

The Recircumscription of *Curcuma* L. to Include the Genus *Paracautleya* R.M.Sm.

J. SKORNICKOVA^{1,2} AND M. SABU¹

¹Department of Botany, University of Calicut, 673635 Kerala, India.

²Department of Botany, Charles University, Benatska 2, Prague, 12802, Czech Republic.

Abstract

Based on recent living material from the type locality, the monotypic genus *Paracautleya* is reduced to synonymy with *Curcuma* and a new combination is made for *C. bhatii* (R.M.Sm.) Skornick. and M.Sabu. A detailed description of the species, including a colour plate, is given.

Introduction

The monotypic and narrowly endemic genus *Paracautleya* was established by R.M. Smith in 1977. Its type species, *Paracautleya bhatii* R.M.Sm., was described based on a collection by K.G. Bhat made near Udipi, South India. In relation to the description, Smith discussed possible affinities of *Paracautleya* with four other genera (*Camptandra* Ridl., *Cautleya* Hook./., *Curcuma* L. and *Roscoea* Sm.) in the tribe *Hedychieae*, which all have a truly versatile anther like *P. bhatii*. Several characters were used to clarify the affinity of *Paracautleya* but unfortunately, many of them were not known satisfactory at the time (Table 1), such as the habit and position of inflorescence, shape of the fertile bract, number of flowers per bract, absence of bracteole, and ovary division.

Kress *et al.* (2002) provided a new classification of the Zingiberaceae based on DNA sequences of the nuclear internal transcribed spacer (ITS) and plastid matK region. However, they lacked samples of a number of rare monospecific genera, *Paracautleya* among them. Based on morphology alone, they tentatively placed the genus *Paracautleya* in the Zingibereae tribe. This was recently confirmed by Ngamriabsakul *et al.* (2004), who elaborated the phylogeny of the tribe Zingibereae using the same nuclear gene as Kress *et al.* (2002) but a different Chloroplast gene, *trnL-F*. Their phylogenetic analysis of the combined data set showed that *Paracautleya* grouped with *Curcuma* subg. *Curcuma* whereas the other genera mentioned by Smith (1997) were placed in distant clades. Ngamriabsakul *et al.* (2004) pointed out that all genera recognized in the *Curcuma* complex may be

Table 1. A re-examination of characters in *Curcuma* and *Paracautleya*. Characters and character states stressed by Smith (1997) in bold.

	<i>Cautleya</i>	<i>Curcuma</i>	<i>Paracautleya</i>	<i>Roscoea</i>
Rhizome Habit	Swollen fleshy roots Leafy stems	Rhizome and tubers Leaf tuft (forming pseudostem or stemless)	Rhizome and tubers Leaf tuft (stemless)	Swollen fleshy roots Leafy stems
Leaf sheath	Closed	Open	Open	Closed
Inflorescence	Terminal	Terminal or radical or both	Terminal	Terminal
Bract	Free	Pouch-like or free	Free or pouch-like	Free
Bracteole	Absent	Present or absent	Present or absent	Absent
Flowers	Single	Cincinni or single	Single	Single
Anther	Spurred, L-shaped, crested	Spurred or not, crested or a vestige present or absent	Spurred, vestige of crest present	Spurred, L-shaped, crested
Epigynous gland apex	Sharp	Blunt	Blunt	Sharp
Ovary	Trilocular	Trilocular , rarely imperfectly trilocular	Imperfectly trilocular	Trilocular
Placentation	Axile, ovules throughout the axis	Axile , many ovules towards the base, less towards the top	Basal	Axile, ovules throughout the axis
Capsule	Many-seeded	Few to many- seeded (10-25 seeds)	Few-seeded (5-12 seeds)	Many-seeded
Seed	Black to brown, grey or red, angled, aril present or absent	Ovoid, light brown to dark brown, shiny, arillate, aril white, lacinate	Ovoid, light brown, shiny, arillate, aril white, lacinate, usually positioned towards one side	Ovoid, arillate

regarded as a single genus, though there are some morphological characters supporting the separation of each taxon. These characters they suggest are, however, autapomorphic. Distinguishing characters of the genera in the *Curcuma* complex, namely *Curcuma* and *Paracautleya*, as tabulated by Ngamriabsakul *et al.* (2004) included the following: in *Curcuma* adnate bracts, several flowers per bracts, bracteoles present, and labellum emarginate and rarely split *versus* in *Paracautleya* free bracts, one flower per bract, bracteoles absent and labellum split.

