Encephalartos kanga Pócs & Q. Luke — A Newly Described 'Red Cone Cycad' from Tanzania

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ABSTRACT

Encephalartos kanga Pócs & Q. Luke is the newly described 'red cone cycad' from Tanzania. This article provides information on the discovery and description of this putative species and discusses its morphological affinities with three other east-central African *Encephalartos*, as well as various plants in cultivation known only as 'Tanzania red cone' or 'red cone *hildebrandtii.*' Having critically examined vegetative and reproductive features, I have concluded that *E. kanga* neither appears to be in cultivation nor differs sufficiently from *E. kisambo* to be considered a valid species.

INTRODUCTION

The cycads of central Africa—which, with the exception of *Cycas thouarsii* R. Br. ex Gaudich., all belong to the genus *Encephalartos* Lehm.—consist primarily of localized endemics, the distributions and phylogenetic affinities of which are largely determined by habitat preference and physical geography (Moretti *et al.*, 1989). While the dwarf central African species tend to prefer open to wooded savannas (*e.g.*, the *E. poggei* Asch. complex [Whitelock, 2002]), and the larger arborescent species typically grow on steep forested slopes that occur sporadically and are often surrounded by vast stretches of dry savanna where cycads do not grow (*e.g.*, *E. kisambo* Faden & Beentje [Faden & Beentje, 1989; Moretti *et al.*, 1989]), there are some notable exceptions (*e.g.*, *E. hildebrandtii* A. Braun & C.D. Bouché is common in "bushland and lowland forest" [Lewis, 1960], and *E. sclavoi* De Luca, D.W. Stev. & A. Moretti grows in "open grasslands, savanna, and rocky slopes" [Norstog & Nicholls, 1997]).

The most recent update of the World List of Cycads (Hill *et al.*, 2007) recognized 65 species of *Encephalartos*, with 40 species occurring in southern Africa (South Africa, Swaziland, and extreme southern Mozambique) and another 25 scattered across 13 countries further north (including central and northern Mozambique; see Tables 1 & 2). The newest described species in the genus, *E. kanga* Pócs & Q. Luke, hails from Tanzania (Pócs & Luke, 2007); if accepted, it would bring the total number of central African species to 26. Of these, 11 have been described since 1970 and 7 are restricted to the east-central African countries of Kenya and Tanzania (Table 1).

BACKGROUND

Tamás Pócs (Eszterházy Károly College, Hungary), the primary author of *Encephalartos kanga*, first encountered what he referred to as a unique cycad with meter-tall, barrel-shaped trunks and "spiny leaflet shoulders" during a visit to northeastern Tanzania in 1970 (Pócs & Luke, *l.c.*; T. Pócs, pers. comm.). Recognizing that it differed from the widespread coastal species, *E. hildebrandtii*, Pócs sent a specimen to the East African Herbarium (EA) in Nairobi, Kenya (Fig. 1A), where it was determined that it most likely represented a new species. Pócs revisited the area in 1987, observing at least ten plants of mature size and collecting specimens of immature female cones (Fig. 1B). In 2006, a team from the Society for Environmental Exploration (UK) collected immature plants of this taxon, but no cones were noted (Pócs & Luke, *l.c.*).

Then, in May 2007, Quentin Luke (East African Herbarium and the Center for Tropical Plant Conservation at Fairchild Tropical Botanic Garden in Miami, Florida), the second author of this species description, participated in an expedition to the region as part of the Critical Ecosystems Partnership Fund's "Redlisting" project (Pócs & Luke, *l.c.*; Q. Luke, pers. comm.). This team was finally able to locate mature female cones, and their discovery quickly led to the description of the putative new species, most closely related to *Encephalartos kisambo, as E. kanga* (Pócs & Luke, *l.c.*).

PREVIOUS REPORTS

Heenan's 1976 account of central African cycads provided considerable details on the better-known species, as well as revised descriptions and distributions of several lesser-known types. Heenan also mentioned three "imperfectly known species" from east-central Africa—which would later be described as *Encephalartos sclavoi* from northeastern Tanzania ("sp. 'A'"), *E. kisambo* from southeastern Kenya ("sp. 'B'"), and *E. delucanus* Malaisse, Sclavo & Crosiers from western Tanzania ("sp. 'C'") (*sensu* R. Osborne, pers. comm.)—but he was apparently unaware of the 'Kanga' plant at that time.

In their description of *Encephalartos kisambo*, Faden and Beentje (1989) noted the differences between it and the 'Kanga' plant, stating that the single specimen of the latter at EA (Pócs 6137/B; Fig. 1A) differed from *E. kisambo* as follows: "adjacent leaflets [of *E. kanga*] are more widely spaced (they do not overlap); the leaflets are oblong (not lanceolate-oblong); and they are not at all falcate."

In their survey of the vegetation of Tanzania's Nguru Mountains, Pócs *et al.* (1990) reported a new species of *Encephalartos* in the "shrub layer of Kanga" Mountain. Later in the report, the authors included "*Encephalartos kanga* Pócs, ined." in a list of narrow endemics (Pócs *et al.*, 1990).

Hurter (1994) also mentioned the Pócs specimen at EA (Fig. 1A) in his 'Focus On' *Encephalartos kisambo* article in the Journal of the Cycad Society of South Africa,

