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Identification of an endangered tree as a new record of *Cordia macleodii*, with an update of *Cordia* in West Bengal, India

Debal Deb^a (D), Bo Li^b (D), Sanjib K. Chattopadhyay^a and Avik Ray^a (D)

^aCentre for Interdisciplinary Studies, Kolkata, India; ^bCollege of Agronomy, Jiangxi Agricultural University, Nanchang, China

ABSTRACT

We have identified a hitherto undescribed tree, locally known as *Sitapatra*, which has never been mentioned in any publication of the region's flora. However, by using morphological and molecular analyses, we identified it as *Cordia macleodii* (Cordiaceae). Several novel traits, never mentioned in previous taxonomic works, were observed and added to the description of the species. We suggest the conservation status of the species to be Critically Endangered, based on the criteria of a critically small population size in a narrow extent of occurrence, and the absence of flowering for 12 years in the past. Subsequently, we have updated here the distribution of *Cordia* L. in West Bengal, based on records from herbaria and recent publications, as well as our field observations. A distribution map for three native and an exotic species is presented. We find that although the protologue of *C. macleodii* indicates its type collection from central India, the herbarium record at Royal Botanic Garden, Kew mistakenly shows its type locality as West Bengal.

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KEYWORDS Cordiaceae; endangered; rare; tree; India; West Bengal

Introduction

Cordia L. is a genus of the Cordiaceae family, and is comprised of about 300 species, distributed in tropical regions (Mabberley 2008). The genus has pantropical distribution, covering Africa, South Asia and tropical America. There have been multiple suggestions about the position and relationship of Cordiaceae as a constituent of Boraginaceae (Gottschling et al. 2005; Luebert et al. 2016). However, the monophyly of Cordiaceae is well-supported, based both on molecular data and on morphological apomorphies such as the presence of an undivided, multilayered endocarp, four-lobed stigma and plicate cotyledons (Gottschling et al. 2005). We therefore chose to treat Cordiaceae as a distinct family, which, together with Ehretiaceae, Heliotropiaceae and Lennoaceae, constitutes the 'Primarily Woody Boraginales' (sensu Gottschling et al. 2014).

In India, 16 species of *Cordia* have been described (Santapau and Henry 1973). Excluding the exotic *C. sebestena* L. reported from Kolkata (Mukhopadhyay and Chakraverty 2008), the genus is represented by three native species in the State of West Bengal. Specimens of *C. dichotoma* Forst. f. and *C. macleodii* (Griff.) Hook. f. & Thoms. are maintained in the National Herbarium of the Botanical Survey of India (BSI). *C. grandis* Roxb. is reported to exist in Darjeeling district of West Bengal, although herbarium specimens are not available. Herbarium details of these species from West Bengal are given in Table 1. Our survey records of these species in 10 Districts of West Bengal are summarised in Supplementary Table S-1. Based on the available data from herbaria, published literature and our own survey, the locations of occurrence of *Cordia* spp. in different districts of West Bengal are given in Figure 1.

During our biodiversity survey in April 2002, one of the authors (DD) encountered and documented two individuals of an unknown Cordiaceous tree, locally known as *Sitapatra*, near a sacred grove of Bhagabandh village (23°13′19.3″N, 87°16′45.5″E), and two in Bhaluk Khulya forest patch (23°12′50.4″N, 87°15′31.1″E), both in Radhanagar Forest Range, Bankura district, West Bengal (Deb 2014). The first two trees, however, were felled by the State forest department during a rotational timber harvest operation in 2005.

Owing to the remarkable absence of flowering of these trees during the period from March 2002 to March 2015, our attempt at identification of the tree was not successful beyond establishing its family Cordiaceae. Vernacular nomenclature clues also proved futile, as the name 'Sitapatra' is not mentioned in any published taxonomic literature dealing with flora of eastern India (e.g. Long 1859; Prain 1903a, 1903b; Sanyal 1994; Saxena and Brahmam 1995; Rajan et al. 2016). Thus, *Sitapatra* has remained taxonomically unidentified in West Bengal.

