

A new species of *Cycas* (Cycadaceae) from Karnataka, India

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Received 18 July 2006; accepted for publication 17 June 2008

Cycas swamyi Singh & Radha, **sp. nov.** (Cycadaceae) is described and illustrated from Karnataka, India. This new species has been confused with *Cycas circinalis* L., which is found in the Western Ghats. However, on the basis of its habit, characteristic isotomous-type dichotomous branching, pinnae anatomy, mega- and microsporophyll morphology and seed anatomy, it has been segregated from *C. circinalis* and is described here as a new species. The distribution and conservation status are also discussed. © 2008 The Linnean Society of London, *Botanical Journal of the Linnean Society*, 2008, 158, 430–435

ADDITIONAL KEYWORDS: *Cycas circinalis* – *Cycas swamyi* – isotomous branching – Karnataka – Western Ghats.

INTRODUCTION

All *Cycas* species on the Indian mainland have been designated as either *C. circinalis* L. or one of its varieties by earlier authors (Raizada & Sahni, 1960; Pant, 1973, 2002), except for the morphologically distinct *C. beddomei* Dyer, which is endemic to the Cuddapah Hills in Andhra Pradesh, and *C. pectinata* Ham.-Buch., which possesses remarkably distinct megasporophylls and is native to Bihar and Assam. Pant (1991, 2002) created several more nomenclaturally invalid varieties, *C. circinalis* var. *circinalis* and *C. circinalis* var. *swamyi*, because he did not designate any types, did not cite any specimens and did not provide any descriptions. The mention of these varieties by Pant (2002) emphasized the problem of the delimitation of *C. circinalis*. To solve the confusion and incipient complex taxonomy of *C. circinalis*, we initiated a reinvestigation of Indian *Cycas* in the field, beginning with the Western Ghats, where Van Rheedee (1682) reported ‘Todda Panna’ in ‘*Hortus Malabaricus*’ and, upon whose line drawings, Linnaeus (1753) described the first botanical species of *Cycas*: *C. circinalis*. Elaborate field investigations of *Cycas* in India during recent years have led us to

conclude that *C. circinalis*, as described by Linnaeus (*sensu* Van Rheedee’s ‘Todda Panna’), has a restricted distribution in the southern Western Ghats (Singh, Radha & Sharma, 2007). Our observations are based primarily on the geographical distribution, habitat, habit and morphology of the vegetative and reproductive parts of the plants growing in wild populations, as well as on the pinnae anatomy, because the leaflets of each extant cycad species have a distinct anatomy. These investigations led to the recognition of a new species, *Cycas annaikalensis* (Singh & Radha, 2006), from the populations located in the southern Western Ghats, which was thought to be the endemic locality of *C. circinalis* L. (Hill, 1995).

During the current study, field explorations were extended from the *Cycas* populations of northern Kerala to those of southern Karnataka, which have also been recognized as *C. circinalis* (Mysore *Cycas*). Detailed life cycle studies of these populations have been provided by Swamy (1948) and Rao (1963). They observed the characteristic dichotomous branching and mentioned this peculiar feature in the Mysore *Cycas*, but did not delve further into its taxonomic significance. Pant (1991) took this peculiar branching pattern as the basis to recognize these *Cycas* populations as a variety, *C. circinalis* var. *swamyi* (*nom. nud.*), without any formal Latin

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diagnosis. Continuing these observations, we have found that, in addition to the regularly occurring isotomous branching pattern in the stem, the plants possess a distinct robust habit, distinct morpho-anatomical characters in the pinnae, distinct megasporophylls and a distinct attachment of the ovules. Thus, the Karnataka *Cycas* population is identified and described here as *Cycas swamyi* Singh & Radha sp. nov.

