence, the potential for hybrids where different taxa adjoin is high, although recorded instances are relatively low (Griffin *et al.* 1988). Populations of hybrid individuals may lead to extinction of the parental species via genetic pollution, although in many cases the progeny are sterile or with reduced viability (Levin 2000). Alternatively, these populations may in time lead to separate speciation events once fertility is restored

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(e.g. via allotetraploidy) and genetic change via selection or genetic drift occurs (Levin 2000).

The situation in *Cycas* is quite dissimilar, insomuch as the plants are dioecious, require pollination by insects (in variations of a mutualistic relationship) and perhaps wind in combination (Kono & Tobe 2007), polyploidy is unknown (Gorelick & Krystle 2011), and distribution of the populations are limited by dispersal (Forster 2007). As noted by Hill (1992) it is perhaps unlikely that strong genetic barriers to cross pollination between different taxa exist and so the only real barrier to hybridism/introgression is isolation in geographic space. Populations of *Cycas* and other Australian cycads are rare in the landscape for the above reasons, quite unlike the situation with most eucalypts. Johnson (1959, 1961) actively promoted the concept of widespread hybridism in cycads, especially for Zamiaceae (*Macrozamia*) species, although some of his examples are merely juveniles of much larger adults (e.g. *M. lucida* × *M. moorei*; juveniles of what is now known as *M. johnsonii* D.L.Jones & K.D.Hill) or represented discrete taxa that he was not aware of. Speciation in *Cycas* and *Macrozamia* is perhaps most likely to occur via genetic drift in isolated populations, rather than genetic selection *per se* (Gorelick 2009). This is reflected in the occurrence of similar appearing taxa, often in a geographic replacement series of allopatric populations. This can be interpreted as an indication of both continuous and incomplete speciation in a non-adaptive radiation where the inter-relationship between environment and morphology is unclear (Savolainen & Forest 2005) and in cycads is probably driven mainly by fragmentation, rather than radical differences in habitat specialisation (*cf.* Linder 2003). Either way, the tempo of speciation is likely to be slow given the long time period between germination and individuals reaching maturity, together with slow turnover of individuals within populations.

With regard to the so called *Cycas media – C. ophiolitica* intermediates south of St Lawrence, Hill (1992) was probably only aware of two populations based on his collection (*Hill 3788 & Stanberg*) and that of *Hind 2878*, or others that he examined and determined as such. There are now five populations of these plants known and perhaps more in what is largely a botanically unexplored part of central Queensland.

Neither of the putative parental species have populations that are particularly geographically close to the Broadsound and Connors Ranges plants. Hill (1996) vaguely stated that the hybrid populations were “wherever different species grow in relatively close proximity”. The closest population of *Cycas media* is *c.* 9 km to the northeast (in different habitat and geology) and the closest population of *C. ophiolitica* some *c.* 45 km to the east of the overall area of occupancy for the five populations. The southern populations of *Cycas media* are predominantly coastal and occur on substrates derived from basalts, finer grained granites or stabilised sand masses. The northern populations of *Cycas ophiolitica* are restricted to serpentinite substrates. By comparison the Broadsound and Connors Ranges plants occur well inland in the ranges on substrates derived from heavily weathered porphyritic granites.

These populations of *Cycas* may well have originated from mixing of the ancestral lineages of both *C. media* and *C. ophiolitica* as postulated by Hill, with speciation following the initial hybridism and subsequent geographic isolation. However, the situation could well be much more complex than this and reflect multiple instances of fragmentation and integration of populations driven by climatic changes since the glacial cycles of the Pleistocene. This hypothetical pattern of change has been actively promoted as one of the main drivers of speciation in Mexican cycads (Vovides *et al.* 2003) and similar reproductive and dispersal biology of the Australian cycads may infer similar patterns of allopatry (Forster 2004).

