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Rediscovery of critically endangered *Gymnocladus assamicus* Kanjilal *ex* P.C. Kanjilal (Leguminosae : Caesalpinioideae) from West Khasi Hills District of Meghalaya

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Abstract

Gymnocladus assamicus Kanjilal *ex* P.C. Kanjilal (Leguminosae : Caesalpinioideae) is a critically endangered tree species that was first described and documented from the West Khasi Hills of Meghalaya by U. N. Kanjilal and his son P. C. Kanjilal in 1920 and the holotype is stored in the ASSAM herbarium. The species was validly published by Kanjilal *et al*. in 1934. Later floristic studies did not mention anything about its existence in Meghalaya. The species is now recorded from Laitkseh, in West Khasi Hills district of Meghalaya with coordinates 25º30'27.4" N and 0.91º 24' 50.7" E at an altitude of 1503 m above mean sea level, where from the type specimen was collected more than nine decades earlier. *G. assamicus* shows sexual dimorphism with functionally male plant and hermaphrodite plant with functional pistil and male sterile anthers on separate trees. Present study deals with habitat, distribution, population status, phenology and vegetative and floral characters of *G. assamicus.*

Key words**:** *Gymnocladus assamicus*; Critically Endangered; phenology; West Khasi Hills; Meghalaya

INTRODUCTION

India is one of the 17 mega diversity countries in the world with rich diversity of biotic resources, having four IUCN recognized Biodiversity Hotspots (CI 2015) covering its territory. According to Takhtajan (1988) NE India and Myanmar is the centre of origin for angiosperms.

The genus *Gymnocladus* was established by Lamarck in 1785 which implies 'naked branches' of the trees during winter. *Gymnocladus assamicus* Kanjilal *ex* P.C. Kanjilal, first described and documented from the West Khasi Hills of Meghalaya by Kanjilalin 1920 later his son illustrated and described the species in 1934. Only two other reports about the presence of *G. assamicus* were available, one from Arunachal Pradesh (Hajra *et al*. 1996) and the other from Nagaland (Sanjappa 2000). In Arunachal Pradesh, the populations of *Gymnocladus assamicus* are extremely small, with hermaphrodite and the functional androdioecy condition and the species exhibits poor natural regeneration owing to several extrinsic and intrinsic factors (Choudhury *et al*. 2007, 2014).

Gymnocladus is a small archaic genus of Leguminosae subfam. Caesalpinioideae with five species G. *angustifolius* (Gagnepain) J.E. Vidal in Vietnam; *G. dioica* (Linnaeus) K. Koch in North America popularly known as Kentucky coffee tree; India, China, and Myanmar having *G. assamicus*, *G. burmanicus*Parkinson, and *G. chinensis* Baillon

respectively. *G. assamicus* and *G. chinensis* are found only in the north-eastern states of India. Mature pods of *G. assamicus* are used as soap by local tribal people for their domestic uses as well as in religious activities (Choudhury *et al*. 2007). *G. assamicus* is a critically endangered tree species of IUCN category.

MATERIALS AND METHODS

Gymnocladus assamicus Kanjilal *ex* P.C. Kanjilal was collected from Laitkseh in the West Khasi Hills of Meghalaya [coordinates 25º30'27.4" N and 0.91º 24' 50.7" E; Fig. 1] during 2012 – 2014 (Fig. 1). The authenticity of the collected material was confirmed by matching with the holotype (40646) at ASSAM herbarium (Plate I, A). The vegetative and floral characters were observed for three consecutive years from 2012 to2014. Floral characters were studies from both male and hermaphrodite flowers in two consecutive years 2012 – 2013 and the photographs were taken with Magnus MSZ-TR stereo microscope. The percentage of seedlings and the number mature trees were enumerated by constructing 5 x 5 m and 50 x 50 m quadrets respectively in their natural habitat (Verma 2011). The physicochemical properties of soil were analysed according to the methods followed by Klute (1986).