MATERIAL AND METHODS

To study the habit, ecology and phenology of these *Cycas* populations, several field visits at different time intervals were made to the wild localities in Karnataka and neighbouring regions of the Western Ghats. The measurements of the leaves, leaflets and number of pinnae were performed both in the field and on herbarium specimens. Large numbers of herbarium sheets were prepared from the collected plant materials from different populations. To study the anatomy, the pinnae were fixed in 50% alcohol, acetic acid and formalin (90 : 5 : 5) (FAA); after 24 h, the materials were washed thoroughly in 70% alcohol and preserved in the same. To obtain a constant and standard result, all measurements were performed on the median leaflets of mature leaves. Hand sections were taken of randomly selected median pinnae, and permanent slides were prepared using the Safranin–Fast Green staining protocol. The diagnostic features of *C. swamyi* are described below, and a comparison with *C. circinalis* is given in Table 1.

DESCRIPTION

CYCAS SWAMYI SINGH & RADHA, SP. NOV.

(FIGS 1–14)

Type: INDIA. Karnataka: Nagmangala, Mandya District, 12°24'N and 76°35'E, *Rita Singh (080)182* (leaf and megasporophylls), open rocky hillocks with granite boulders and hard, rocky, red gravel soil with hardly any other tree vegetation [holotype: IPUH, (080)182; isotype: DD, *Rita Singh (080)183*].

Diagnosis: Planta arborescens, erecta; stipes ad 8 m altus, 26–96 cm diametro. Folia 0.75–1.5 m longa, pinnatisecta, pinnis 55–100; pinnae medianae 13–21' 0.65–0.9 cm [canalibus mucilaginis carentes]. Megasporophylla 12–25 cm longa, apice sterili late trullato, 4–6' 3–4.5 cm; ovula magis minusve sphaerica, 2.5–4 cm longa.

Description: Stem arborescent, columnar or branched with a broad base, reaching 8 m in height, 26–96 cm in diameter. Two kinds of habit were observed in the natural habitat: (1) plants having a columnar trunk with a maximum circumference of 80–100 cm at the base and 60–70 cm at chest height; (2) plants having an isotomous and decussate branched robust trunk with a circumference of about 100–200 cm at the base, with each dichotomy measuring 50–40 cm in circumference at chest height. A persistent armour of leaf bases is found on the small plants, but those attaining a height of 1.5 m or more mostly do not have a persistent armour of leaf bases; instead they

Table 1. A comparison of *Cycas swamyi* with *C. circinalis*

Character	<i>C. circinalis</i>	<i>C. swamyi</i>
Plant height (cm)	70–500	70–800
Diameter (cm)	18–83	26–96
Number of pinnae per leaf	100–200	70–150
Length of leaf (m)	1–2.5	0.75–1.5
Petiole length (cm)	50–70	15–30
Median pinnae length (cm)	30–35	13–21
Median pinnae width (cm)	0.9–1.4	0.65–0.9
Median pinnae angle to rachis (deg)	40–50	40–45
Megasporophyll length (including fertile and sterile portion) (cm)	15.3–30	12–25
Megasporophyll sterile apex length (including apical spine) (cm)	5–8.8	4–6
Sterile apex width (cm)	2–4.1	3–4.5
Ovule dimension (cm)	2.5–5.2 × 2–4.5	2.5–4 × 2.3–4
Number of ovules/megasporophyll	6–12	4–10
Pinnae anatomy		
Thickness of pinna (mm)	0.25–0.32	0.36–0.4
Palisade cell dimensions (mm) (upper surface)	0.04–0.1 × 0.01–0.03	0.1–0.18 × 0.01–0.023
Size of vascular bundle (mm)	0.37–0.55 × 0.51–0.62	0.31–0.4 × 0.37–0.46
Stomatal index	5.89	4.97
Stomatal size (µm)	61.8 × 28.2	64.4 × 29.4