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CONTACT Debal Deb 🖾 debdebal@gmail.com

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Table 1. Herbarium	specimens of	Cordia spp.	collected	from Wes	st Bengal

Species	Herbarium	Collector	Collection date	Collection No.	Barcode No.	Location	Coordinates
C. dichotoma	CAL	G. Sen Gupta	20 May 1963	528		Kankrajhor forest, Dist. Paschim Medinipur	22°41′35.4″N, 86°36′07.5″E
	CAL	A.K. Dutta	15 March 1965	680		Bhedia, Dist. Purba Bardhaman	23°35′26.4″N, 87°42′32.2″E
С. туха	CAL	s. coll.	May 1979	837		Bela riverside, Dist. Jalpaiguri	Not located
	CAL	s. coll.	s.d.	315		Murul (= Murlu) Hill, Dist, Puruliva	23°31′28.8″N, 86°54′13.9″E
	CAL	A.K. Dutta	14 June 1965	s. no.		Kalyani, Dist. Nadia	22°58′29″N, 88°26′4″E
	CAL	A.K. Dutta	14 June 1965	840		'Around Burdwan', Dist. Purba Bardhaman	Not located
	К	s. coll.	1808	889	K001110166	Dinhatta, Dist. Cooch Behar	26°07'N, 89°28'E, non-existent
	Basudha	D. Deb	May 2016	B005		Bhagabandh, Dist. Bankura	23°13'12.0"N, 87°16'53.9"E
C. macleodii	CAL	G. Sen Gupta	21 May 1963	2248, 2250, 2251, 2252		Kankrajhor forest, Dist. Paschim Medinipur	22°41'42.4"N, 86°35'57.5"E
	K Basudha	W. Griffith D. Deb	Distributed 1862–3 March 2015	5996 B004	K000998063	West Bengal* Bhaluk khulya, Dist. Bankura	? 23°12′50.4″N, 87°15′31.1″E

*Erroneous. See text for details.

Herbarium codes according to Thiers (2014).

The tree's vernacular name *Sitapatra* (= Sita's letter, in Sanskrit and Bengali) derives from the mythological princess Sita, who wrote letters (patra) to her husband Rama on the leaf of this tree. Scratches on the upper surface of the leaf elicit permanent black marks (Figure 1A). This character is not mentioned in the published literature for any tree of Cordiaceae. To identify this tree, we studied all the *Cordia* taxa existing in the State of West Bengal, and compared the morphological characters of each of them to those of our specimen.

Identification of *Sitapatra* with *Cordia* macleodii

After the Sitapatra trees had come to flowering in late March 2015, we were able to examine the diagnostic characters of the plant for taxonomic identification. Comparison of our voucher specimens of leaves, flowers and fruits of Sitapatra showed no morphological difference from the herbarium specimens of C. macleodii (Griffith 5996 K! and Sen Gupta 2248, 2250, 2251, 2252 CAL!) and to a known specimen at the Regional Plant Resource Centre (RPRC) Botanic Garden, Odisha. References to the herbarium specimens are given in Table 1. The identity of Sitapatra as C. macleodii was confirmed based on its morphological descriptions in published literature (Griffith 1843, p. 363-364; Prain 1903a, p. 714; Hooker 1858, p. 128; Clarke 1883, p. 139-140; Roy et al. 1992, p. 283; Saxena and Brahmam 1995, p. 1136-1137; Patil 2003, p. 418-420, 727-728; Mahekar and Yadav 2006, pp. 308-309; Qureshi 2010, pp. 6-7; Rajan et al. 2016, p. 452).

In addition, we conducted molecular analysis of tissues from our material and *C. macleodii*, using sequences of specific chloroplast markers and nuclear DNA fragments from the ITS region, and compared with the sequences of *Cordia* spp. available at GenBank.

Materials and methods

Collection of voucher specimens

Voucher specimens of *Sitapatra* were collected in May 2009 and March 2015 (see Appendix 1).

Examination of type specimens

Comparison of our voucher specimens of *Sitapatra*, collected in 2009 and 2015, showed no morphological difference from the herbarium specimen of *C. macleodii* at Royal Botanic Gardens, Kew (seen by DD in 2009) and the National Herbarium of BSI, Howrah (seen by SKC in 2017). References to the herbarium specimens are given in Table 1.

Specimens examined

INDIA: West Bengal: Bhalukkhulya forest plot, Bankura district, 23°12′57.7″N, 87°15′56.08″E, 77 m, *V.S.* 12 March 2015, *D. Deb, B0001/2015* (Basudha Laboratory, Kolkata); *V.S.* 29 March 2015, *D. Deb, B0004/2015* (Basudha Laboratory, Kolkata) (see Appendix 1).

For molecular analysis, leaf samples of *Sitapatra* were collected from the voucher specimens; samples of *C. macleodii* were collected from RPRC, Bhubaneswar, Odisha.