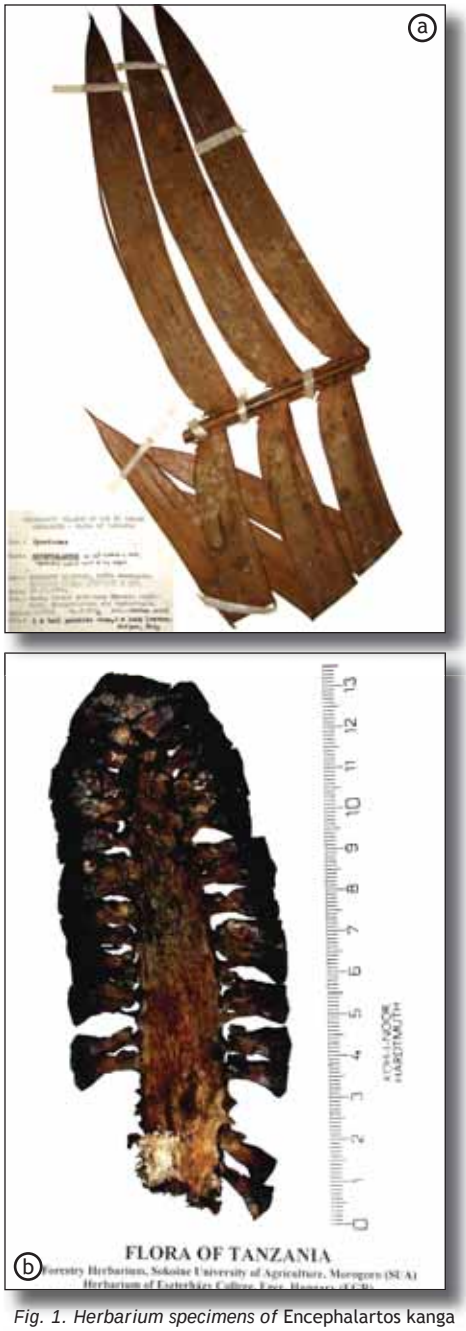

Fig. 1. Herbarium specimens of Encephalartos kanga *from Mt. Kanga, northeastern Tanzania: (A) part of leaf from Pócs's 1970 expedition (duplicate deposited in Univ. of Dar es Salaam Herbarium, Tanzania – DSM); (B) immature female cone from Pócs's 1987 expedition deposited in the Herb. Eszterházy Károly College, Hungary - EGR) (photos by Flora AbdulRahman Ismail [A] and Tamás Pócs [B]).*

*With contributions from Jan Andersson, Roberto Bruno, Andrew Cameron, John Donaldson, Greg Holzman, Johan Hurter, Quentin Luke, Roy Osborne, Tamás Pócs, Piet Vorster, and Loran Whitelock

Fig. 2. Previously unpublished archival photos from Pócs's 1970 expedition to northeastern Tanzania: (A) Mt. Kanga from a distance; (B) typical habitat of Encephalartos kanga *(cycad leaf at bottom left); (C,D)* E. kanga *plants on Mt. Kanga (photos by Tamás Pócs).*

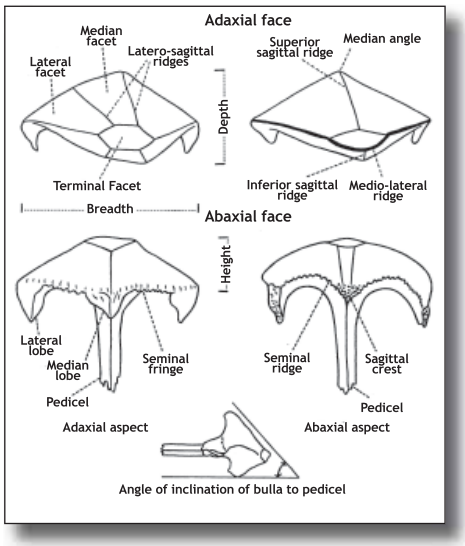

Fig. 3. Melville's proposed terms for describing the bullae of Encephalartos *cones (adapted from Fig. 2 of Melville [1958]; original figure remains under copyright of Crown Agents, London, UK).*

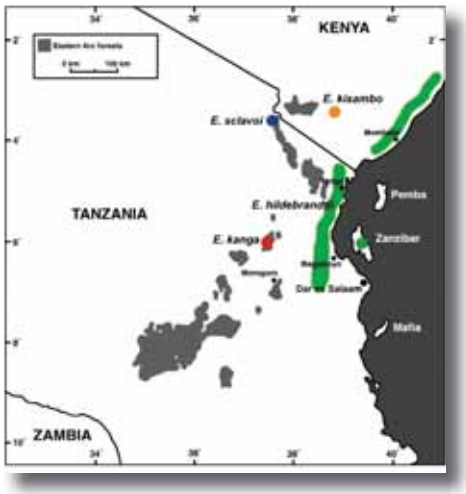

*Fig. 4. Distribution of four east-central African cycads (modified from Fig. 1 of Pócs & Luke [2007]; original figure remains under copyright of Nature Kenya/*J. E. Afr. Nat. Hist.*).*

stating that it needed to be investigated to "shed further light as to its affinities."

In his book, *Cycads of Central Africa*, Heibloem (1999) briefly mentioned an undescribed species in Tanzania that closely resembled *Encephalartos hildebrandtii* with red cones, but provided no details.

In his second book on the cycads of Africa—ironically titled *Cycads of Africa, Vol. 1*—Goode (2001) made mention of plants resembling *Encephalartos hildebrandtii* but bearing red rather than yellow cones from an area south of Tanga, Tanzania. Goode also reported that two expeditions into the area in the late 1990's were unsuccessful in locating any red-coned plants. Goode further alluded to reports of cycads growing in the foothills of the mountains west of Tanga but failed to speculate on their possible taxonomic affinities.

Although he was aware of a so-called 'red cone hildebrandtii' when he was writing his now-famous book, *The Cycads*, Whitelock (2002) chose not to mention it because he wanted to focus only on validly published species (L. Whitelock, pers. comm.).

Golding and Hurter (2003) included "*Encephalartos kanga* Pócs ined." in their Red List account of African cycads, stating that it was known from a single locality in Tanzania (as reported by Pócs *et al*., 1990) and that its global conservation status was considered 'Data Deficient'. The authors further suggested that additional exploration would "undoubtedly enable a full taxonomic description of *E. kanga* and a more formal Red List assessment" (Golding & Hurter, 2003).

As a result of the Golding and Hurter (*l.c.*) report, Donaldson (2003) included "E. kanga (ined)" in the IUCN/Species Survival Commission's 'Cycad Action Plan' (J. Donaldson, pers. comm.; see below). Donaldson also reported that the species was not growing in any protected reserves and reiterated its 'Data Deficient' conservation status.

In a later chapter of the Cycad Action Plan, Walters (2003) stated that "*Encephalartos kanga*" was, at that time, represented in private collections but not in any general or genebank collections. (Note: The latter is defined as "a collection [that] represents a significant genetic sample of a known population and … is maintained and managed as a genebank" [Walters, 2003].)

"*Encephalartos kanga* (*ined.*)" was then listed—again as 'Data Deficient'—in the CITES Significant Trade Review of Cycads report compiled by TRAFFIC East/Southern Africa (2003).

Finally, prior to its formal description, "*Encephalartos sp. nov.* 'kanga'" was included in the 2007 Red List of Threatened Species, where its conservation status was once again given as 'Data Deficient' (IUCN, 2007).