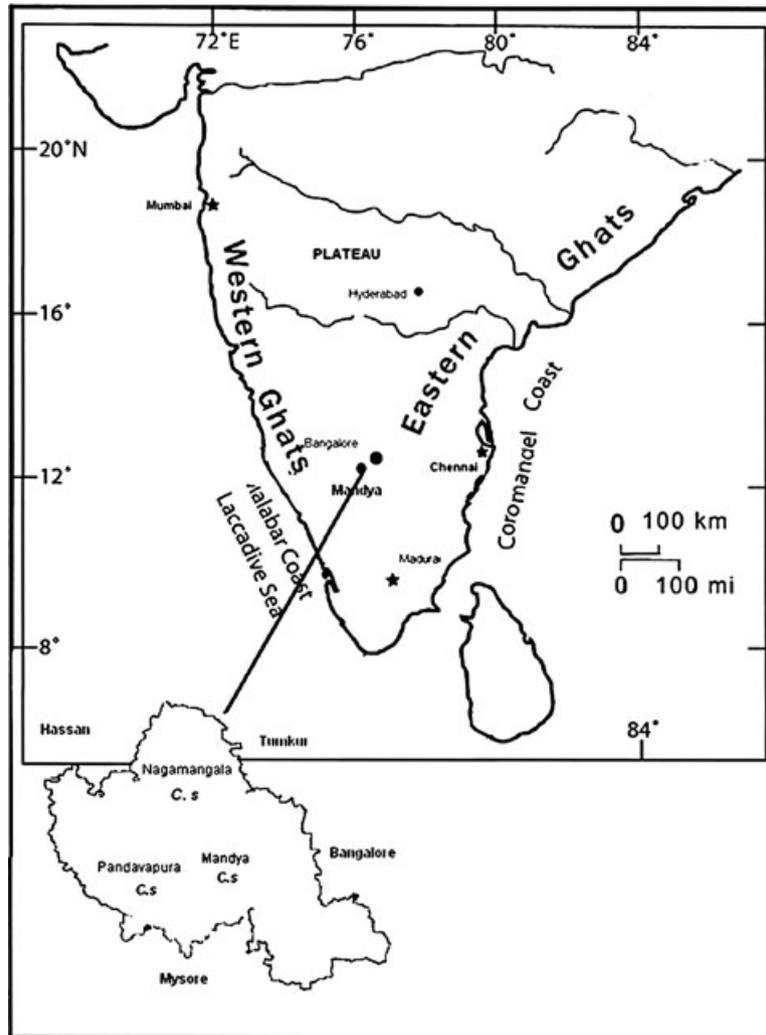


Figure 1. Distribution map of *Cycas swamyi* sp. nov.

show a flatted bark pattern. Young plants of 50–75 cm in height have a broad base tapering distally. Leaves pinnately compound, 0.75–1.5 m long, with 55–100 pairs of pinnae. Developing leaves are covered with ferruginous hairs on the abaxial surface. Mature pinnae lanceolate, shiny dark green, $13\text{--}21 \times 0.65\text{--}0.9$ cm, attachment of median pinnae on rachis at $40\text{--}45^\circ$. Margin entire. Tip spinescent. The median pinnae in the vertical section lack the characteristic mucilage canals found in other species of *Cycas* from the Western Ghats. Petiole 15–30 cm long with opposite or subalternate pinnacanth. Pinnacanth 2–3 mm long. Microsporangiate cone oblong, reddish-orange, about 50 cm long. Megasporophylls 12–25 cm long from the base of the fertile stalk, bearing ovules up to the base of the sterile apex. Sterile apex broadly trullate, $4\text{--}6 \times 3\text{--}4.5$ cm with 15–19 regular lateral teeth on either side. Lateral teeth 2–8 mm long, clearly visible after the shedding of ferruginous tri-

chome prior to or after fertilization. Ovules 4–10, glabrous, spherical, 2.5–4 cm, brownish-red at maturity. Seeds platyspermic, fibrous layer absent. Germination cryptocotylar.

Etymology: The specific epithet '*swamyi*' is named in honour of Dr B.G.L. Swamy, who first observed and described the characteristic branching of this species in 1948.