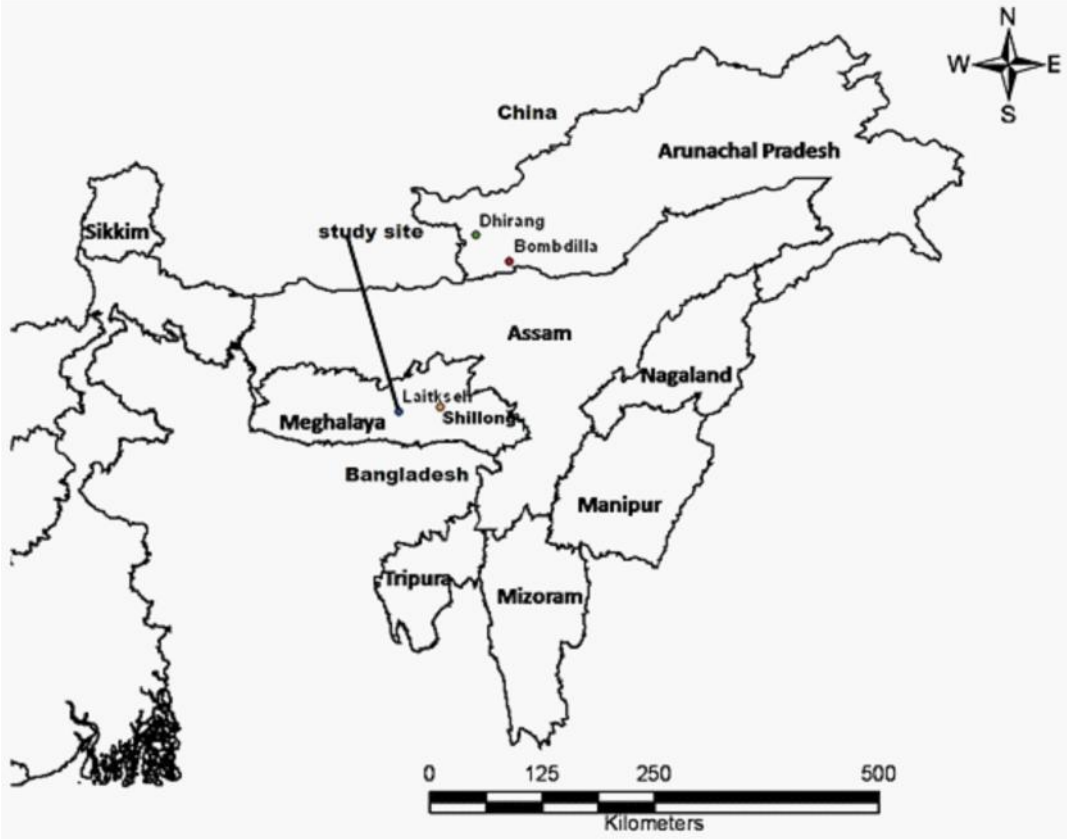

Fig. 1. Map showing the place of occurrence of *Gymnocladus assamicus* and location of the study sites in the state Meghalaya, India.

Taxonomic treatment

GymnocladusassamicusKanjilal*ex* P.C. Kanjilal, Assam Forests Rec. Bot. 1:7 – 8. 1934; Y.T. Lee in *J. Arnold Arb.* 57(1): 91–112. 1976.

Specimens examined: Holotype collected by U.N. Kanjilal, Accession no. 40646, in 1920 at ASSAM Herbarium, Shillong. *G. assamicus* collected by A. Arunachalam, Accession No. 7624 deposited at NERIST-herbarium, Nirjuli Arunachal Pradesh. *Stella, NEHU Herbarium Accession No.NEHU-11839,* dated April 02, 2014.

Distribution: *Gymnocladus* is a small archaic genus of Leguminosae, sub-family Caesalpinioideae with five species *G. angustifolius* (Gagnepain) J.E. Vidal in Vietnam; *G. dioica* (Linnaeus) K. Koch in North America, popularly known as Kentucky coffee tree; India, China, and Myanmar having *G. assamicus, G. burmanicus* Parkinson, and *G. chinensis* Baillon respectively. *G. assamicus* and *G. chinensis*are found only in the north-eastern states of India as South East Asian countries.