PERSONAL ACCOUNTS

Tamás Pócs – on discovering the species:

"February 27th was one of the hottest days of 1970, when at dawn I started out for Mt. Kanga, an eastern satellite of the Nguru Mountains in Tanzania. The mountain had tempted me since 17 December of the previous year, when I first visited and collected plant specimens in the foothills of the steep, 2,018-meter-high, rocky giant. Starting from Morogoro, I first had to get through the bushes and swamps of the Mkata Plains in my VW beetle [Fig. 2A]. Being at the end of the short rainy season, the air was still very damp, but luckily the often impassable 20-km stretch was more dusty than muddy. I reached the base of the Nguru Mountains before 8:00 a.m. and looked after the forest officer. He was a very kind fellow who was ready to accompany and guide me on the trip. We reached Mt. Kanga at about 9:00 a.m. and immediately started up the mountain. At that time the slopes of Mt. Kanga were forested to the bottom, due to the belief that the mountain spirit punishes intruders. The miombo woodland gave way to closed forest at 450 m altitude, with its buttressed mwule trees (*Milicia excelsa*) and stilt-root *Pandanus*. The damp heat in this lowland forest was almost unbearable, and to quench my thirst I used the edible, acidic pulp surrounding the seeds of a *Cola* species with flame-red fruits. It was a common canopy tree of the forest and turned out to be unknown at that time in the East African Herbarium. At 650 m altitude the forest became a bit cooler, and more and more ferns appeared on the forest floor. At 900 m we could see the first filmy ferns. Above 1,000 m altitude on a sharp ridge, an interesting community of pachycaul trees appeared on granitic boulders. Below the loose canopy of 4-to-6-meter-tall wild date palms (*Phoenix reclinata*), numerous cycad specimens with barrel-shaped trunks measuring 1–1.5 m tall and 0.5 m thick and dark green foliage were visible [Figs. 2B–2D]. The leaves were up to 2 m long, and their peculiarity was the spinose leaflet shoulder—which at first sight distinguished them from the common *Encephalartos hildebrandtii*, which I knew from the foothills of the Usambara Mountains. Sadly, all plants were sterile (without cones), and I carefully collected specimens [see Fig. 1A]. At the same site, numerous ferns, interesting Rubiaceae shrubs, and an African violet with densely hairy leaves—the endemic *Saintpaulia brevipilosa* (now *S. ionantha* ssp. *velutina*)—were also collected.

We continued climbing and by noon reached a smaller 1,100 m summit. From here began the slope of the main peak, which became more and more steep and rocky. I really suffered from thirst and had already finished the water in my thermos.

Probably it was a mistake to eat the fleshy but very acidic *Cola* fruit, which I was told was edible by the forester. Between 1,200-1,300 m, we climbed through ericaceous heath vegetation rich in epiphytic orchids (three species of *Polystachya*, a *Tridactyle*, and *Rangaeris muscicola* with a 6.5-cm-long spur) and purplish-yellow-flowering *Gladiolus psittacinus* on the rocky ground. Finally we ended at 1,370 m altitude in a beautiful mountain rainforest with trees fully covered by mosses, ferns, and orchids. Hanging from the branches was the epiphytic, fleshy-stemmed and purple-flowering balsam, *Impatiens keilii*. Here we could cool down from the sprinkling drops of a nice waterfall. We reached the head of the falls at 2:30 p.m. and, having a one-hour rest with collecting at this rich habitat, started back down at 3:30 p.m. and reached the base of the mountain and the car on the road at 7:00 p.m., almost in total darkness. Then my companion guided me to the old, colonial-style guesthouse of the 'maji' (waterworks) office, situated on some rocks above the cataracts. Here, after a quick meal in the mosquito-proof veranda, I laid down on my bed and quickly fell asleep, deep and dreamless, by the nice sounds of the river. Around 10:00 p.m., I heard shouting and a car horn blowing. Waking up and quickly recovering, I realized that my friend, the zoologist Hosea Kayumbo, had sent two colleagues with my wife's message calling me back; in Morogoro our half-year-old son, Abel, was very ill with a 40°C fever. I started back by night on the dusty road, as quickly as I could, escorted by the university car. It was a nightmare when, in the bush, one of my tires was punctured, and at high speed the small car started to dance and I completely lost control. The only thing I could do was slow down without pressing the brakes and wonder when the car was going to overturn. Thank God, the car soon stopped. My companions quickly helped change the tire, and from this point onwards we slowly but safely reached home around midnight. The state of my son improved in the morning. Afterwards, I sent duplicate specimens of the material collected on Mt. Kanga to the East African Herbarium in Nairobi, Kenya, and the herbarium at the University of Dar es Salaam, Tanzania. The former wrote to me later saying that the peculiar *Encephalartos* species was unknown to them and was probably a new species. I provisionally called it *E. kanga* after its locality.

Once more, in 1987, I visited Mt. Kanga within the framework of the Swedish-Tanzanian-Hungarian Usambara Rainforest Project. This visit was not without complication, as before climbing up, due to the aforementioned belief of the spirit of Mt. Kanga, the village elders obliged us to undergo a conciliatory ceremony, urging us to buy a black goat and offer it to the

Fig. 5. Effects of light availability on leaves of juvenile Encephalartos kisambo *plants of the same size and age, and from the same population, being grown in cultivation in Kenya: (A) plant growing in full sun; (B) plant growing under closed canopy with dappled sunlight (photos by Andrew Cameron).*

Fig. 6.(A) Emerging leaves of Encephalartos hildebrandtii *in cultivation in Kenya;* E. kisambo *in cultivation in (B) Florida and (C) Hawaii; (D)* E. kanga *in habitat in Tanzania; and (E,F)* E. sclavoi *in cultivation in Hawaii (photos by Andrew Cameron [A], Greg Holzman [C, E, F], and Quentin Luke [D]).*

spirit. My son went to the marketplace, where there was no black goat and only a black rooster available. Finally, the elders were satisfied with this and slaughtered it. The chief conducted a very serious ceremony, praying to the spirit and sprinkling all participants using a birch-rod coated with the blood of the cock. Then we could start. With my Tanzanian colleague, Prof. Ruwa-Aichi P.C. Temu, we climbed up to 1,300 m altitude, where, in a very species-rich, rocky, ericaceous heath intermixed with man-size *Xerophyta spekei*, we again collected the new *Encephalartos*, this time with young female cones [see Fig. 1B] and associated with the rare climbing orchid, *Neobenthamia gracilis.*

But the new species still proved to be a 'Sleeping Beauty' for more than thirty years after its discovery, until in 2004 when—with my wife, Saci, volunteering in the East African Herbarium—our botanist colleague Quentin Luke from Nairobi showed great interest in the new species. Due to my operated leg, I could not do any more climbing, so I handed over all of the information to Quentin, who, after obtaining the necessary permits and support from the concerned authorities, organized a small expedition within the framework of the 'redlisting' project of the Critical Ecosystems Partnership Fund. Finally, on the 9th of May 2007 they—W.R.Q. & P.A. Luke, L. Festo, and G. Laizer, along with a local guide—succeeded in collecting ripe female cones. On this basis [mature female cones] we could now describe *Encephalartos kanga* Pócs & Q. Luke, a typical (and critically endangered) endemic of the crystalline Eastern Arc Mountains of Tanzania. Our only hope is that plant 'lovers' will not eradicate this rare and very peculiar cycad."