The purpose of the present paper is to evaluate whether the morphological evidence based on newly available material still justifies keeping *Paracautleya* separate from *Curcuma*.

Material and Methods

In June 2004, *Paracautleya bhatii* was observed flowering in its type locality. Plants were collected and transplanted to Calicut University Botanic Garden for further observation. During the past four years we have also extensively studied *Curcuma* species throughout the Indian subcontinent both from living flowering material as well as herbarium specimens including type material (BM, BSI, CAL, CALI, E, G, K, L, MH, PDA, PR, SING) paying particular attention to the extreme variability of vegetative and floral characters.

Paracautleya R.M.Sm. versus *Curcuma* L.

Rhizome structure

The genus *Curcuma* has a conspicuous rhizome structure. The main rhizome can be simple or branched and the roots end in round, ovoid root tubers, which may be almost sessile or distant 20–30 cm from the main rhizome or branches. Root tubers are present invariably in both seed-setting and non seed-setting species. They are not capable of sprouting and their exclusive function is to sustain the plant during dry periods when the leafy shoots dries up. Our recent studies reveal that *Paracautleya bhatii* has an ovoid main rhizome usually without branches or with one branch and root tubers, typical for the genus *Curcuma*.

Bract

As described by Smith (1977), unlike *Paracautleya* with singly borne flowers and bracts that do not form pouches, the flowers of *Curcuma* commonly arise in cincinni held within pouches formed by adnate bracts. This traditional diagnostic character of the genus *Curcuma* is based mainly on early descriptions made by Roxburgh (1820) and subsequent workers when only a few species of *Curcuma* were known. However, species lacking this bract formation were described from Sri Lanka (*C. albiflora* Thwaites, and to some extent also *C. oligantha* Trim.). Kress *et al.* (2002) have pointed out that pouched inflorescences are neither unique nor universal in the genus *Curcuma*.

As a matter of terminology, the term 'adnate' is used when two non-homologous entities are fused, while the term 'connate' is appropriate when two homologous entities are fused, e.g. two bracts. Thus, the pouches

in *Curcuma* are, in most species, formed by both means on the same inflorescence. It is possible to say that pouches in all *Curcuma* species are formed at their base by being adnate to the inflorescence axis and in most species their sides further up are connate to the basal part of the bracts positioned above them. The degree of connation varies considerably within the genus and may in some species be negligible.

Smith (1977) mentioned that in *Curcuma albiflora* a few free bracts may occur at the base of the inflorescence. We have studied *C. albiflora* from herbarium material (BM, E, G, K, PDA). For most sheets, including type specimens, there is no connation of bracts at all; the bracts form shallow pouches by the basal part being adnate only to the inflorescence axis. Bracts of *C. albiflora* are rarely connate to each other and if so, then only in the uppermost part of inflorescence. Connation of bracts is also very much reduced in the case of *C. oligantha*, where the situation is less obvious than in *C. albiflora*. In *C. oligantha*, one or two free fertile bracts may occur in the basal part of the inflorescence, where the lowest bracts may be joined only to the inflorescence axis and the upper bracts are connate just in its lowermost, c. 1–6 mm, portion.

During our fieldwork, we have examined over 30 inflorescences from different populations from the type locality and found that bracts in *Paracautleya bhatii* are mostly free but do form pouches by being adnate at its base to the inflorescence axis. Such a pouch can be almost a third of the bract length, but individuals with their bracts connate for 1–2 mm can also be found and if such are present, they are usually positioned in the upper part of the inflorescence. There is no doubt about the generic identity of *C. albiflora* and *C. oligantha* and therefore the pouched bract character alone is not sufficient to maintain *Paracautleya bhatii* separate from *Curcuma*.