Description of Sitapatra

Medium-sized deciduous tree, height not exceeding 6 m. Light brown bark. Leaves: light green, ovate, 8-12 cm \times 6-9 cm; obtuse-ovate; petiolate. Upper surface of



Figure 1. Leaf, flower and fruit morphologies of *Sitapatra*. (A) A leaf blade with scratch marks. (B) A branch with leaves and buds. (C) Corolla tube with or without calyx. (D) Pentamerous corolla with stamens. (E) Hexaermous corolla with stamens. (F) Ovary and style. (G) Young fruits with persistent calyces and style. (H) Mature fruits.

young leaves pubescent. Undersurface of a light colour, densely tomentose with grey or yellowish hairs; subentire, slightly undulate, finely serrate margin in mature leaves. Base: often cordate. Three to five-nerved from base. Petiole long (4–7.5 cm). Pinnate venation. Upon scratching on upper surface, exudate turns black upon contact with air, leaving a permanent black mark on the leaf surface (Figure 1A). Leafless when in flower. Phyllotaxy: alternate (Figure 1B). Polygamous: male and female flowers occur on different trees. Inflorescence: particulate cyme; flowers paniculiform, in terminal axillary corymbs, diameter 5-10 cm. Creamy white flowers, either male or female, in short terminal corymbs. Calyx: five sepals, gamophyllous, green, tomentose outside, cupuliform; length equal to that of corolla (Figure 1C), 6-8 mm in flower, 8-10 mm in fruit, five to six-ribbed, suboblate in shape. Corolla: pentamerous (Figure 1D), sometimes hexamerous (Figure 1E); gamophyllous, salver shaped, 9-15 mm diameter, subrotate; corolla tube ligulate-obtuse, 8 mm, glabrous within. Pentamerous

and hexamerous flowers occur on the same tree. Petals: united, connate, reflexed, creamy white. Style: terminal, simple, 1 cm, then two-cleft; branches again two-cleft (Figure 1F); often seen remnant in immature fruits (Figure 1G); no style in male flowers. Ovary: superior, 0.9 mm, with erect style; four-celled; rudimentary in male flowers. Stamens (five or six) alternate with corolla lobes; adnate to corolla tube; filaments 4 cm. Anthers exserted, sagittate; larger in male flowers than in bisexual flowers. Fruit: drupe, yellow-brown, black upon drying, 1.2–2.2 cm long, 1.2 mm broad at middle, ovoid, acute with apical hook of length 1.9–3 mm, somewhat tomentose (Figure 1H); seated on campanulate, ribbed or striated calyx. Seed single, exalbuminous.

Phenology

Flowering: March to April. None of the trees in the area came to flowering in 12 years (from March 2002 to April 2015). Fruiting: May.

Notes

- (1) The morphological characters match those of *Cordia macleodii* (Griff.) Hook. f. & Thoms, except two following features:
- (i) Flowers with five (pentamerous) and six (hexamerous) petals and stamens occur on the same tree (Figure 1C) (vs tetramerous and pentamerous).
- (ii) Absence of flowering for a period longer than a decade (never reported in literature).
- (2) Autecological characters like the prolonged absence of flowering, and the occurrence of male and female flowers on different trees cannot be discerned from any type specimen in the herbarium.

Based on the autecological variation described above, the possibility of the specimens of *Sitapatra* under study representing a subspecies of *C. macleodii* may not be ruled out. Nevertheless, the above characters appear to be adaptive features of the local population, possibly in response to certain unknown environmental stress. We surmise that the *Sitapatra* trees described here may constitute a subpopulation within the species population of *C. macleodii*.

Molecular analysis

Total genomic DNA were isolated from leaf samples of *Sitapatra* (our voucher specimens), *Cordia macleodii* (collected from Odisha) and *C. dichotoma* (collected from West Bengal) according to CTAB procedure (Doyle and Doyle 1987) with minor modifications. The polymerase chain reactions were performed in a total volume of 25 μ l, which contained 30–60 ng plant DNA, 50 mM Tris-HCl, 1.5 mM MgCl₂, 0.5 mM dNTPs, 2 mM of each primer and 0.5 units of Taq polymerase, following thermal cycles of standardised protocol of respective primers. Sequencing and successive purifications were performed using an ABI Prism Big Dye Terminator Cycle V3.1 Sequencing Kit (Applied Biosystems, Foster City, CA, USA) following the manufacturer's protocols.