Johan Hurter – on visiting the habitat:

"We were never allowed to photograph the plants by the local clan - also I don't know how people got in there to get plants or seed - the place is taboo and local custom dictates that if you offend the gods your head should be bashed in. You are not even allowed to look at the Northern plains from there.... On my first trip there we were basically taken hostage by the locals and interrogated for hours by the local witch doctors. It was a holy place and a great wind would come down from the mountain and consume the village. On my second trip it took 5 days of negotiations even by the local government official with us before we were allowed on the mountain but only with an entourage of local politicians and witch doctors. It was actually quite scary. One last note from my [field] notes – 'probably most closely related to *E. tegulaneus*' is what I wrote."

John Donaldson - on the description:

"I have not seen *E. kanga*... [but here is] what I know about the process leading to its description. In a manuscript dealing with African cycads, Janice Golding and Johan Hurter referred to *E.* sp. '*Kanga.*' I therefore included the tentative species in the 2003 Cycad Action Plan in the belief that the species was being described. Later I was contacted by Quentin Luke in Kenya, who has done a lot of surveying and taxonomic work in Kenya and Tanzania, and who wanted to resolve the taxonomy of some of the populations he was finding. When I contacted Johan he said he was not working on it but that he had surmised that Tamás Pócs might be working on it. Quentin then contacted Pócs, got more material, and they jointly described the species."

Piet Vorster – on his review of the description manuscript:

"I recommended that the paper should only be considered for publication after thorough revision, yet the editor saw fit to go ahead with only a few minor changes. I told the authors that, because large geographical discontinuities are rare in *Encephalartos*, this population may well represent a new species, but that their diagnosis as per the original manuscript does not convince me as reader that it is a separate species. The accompanying illustrations, notably Figs. 2 and 3a, look exactly like *E. kisambo*.... I drew [the authors'] attention to the soapy green colour of the leaflets in *E. kisambo*, and in the published version they responded by saying that in *E. kanga* they are 'dark vivid green'. It should be kept in mind that the description of leaf colour tends to be very personal. I also recommended that the publication should be delayed until male cones become available as these may contain important information. In its present form the paper still does not enable me to separate *E. kanga* convincingly from *E. kisambo*."

Fig. 7. Median leaflets illustrating typical shape, spacing, serration, and orientation: (A) Encephalartos hildebrandtii; *(B)* E. kanga; *(C)* E. kisambo ; *(D)* E. sclavoi *(photos by Greg Holzman [B, D] and Tamás Pócs [C]).*

CONSERVATION STATUS

As suggested by the previous reports of *Encephalartos kanga* summarized above, very little was known of its status in habitat between the time it was discovered in 1970 and last year, when Pócs and Luke (2007) finally filled this void, noting that it consists of no more than 50 mature plants spread across a few scattered populations occupying an area no larger than 10 km^2. Although it is reportedly reproducing in the wild, the authors of *E. kanga* considered it Critically Endangered because of the small number of mature plants, the small area of occupancy, and the illicit collection of seedlings and small plants (Pócs & Luke, *l.c.*). They further recommended the following conservation assessment based on the most recent version of the IUCN Red List categories and criteria (IUCN, 2001): CR B2ab+C2a(i) (Pócs & Luke, *l.c.*).

TAXONOMIC AFFINITIES

Although Pócs and Luke (2007) noted an absence of male cones in both populations surveyed, they decided to proceed with

the description of *Encephalartos kanga* without this information; after all, it had already been more than 35 years since the plants were first discovered on Mt. Kanga! As mentioned above, however, P. Vorster (pers. comm.)—notably one of the world's foremost taxonomic authorities on *Encephalartos*—believes that, in doing so, the authors failed to sufficiently diagnose it as a species. In addition to the absence of male cone traits, the female cone was reportedly described from a single plant (Pócs & Luke, *l.c.*), thereby providing no indication of the level of variability that might be present (or could be expected) in this putative species.

One of the initial goals of the current article was to locate and examine plants in cultivation in an effort to complement the formal description of *Encephalartos kanga*. Unfortunately, after an exhaustive search, none of the plants that have been located to date have been *E. kanga*; therefore, this particular goal seems unobtainable at present. A more realistic goal now becomes the hope that this article may at least contribute to a better understanding of what *E. kanga* is (and what it is not), as well as how it compares to other species in east-central Africa.

Background

In response to the need for "a more detailed system of terminology [up]on which critical comparative descriptions [could] be based," Melville (1957) proposed and discussed several standardized terms (in both English and Latin) and taxonomically useful traits for the genus *Encephalartos*. Of particular interest were the terms he introduced to describe the sporophyll bullae (Fig. 3)—many of which have been in regular use ever since. (*Note: The term "bulla" is defined as the "expanded shield-like distal portion of some cycad sporophylls such as* Encephalartos *megasporophylls" [Osborne & Walters, 2004].*)

Vorster (1993) provided a revised list of taxonomically useful characters and character states for the genus. He then discussed taxonomically important characteristics in, and provided a well-researched summary of, the arborescent tropical African species (Vorster, 1999). Vorster (2004) later circumscribed 18 groups within *Encephalartos* based on shared morphology and geographical proximity. His Group 13 included *E. hildebrandtii*, *E. kisambo*, and *E. sclavoi*—along with *E. bubalinus* Melville, *E. equatorialis* P.J.H. Hurter, *E. ituriensis* Bamps & Lisowski, *E. tegulaneus* Melville, and *E. whitelockii* P.J.H. Hurter—because of their east-central African distributions and the presence of the following morphological features: hard-textured leaves, progressive reduction of leaflets to a series of prickles with no clear petiole, green to yellow and glabrous cones, cylindrical to ovoid female cones, megasporophylls with smooth facets and only a moderately raised terminal facet, and male cones that emerge in succession. In addition to sharing morphology and geography, a recent molecular study suggests that *E. hildebrandtii*, *E. kisambo*, and *E. sclavoi* are also closely related genetically (Treutlein *et al.*, 2005).