Number of flowers per bract

In the genus *Curcuma*, there are usually two or more flowers subtended by each bract forming a cincinnus while *Paracautleya* has its flowers borne singly. Yet, there is in India a complex of four species, namely *C. reclinata* Roxb., *C. decipiens* Dalzell, *C. inodora* Blatt. and *C. sulcata* Haines, which share in common strongly reduced or missing bracteoles and flowers that are born singly or with a maximum of two per bract.

We have re-collected all these species from their type or near to their type localities. *Curcuma decipiens* (Skornickova 73443 and 73445; CAL, CALI, K, MH, PR, SING) has 1–2 flowers per bract and the number of flowers may not be consistent throughout the spike. In some plants every bract subtends just one flower, in others bracts subtend two flowers in the basal part of inflorescence and one flower in its upper part. *C. sulcata*

(Skornickova 73467; CALI, MH, K, PR, SING), *C. reclinata* (Skornickova 73477; CAL, CALI, MH, K, PR, SING) and *C. inodora* 73403 (Skornickova 73403; CALI, SING) have only one flower per bract and we did not encounter a single plant that had two or more flowers per bract.

Bracteole

Paracautleya has been distinguished from *Curcuma* on the grounds of its lacking bracteoles (Smith, 1977). Based on earlier generic and specific descriptions of *Curcuma*, there is one boat-shaped bracteole per flower. From our field observations, there are great differences in bracteole size across the genus *Curcuma*. The non-seed setting species usually possess large bracteoles that can reach over 3 cm long while the bracteoles of some seed-setting species can either be well developed (e.g., *C. montana* Roxb.) or more or less reduced. As already mentioned above, *C. decipiens*, *C. inodora*, *C. reclinata* and *C. sulcata* bracteoles are reduced to 1–2 mm or are often absent. This feature may not be constant within the species or whole population (e.g., the same population includes plants with strongly reduced bracteoles as well as plants where the bracteoles are completely lacking), but it is usually constant within a single plant. In the type locality of *P. bhatii*, we found plants without bracteoles (more common) as well as plants with bracteoles up to 2.5 mm long.

Labellum

An emarginate labellum is commonly found in a number of Indian seed-setting species distributed in Western Ghats area, e.g. *C. oligantha*, *C. mutabilis* Skornick. *et al.*, *C. pseudomontana* J.Graham, where the split often progresses as the flower ages towards the end of the day and wilts. This is thus not unique to *Paracautleya* contrary to what was tabulated by Ngamriabsakul *et al.* (2004).

Anther structure

Anther structure of *Paracautleya* is similar in structure to several seed-setting *Curcuma* species being versatile, having two anther spurs at its base and, in the adaxial part of the anther, a vestige of a reduced anther crest. The whole morphology of the anther closely resembles, for example, anthers of *C. neilgherrensis* Wight, *C. decipiens* or *C. oligantha*.

Ovary structure

As far as we know, there is no specific work dealing in detail with ovary structure in the genus *Curcuma*. The ovary in Zingiberaceae is tricarpellate (except the tribe *Globbae* and genus *Tamijia*, in which the ovary is unilocular with parietal placentation), and is generally described as trilocular with

axile placentation. Hamza (1989) observed that many Zingiberaceae species described with trilocular ovaries and axile placentation, have incomplete septation at the top and are thus unilocular in this region. He did not include any representatives of the genus *Curcuma* in his study, but we have seen similar ovaries when observing transverse sections from different parts of ovaries of different species of *Curcuma* e.g., *C. decipiens*, *C. oligantha*, *C. neilgherrensis*, *C. karnatakensis* Amalraj *et al.* Sections near the base are always trilocular with a large number of ovules, but sections towards the top have a much reduced ovule number or are empty and the septa are not always joined. In *Paracautleya* incomplete septa are clearly visible.