Initially, we amplified the primer pairs for four chloroplast regions (*rbcL*, *matK*, *trnL-trnF*, *rps16*) and a nuclear region in a subset of the samples. However, based on sequence availability in the GenBank, sequencing quality and discriminatory power, two chloroplast markers, *trnL-trnF* (Taberlet et al. 1991) and *rps16* (Oxelman et al. 1997), as well as nuclear DNA fragments

from the ITS region (Gottschling et al. 2001) were used for further analysis.

All DNA sequences were double-checked manually, and insertions/deletions (indels) were excluded. Multiple sequence alignment was performed for each gene separately with ClusalW implemented in MEGA 5.2 (Tamura et al. 2011). Individual alignments were then concatenated to produce a three-gene alignment for the two samples of *C. dichotoma*, one sample of *C. macleodii* and the sample of *Sitapatra* (Table 2). In order to build a phylogenetic tree to ascertain the identity of *Sitapatra*, the sequences of in-group and out-group taxa from Cordiaceae, Ehretiaceae and Heliotropiaceae were retrieved from GenBank following Gottschling et al. (2014) (Supplementary Table S-2).

A phylogenetic tree was constructed using the Maximum Likelihood (ML) method, implemented in RAxMLGUI (Silvestro and Michalak 2012). For the ML analysis, robustness was assessed by running 10,000 fast bootstrap replicates using the GTR + GAMMA nucleotide model. Model selection was based on the Akaike Information Criterion using the program jModelTest v.2.1.7 (Darriba et al. 2012).

The phylogenetic tree reveals two distinct clades: clade one mostly replete with Cordiaceae and Heliotropiaceae taxa; and clade two with Ehretiaceae members. *Sitapatra* being nested in Cordiaceae clade remained the closest sister taxon to *Cordia macleaodii* voucher specimens collected from Odisha, thereby confirming the higher phylogenetic relatedness between *Sitapatra* and *C. macleodii*, compared to any other species (Figure 2).

This confirms our inference from the examination of morphological characters that *Sitapatra* is no different from *C. macleodii*, except for two autecological characters described above.

Key to Cordia spp. in West Bengal

- (3a) Leaves glabrous or only hairy on the nerves. Calyx glabrous or slightly pubescent. Fruit 15–20 mm long *C. dichotoma*

Table 2. GenBank accession codes of the marker gene sequences from specimens of Sitapatra, authenticated C. macleodii and C. myxa.

	GenBank Accession No.				
Gene or gene associates	Sitapatra (BAF2009-spatra_WB)	Cordia macleodii (BAF2016-spatra_ Orissa)	Cordia dichotoma (BAF2015-bkuri_WB)		
ITS	KX951413	KY464044	KY458758		
rps16	KY486777	KY486778	KY486779		
trnL-trnF	KY463771	KY463772	KY463773		
rbcL	KY497954	KY497955	KY523901		
matK	KY497953	KY523899	KY523900		



Figure 2. Maximum Likelihood tree showing the taxonomic relationship of *Sitapatra* with other taxa of Cordiaceae, Ehretiaceae and Heliotropiaceae. The numbers at the nodes indicate bootstrap support.

Distribution of Cordia spp. in West Bengal

Cordia sebestena L. Prain, Bengal Pl. 2: 714, 1903. Bengali: *Raktarag*.

A non-native species, planted in gardens as ornamental tree with bright orange to red flowers. One such specimen is in the garden of the Raj Bhavan (the Governor's residence), Kolkata (Mukhopadhyay and Chakraverty 2008, p. 34), and another in the AJC Bose Indian Botanic Garden, Shibpur. Record of other specimens in West Bengal, if any, is not available.

Cordia dichotoma G. Forst. f. Prodr. Fl. Ins. Austr. 18: n. 110, 1786;

Sanyal, Fl. Bankura Dist. 277, 1994; *C. obliqua* Willd. Phytogr. 1(4): t.4, 1794; C.B.Cl. in Hook. f., Fl. Brit. India 4: 137, 1883, excl. var. *C. myxa* auct. plur. non L., 1753; Roxb. Fl. Ind. 2: 332, 1824; C.B.Cl. in Hook. f., Fl. Brit. India 4: 136, 1883; Prain, Bengal Pl. 2: 714, 1903. Bengali: *Boyerkuri, Atha phal.*

Although *C. myxa* and *C. dichotoma* are distinct species, their descriptions in the context of Indian flora are often

confusing. *C. dichotoma* is not mentioned in Clarke (1883, p. 136) nor in Prain (1903a, p. 714, 1903b, p. 231), who describe *C. myxa* L. Early herbarium specimens at Kew, collected from West Bengal, describe *C. myxa* L. In the National Herbarium of BSI, specimens of both *C. myxa* and *C. dichotoma* exist, but *C. myxa* is now understood to be confined to Asia Minor and Egypt. The literature based on these specimens, namely Sanyal (1994, p. 277) and Rajan et al. (2016, pp. 452–453), treat '*C. myxa* auct, non L' as a synonym of *C. dichotoma* Forst. One of the prominent traits that distinguish the two species is the fruit colour: the ripe fruit of *C. myxa* is blackish (Bouby et al. 2011), whereas the *C. dichotoma* fruit is soft pink when ripe.