Specific Comparisons

Vorster's (1993; 1999) lists of taxonomically important characters and character states were used as the basis for creating a detailed comparison of the following four putative species whose east-central African distributions are also geographically closest to Mt. Kanga: *Encephalartos hildebrandtii*, *E. kisambo*, *E. kanga*, and *E. sclavoi* (Fig. 4, Table 3). It should be noted that differences in growing conditions (such as light and/or water availability) can cause marked variability in certain morphological characteristics, particularly vegetative traits such as leaf length and leaflet size, shape, and spacing (Fig. 5). With that said, below is a brief summary of the most noteworthy similarities and differences among these four putative species, as reported in their respective descriptions and other summary works for plants growing in habitat (see complete list of references in Table 3). Because of the difficulty in obtaining habitat photos, most characters are illustrated using plants in cultivation.

Vegetative Traits

In addition to the traits mentioned above that Vorster (2004) used to justify their inclusion in the same 'morphogeographic' group, the four putative species compared herein also have arborescent trunks to 1+ m; relatively long (to 2+ m), upright, non-keeled (or only slightly keeled) leaves; and relatively long (up to 35-45 cm) leaflets with serrated, revolute margins. The most notable differences in vegetative morphology are outlined below:

- Trunks (in habitat) range from short and stout (1.5 m × 50 cm) in *Encephalartos kanga* to tall and slender (6 m × 30 cm) in *E. hildebrandtii*. Trunks of *E. hildebrandtii* and *E. kanga* are normally erect, while those of *E. kisambo* are erect to leaning, and in *E. sclavoi* they often become procumbent with age.
- Maximum leaf length ranges from 2 m in *E. sclavoi* to 3–3.5 m in *E. hildebrandtii* and *E. kisambo* to an impressive 4 m in *E. kanga*.
- Leaf orientation is typically straight (non-twisted), although *E. sclavoi* occasionally produces spirally twisted leaves.
- Emergent leaf color ranges from reddish-orange/white lanate in *E. hildebrandtii* (Fig. 6A) to blue-green/tan lanate (Fig. 6B) turning to "soapy" green/glabrous (Fig. 6C) in *E. kisambo*, with *E. kanga* being dull mid-green/tan to reddish-brown lanate (Fig. 6D) and *E. sclavoi* being either glossy mid-green/glabrous (Fig. 6E) or dark brown/tan tomentose (Fig. 6F).
- The following is a summary of the shape, spacing, and orientation of the median leaflets of the four putative species:
  - *E. hildebrandtii* – linear to linear-lanceolate, non-falcate to falcate, widely spaced, oriented in the same plane, green rachis attachment,

Fig. 8. Cones of Encephalartos hildebrandtii *cultivated in Kenya: (A) female; (B) male; (C) mature 'red form' female cones cultivated in Hawaii (photos by Andrew Cameron [A, B] and Greg Holzman [C]).*

length-to-width (L:W) ratio > 7.5, < 100 leaflet pairs (Fig. 7A)

- *E. kisambo* – oblanceolate, falcate, incubously overlapping, oriented in the same plane, green rachis attachment, L:W ratio > 7.5, < 100 leaflet pairs (Fig. 7B)
- *E. kanga* – oblanceolate to linear-lanceolate, non-falcate to subfalcate, closely spaced but non-overlapping, oriented in the same plane, green rachis attachment, L:W ratio much > 7.5, > 100 leaflet pairs (Fig. 7C)
- *E. sclavoi* – oblong to elliptic with recurved apex, non-falcate, crowded, succubously overlapping, occasionally oriented in different planes, yellow rachis attachment, L:W ratio < 7, < 100 leaflet pairs (Fig. 7D)

Fig. 9. (A) Female and (B) male cones of Encephalartos kisambo *in cultivation in Hawaii (photos by Greg Holzman).*

Fig. 10. Mature female cones of Encephalartos kanga *in habitat in northeastern Tanzania (photo by Quentin Luke).*

- Both leaflet margins are dentate in *E. hildebrandtii* and *E. sclavoi* (although the serrations are often reduced to callose bumps in the latter), whereas only the distal margin is dentate in the other two species (Fig. 7). In *E. hildebrandtii*, a few serrations are often clustered near the base of the distal margin, with the rest being fairly evenly spaced along the length of both margins (Fig. 7A). In *E. kisambo* and *E. kanga*, the serrations are greatly reduced in number and are often tightly clustered near the base of the distal margin, with the first three typically extending across the rachis on an enlarged "shoulder" in the latter species (see Figs. 7B & 7C, respectively).
- Three of the putative species have tomentose linear to lanceolate cataphylls; only those of *E. sclavoi* are tomentose narrowly triangular.

Reproductive Traits

All four putative species compared herein have the ability to produce multiple female cones on a single apex, and the shapes and sizes of the cones are relatively similar. A few of the more prominent reproductive characteristics are compared and contrasted below, but because the male cone of *Encephalartos kanga* is still unknown, the primary focus of this discussion will be on female cones:

