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RESEARCH ARTICLE

Cleistanthus nokrensis (Euphorbiaceae), a New Species from Indian Himalaya

Bikarma Singh[1,2*], S.K. Borthakur[3] and S. J. Phukan[4]

1. Plant Biotechnology Division (Herbarium & Plant Systematic Section), CSIR-Indian Institute of Integrative Medicine, Canal Road, Jammu-Tawi-180001, India.
2. Academy of Scientific and Innovative Research, Anusandhan Bhawan, 2 Rafi Marg, New Delhi-110001, India.
3. Department of Botany, Gauhati University, Guwahati-781014, Assam, India.
4. Botanical Survey of India, Eastern Regional Circle, Shillong 793001, India.
** Corresponding author. Email: drbikarma@iiim.ac.in*

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ABSTRACT: A new species, *Cleistanthus nokrensis* (Euphorbiaceae), was collected and described from Indian Himalaya. This species is confined to the Nokrek Biosphere Reserve where it grows on the calcareous habitat in karst topography. On the basis of the critical features of its habitat, branches, petioles, leaves, and fruits, the species is compared with the closely related allied species, *C. tonkinensis* Jabl. and *C. balakrishnanii* Chakrab. Notes on its taxonomic description, photographs, ecology, associated species, population data, and threat perspective as per latest IUCN conservation status are provided. A key to the other taxa in the genus reported from India is provided for the first time, along with their distributional records and endemism.

KEY WORDS: *Cleistanthus nokrensis*, Euphorbiaceae, Indian Himalaya, IUCN Red List, new species.

INTRODUCTION

Myers et al. (2000) estimated that 133,149 plant species and 9,645 vertebrate species occur in 25 hotspots at global level. The presence of two biodiversity hotspots in India viz., Northeast India in Eastern Himalaya (part of the Indo-Myanmar region) and Western Ghats, reiterates the need to undertake effective conservation measures for the endemic and threatened plant species in India (Singh et al., 2012; 2013). Northeast India is one of the most threatened hotspot, due to the rate of resource exploitation and habitat loss. Despite the tough hilly terrain, the region has been explored and studied from a floristic point of view by many distinguished scientists, professors and prominent officers from Botanical Survey of India, Universities and NGOs, although such sporadic inventory work from many interior regions remains unpublished. During the last few decades, a large number of new species, subspecies and varieties have been reported from these regions. During January 2007 to June 2012, several botanical explorations and biodiversity survey works were undertaken by the authors in the Eastern Himalaya and collected unknown bushy shrub specimens of the genus *Cleistanthus* Hook.f. ex Planch. (Euphorbiaceae), with only one population recorded in Nokrek Biosphere Reserve. The taxonomic studies and examination of minor characters revealed this specimen to be a new and distinct species.

The genus *Cleistanthus* (Euphorbiaceae), according to Chakrabarty et al. (2002) and Mabberley (2008) has its centre of diversity in the Old World tropics and represented by 148 species. The Old World tropics comprise Africa, Madagascar, Asia, Malesia, Australia, Micronesia, New Caledonia and Fiji (Dressler, 1999). As per as the published literatures (Chakrabarty et al., 2002; Chakrabarty, 2004; Balakrishnan and Chakrabarty, 2007; Balachandran, 2010), the genus in India were represented by 8 species *viz*., *C. andamanicus* N.Balach., Gastmans et Chakrab., *C. balakrishnanii* Chakrab., *C. oblongifolius* (Roxb.) Müll.Arg. (Basionym=*Clutia oblongifolia* Roxb.), *C. collinus* (Roxb.) Benth. (Basionym=*Clutia collina* Roxb.), *C. malabaricus* (Muell.Arg.) Muell.Arg. (Basionym=*Lebidiera malabarica* Muell.Arg.), *C. patulus* (Roxb.) Muell.Arg. (Basionym=*Clutia patula* Roxb.), *C. travancorensis* Jabl., and *C. sankunnianus* Sivar. & Indu Balach. *C. collinus* is known to be a toxic plant and commonly used as suicidal, homicidal, cattle and fish poison, and for inducing criminal abortion (Parasuraman and Raveendran, 2012). Published floras by Haridasan and Rao (1987), and Kanjilal et al. (1940) reveals that only *C. chartaceus* Muell.-Arg., which is a synonym of *C. oblongifolius* occurs in the Eastern Himalaya of India. The new species description of *Cleistanthus* from the present study area in Himalaya increases its number to 2 species from Northeastern states of India or the Eastern Himalaya, and increases its total number to 9 from India.