C. dichotoma has pan-Indian distribution. Prain (1903a, p. 714) describes the distribution of the species to be ubiquitous – 'in all the provinces' of India (then including Pakistan and Bangladesh). No type was described from West Bengal, but an isotype (*N. Wallich 893* MO) was collected in 1813 from Sylhet, Bangladesh. The BSI herbarium specimens show collections from the districts of Midnapore (now Paschim Medinipur), Bankura, Cooch Behar, Bardhaman (now Paschim Bardhaman), Jalpaiguri, Puruliya and Nadia. Roy and Mukherjee (2011, p. 691) also reported its occurrence in a township of Nadia district. Prain (1903b, p. 321) surmised the trees of this species were 'often planted' in the Sunderban area (across the districts of North and South

24 Parganas). Our survey indicates a large population of this species distributed in 10 districts of West Bengal (Supplementary Table S-1 and Figure 1).

Cordia grandis Roxb. Fl. Ind., ed. Carey & Wall. 2: 335, 1824;

C.B.Cl. in Hook. f. Fl. Brit. India 4: 137, 1883; Gamble, Trees, Shrubs, Climbers, Darjeeling Distr. 57, 1896; Prain, Bengal Pl. 2: 714, 1903; Grierson & D.J. Long. Fl. Bhutan 2(2): 871, 1999. Syn. *C. cordifolia* Wall. Numer. List [Wallich] 894, 1829.

The Kew catalogue data of this species, namely 1867, *J.D. Hooker s. n.* (K[K000998069]) and n.d., *s.coll. 892* (K[K001110183, K001110184, K001110185, K001110186, K001110187]) collected from India show its name as '*C. grandis* Wall', which is incorrect.

Within West Bengal, this species occurs sparsely in the district of Darjeeling (Gamble 1878, p. 57; Rajan et al. 2016, p. 453), neighbouring to Sikkim and Bhutan, where it is common (Grierson and Long 1999). *Cordia macleodii* (Griff.) Hook. f. & Thoms., J. Proc. Linn. Soc. Bot. 2: 128, 1858.

C.B.Cl. in Hook. f. Fl. Brit. India 4: 139. 1883. Bas. *Hemigymnea macleodii* Griff. Calcutta J. Nat. Hist. 3: 363, 1843. (=) *Gerascanthus macleodii* (Hook. f. & Thoms.) Borhidi, Acta Bot. Hung. 34: 405. 1988. Bengali: *Sitapatra*.

Early records of *C. macleodii* (Griffith 1843; Clarke 1883; Prain 1903a) show its distribution in central India and Chota Nagpur, to the west of today's West Bengal.

The type specimen (n.d., *Griffith 5996*, K!), originally in the East India Company's collection, was transferred to the Royal Gardens, Kew in 1862–3. The catalogue data of this specimen describe East Bengal as origin, although Griffith (1843) mentions the original collection by D. Macleod from Jabalpore, Central India. Furthermore, in the Kew herbarium label, the printed word 'East' is struck out and 'West' is written, to indicate West Bengal as the origin. It is plausible that the herbarium was sent



Figure 3. Map showing distributions of *Cordia dichotoma* (red circle), *C. macleodii* (green circle), *C. grandis* (black circle) and *C. sebestena* (blue circle) in West Bengal. The locality data derived from our own field survey are indicated by circles with a white dot.

from one of the East India Company's offices in 'East Bengal' to Kew. Understandably, this place name posed some confusion to the modern curators of Kew, who failed to locate East Bengal on the world map, and eventually decided to change the place name instead to West Bengal. Because Griffith's type was originally collected from central India (Griffith 1843), and because the State of West Bengal did not exist until 1947, Kew's record of the place of collection as 'West Bengal' (http://specimens. kew.org/herbarium/K000998063) is an obvious error.