- Female cone shape ranges from cylindrical in *E. hildebrandtii* to cylindrical or ovoid-cylindrical in *E. kisambo* and *E. sclavoi* to oblong-cylindrical in *E. kanga* (Figs. 8–11).
- Female cone length ranges from 40 cm in *E. sclavoi* to 66 cm in *E. kanga*. The most striking difference with respect to female cone size is in the length-to-diameter ratio, which is greatest in *E. kanga*—indicating a taller, thinner cone compared to the other three species.
- Female cone peduncles are relatively short in *E. hildebrandtii* and *E. sclavoi* (typically 6 cm or less), but they can reach 12-15 cm in *E. kanga* and *E. kisambo*, respectively. The peduncles of all four putative species are glabrous, with the exception of some (but not all) in *E. kisambo* that are covered in dark brown tomentum.
- Newly emerging female cones of *E. kanga* are purplish-brown (T. Pócs, pers. comm.), while the other species are typically green to yellow—although the sporophylls of some *E. hildebrandtii* cones have a pink margin, and certain individuals of *E. hildebrandtii* and *E. sclavoi* produce cones with a brownish, pinkish, or orangish tint at emergence (these arise only from brown-emergent plants in the latter species). Cone color then undergoes gradual changes as the cones mature, with *E. hildebrandtii* turning from greenish-yellow to bright yellow, orange, or reddish-brown (Fig. 8); *E. kisambo* going from a whitish-yellow to pale yellow, orange, or tan (Figs. 9); *E. kanga* lightening from purplish-brown to yellowish-orange (Fig. 10); and *E. sclavoi* changing from green to yellowish-green or, in brown-emergent plants, from pinkish-orange to golden orange (Fig. 11).
- The median megasporophylls of all four putative species have rhomboid-shaped bullae with concave or slightly concave terminal facets and adaxial faces bearing two lateral trapezoidal facets. However, the bullae of *E. hildebrandtii* and *E. kisambo* measure around 3.5–5 cm wide, while those of *E. sclavoi* and *E. kanga* are 6.5-7.0 cm wide, respectively. The bullae of *E. kisambo* are less than 2 cm high, while the height is often 3 cm or greater in the other three species. Beyond these size differences, the megasporophyll bullae exhibit a relatively unique suite of morphological traits in each of the four putative species; these are much too technical to summarize here but are presented in detail in Table 3 (some of these traits can also be seen in Figs. 8–11).
- Although the three species for which male cones are known have sporangia clustered in a single patch on the abaxial side of the microsporophylls (Figs. 8B, 9B & 11B), only *E. hildebrandtii* exhibits a characteristic V-shaped notch on the outer edge of the sporangial patch (Fig. 8B).
- Sarcotesta color is reported to be bright yellow, orange, or vermillion in *E. hildebrandtii*, orange-yellow in *E. kisambo*, orange in *E. kanga*, and yellow to vermillion in *E. sclavoi*. Sclerotesta size and shape appear to be similar in all four putative species (with the exception of *E. sclavoi*, as no reports of sclerotesta dimensions have yet been found).

SYNOPSIS

Red-coned Tanzanian Plants

Plants going by the names 'red cone *hildebrandtii*' and 'Tanzania red cone' have been in cultivation for many years. Most collectors that have grown these plants from the seed or seedling stage have reported varying levels of similarity to *Encephalartos hildebrandtii*. Interestingly, there are plants growing in habitat near Mt. Kanga that resemble both *E. hildebrandtii* and 'Tanzania red cone' plants in cultivation. In contrast to *E. hildebrandtii*, *E. kanga* completely lacks the bifurcate/

trifurcate leaflet apices exhibited by the former and is vegetatively much closer to *E. kisambo*. Examination of photos of cultivated plants from several sources in various countries around the world suggests that most plants labeled 'red cone *hildebrandtii*' or 'Tanzania red cone' likely represent a form (geographic variant?) of *E. hildebrandtii* with reddish or reddish-yellow cones. There is reportedly a "prolific colony" of plants like *E. hildebrandtii* plants growing near Bagamoyo, Tanzania, "with wider and less spiny leaflets and both red and yellow cones" (R. Bruno, pers. comm.); conversely, only yellow cones are present in the *E. hildebrandtii* populations near Tanga, Tanzania, and Mombasa, Kenya (Goode, 2001; R. Bruno, pers. comm.). Contributing even more to the confusion is another 'red cone' plant from Tanzania (T. Pócs, pers. comm.; R. Bruno, pers. comm.) that may represent an undescribed species, and it is still unknown to which species Heibloem's (1999) and Goode's (*l.c.*) reports of red-coning *Encephalartos* in Tanzania actually refer. What is known is that the vast majority of central African 'red cone' plants currently in cultivation are not *E. kanga*.

Validity of *Encephalartos kanga*

Of the four putative species compared in Table 3 and discussed above, *Encephalartos kanga* and *E. kisambo* are the most similar vegetatively, which—given the level of variability often exhibited within species of *Encephalartos*—supports P. Vorster's (pers. comm.) contention that an inadequate portrayal of the former could easily lead one to believe it is nothing more than a form or variety of the latter. This morphological affinity is exemplified in cultivated *E. kisambo* plants from the Taita Hills region being grown in a private garden in Kenya—complete with the "leaflet shoulder" bearing serrations that protrude across the rachis (a trait that is reportedly diagnostic of *E. kanga*; Pócs & Luke, *l.c.*), as well as marked differences in leaflet shape and spacing on plants growing under differing light conditions (see Figs. 12 & 5, respectively). It might also be noted that, upon reading the formal description of *E. kanga*, a fellow cycad enthusiast who has visited numerous populations of cycads throughout central Africa made the following observation: "Does this not look like a bit of a mixture between *hildebrandtii* and *kisambo*?" (J. Andersson, pers. comm.). A very similar personal note was provided by another enthusiast in Kenya who is growing both of these species in cultivation: "… a cross between *kisambo* and *hildebrandtii* might produce something very similar to the *kanga* cycad" (A. Cameron, pers. comm.).

As for reproductive morphology, *Encephalartos kanga* exhibits slight differences compared to *E. kisambo*, having an oblong-cylindrical rather than cylindrical to ovoid-cylindrical shape, larger megasporophylls, a few relatively minor differences in the morphology of the median megasporophyll bullae, and differences in female cone color. It is well known that cone color can vary within species and sometimes even within populations of *Encephalartos*, and the mature color of *E. kanga* cones as reported in the description (and as observed in photos of *E. kanga* plants in habitat) is within the range of variability expressed in the other species compared herein (Figs. 8C, 10 & 11C). In addition, because only one mature female plant of *E. kanga* has ever been reported, there is no way of knowing if this plant is representative of the entire population on Mt. Kanga. Then there is the problem of the complete lack of male cone characteristics.

In summary, the high degree of overlap with *Encephalartos kisambo* in vegetative traits, the lack of male cone traits, and the female cone traits reported from a single plant lead this author—as well as a reviewer of the species description (P. Vorster, pers. comm.) and the authors of the World List of Cycads (R. Osborne, pers. comm.)—to believe that *E. kanga* should be placed into synonymy with *E. kisambo* until it can be more convincingly diagnosed and/or examined genetically.

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Fig. 11. Cones of Encephalartos sclavoi: (A) *female; (B) male; (C) mature 'red form' male cone in cultivation in Hawaii (photos by Greg Holzman).*

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Table 1. The central African cycads species, their authorities, dates of publication, countries of origin, and conservation status (compiled from Hill et al. [2007], IUCN [2007], and Pócs & Luke [2007]; extreme southern Mozambique not included).