Habitat and population status:

Plants have located atLaitksehin West Khasi Hills of Meghalaya, with 25º30’27.4" N and 0.91º 24' 50.7" E coordinates and at an altitude ranges from 1496 to 1593 m above mean sea level. It is a sub-tropical region withwet climate and receives rainfall over 9900 mm per year. Highest rainfall occurs during July and August which is over 1000mm per year. In winter, temperature ranges from 7 to 10^0C and during summer mean temperature ranges from 18to 28^0C. The soils are fairly deep to very deep and ranging from light to medium sandy loam in texture with pH around 5.3 and of moderate fertility having medium organic matter content. However, they are generally medium in available Nitrogen (162 kg/acre), medium in available phosphorus (16 kg/ acre) and medium in available potassium (65 kg/acre).During the present study, ten populations with 50 individuals were documented in Laitkseh forest range (Table 1). The populations are distributed over an 10 km^2 area. The population of *G. assamicus* consists of about 50 - 60 mature trees out of which 10 and 15 trees have 40 and 45cm diameter at breat height (DBH) respectively. There are only few seedlings near the vicinity of each functionally female plant. But the seedlings are absent in and around the male plants. All these observation were based on the quadrets of 5x5m. The species is mostly distributed on the hill slopes and along the banks of streams. *Panax wangianus,Tricyrtishirta, Diascorea bulbifera, Myrica esculenta, Schima wallichii and Castanopsis indica* are the most common associated trees in the eight study sites.The

Table 1. Locations for the study sites for *Gymnocladus assamicus* populations

Serial number	Location Sites*	Elevation (m)	Latitude (N)	Longitude (E)	Tree population size
1.	Site I	1503	25^{0}30’274”	91^{0}24’50.7”	5
2.	Site II	1506	25^{0}30’066”	91^{0}24.855”	7
3.	Site III	1514	25^0 30’ 07”	91^{0}24’80.5”	6
4.	Site IV	1518	25^{0}30’017”	91^{0}24’59.2”	7
5.	Site V	1535	25^{0}30’027”	91^{0}24’87.6”	8
6.	Site VI	1541	25^{0}30.011”	91^{0}24.895”	8
7.	Site VII	1556	25^{0}29’245”	91^{0}25’29.1”	9

*All the eight location sites are in and around Laitkseh range

PLATE – I: A. Holotype of *Gymnocladus assamicus* Kanjilal *ex* P.C. Kanjilal; **B.** Habit (Male plant); **C.** Male inflorescence [*Inset*: a flower]; **D.** Female inflorescence; **E.** V.S. of Male flower showing fertile anthers and rudimentary pistil; **F.** V.S of female flower showing sterile anthers and well developed pistil; **G.** Pods; **H.** Seeds

percentage of seedlings is less than the mature trees because seedlings grow only under functionally female plants and on the other hand no seedlings are found in and around the vicinity of the male plant. Moreover, the number of functional female trees are less in number.

Phenology in Meghalaya:

The sprouting of young leaf buds was observed on 6th of January when the tree was barren. However, the leaf emergence was noticed in the month of March and extended till April. Flower initiation and flowering was observed in the middle of March and extended till April. Senescence of leaves was noticed in November and leaf fall and barren tree was observed during December to January. Fruits mature during the May and extended till February. Seeds were observed during June - July and the young seedlings of 15 - 20 cm high was observed during the autumn i.e. September to November (Fig. 2). To break the seed dormancy high water content in the soil is necessary which is provided by the south-east monsoon during June - July.

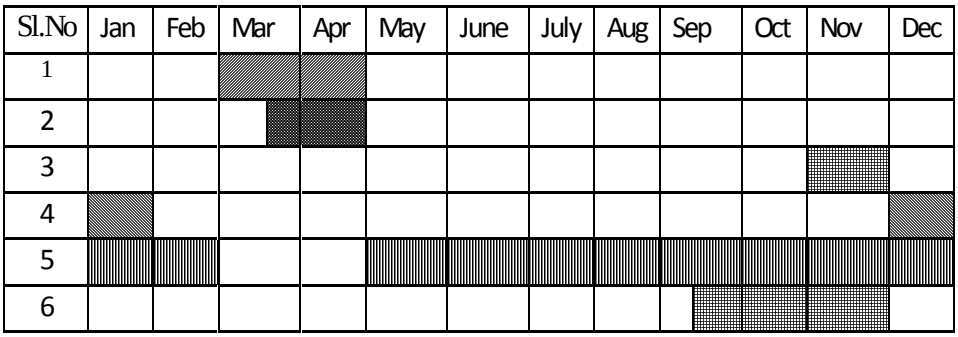

Fig. 2. Phenology of *Gymnocladus assamicus* in Meghalaya

Vegetative and Floral morphology:

Trees 10 – 12 mtall (Plate I, B), bark dark reddish brown, reticulate. Leaves 2-pinnate, with 7-10 pairs of pinnae, alternate; rachis terete, 30 – 40 cm long; pulvinous prominent, glandulose when young; each pinnae 13 – 23 cm long, slightly channeled; leaflets 12 – 14 pairs on each pinna, minutely petiolulate, alternate, 0.6 – 1.0 cm long, oblong to ovate oblong, base rounded to slightly cuneate, often slightly oblique, minutely brown pubescent on both surfaces; stipel 1, ca. 1 mm. long, thick, awl-shaped, caduceus, brownish, leathery.