Although Griffith (1843) did not explicitly designate a type collection, the protologue (Griffith 1843) is obviously based on Griffith's own collection (sent to him by D. Macleod). In the absence of any older specimen, we choose to designate this specimen (*Griffith 5996* K!) as the holotype of the name *Hemigymnia macleodii* (which Griffith placed, curiously, under Verbenaceae family). However, in view of the fact that Hooker (1858, p. 128) mentioned several syntypes collected after Griffith (1843), *Griffith 5996* (K) may also be designated as lectotype of the name *Cordia macleodii*.

The occurrence of *C. macleodii* in West Bengal was first mentioned in Sanyal (1994, p. 277), based on which Rajan et al. (2016, pp. 452–453) include it in their *Flora of West Bengal*, and the National Herbarium of BSI collection (CAL) contains a few specimens from the district of Paschim Medinipur (Table 1).

Conservation status of *Cordia macleodii* in West Bengal

Based on the available data from herbaria (Table 1), published literature and our own survey data (Supplementary Table S-1), the locations of occurrence of *Cordia* spp. in different districts of West Bengal are depicted in Figure 3, which shows the limited extent of occurrence of *C*. macleodii in West Bengal. C. macleodii is rare in eastern India, and recently reported to be Endangered in Odisha (Rawat 2008, p. 182). In West Bengal, no mention of Sitapatra as the vernacular name of C. macleodii and its status is available. Our own survey, conducted intermittently from 2002 to 2014, recorded the existence of only five mature individuals, occurring in two locations of Bankura district (Supplementary Table S-1). While IUCN assessment of the species is not available, our survey records indicate its status to be Critically Endangered, based on the IUCN (2001) Red List criteria B1 (extent of occurrence estimated to be $< 100 \text{ km}^2$), B2 (habitat severely fragmented; observed, inferred or projected decline in area, extent and/or quality of habitat), C (number of mature individuals < 250), C2 (no subpopulation containing > 50 mature individuals) and D (population size estimated to number < 50 mature individuals). Considering the critically small number of mature individuals in West Bengal, combined with its status of Endangered in Odisha (Rawat 2008), and the absence of flowering and fruiting for 12 years until

2015 in the population in Bankura district, we conclude that the species is Critically Endangered in eastern India.

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Disclosure statement

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ORCID

Debal Deb http://orcid.org/0000-0002-7230-659X *Bo Li* http://orcid.org/0000-0003-1628-8128 *Avik Ray* http://orcid.org/0000-0003-1662-7679

References

- Bouby L, Bouchett A, Figueiral I. 2011. Sebesten fruits (*Cordia myxa* L.) in Gallia Narbonensis (southern France): a trade item from the Eastern Mediterranean? Veget Hist Archaeobot. 20:397–404.
- Clarke CB. 1883. Order Loganiaceae. In: Hooker, JD, editor. The flora of British India. Vol. 4, Part X. L. Kent: Reeve & Co. http://krishikosh.egranth.ac.in/handle/1/2027746.
- Darriba D, Taboada GL, Doallo R, Posada D. 2012. jModelTest 2: more models, new heuristics and parallel computing. Nat Methods. 9:772.
- Deb D. 2014. The value of forest: an ecological economic examination of forest people's perspective. In: Fenning T, editor. Challenges and opportunities for the world's forests in the 21st century. Heidelberg: Springer; p. 123–159.
- Doyle JJ, Doyle JL. 1987. A rapid DNA isolation procedure for small quantities of fresh leaf tissue. Phytochem Bull. 19:11–15.
- Gamble JS. 1878. List of the trees, herbs and large climbers, found in the Darjeeling District, Bengal. Calcutta: Bengal Secretariat Press.
- Gottschling M, Hilger HH, Wolf M, Diane N. 2001. Secondary structure of the ITS1 transcript and its application in a reconstruction of the phylogeny of Boraginales. Plant Biol. 3(6):629–636.
- Gottschling M, James S, Wiegend M, Hilger HH. 2005. Congruence of a phylogeny of Coridaceae (Boragniales) inferred from ITS1 sequence data with morphology, ecology, and biogeography. Ann Missouri Bot Gard. 92:425–437.
- Gottschling M, Luebert F, Hilger HH, Miller JS. 2014. Molecular delimitations in the Ehretiaceae (Boraginales). Mol Phylogen Evol. 72:1–6.