Aril and seed shape

For the genus *Curcuma*, there are few descriptions or drawings of fruits and seeds but we have been able to observe fruits and seeds of more than 15 species. Seeds are ovoid, light brown to dark brown and shiny. The aril is white, laciniate and is rather uniform throughout the genus, although the size of the aril may vary among the species. The only *Curcuma* species with seeds described as exarillate appears in the original description of *C. oligantha* (Trimen, 1885). We have examined the type specimen of *C. oligantha* (PDA) and confirmed the presence of an aril on the seeds from an unopened fruit. Seeds of *Paracautleya bhatii* agree in shape and colour and the presence of a laciniate aril with those observed in the genus *Curcuma*. The laciniate aril in *Paracautleya* is usually positioned towards one side and its size and shape vary slightly within a population. The aril in unripe seeds is smaller than in fully ripe seeds.

Other observations

The inflorescence in *Paracautleya bhatii* is invariably terminal on a long naked peduncle and its leaves are rather narrow. In its general habit it most resembles some of the SE Asian *Curcuma* species, e.g. *C. gracillima* Gagnep., which also has this type of inflorescence and narrow leaves. In the Indian region, the most similar species are perhaps *C. oligantha* (India and Sri Lanka) and *C. albiflora* (Sri Lanka).

While dealing with the ovary and fruit of *Paracautleya bhatii*, we also studied the shape of the epigynous glands. They agree well with those found in the genus *Curcuma* in being linear with a blunt apex. The shape of the stigma and presence of cilia at the ostiole of *Paracautleya bhatii* also agrees well with *Curcuma*.

Conclusion

The conclusion is that the generic delimitation of *Paracautleya* as defined by Smith (1977) is not strong enough to warrant keeping it as a separate genus. As well as similarity in habit, we found that the generic diagnostic characters including floral morphology described for *Paracautleya* can be observed in at least some members of the genus *Curcuma*. Thus, its generic status cannot be justified. This necessitates a new combination for the *Paracautleya* species.

Curcuma bhatii (R.M.Sm.) Skornick. and M.Sabu **comb. nov.**

Basionym: *Paracautleya bhatii* R.M.Sm., Notes Roy. Bot. Gard. Edinburgh. 35 (1977) 367; K.G. Bhat, FL Udupi. (2003) 634.

Type: India, Karnataka, South Kanara, Manipal, 1.VII. 1975 *Bhat 204* (holo E!; iso BSI!, C, CAL!).

Small rhizomatous herb, 5–20 cm tall. *Rhizome* ovoid mostly unbranched, 5–10 x 4–5 mm, rarely with one branch, which gives rise to a new plant, light brown externally, sheathed by papery remains of leaf sheath bases, creamy yellowish internally, non-aromatic. *Roots* fleshy, root tubers up to 1–2.5 x 0.5 cm, almost sessile to the main rhizome, externally whitish (when young) to brown (when older), internally pure white, non-aromatic. *Pseudostem* 2–5 cm long, formed by leaf sheaths and 1–2 sheathing bracts, whitish, drying soon and becoming light brown, thin and papery, *ligule* 1.5 mm, bilobed, translucent greenish-white, glabrous. *Leaves* 2–5 (–7), sessile or with a very short petiole *c.* 1 cm long (gradually changing into a narrowly attenuate lamina base); *lamina* lanceolate, 5–12 x 0.7–1.5 cm, adaxially green, glabrous, abaxially lighter green, glabrous; margin hyaline, translucent white, *c.* 0.1 mm wide, tip acute, base attenuate, midrib green, glabrous. *Inflorescence* invariably central. Peduncle 3.5–13 cm, *c.* 1–1.5 mm diam., green, glabrous, partly hidden within the pseudostem. Spike 2–5 x 1–2.5 cm, consisting of 5–23 green bracts. Coma inconspicuous, usually only the uppermost 2–3 bracts are sterile and smaller in size than the fertile ones. *Fertile bracts* ovate, 1–1.4 x 0.7–1 cm, tip acute, both sides glabrous, green, usually free especially at the base of inflorescence, but occasionally connate by the lower fifth of bracts (*c.* 1.5–2.5 mm), 1 flower per bract. *Bracteoles* usually absent (reduced), rarely present, one per flower, 0.5–2.5 x 0.5–1 mm, translucent white, glabrous. *Flowers* 1.8–2 cm long, exerted from bracts. *Calyx* 3.5 mm long, obscurely 3-toothed, translucent white with greenish tinge, glabrous. *Corolla tube* *c.* 9 mm, deep yellow, glabrous; *dorsal corolla lobe* *c.* 6–7 x 7 mm, triangular-ovate, concave, apex with obscure blunt mucro 0.2 mm, translucent yellow, glabrous, lateral corolla