Given that the recorded populations of these *Cycas* are disjunct over an area of occurrence of at least 800 km², it is likely that the hypothesised speciation event is well advanced with subsequent fragmentation following an initial introgression. It is unlikely that these populations are any less fit than the core *Cycas media* or *C. ophiolitica* populations and to all extents they appear to exist and operate much like any other healthy cycad populations. If of hybrid origin, then they probably commenced as a neutral hybrid zone with genetic compatibility and superficially similar habitats, although such zones are usually in close proximity to the putative parental species (Levin 2000) which is no longer the case here. Whatever the origin, these populations possess character states that enable them to be distinguished from both *Cycas media* and *C. ophiolitica*; hence, they are described below as a new species. The hypothesised species origin is also relevant for speciation elsewhere in *Cycas* and other genera of cycads, particularly *Macrozamia* Miq. from Australia (Forster 2004), *Encephalartos* Lehm. in Africa (Vorster *et al.* 2004) and *Ceratozamia* Brongn. and *Zamia* L. in the New World (Vovides *et al.* 2003, 2004).

Materials and methods

The species description is based on examination of both live plants in habitat and herbarium collections at the Queensland Herbarium.

Taxonomy

Cycas terryana P.I.Forst. species nova a *C. ophiolitica* differt praecipue foliis valde fragilibus (adversum non), multo parcius carinatis et juvenilibus non glaucis, extra colore indumenti; quum a *C. media* subsp. *media* differentiae principales sunt folia valde (non infirme) fragilia, maturitate indumentum gerentia (adversum indumentum deficiens) et valde carinata (adversum plus minusve non vel infirme carinata), cum colore indumenti in cataphyllis. **Typus:** Queensland. PORT CURTIS DISTRICT: Broadsound Range, 9 March 2005, *P.I.Forster PIF30618 & P.J.Machin* (holo: BRI [4 sheets, ♀ carpological and spirit samples]).

Arborescent cycad with stems to 3 m high (rarely multiheaded), 12–22 cm thick. Leaves 80–190 cm long, straight and becoming wavy towards the apex, weakly to strongly keeled in cross-section, pale green to somewhat glaucous green-grey above; opposing leaflets inserted at 20–50º to the rhachis, the rhachis usually terminated by paired leaflets, tomentose; petiole 17–30 cm long, 7–15 mm diameter, dull olive grey-green, with 4–40 short teeth (pinnacanths) 1.5–2 mm long and spaced 8–17 mm apart, sometimes spineless. Leaflets 184–320 per leaf, 7–10 mm apart, being evenly spaced in lower half of leaf, then becoming more interleaved and more strongly keeled in upper half of leaf, brittle, margins recurved; median leaflets at 25–45º to the rhachis, 105–230 mm long, 5–7 mm wide, green-grey with fawn-tan bloom when young; weakly convex in cross section, decurrent for 5–7 mm, up to 13 mm at base of leaf. New growth densely tomentose with pale cream-fawn indumentum, glabrescent. Cataphylls pungent, linear, 8–12 cm long, densely tomentose for entire length with pale fawn indumentum. Microsporangiate cones elongate-ovoid, 21–28 cm long, 6.5–8 cm diameter, with dense ferruginous-brown indumentum; microsporophylls 28–40 mm long, fertile zone 17–28 mm long, 4–12 mm wide; apical spine antrorsely recurved, 4–10 mm long. Megasporophylls 20–33 cm long, when young with dense fawn-tan indumentum, aging grey, eventually glabrescent and olive-green; ovules 4 to 6; lamina broadly triangular 50–70 mm long, 30–38 mm wide, strongly dentate with well developed antrorse teeth 4–7 mm long, apical spine 17–33 mm long. Seeds ovoid, 37–40 mm long, 30–35 mm diameter, sarcotesta *c.* 5 mm thick, weakly grey pruinose, olive green beneath wax covering, becoming orange when ripe. **Figs. 1–5.**