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MATERIALS AND METHODS

Study Area

The present new species is recorded from Nokrek Biosphere Reserve (NBR), located in the western parts of the Meghalaya (25˚15' N to 25˚29' N and 90˚13' E to 90˚30', Fig. 1). It was established as a biosphere reserve on 13th September, 1988 and recognized under the UNESCOs Man and Biosphere (MAB) program in 2009 (Singh et al., 2013). The study area spreads in 820 sq km and covers three Hills of Garo districts (Singh et al., 2012). The altitude ranges from 200 m MSL to 1412 m MSL, and the area has a tropical and subtropical climate (Singh et al., 2013). The place is known for the Garo tribe (Achik), Citrus Gene Pool Sanctuary (*Citrus indica*-natural growth), Mahseer fish (*Tor putitora*-an endangered fish), Hoolock Gibbon (*Hoolock hoolock*-an endangered species and the only living Ape in India), Pitcher plant (*Nepenthes khasiana*-insectivorous endemic plant), and many other endemic and RET plant and animal species (Singh et al., 2012; Singh et al., 2011).

Data collection

Extensive field observations were made by the author during eleven expeditions in January 2007 and June 2012 in the Garo Hills, under the Ministry of Environment and Forest, Government of India, funded Project, and for his own doctorate research. The floristic work of the study area was carried out by the author at the Botanical Survey of India at Shillong. The study was conducted in a systematic way of 10 km × 10 km grids for this particular species, which were further divided in forested grids of 1 km × 1 km subgrids in the NBR. The species was also searched in similar habitat of Assam, Arunachal Pradesh, Mizoram, Sikkim, West Bengal and Khasi hills and Jaintia hills of Meghalaya, but could not be recorded in the other localities. The collected new species and other plant specimens were partially described in the field during survey. General habitat, ecology, shape and size of floral elements, leaves, fruits and seeds were studied macroscopically in the field as well as in the laboratory. Digital photographs of the type specimens as well as other species of the area were taken in field and stored. All the collected specimens were processed as per Jain & Rao Herbarium Technique (Jain and Rao, 1977). Specimens prepared from the study area are deposited at the ASSAM herbarium of the Botanical Survey of India and Janaki Ammal Herbarium (Acronym: RRLH) at CSIR-Indian Institute of Integrative Medicine.

Data analysis

Critical studies on the newly discovered specimens were done by comparing and evaluating the herbarium of the new taxa with that of the different herbarium specimens housed at the various herbaria, viz., Central National Herbarium at Kolkata (CAL), Herbarium of Botanical Survey of India (BSI) at Dehradun (BSD), Herbarium of BSI at Andaman & Nicobar Islands (BPL), Herbarium of Forest Research Institute at Dehradun (DD), Herbarium of BSI at Shillong (ASSAM), Herbarium of North-Eastern Hill University (NEHU), Herbarium of Gauhati University (GU), Chinese Virtual Herbarium (CVH), website (http://www.tropicos.org/Name/40010012), expert advice and perusal of literatures (Chakrabarty et al., 2002; Chakrabarty, 2004; Balakrishnan and Chakrabarty, 2007; Balachandran, 2010) relevant to the genus. The specimen is identified as a new species of *Cleistanthus* and is named *C. nokrensis* after the type locality "Nokrek Hills" in the Eastern Himalaya of India. While describing the species, the data collected from the field on habit, ecology, shape and size of floral elements, leaves, fruits and seeds were incorporated from the field diary. Associated plants of this particular species were presented along with the photographs.