Species & Authority	Date	Distribution	Conservation Status
E. barteri Carruth. ex Miq.	1868	Nigeria, Benin, Ghana	VU A2cd
E. septentrionalis Schweinf.	1871	Sudan, Uganda	DD
E. hildebrandtii A. Braun & C.D. Bouché	1874	Kenya, Tanzania	NT
E. poggei Asch.	1878	Dem. Rep. Congo	LC
E. laurentianus De Wild.	1903	Angola, Dem. Rep. Congo	DD
E. gratus Prain	1916	Mozambique, Malawi	VU A4cd
E. manikensis (Gilliland) Gilliland	1939	Zimbabwe, Mozambique	VU A2acd
E. bubalinus Melville	1957	Tanzania, Kenya	LC
E. tegulaneus Melville	1957	Kenya	LC
E. marunguensis Devred	1958	Dem. Rep. Congo	NT
E. chimanimaniensis R.A. Dyer & I. Verd.	1969	Zimbabwe, Mozambique	EN A2ad; B1ab(i,ii,iv,v)+ 2ab(i,ii,iv,v); C1
E. concinnus R.A. Dyer & I. Verd.	1969	Zimbabwe	EN A2acd; B1ab(iii,iv,v)+ 2ab(ii,iv,v); C1
E. munchii R.A. Dyer & I. Verd.	1969	Mozambique	CR A2d; B1ab(ii,iv,v); C1+2a(i); D
E. pterogonus R.A. Dyer & I. Verd.	1969	Mozambique	CR A2cd; B1ab(ii,iv,v)+ 2ab(ii,iv,v); C1+2a(i); D
E. schmitzii Malaisse	1969	Dem. Rep. Congo, Zambia	NT
E. turneri Lavranos & D.L. Goode	1985	Mozambique	LC
E. kisambo Faden & Beentje	1989	Kenya	EN A2cd; B1ab(ii,iii,v)+ 2ab(ii,iii,v)
E. sclavoi De Luca, D.W. Stev. & A. Moretti	1989	Tanzania	VU B1ab(iii,iv,v); C1
E. ituriensis Bamps & Lisowski	1990	Dem. Rep. Congo, Uganda	NT
E. delucanus Malaisse, Sclavo & Crosiers	1992	Tanzania	VU B1ab(iii,iv,v)+ 2ab(iii,iv,v); C2a(i)
E. schaijesii Malaisse, Sclavo & Crosiers	1993	Dem. Rep. Congo	VU B1ab(i,ii,iii,iv,v)+ 2ab(i,ii,iii,iv,v)
E. whitelockii P.J.H. Hurter	1995	Uganda	VU B1ab(iii,v)+2ab(iii,v); D2
E. equatorialis P.J.H. Hurter	1995	Uganda	CR B1ab(ii,iii,v)+ 2ab(ii,iii,v)
E. macrostrobilus S. Jones & J. Wynants	1997	Uganda	VU B1ab(iii,iv,v); C2a(i)
E. mackenziei L.E. Newton	2002	Sudan	Not yet reported
E. kanga Pócs & Q. Luke	2007	Tanzania	CR B2ab+C2a(i)

Table 2. Number of endemic, non-endemic, and threatened/endangered cycad species in each central African country (compiled from Hill et al. [2007], IUCN [2007], and Pócs & Luke [2007]; extreme southern Mozambique not included).

Country	Endemic	Non-endemic	Threatened/ Endangered
Dem. Rep. Congo	3	3	1
Mozambique 3		3	5
Tanzania 3		2	3
Uganda 3		2	3
Kenya 2		2	1
Zimbabwe 1		2	3
Sudan 1		1	0
Angola 1		0	0
Benin 1		0	1
Ghana 1		0	1
Malawi 1		0	1
Nigeria 1		0	1
Zambia 1		0	0

Table 3. Morphological comparison of four putative east-central African cycad species (list of characters and character states modified from Vorster [1993, 1999]).