***Additional specimens examined*: Queensland.** LEICHHARDT DISTRICT: Broadsound Range, Mar 1964, *Everist 7624* (BRI); *ditto loc.*, Nov 2003, *Forster PIF29714 & Halford* (BRI); *ditto loc.*, Nov 2003, *Forster PIF29715 & Halford* (BRI); *ditto loc.*, Mar 2005, *Forster PIF30617 & Machin* (BRI); *ditto loc.*, Dec 2010, *Mathieson MTM965 & 966* (BRI); *ditto loc.*, Jun 2011, *Forster PIF38217 & Machin* (BRI). PORT CURTIS DISTRICT: St Lawrence towards Croydon, Aug 1990, *Hill 3788 & Stanberg* (BRI, NSW); Croydon Station – St Lawrence Road, Jun 2011, *Forster PIF38218 & Machin* (BRI); 5 km W of Prospect Hill, Nov 1992, *Forster PIF12276 & Machin* (BRI); near Burwood [as ‘Barwood’], Broadsound, Jun 1981, *Maconochie 2757* (BRI; CANB, DNA, NY *n.v.*).

Fig. 1. *Cycas terryana*. Plants in habitat (population voucher: *Forster PIF29714 & Halford* [BRI]). Photo: P.I.Forster

***Distribution and habitat*:** *Cycas terryana* is restricted to the Broadsound and Connors Ranges northwest of Marlborough and southwest of St Lawrence. Populations occur on undulating low hills on stony soil derived from porphyritic granite in woodland dominated in various combinations by *Corymbia clarksoniana* (D.J.Carr & S.G.M.Carr) K.D.Hill & L.A.S.Johnson, *C. dallachiana* (Benth.) K.D.Hill & L.A.S.Johnson, *Eucalyptus crebra* F.Muell., *E. drepanophylla* F.Muell. ex Benth. and *Petalostigma pubescens* Domin.

***Notes*:** *Cycas terryana* appears to have first been collected by Selwyn Everist in 1964; however, this herbarium specimen has been variously identified as *C. media* or an intergrade between *C. media* and *C. ophiolitica* (determination of K.D.Hill).

The primary morphological differences between *Cycas terryana*, *C. media* and *C. ophiolitica* are summarised in **Table 1**. The leaflets and rhachis of *C. terryana* are very brittle and easily snapped, as opposed to the situation in *C. media* and *C. ophiolitica* where they are less brittle in the former and robustly flexible in the latter. The megasporophylls in *Cycas terryana* are generally broader than in the other species being compared here and indumentum on the new growth, cataphylls and megasporophylls is pale grey-fawn to fawn-tan whereas in the others it is usually orange-brown, only becoming greyish if particularly weather beaten. *Cycas terryana* differs from *C. ophiolitica* mainly in the leaves being markedly brittle (versus not), much less strongly keeled and not glaucous when young, as well as the indumentum colour; whereas from *C. media* subsp. *media* the main differences are the leaves being markedly brittle (versus weakly brittle), with indumentum at maturity (versus none) and strong keeling (versus ± flat to weakly keeled), together with the indumentum colour on the cataphylls.

Fig. 2. ***Cycas terryana***. Apex of mature plant showing cataphylls (population voucher: *Forster PIF30617 & Machin* [BRI]). Photo: P.I.Forster

Cycas media and *C. ophiolitica* were classified in different series by Hill (1996, 1998) on the basis of anatomy and morphology. Given that species such as *C. terryana* exist, there seems little point in the continued recognition of such artificial supraspecific taxa.

***Etymology*:** This species is named for Dr L. Irene Terry of the University of Utah, U.S.A., in recognition of her ground breaking work on cycad pollination, both in Australia and on Guam (e.g. Terry 2001; Terry *et al.* 2004, 2005, 2007, 2009).

***Conservation status*:** The species is known from five populations with an area of occurrence of *c.* 800 km and an area of occupancy that is much less. An appropriate status is Vulnerable based on the D2 criterion (IUCN 2001). None of the populations occur in conservation reserves and at least one has been reduced to non viable numbers of plants.

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References

Forster, P.I. (2004). Classification concepts in *Macrozamia* (Zamiaceae) from eastern Australia. In T. Walters & R. Osborne (eds.), *Cycad Classification: Concepts and Recommendations*, pp. 85–94. CABI Publishing: Wallingford.