RESULTS

The present communication deals with *Cleistanthus nokrensis* sp. nov. (Euphorbiaceae) recently discovered and described from Indian Himalaya. This species is confined to the Nokrek Biosphere Reserve where it grows on calcareous habitat of karst topography. On the basis of the critical features of its habitat, branches, petioles, leaves, and fruits, the species is compared with the closely related allied species, *C. tonkinensis* Jabl. and *C. balakrishnanii* Chakrab. Notes on its taxonomic description, photographs, ecology, associated species, population data, and threat perspective as per latest IUCN conservation status are provided in this research paper. The assessment of the IUCN status of this taxa were evaluated following 2001 IUCN Red List Categories and Criteria version 3.1 and IUCN Guidelines for Application of IUCN Red List Criteria at Regional and National Levels and Criteria version 4.0 (IUCN, 2010) (http://www.iucnredlist.org/technical-documents/categories-and-criteria, accessed 30 July 2013). A key to the other taxa in the genus reported from India is provided for the first time, along with their distributional records and endemism.

Taxonomic enumeration of new taxa

Taxonomic classification as per APG III (APG, 2009):

Regnum (=Kingdom): Plantae Haeckel, 1866
Cladus/Divisionae (=Phylum): Angiosperms (=Tracheo-

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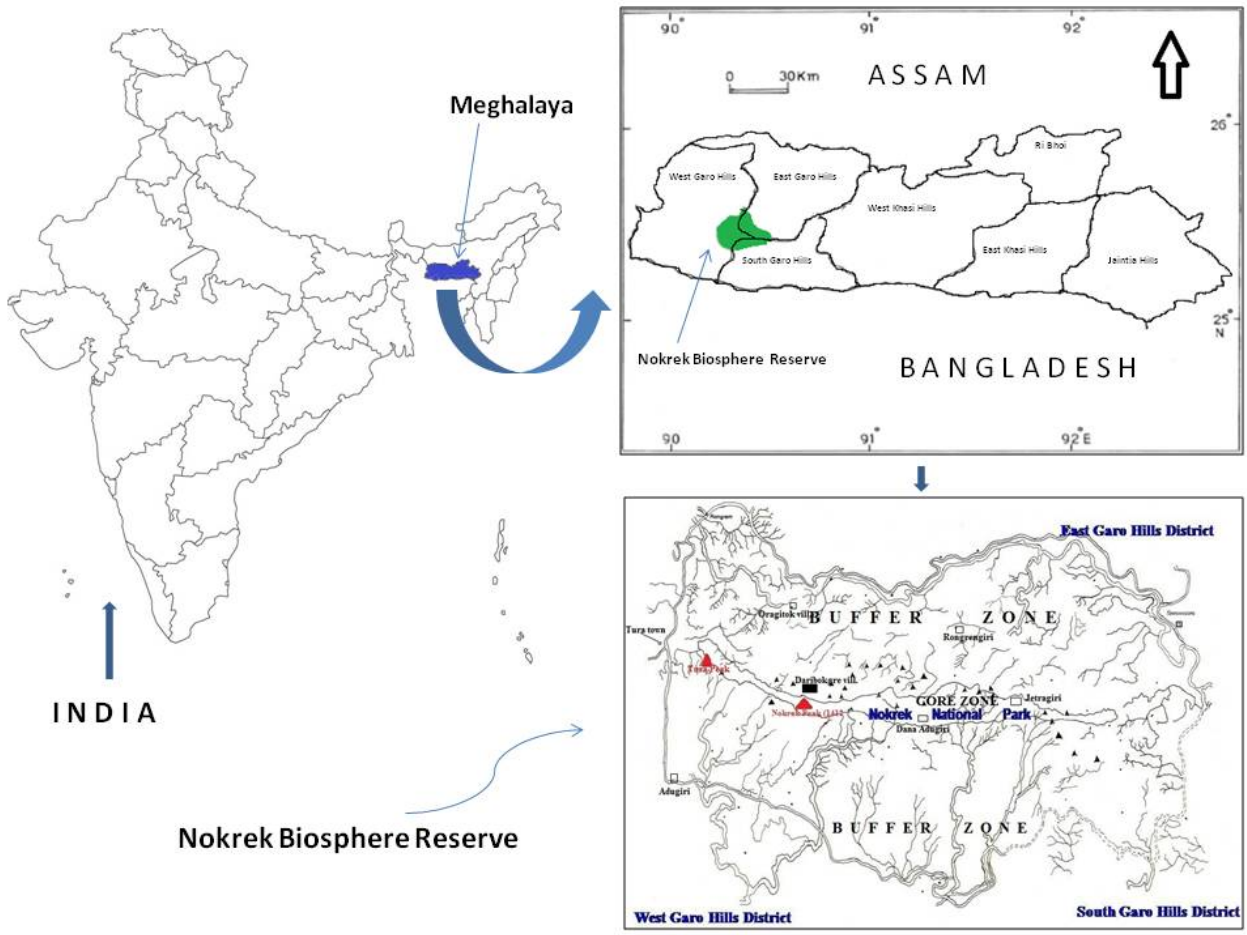