Distribution and habitat: This species appears to be indigenous to south-eastern Karnataka, having scattered old populations over the open sunny rocky terrains in Nagamangala and comparatively younger populations under the partially shadowed forests of Nagamangala and Narayana Durga Reserve Forest, Pandavapura. However, the populations growing in open rocky habitats are more robust than those growing as understory elements. *Cycas swamyi* is

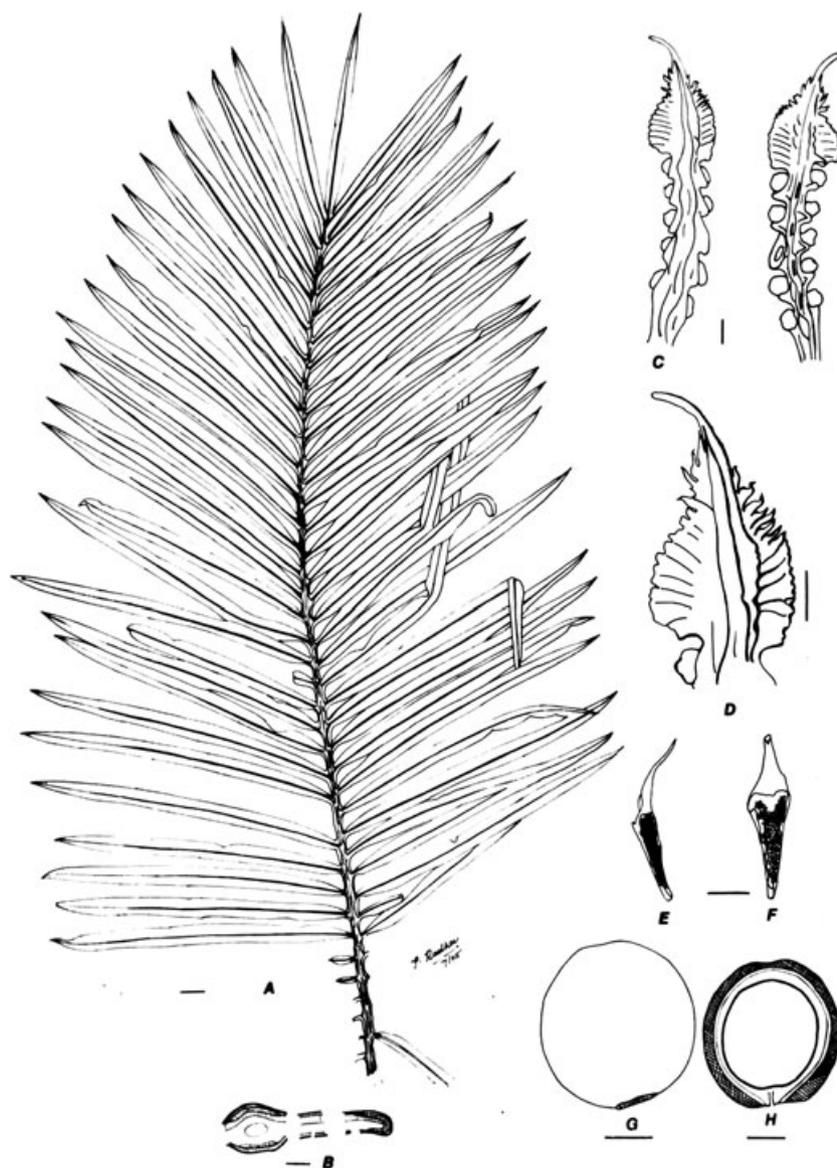
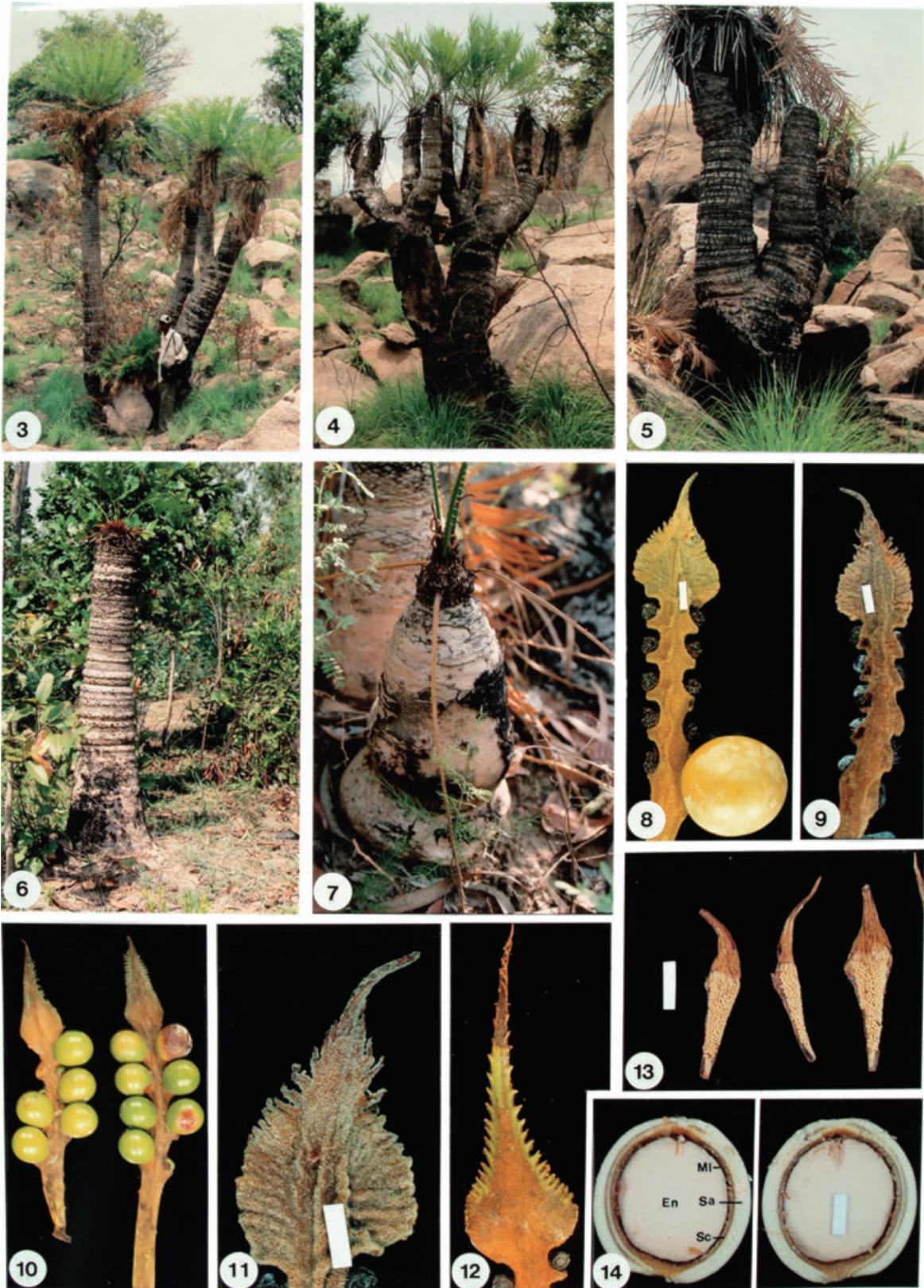