	E. hildebrandtii [1]	*E. kisambo* [2]	*E. kanga* [3]	*E. sclavoi* [4]
TRUNK				
Length × diameter; orientation	• To 6 m × 30 cm • Erect	• To 4 m × 60 cm • Erect or leaning	• To 1.5 m × 50 cm • Erect	• To 4 m × 35 cm • Often procumbent
LEAF				
Length	200–300 cm	239–360 cm	To 400 cm	175–200 cm
Orientation	Straight	Straight	Straight	Straight to spirally twisted
Emergent color; pubescence	• Bright green to pinkish-brown or reddish-orange • White pubescent to lanate, quickly becoming glabrous	• Glaucous blue-green, turning to light "soapy" green • Tan lanate, quickly becoming glabrous	• Dull mid-green • Tan to reddish-brown lanate, quickly becoming glabrous	• Green or brown • Glabrous to tan tomentose, quickly becoming glabrous
Mature color	Dark glossy green, may be weakly discolorous	Dull medium to glaucous dark green, weakly discolorous	Dark glossy green	Dark green to glaucous blue-green
Petiole length	0–7 cm	0–5 cm	None	2–20 cm
Number of leaflet pairs	50–70	89–96	140–170 (estimated)	50–70 (estimated)
LEAFLETS (median unless otherwise specified)				
Orientation: transverse view; plane view; in relation to each other	• Ascending in same plane • Directed apically • Non-overlapping	• Ascending in same plane • Spreading or directed apically • Incubous, sometimes crowded	• Ascending in same plane • Spreading • Non-overlapping	• Ascending, often different planes • Directed apically • Succubous, crowded
Shape; texture	• Linear to linear-lanceolate, non-falcate to falcate • Coriaceous	• Oblanceolate, falcate • Strongly coriaceous	• Oblanceolate to linear-lanceolate, non-falcate to subfalcate • Coriaceous	• Oblong to elliptic, non-falcate, apex recurved/hooked • Strongly coriaceous
Length × width; L:W ratio	• 15–35 × 1.3–4.5 cm • 7.8–11.5	• 24–42.5 × 2.9–4 cm • 8.3–10.6	• 30.3–35.3 × 3.0–3.6 cm • 9.8–10.1	• 15–35 × 4–5 cm • 3.8–7
Margin	• Both margins dentate • Flat to slightly revolute	• Distal margin dentate, proximal usually entire • Slightly revolute	• Distal margin dentate, proximal entire • Revolute	• Both margins slightly dentate to entire • Strongly revolute
Serrations; apex	• 2–9 on each margin, fairly evenly spaced or crowded near base • Apex bifurcate or trifurcate, occasionally pungent	• 3–10 on distal margin within 7 cm of base, occasionally with 1 on proximal margin • Apex pungent	• 3–7 on distal margin within 2–2.5 cm of base, first 3 often extending across rachis on basal curve • Apex pungent	• 0–3 on basal half of either margin, often reduced to callose bumps • Apex pungent
Attachment color	Green	Green	Green	Yellow
Cataphylls	• Linear to linear-lanceolate • Densely yellowish to grayish tomentose	• Linear to linear-lanceolate • Base dark brown tomentose, tip glabrous	• Lanceolate • Densely brown tomentose	• Narrowly triangular [5] • Grayish tomentose
FEMALE CONE				
Number	2–5	2–3	To 5	1–3
Length × diameter; L:D ratio	• 28–60 × 15–25 cm • 1.9–2.4	• 42–60 × 15–35 cm • 1.7–2.8	• 60–66 × 17–19.5 cm • 3.4–3.5	• 30–40 × 15–35 cm • 1.1–2
Shape	Cylindrical	Cylindrical to ovoid-cylindrical	Oblong-cylindrical	Cylindrical to ovoid-cylindrical
Color	• Emerge light green to yellow • Mature dull light green to yellow or reddish-brown; sporophylls sometimes with pinkish margin	• Emerge green to yellow • Mature pale yellow to orange or tan	• Emerge purplish-brown • Mature yellowish-orange	• Emerge green to brownish pink • Mature yellow to tan or apricot
Peduncle length; pubescence	• 4–6 cm • Glabrous	• 5–15 cm • Glabrous to dark brown tomentose	• 12 cm • Glabrous	• 2–4 cm • Glabrous
Median sporophylls	• Bulla deflexed rhomboidal, 3.5–5 cm wide, 2–3.3 cm high, facets centrally smooth with irregular warts or ridges and rounded/umbilicate tubercles at margins • Terminal facet concave, compressed hexagonal or pentagonal • Adaxial face with two lateral trapezoidal facets, median rectangular facet, median lobe absent • Abaxial face receding, subcrescentic with two obscure latero-saggital ridges; lateral lobes triangular to irregular, with lateral facets warty-tuberculate and acute angles irregularly dentate	• Bulla rhomboidal, 3.5–4.8 cm wide, 1.8 cm high • Terminal facet slightly concave, hexagonal • Adaxial face with two lateral trapezoidal facets, median rectangular to trapezoidal facet, short median lobe; margin and seminal fringe tuberculate • Abaxial face with two lateral trapezoidal facets; median rectangular to trapezoidal facet with obtuse lateral saggital ridges; inferior ridge and saggital crest tuberculate	• Bulla deflexed rhomboidal, 6.6–7 cm wide, 3.1–3.6 cm high • Terminal facet concave, compressed elliptical, upper side 3-angled, lower side curved • Adaxial face with two lateral trapezoidal facets, med. rectangular facet, short inconspicuous median lobe; seminal fringe rounded-tuberculate toward terminal facet, sharp irregular-tuberculate/dentate toward seed chalaza • Abaxial face partly exposed, horizontal depression midway between terminal facet and seminal ridge, almost lacking in division; seminal ridge sparsely verrucose; inferior ridge and saggital crest sharply tuberculate/dentate	• Bulla rhomboidal, 6.5 cm wide, 3.8–4 cm high • Terminal facet slightly concave, hexagonal • Adaxial face with two lateral trapezoidal facets, median trapezoidal facet, short inconspicuous median lobe; margin and seminal fringe tuberculate • Abaxial face with two lateral trapezoidal facets; median trapezoidal facet with obtuse lateral saggital ridges; inferior ridge and saggital crest tuberculate
Sarcotesta color	Bright yellow, orange, or vermillion	Orange-yellow	Orange	Yellow to vermillion
Sclerotesta shape; size	• Ellipsoid • 3.3 cm long × 1.9 cm diam.	• Ellipsoid • 3–3.9 cm long × 1.7–2.5 cm diam.	• Ellipsoid, irregularly angled • 3.8–4.3 long × 2.1–2.7 cm diam.	• Ellipsoid • Not reported
MALE CONE				
Number	3–8	3–10	?	1–3
Length × diameter; L:D ratio	• 20–50 × 5–9 cm • 4–5.6	• 49–90 × 10–30 cm • 3–4.9	?	• 20–40 × 15–25 cm • 1.3–1.6
Shape	Cylindrical to subconical or fusiform	Cylindrical, sometimes curved	?	Ovoid to subconical
Color	• Emerge greenish-yellow • Mature greenish-yellow to bright yellow or dull red	• Emerge greenish-yellow to canary yellow • Mature creamy yellow to tan	?	• Emerge greenish-yellow • Mature yellow to apricot
Peduncle length; pubescence	• 5–25 cm • Glabrous	• 5–32 cm • Glabrous to dark brown tomentose	?	• 2–6 cm • Glabrous
Median sporophylls	• Distinctly ascending • Bulla rhomboidal to sub-triangular, sharply deflexed, with rounded adaxial margin • Terminal facet concave, rhomboid, parallel to axis	• Perpendicular or ascending • Bulla triangular to rhomboidal, deflexed, truncate • Terminal facet rhomboidal	?	• Perpendicular to axis • Deltoid, 2 cm wide • Bulla deflexed
Sporangia	Covering entire abaxial side of sporophyll in regularly shaped patch except for prominent V-shaped notch at outside edge	Single patch on abaxial side of sporophyll	?	Single, somewhat irregular patch on abaxial side of sporophyll

[1]Braun & Bouché (1874), Melville (1957; 1958), Lewis (1960), Moretti et al. (1989), Osborne (1990), Vorster (1999), Goode (2001), Whitelock (2002).
[2]Faden & Beentje (1989), Moretti et al. (1989), Hurter (1994), Vorster (1999), Goode (2001), Whitelock (2002).
[3]Pócs & Luke (2007), plus personal interpretation of habitat photos.
[4]Melville (1958), De Luca et al. (1989), Stevenson et al. (1990), Slabbert & Hurter (1994), Vorster (1999), Goode (2001), Whitelock (2002).
[5]P. Vorster (pers. comm.)