Fig. 1. Location map of the study site Nokrek Biosphere Reserve in India

phyta) APG III, 2009
Class: Magnoliids (Magnoliopsida=Dicotyledons Thorne, 1920) APG III, 2009
Subclass: Magnoliidae APG III, 2009
Superorder: Rosanae Takht., 1967 (APG III, 2009)
Order: Malpighiales Juss. ex Bercht. & J.Presl, 1820 (APG III, 2009)
Family: Euphorbiaceae Juss., 1789, nom. cons.
Genus: *Cleistanthus* Hook.f. ex Planch., 1848
Species: *Cleistanthus nokrensis* B. Singh, *sp. nov.*

Cleistanthus nokrensis B. Singh, ***sp. nov.*** Fig. 2(A–C)

TYPE: INDIA, Eastern Himalaya, Nokrek Biosphere Reserve, Rongsingiri, 267 m, 25˚20'15.43" N, 90˚26'43.37"E, 08 October 2007, *B Singh* 115856 (Holotype, ASSAM).

Etymology: The new specific epithet *nokrensis* refers to the type locality "Nokrek Hills" in the Eastern Himalaya of India. These hills are situated in Nokrek Biosphere Reserve, and the area is known for Nokrek National Park, Citrus Gene Pool Sanctuary (wild habitat of *Citrus indica* Tanaka), Hoolock gibbon (*Hoolock hoolock* -the only living Ape in India) and Mahseer fish (*Tor putitora*-considered as the most sporting species by anglers).

Description: Evergreen bushy medium size shrubs, 2.5–3.5 m tall, profusely branched, prefers karst topography; bark brown, often lenticellate mark; stems glabrous, lenticellate; branchlets scandent, white lenticellate, terete below, flattened and striate towards apices, 0.2–0.4 cm thick, grayish brown to green. Stipules absent, if present minute and deciduous. Leaves alternate, bifarious, elliptic to lanceolate, 7.4–11.6 × 1.7–2.4 cm, base rounded or slightly cuneate, apex shortly acuminate, acumen 0.5–1 cm long, glabrous, margins entire, adaxially glossy, coriaceous, green above, glaucescent below; midrib inconspicuously raised above, conspicuously raised beneath; lateral nerves 5–6 per side, faint, arcuate, anastomosing near margin;

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Fig. 2. *Cleistanthus nokrensis* B. Singh. A: Natural habit. B: Close view of leaves, branches and petioles. C: Close view of capsule. Photo by Dr. Bikarma Singh

tertiary nerves not prominent, faintly looks reticulate; petioles glabrous, semi-terete, slightly red at origin, whitish green thereon, 0.8–1.2 cm long. Inflorescence axillary, few flowered fascicles, 1.5–2.5 cm long; bracts ovate-triangular, margin membranous, ciliate, abaxially pubescent. Flowers monoecious. Male flowers: sepals 5, lanceolate or ovate-triangular, 0.2–0.3 cm, puberulent to glabrous; petals 5, small, scale-like, rhomboid or obliquely quadrate, c. 0.1 cm, margin denticulate; disk cup-shaped; stamens 5; filaments connate more than half their length, topped with rudimentary ovary; anthers usually oblong to ovoid, dorsifixed, extrorse, bilocular, c. 0.1 cm, longitudinally dehiscent; rudimentary ovary trigonous ovoid, glabrous. Female flowers: number of sepals and petals same as in the case of male flowers; disk annular, surrounding base of ovary, tearing into lobes during capsule development; ovary globose, 3-celled; ovules 2 in each cell; styles 3, bifid at apex. Fruiting pedicel very minute, 0.3–0.4 cm long. Capsules sessile, somewhat depressed-globose, 1–1.6 × 1.3–2 cm, scattered puberulous, 3-lobed, green when young, becomes greenish-pink when matured, dark brown when dry; seed 1, obovoid-trigonous, 0.6–0.8 × 0.3–0.4 cm, flattened, greenish-white when young, looks brown when dry.