lobes ovate, slightly concave at tip, translucent yellow, glabrous. *Lateral staminodes* c. 7 x 4.5 mm, deep yellow, glandular hairs present on the slightly raised middle portion. *Labellum* c. 9 x 9 mm, emarginate, split 3–4 mm long (opening deeper and wider as the flowers age and wilt), deep yellow. *Anther* versatile, spurred, deep yellow, short glandular hairs present on the sides and adaxially, anther thecae whitish, 1.5 x 0.4 mm; filament 1 mm long, deep yellow, constricted, 2.5 mm broad at base, 1 mm broad at upper part. *Anther* spurs 0.9–1 mm long, yellow. *Anther crest* small, reduced c. 0.5 x 0.4 mm, yellow. *Ovary* imperfectly trilocular (trilocular at basal part, septa incomplete in the upper part), c. 1.8 x 2 mm, white, glabrous, ovules c. 3–8. *Stigma* c. 0.7–0.9 x 0.7–0.9 mm, creamy white, ciliate, not exerted. *Epigynous glands* 2, creamy yellowish, c. 1–1.2 mm long, 0.2–0.3 mm diam. *Fruit* a dehiscent capsule, spherical, 5–6 x 5–6 mm light green to whitish, glabrous, calyx persistent. *Seeds* 3.5–4 x 2 mm, greenish creamy (unripe) to light brown (ripe), shiny glabrous, non-aromatic, aril translucent white, lacinate, lobes up to 4 x 0.5–1 mm (smaller in unripe seeds), arranged towards one side.