A. Male plant: Racemes 12 – 20 cm long (Plate I, C), bracts covered with ramenta like dense trichomes on its outer surface; flowers 40 – 90 per inflorescence, purple; calyx 5-lobed, free at the apex, lobes ovate, villous outside, pilose inside, 0.5 – 1cm long; petals 5, free,, purplish, alternate with calyx lobes, narrowly ovate, 0.5 – 0. 7 cm long; stamens 5+5, diplostemonous,epitpetalous, exserted,fertile; filaments short, purple, densely villose; anther lobes oblong, dorsifixed, bilobed,deshiscence lateral,pollen grains viable; pistil rudimentary.Male flowers produce viable pollens and hence these are functionally male with rudimentary pistil (Plate I, E).

Hermaphrodite plant ["functionally female"]: Racemes 3.5 - 4.5 cm long (Plate I, D), bracts externally covered with ramenta like dense trichomes, flowers 2 – 12 per inflorescence; calyx 5-lobed, free at the apex, lobesovate, villous outside, pilose inside, 0.7- 1.5 cm long; petals 5, purplish, alternate with calyx lobes, narrowly ovate, 0.6-0.8 cm long; stamens 5+5, sterile, diplostemonous, epitpetalous, exserted; filamentsshort, purple, densely villose; anthers stony and sterile, dorsifixed, lobes 2, globose; pistil well-developed 1.0 cm long, style 0.5cm.

long, stigma wet, linear, papillate; ovary with 6 – 8 ovules (Plate I, F). Pods (Plate I, G) 14 – 17 cm x 2.5 – 3.8 cm; transversely ridged and grooved exposing the seeds within, valves fleshy; pericarp polished,mesocarp saponaceous; seeds 6 – 8 (Plate I, H), ovoid or subglobose, bluntly trigonous; testa black, extremely hard;funicle persistent, erect. This hermaphrodite flower is functionally female with sterile anthers and well developed pistil.

DISCUSSION

Gymnocladus assamicus was first collected from Laitkseh, Khasi Hills of Meghalaya by U.N. Kanjilal in 1920 and coined the name on the herbarium-sheet and remained as an invalid *nomen nudum*. The holotype was deposited in ASSAM herbarium in the same year. Later on, his son, P. C. Kanjilal (1934) validly published in 'Assam Forests Rec. Bot.' in 1934 (Barbhuiya & Gogoi 2010). So far, in Meghalaya, after 1920, the species was not documented by any worker (Haridasan& Rao 1985; Balakrishnan 1992). After a gap of ninedecadespresent authors collected the same taxon from the same 'Type locality'.*G. assamicus* also exists in Arunachal Pradesh (Hajra*et al*. 1996)and Nagaland (Sanjappa 2000).This taxon has become critically endangered due to anthropogenic activities and religious practices by the local tribals, with having only few individuals (Choudhury *et al*. 2007).The species is endemic to Northeast India particularly in Meghalaya, Arunachal Pradesh and Nagaland.

G. assamicus is locally knownas *'Sohnup'* by Maram clanof West Khasi Hills, Meghalaya. It is dioecious species characterized by the presence of ramenta like bracts in the axile of which young leaves and inflorescence are borne; the cauducous nature of its bracts were not recorded by previous workers (Choudhury *et al*. 2007; Singh *et al*. 2010; Lee 1976). Singh *et al*. (2010) did not distinguish male and hermaphrodite plants *G. assamicus* in Arunachal Pradesh.The operational sex ratio i.e. sexually competent male male and female sex ratio of trees is 15:1. These two sexually different plants are spatially isolated. The number of female flowers per inflorescence ranges from 5 - 8.The fruit set in functionally female tree is very low about 10 %, when compared to the flower production. This may be due to anemophily or rarely entemophilous pollination.

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