Phenology: *Cleistanthus nokrensis* was observed in flower from March to May, while fruits were seen from May to July.

Associated species: Common associated species in the study area along with the present species (*C. nokrensis*) includes *Ficus rumphii* Blume, *Duabanga grandiflora* (DC.) Walp., *Bridelia retusa* (L.) Spreng, *Glochidian sphaerogynum* (Müll.Arg.) Kurz, *Lantana camara* L., *Leea indica* (Burm.f.) Merr. and *Pterospermum acerifolium* Willd.

Specimens examined: **INDIA**, Eastern Himalaya, Nokrek Biosphere Reserve, Rongsingiri, 267 m, 25˚20'15.43"N, 90˚26'43.37"E, 08 October 2007, *B Singh* 115856 (Holotype, ASSAM); Rongsingiri, 267 m, 25˚20'15.43"N, 90˚26'43.37"E, 18 May 2009, *B Singh* 51100 (Figure 3 Isotype, RRLH 22396).

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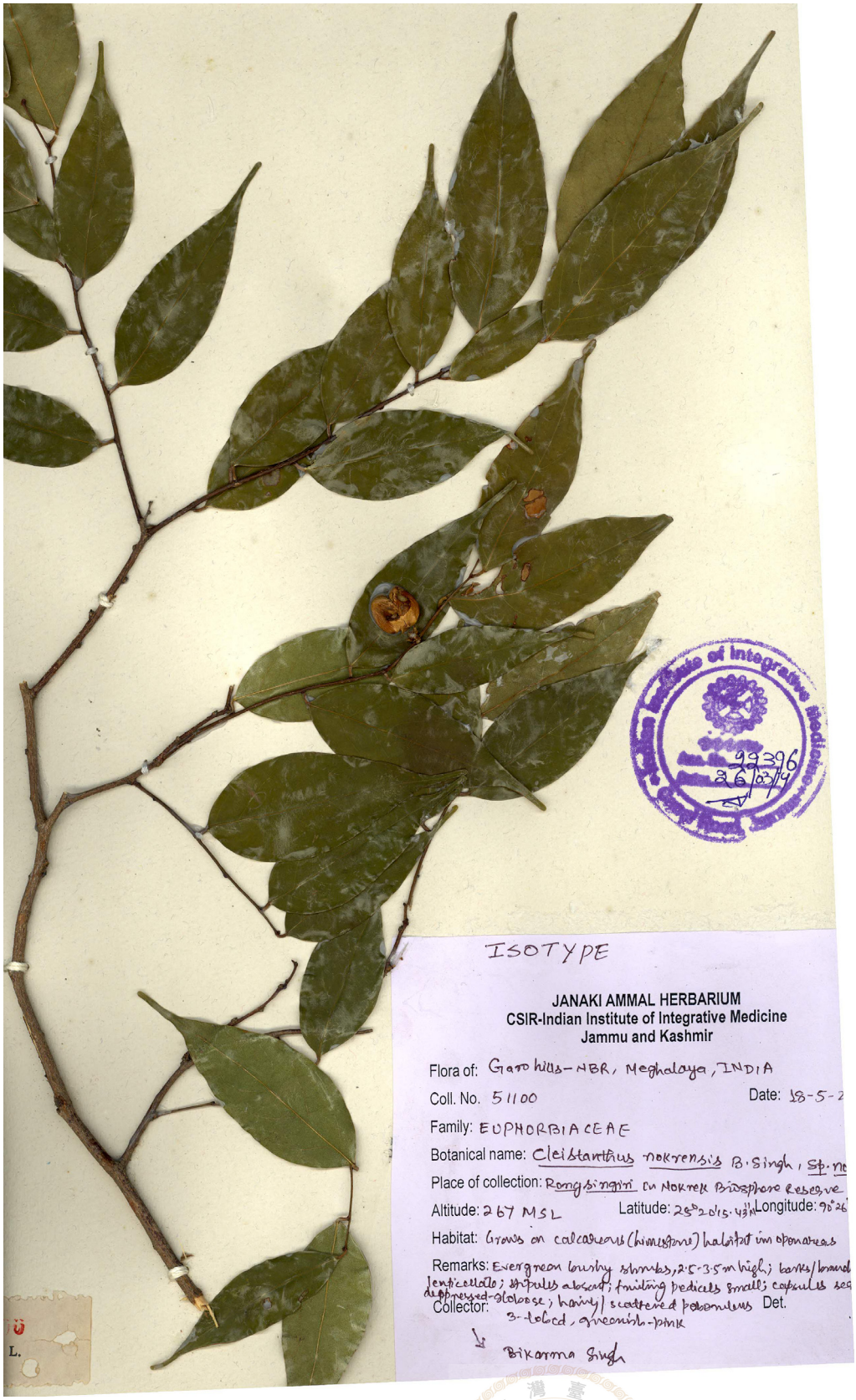