—— (2007). Recovery plans for endangered cycads: a model set of objectives and actions using the example of *Cycas megacarpa* from Queensland, Australia. *Memoirs of the New York Botanic Garden* 97: 3–31.

Gorelick, R. (2009). Evolution of cacti is largely driven by genetic drift, not selection. *Bradleya* 27: 37–48.

Table 1. Comparison of character states for *Cycas media, C. ophiolitica and C. terryana*

Character State	*C. media*	*C. ophiolitica*	*C. terryana*
Mature leaf indumentum	glabrous	tomentose below and on rhachis	tomentose below and on rhachis
Leaflet insertion	± flat to weakly keeled	strongly keeled	keeled
Leaflet number	160–300	170–220	184–320
Leaflet colour mature leaves	glossy green	glaucous grey-blue	glossy green to glaucous green-grey
Leaflet texture	flexible to weakly brittle	flexible	strongly brittle
New growth indumentum colour	pale orange-brown	mixture of grey-white and pale orange-brown	pale grey-fawn
Cataphyll indumentum colour	orange-brown	orange-brown	pale grey-fawn
Megasporophyll indumentum	ferruginous or grey	brown	fawn-tan
Megasporophyll width (mm)	17–30	12–30	30–38
Seed sarcotesta colour	green becoming orange-yellow, not pruinose	green becoming yellowish, pruinose	green becoming orange, not or only weakly pruinose
Seed size: length × wide (mm)	31–38 × 26–32	29–33 × 28–32	37–40 × 30–35

Gorelick, R. & Olson, K. (2011). Is lack of cycad (Cycadales) diversity a result of a lack of polyploidy? *Botanical Journal of the Linnean Society* 165: 156–167.

Griffin, A.R., Burgess, I.P. & Wolf, L. (1988). Patterns of natural and manipulated hybridisation in the genus *Eucalyptus* L'Herit. – a review. *Australian Journal of Botany* 36: 41–66.

Hill, K.D. (1992). A preliminary account of *Cycas* (Cycadaceae) in Queensland. *Telopea* 5: 177–206.

—— (1994). The *Cycas rumphii* complex (Cycadaceae) in New Guinea and the Western Pacific. *Australian Systematic Botany* 7: 543–567.

—— (1996). A taxonomic revision of the genus *Cycas* (Cycadaceae) in Australia. *Telopea* 7: 1–95.

—— (1998). Cycadophyta. In A.Orchard (ed.), *Flora of Australia* 48: 597–661. CSIRO Publishing: Melbourne.

—— (2004). *Cycas candida* (Cycadaceae), a new species from Queensland together with an extension of range and amended description of *Cycas yorkiana*. *Telopea* 10: 607–611.

—— (2008). The genus *Cycas* (Cycadaceae) in China. *Telopea* 12: 71–118.

Hill, K.D., Nguyen, H.T. & Loc, P.K. (2004). The genus *Cycas* (Cycadaceae) in Vietnam. *The Botanical Review* 70: 134–193.

Iucn (2001). *IUCN Red List Categories and Criteria*. Version 3.1. Gland: IUCN – The World Conservation Union.

Johnson, L.A.S. (1959). The families of cycads and the Zamiaceae of Australia. *Proceedings of the Linnean Society of New South Wales* 84: 64–117.

Fig. 3. *Cycas terryana*. Detail of megasporophylls with near mature seeds (population voucher: *Forster PIF30618 & Machin* [BRI]). Photo: P.I.Forster

Fig. 4. *Cycas terryana*. Detail of megasporophyll teeth (population voucher *Forster PIF30618 & Machin* [BRI]). Photo: P.I.Forster

—— (1961). *Flora of New South Wales*, 1: Zamiaceae. *Contributions from the New South Wales National Herbarium*, *Flora Series* 1–18: 21–41.

—— (1976). Problems of species and genera in *Eucalyptus* (Myrtaceae). *Plant Systematics & Evolution* 125: 155–167.