- Grierson AJC, Long DG. 1999. Flora of Bhutan. Edinburgh: Royal Botanic Garden Edinburgh & Royal Government of Bhutan.
- Griffith W. 1843. Remarks on a few plants from central India. Calcutta J Nat Hist. 3:361–367 https://babel.hathitrust. org/cgi/pt?id=umn.31951d02153723j.
- Hooker JD. 1858. Note. J Proc Linn Soc Bot. 2:128. http://www. biodiversitylibrary.org/item/8352#page/340/mode/1up.
- International Union for the Conservation of Nature and Natural Resources. 2001. Red list: categories and criteria (version 3.1). Cambridge (UK): IUCN/SSC Red List Programme. http://www.iucnredlist.org/apps/redlist/ static/categories_criteria_3_1#critical.
- Long RJ. 1859. Indigenous plants of Bengal. Calcutta: Bishops College Press.
- Luebert F, Cecchi L, Frohlich MW, Gottschling M, Guilliams CM, Hilger HH, Hasenstab-Lehman KE, Miller JS, Mittelbach M, Nazaire M, et al. 2016. Familial classification of the Boraginales. Taxon. 65(3):502–522.
- Mabberley DJ. 2008. Mabberley's plant book: a portable dictionary of plants, their classification and uses. 3rd ed. Cambridge: Cambridge University Press.
- Mahekar PD, Yadav SR. 2006. Biodiversity in India. Vol 4, Pullaiah T, editor. New Delhi: Regency Publications. Medicinal plants of southwestern Maharashtra; p. 75–563.
- Mukhopadhyay DP, Chakraverty RK. 2008. Plant wealth of the Raj Bhavan, Kolkata. Kolkata: Raj Bhavan. Occasional Paper 5.
- Oxelman B, Lidén M, Berglund D. 1997. Chloroplast rps16 intron phylogeny of the tribe Sileneae (Caryophyllaceae). Plant Syst Evol. 206(1–4):393–410.
- Patil DA. 2003. Flora of Dhule and Nandurbar districts (Maharashtra). New Delhi: Botanical Survey of India.
- Prain D. 1903a. Bengal plants. Vol. II. Calcutta: N.W. & Co.
- Prain D. 1903b. Flora of the Sunderbuns. Rec Bot Surv India. 2:231–345.
- Qureshi MN. 2010. Phytochemical and pharmatological evaluation of *Cordia macleodii* and *Leucas ciliate* [Ph. D. dissertation]. Kolkapur: Shivaji University. http:// shodhganga.inflibnet.ac.in/handle/10603/4272.
- Rajan V, Lakshminarasimhan P, Das SS, Chowdhery HJ, editors. 2016. Flora of West Bengal. Vol. 3. Kolkata: Botanical Survey of India.
- Rawat GS. 2008. Special habitats and threatened plants of India. ENVIS Bull: Wildlife Protected Areas. 11(1):175–186.

- Roy D, Mukherjee SK. 2011. Diversity of trees in Kalyani township in West Bengal. J Econ Taxon Bot. 35:687–695.
- Roy GP, Shukla BK, Dutt B. 1992. Flora of Madhya Pradesh: Chhattarpur and Damoh. New Delhi: Ashish Publishing House.
- Santapau H, Henry AW. 1973. A dictionary of flowering plants of India. New Delhi: Publication and Information Directorate, CSIR.
- Sanyal MN. 1994. Flora of Bankura District, West Bengal. Dehra Dun: Bishen Singh Mahendra Pal Singh.
- Saxena HO, Brahmam M. 1995. The flora of Orissa. Vol.2. Bhubaneswar (India): Orissa Forest Development Corporation Ltd.
- Silvestro D, Michalak I. 2012. raxmlGUI: a graphical frontend for RAxML. Org Diversity Evol. 12(4):335–337.
- Taberlet P, Gielly L, Pautou G, Bouvet J. 1991. Universal primers for amplification of three non-coding regions of chloroplast DNA. Plant Mol Biol. 17(5):1105–1109.
- Tamura K, Peterson D, Peterson N, Stecher G, Nei M, Kumar S. 2011. MEGA5: molecular evolutionary genetics analysis using maximum likelihood, evolutionary distance, and maximum parsimony methods. Mol Biol Evol. 28:2731– 2739.
- Thiers, B. 2014. Index herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/ ih/.

Appendix 1

- Type specimen of *C. macleodii*: *Griffith* 5996 (K!), http://apps.kew.org/herbcat/detailsQuery.do?barcode=K000998063. Paratypes of *C. macleodii* from West Bengal: *Sen Gupta* 2248, 2250, 2251, 2252 (CAL!).
- (2) Two voucher specimens of *Sitapatra* were collected from Bankura. The first specimen was collected by Debal Deb on 12 May 2009, No. B001; the second was collected by Debal Deb on 29 March 2015, No. B004; both herbaria preserved at Basudha's laboratory in Kolkata. http://cintdis.org/wp-content/ uploads/2017/12/Sitapatra.jpg.