Fig. 3. Herbarium of the *Cleistanthus nokrensis* B. Singh from Nokrek Biosphere Reserve.

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Similar taxa

The new species (*C. nokrensis*) is closely related to *C. tonkinensis* Jabl., whose distribution is recorded so far from China and Vietnam, and *C. balakrishnanii* Chakrab., one of the endemic species of Great Nicobar in India. The species differs by having habit of evergreen bushy medium size shrubs, branches with white lenticellate, petioles red and glabrous (excluding *C. tonkinensis*), acumen 0.5–1 cm long, lateral nerves 5–6 per sides, fruits depressed globose (excluding *C. balakrishnanii*) and size of pedicels, fruits and seeds bigger than the two compared species. The detailed comparisons of the diagnostic characteristics between them are summarized in Table 1.

Distribution and threat status

Cleistanthus nokrensis presented here as an endemic Indian element, is known only from the type locality in tropical dry deciduous forest in Nokrek Biosphere Reserve where it is very rare and local. It grows on calcareous soil in limestone areas, and on rocky substratum, preferably karst topography, i.e. limestone terrain, and the absence of surface water flow. The altitudinal distribution range of the species is between 200–300 m MSL.

According to the author's observation in natural habit, its population size seems to be very restricted. In spite of repeated search in the entire study area in 10 km × 10 km grids, only one population with 56 individuals of the species could be located in Nokrek Biosphere Reserve. Most of the individuals in this locality were adults and were in fruiting stage. Very few saplings of the species were encountered, indicating poor regeneration of the species. The range of this new species is restricted to a single location. The total area of occurrence is approximately 5 ha. Therefore, the new species is classified here from a threat perspective based on population size, extent of occurrence, area of occupancy, and habitat quality following the criteria of IUCN (IUCN, 2001) i.e. 2001 categories & criteria Version 3.1. The author suggest that this species should be placed under the IUCN category "Critically endangered" (CR A2ab (ii, v); B3bc). The details of population data gathered during the field investigation are summarized in Table 2.

Endemism in Indian *Cleistanthus*

Most of the Indian *Cleistanthus* are endemic and their distribution is restricted to one or a few climatic zones. The data reveals that of the total of 9 species (including the new species) recorded so far from Indian states and union territories, 6 species viz. *C. andamanicus, C. balakrishnanii, C. malabaricus, C. nokrensis* (present study), *C. sankunnianus* and *C. travancorensis* are endemic to Indian soil, and the other 3 species extended their geographic distribution in other parts of Southeast Asia and Africa (Table 3). Modeling strategies for predicting the potential impacts of climate change on the natural distribution of species have focused on the characterization of a species bioclimatic envelope (Pearson and Dawson, 2003). Data indicate that most of the endemic species of Indo-Myanmar hotspot are rare, and their distributions are localized. The rare species tended to be more aggregated than abundant ones, and that smaller individuals of a species tended to be more aggregated than larger individuals.