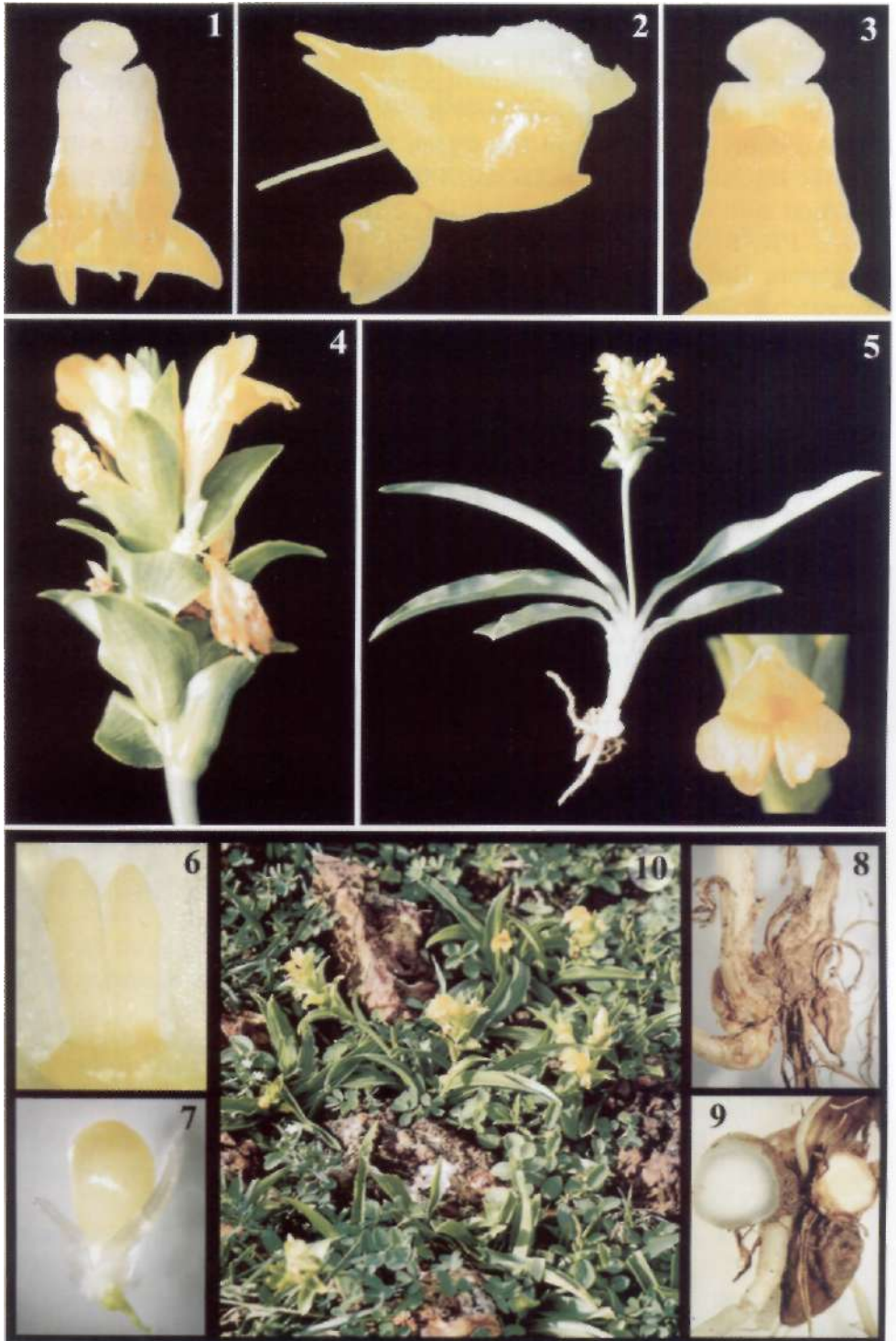
Other specimens examined: India, Karnataka, Udipi Dt., Manipal, Skornickova- 73446 (CAL, CALI, K, MH, SING, PR); Manipal, Sabu s.n. (CALI); Alevoor, Bhat 11349 (E!).

Distribution, habitat and phenology: This species is very rare and so far is known to occur only in Karnataka, Udipi District, at its type locality and adjacent territory. *Curcuma bhatii* grows on lateritic slopes in rock crevices in areas that are rich in monsoon rains. Its small size may be due to its habitat, which is unique compared with other *Curcuma* species. It flowers from June to August. This species is highly endangered due to rapid loss of its habitat.

It is notable that maximum diversity of seed-setting *Curcuma* species is along the western side of the Western Ghats, South India, where, for example, *C. oligantha*, *C. vamana* Sabu et Mangaly; *C. karnatakensis* Amalraj et al; *C. pseudomontana* Graham, as well as *C. bhatii*, occur. This region is known as one of the world's biodiversity 'hot spots'.

Plate 1. *Curcuma bhatii* (R.M.Sm.) Skornick. and M.Sabu

1. Anther (front view); 2. Anther (lateral view); 3. Anther (back view); 4. Inflorescence with flower in side view (half bract dissected); 5. Whole plant with detail of the flower in front view; 6. Epigynous glands; 7. Detail of the arillate seed; 8. Rhizome structure - main rhizome on the right, root tuber on the left; 9. Rhizome structure dissected - main rhizome on the right, root tuber on the left; 10. *Curcuma bhatii* on its type locality. (Skornickova 73446).
Photo J. Skornickova.



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