Supplementary Information

District	Location of	Coordinates	Species	No. of
	Occurrence	(Closest within 150 m)		Trees
Alipurduar	Jayanti riverside	26°37'43.2"N, 89°40'13.1"E	C. dichotoma	2
	Bhaluk Khulya forest	23°12'57.7"N, 87°15'56.08"E	C. macleodii	2
	Amchura	23°13'50.1"N, 87°19'30.8"E	C. macleodii	3
Bankura	Bhagabandh	23°13'13.54"N, 87°16'55.8"E	C. dichotoma	4
	Panchal	23°13'43.6"N, 87°17'28.4"E	C. dichotoma	2
	Arjunpur	23°12'23.08"N, 87°17'35.6"E	C. dichotoma	1
	Boidhya	23°12'55.24"N, 87°17'07.07"E	C. dichotoma	1
Purba Bardhaman	Kasthasali	23°27'42.39" N, 88°21'03.54"E	C. dichotoma	1
Dirhhum	Garia	24°07'19.3" N, 87°38'7.7" E	C. dichotoma	1
Bironum	Chhora	23°55'1.4" N, 87°28'50.0"E	C. dichotoma	3
Durba Madininur	Tiorkhali	22°0'41.2"N, 87°50'20.3"E	C. dichotoma	2
Purba Medinipur	Lakhi	21°59'20.6" N, 87°50'20.3" E	C. dichotoma	2
Paschim	Purnapani	22°33'58.9" N, 87°04'52.1" E	C. dichotoma	4
Medinipur	Balijuri	22°23'38.6" N, 87°08'23.3" E	C. dichotoma	3
	Kalyani University	22°59'01.2"N, 88°26'44.8"E	C. dichotoma	3
Nadia	Kalyani Township	22°58'04.3"N, 88°25'49.8"E	C. dichotoma	1
	Nabadwip	23°23'49.3"N, 88°22'15.7"E	C. dichotoma	1
Duraliyo	Panchet Hill	23°37'11.6"N,86°45'31.59"E	C. dichotoma	5
Fulunya	Ayodhya Hill	23°09'42.19"N, 86°06'20.65"E	C. dichotoma	3
North 24 Parganas	Andharmanik	22°45'44.5"N, 88°46'17"E	C. dichotoma	2
South 24	Batanagar	22°30'46.8"N, 88°13'23.6"E	C. dichotoma	1
Parganas	Barjuli	22°31'22.3"N, 88°46'17.9"E	C. dichotoma	1

Table S-1: Authors' Survey Records of live specimens of *Cordia* spp. in West Bengal.

Supplementary Information

Species	rps16	trnL-trnF	ITS
Bourreria exsucca	KF673332	KF673291	KF673264
Bourreria moaensis	KF673326	KF158205	KF673250
Cordia dentata	HQ286263	EU600006	AY176069
Cordia decandra	EF689005	EF688851	EF688903
Cordia guineensis	KF158172	KF158203	JF332096
Cordia lutea	KF158186	KF158215	AY176070
Cordia monoica	KF158171.1	KF158202	JF332095
Cordia myxa*	HQ286262	EU600004	JF332094
Cordia nodosa	HQ286261	HQ286269	AY176072
Cordia saccellia	KF158177	KF158208	JF332111
Ehretia (Rotula) aquatica	HQ286264	EU600011	AF385791
Ehretia anacua	KF158175	EU600009	AF385796
Ehretia cymosa	HQ286265	EU600012	AF385790
Ehretia longiflora	KF158178	EU600010	AY331400
Ehretia microphylla	KF158173	KF158204	AF469166
Ehretia tinifolia	HQ286266	HQ286270	AF385793
Euploca campestris	EF688959	EF688803	EF688856
Halgania cyanea	KF158179	KF158209	KF673254
Heliotropium adenogynum	HQ286232	HQ286139	HQ286111
Ixorhea tschudiana	HQ286260	HQ286166	HQ286134
Hoplestigma klaineanum	DQ197035	KF158216	DQ197283
Rochefortia lundellii	KF158180	KF158210	KF673258
Rochefortia spinosa	KF673327	KF673276	KF673251
Tiquilia dichotoma	KC542729	KC542551	KF673269

Table S-2: A list of species and their corresponding GenBank accession numbers used in building phylogenetic tree in Fig. 3.

* syn. of *C. dichotoma*.