Taxonomic keys to the Indian *Cleistanthus* taxa

While evaluating the new species from the different herbaria of the country and abroad, and comparing the description of the species, the authors prepared a key for the easy identification of the Indian *Cleistanthus*. The key is mainly based on morphological characters of the 8 *Cleistanthus*, which were recorded from the wild. One of the species *C. sankunnianus* is a cultivated species and therefore, its identification is easy, and not included in the presented key.

Artificial key to the species of *Cleistanthus* in India

1a. Leaves coriaceous, short acumen, and lateral nerves fewer, petioles and fruits are glabrous ……. ***C. andamanicus***
1b. Leaves otherwise, acumen longer, and lateral nerves, petioles and fruits are otherwise ……. 2
2a. Leaves rounded, retuse or apiculate at apex ……..… ***C. collinus***
2b. Leaves acuminate or caudate at apex ……... 3
3a. Fruits stipitate (with a gynophore); leaves densely (or rarely sparsely) and finely appressed golden brown, coppery or silvery sericeous beneath ……..…….. ***C. oblongifolius***
3b. Fruits not stipitate; leaves not sericeous beneath, glabrous or pilose or hirsute on the nerves or tomentose beneath …….. 4
4a. Stipules present, size ranges between 0.6–1.1 cm long …… 5
4b. Stipules absent or if present, size ranges between 0.2–0.5 cm long ……. 7
5a. Leaves pilose or scattered hirsute on major nerves beneath; inflorescences arising on main leafy branches … ***C. malabaricus***
5b. Leaves otherwise; inflorescences arising on special small-leaved branches …… 6
6a. Leaves chartaceous, sparsely rufous-pilose beneath; ovate or elliptic, acumen 1.5–3 cm long; lateral nerves 7–10 per side; capsules sessile to subsessile, scattered ochraceus-puberulous, green, 3-lobed when matured, 0.6–0.7 × 0.7–0.8 cm; seeds 1, broadly ovoid-oblong, ca 0.4 cm ……. ***C. balakrishnanii***
6b. Leaves chartaceous, glabrous on both sides, elliptic to lanceolate, rounded or slightly cuneate, shortly acuminate at apex, acumen 0.5–1 cm long; lateral nerves 5–6 per sides; capsules sessile, scattered puberulous, green when young, greenish-pink when matured, 3-lobed when matured, 1–1.6 × 1.3–2 cm; seeds 1, obovoid-trigonous, ca 0.8 cm ……..…….. ***C. nokrensis***
7a. Inflorescences borne on special small leaved or leafless branchlets; fruits depressed, 0.5–1.2 × 1-1.5 cm, sessile ……... ……. ***C. patulus***
7b. Inflorescences borne on main leafy branches; fruits subglobose, 0.3–0.5 × 0.4–0.6 cm, pedicellate ……. ***C. travancorensis***

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Table 1. Morphological comparison of the diagnostic characteristics of *Cleistanthus nokrensis* and two congenera.

Character	*C. nokrensis*	*C. balakrishnanii*	*C. tonkinensis*
Habit	evergreen bushy medium size shrubs, 2.5–3.5 m tall	normal medium size shrubs, 3.5–4 m tall	tree-like shrubs, 3–5.5 m tall
Branches	brown to greenish-white, glabrous, white lenticellate	brown to black, rufous-villous when young, scattered pilose when matured, lenticellate absent	green, pilose when young, glabrous when matured, brown lenticellate
Petioles	slightly red, glabrous, 0.8–1.2 cm long	green, scattered puberulous, 1–1.5 cm long	green, glabrous, 0.4–0.8 cm long
Leaves	alternate; leaflets chartaceous, glabrous on both sides, elliptic to lanceolate, rounded or slightly cuneate, shortly acuminate at apex, acumen 0.5–1 cm long; lateral nerves 5–6 per sides	alternate; leaflets chartaceous, sparsely rufous-pilose beneath; ovate or elliptic, base obtuse, apex acuminate, acumen 1.5–3 cm long; lateral nerves 7–10 per side	alternate; chartaceous, glabrous on both side, ovate or elliptic, leathery, base obtuse, apex long acuminate, acumen 1.5- cm long; lateral veins 8–10 per side
Inflorescence	axillary, few flowered fascicles	axillary, glomerulate spikes	axillary glomerulate spikes
Flowers	monoecious	monoecious	monoecious
Fruiting pedicels	0.3–0.4 cm long	0.2–0.3 cm long	minute, or absent
Capsules	sessile, depressed globose, scattered puberulous, green when young, greenish-pink when matured, 3-lobed when matured, 1–1.6 × 1.3–2 cm; seed 1, obovoid-trigonous, ca 0.8 cm	sessile to subsessile, depressed globose, scattered ochraceus-puberulous, green, 3-lobed when matured, 0.6–0.7 × 0.7–0.8 cm; seed 1, broadly ovoid-oblong, ca 0.4 cm	subsessile, ovoid to subglobose, glabrous, green to purplish red, 3-valved when matured, 0.3–0.4 × 0.4–0.5 cm; seed 1, ovoid, ca 0.3 cm
Flowering period	March–May	March–April	April–June
Fruiting period	May–July	May–June	June–August
Altitudinal distribution	200–300 m MSL	300–600 m MSL	600–900 m MSL
Forested distribution	tropical dry deciduous forests	tropical dry deciduous to stunted semi-evergreen forests	tropical moist deciduous forests