Figure 2. *Cycas swamyi*: A, a unipinnate compound leaf; B, vertical transverse section of the pinna (note the absence of mucilage canals in the vascular bundle region); C, megasporophyll bearing unfertilized ovules; D, enlarged sterile apex of the megasporophyll; E, F, microsporophylls – side and dorsal views; G, seed with fleshy sarcotesta; H, longitudinal section of a seed showing different wall layers of the integument. Scale bar, 1 cm.

currently described from Kanchanhalli, Nagamangla in Mandya District and Karnataka, India. All of these localities are parts of the Mysore plateau or south Karnataka plateau. This particular plateau has many undulations, and is bounded on the west and south by the Western Ghats, constitutes the easternmost edge of the southern Western Ghats and joins the Biligirirangan Hills. The extension of the Biligirirangan hills to the east forms a continuous geographical link between the Western Ghats and Eastern Ghats, and perhaps acts as a corridor for the migration and mixing of the Western Ghats elements with those of the Eastern Ghats.

DISCUSSION

In his paper on the life history of *C. circinalis*, Swamy (1948) stated that, 'A frequently observed and very interesting feature of these cycads is the branching of the trunk, which is typically dichotomous, with each successive branching at right angles to the previous one'; he observed this phenomenon up to the fourth order. *Cycas swamyi* can be distinguished easily from other *Cycas* species of the adjacent geographical regions and other species in India by the robust, isotomous, decussate branched or unbranched habit. Although most *Cycas* species of South-East Asia show



Figures 3–14. Figs 3–9, 11, 13, 14. *Cycas swamyi*. Figs 3–5. Habit showing isotomous type of dichotomous branching. Fig. 6. Unbranched columnar habit. Fig. 7. A young plant showing broad base and tapering apex. Figs 8, 9. Megasporophyll bearing ovules – abaxial and adaxial surfaces, respectively. Fig. 11. Enlarged trullate sterile apex of megasporophyll. Fig. 13. Lateral and abaxial profile of microsporophylls. Fig. 14. Longitudinal section of seeds; En, endosperm; ML, membranous layer (scaly); Sa, sarcotesta; Sc, sclerotesta; Scale bar, 1 cm. Figs 10, 12. *Cycas circinalis* – megasporophylls. Fig. 10. With fertilized ovules. Fig. 12. Magnified sterile apex. Scale bar, 1 cm.

branching, the branches are produced either after decapitation or by the growth of an adventitious bud, and none have been reported to have an isotomous branching pattern. Another feature which distinguishes *C. swamyi* from the other species is its typical bark. Instead of an armour of leaf bases, mature plants have fissured bark, such that they may easily be confused with a dicot tree in the absence of an apical crown of characteristic pinnately compound foliage (Fig. 6). *Cycas circinalis* var. *orixensis* of the Eastern Ghats (Orissa) also attains a height of about 5 m, but has a smooth trunk after the shedding of the persistent leaf bases. Another interesting character of the new species is the number of male cones produced on a single plant. Srivastava & Chauhan (2004) reported that as many as 34 male cones are produced at a time on each dichotomous branch; this contrasts with other Indian species, which bear a maximum of two or three cones on a single mature plant. All of these characters make *C. swamyi* a distinct entity.

Most of the young foliage in the populations studied is devoured by caterpillars of the lycaenid blue butterfly, *Euchrypsops pandava* Horsefield. The remaining foliage, which survives the attack of these pests, is harvested by residents of the adjoining villages to generate revenue, as this area of Karnataka has limited cultivatable land and resources. The leaves are used for decoration in the majority of auspicious cultural ceremonies. As a consequence, most mature trees are defoliated as soon as they produce shiny new leaves. This not only hinders the production of the metabolites required for the growth of the plants, but also reduces the frequent production of cones and seeds. From an assessment of all the biological pressures on the populations of *C. swamyi*, the species currently may be classified as threatened according to the World Conservation Union (IUCN) Red List Categories (2001), and is in dire need of a sustainable conservation programme.

ACKNOWLEDGEMENTS

We thank the Principal Conservator of Forests, Karnataka, Forest Officials of Mandya and Hassan Districts, Karnataka, Mr P. Mukundan and Mr G.

Kumarasan for their help during field studies and in the collection of plant materials. Dr Shivmurthy, Department of Botany, University of Mysore, Mysore is acknowledged for sending preserved plant material for further comparative studies. We are also grateful to the Ministry of Environment and Forests, Government of India, for financial support [AICOPTAX – Project, D.O. No. J. – 2018/54/2000/CSC (BC)].

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