Kirkpatrick, J.B. & Potts, B.M. (1987). Isolated intermediates – products of long distance gene dispersal, phantom hybridity or convergent evolution? The case of the half-barked *Eucalyptus amygdalina*. *Papers & Proceedings of the Royal Society of Tasmania* 121: 15–22.

Kono, M. & Tobe, H. (2007). Is *Cycas revoluta* (Cycadaceae) wind- or insect-pollinated? *American Journal of Botany* 94: 847–855.

Levin, D.A. (2000). *The Origin, Expansion, and Demise of Plant Species*. Oxford University Press: Oxford/New York.

Linder, H.P. (2003). The radiation of the Cape flora, southern Africa. *Biological Reviews* 78: 597–638.

Parsons, R.F. & Kirkpatrick, J.B. (1972). Possible phantom hybrids in *Eucalyptus*. *New Phytologist* 71: 1213–1219.

Pryor, L.D. (1951). A genetic analysis of some *Eucalyptus* species. *Proceedings of the Linnean Society of New South Wales* 76: 140–148.

Pryor, L.D. & Johnson, L.A.S. (1971). *A Classification of the Eucalypts*. Australian National University: Canberra.

Savolainen, V. & Forest, F. (2005). Species-level phylogenetics from continental biodiversity hotspots. In F.T.Bakker *et al.* (eds.), *Plant species-level systematics: new perspectives on pattern and process*, pp. 17–30. A.R.G.Ganter Verlag: Ruggell.

Schaal, B.A. & Olsen, K.M. (2000). Gene genealogies and population variation in plants. *Proceedings of the National Academy of Sciences of the United States of America* 97: 7024–7029.

Terry, I. (2001). Thrips and weevils as dual, specialist pollinators of the Australian cycad *Macrozamia communis* (Zamiaceae). *International Journal of Plant Sciences* 162: 1293–1305.

Terry, I., Moore, C.J., Walter, G.H., Forster, P.I., Roemer, R.B., Donaldson, J.S. & Machin, P.J. (2004). Association of cone thermogenesis and volatiles with pollinator specificity in *Macrozamia* cycads. *Plant Systematics & Evolution* 243: 233–247.

Terry I., Walter, G.H., Donaldson, J.S., Snow, E., Forster, P.I. & Machin, P.J. (2005) Pollination of Australian *Macrozamia* cycads: Effectiveness and behavior of specialist vectors in a dependent mutualism. *American Journal of Botany* 92: 931–940.

Terry, I., Walter, G.H., Hull, C.R., Moore, C.J. & Roemer, R.B. (2007). Odor mediated push-pull pollination in cycads. *Science* 318: 70.

Terry, I., Roe, M., Tang, W. & Marler, T.E. (2009). Cone insects and putative pollen vectors of the endangered cycad, *Cycas micronesica*. *Micronesica* 41: 83–99.

Vorster, P. Van Der Bank, F.H., Van Der Bank, M. & Wink, M. (2004). Phylogeny of *Encephalartos*: some Eastern Cape species. *The Botanical Review* 70: 250–259.

Vovides, A.P., Pérez-Farrera, M.A., Gonzáles-Astorga, J., Gonzáles, D., Gregory, T., Chemnick, J., Iglesias, C., Octavio-Aguilar, P., Avendaño, S., Bárcenas, C. & Sales-Morales, S. (2003). An outline of our current knowledge on Mexican cycads (Zamiaceae, Cycadales). *Current Topics in Plant Biology* 4: 159–174.

Vovides, A.P., Gonzalez, D., Perez-Farrera, M.A., Avendafio, S. & Barcenas, C. (2004). A review of research on the cycad genus *Ceratozamia* Brongn. (Zamiaceae) in Mexico. *Taxon* 53: 291–297.

Fig. 5. ***Cycas terryana***. Male plant with microsporangiate cone (population voucher: *Mathieson MTM965* [BRI]). Photo: M.T.Mathieson.