Note: monoecious meaning separate male and female flowers on the same plant

DISCUSSION

Recently published research papers (Gogoi and Borah, 2013; Singh et al., 2010, 2011, 2012; Dey et al., 2010; Gogoi, 2013; Barbhuiya et al., 2012; Chettri et al., 2013; Pulsakar, 2011; Takhtajan, 2009; Tandon et al., 2012) on new species, new records, rediscovery and extended distribution on many species enriched the flora of Eastern Himalaya. The present new species (*Cleistanthus nokrensis*) from Nokrek Hills in Northeast India adds an endemic floral species from the hotspot area in Eastern Himalaya. Population data and field observation on this species indicate that the habitats are increasingly exposed to disturbance and habitat destruction caused by felling of trees for timber and firewood, unsustainable extraction of associated wild medicinal plants and wild edible foods, charcoal making, rat-hole method of digging of coal and limestone extraction. In view of the high intensity of disturbance to its natural habitat, the species might be extinct in the near future. Therefore, future research on this new species should focus on identifying the reasons for its rare restricted and endemic distribution. Efforts must be made to multiply its numbers and increase its population size through tissue culture and introduction of seeds of the species in nearby areas of similar habitat.

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Table 2. Population data for *Cleistanthus nokrensis* used for classification of threatened categories of species as per IUCN 2001, Version 3.1.

A. Population reduction	A1. ≥30% decline per generation (a) Direct observation: very less occurrences (b) Density per 10 m^2 : 3-5 individuals (c) Quality of habitat: disturbed, fragmented, karst topography (d) Exploitation: exposed to disturbance due to limestone and coal mining
B. Geographic range	B2. Area of occupancy (AOO): < 10 km^2 (a) Severely fragmented, 1 location (b) Continuing decline, (ii) Area of occupancy: 500 m^2 (IV) Number of location: 1 (v) Number of mature individuals: 56
C. Small population size and decline	Number of mature Individuals: <250 C2. Continuing decline (a i) Number of mature individuals in each sub population: <50

Table 3. Phenology and restricted distributional record of Indian *Cleistanthus*

Species	Phenology	Distribution record
C. andamanicus	March-April	endemic to Andaman Islands in India
C. balakrishnanii	April-September	endemic to Great Nicobar in India
C. collinus	January-December	India, Sri Lanka, Africa, and Malaysia
C. malabaricus	December-October	endemic to Western Ghats in India
C. oblongifolius	December-July	Andaman & Nicobar Islands and Eastern Himalaya in India, Bangladesh, Myanmar, China and Thailand
C. patulus	April-October	Western Ghat in India, Sri Lanka
C. nokrensis	March-July	endemic to Nokrek hills in Eastern Himalaya of India
C. sankunnianus	January-December	endemic to peninsular India
C. travancorensis	March-February	endemic to Western Ghats in India

ledged the help received from seniors while studying the plant at Botanical Survey of India and the local people who were associated with the field work while studying the population size of the species in tough terrains.

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