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Research Letter

Ecology and Conservation of the Critically Endangered Tree Species *Gymnocladus assamicus* in Arunachal Pradesh, India

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Recommended by Madhur Anand

Gymnocladus assamicus is a critically endangered leguminous tree species endemic to Northeast India. Mature pods of the trees yield soap material and are collected by local people for domestic purposes and religious activities. *G. assamicus* grows on hill slopes and along banks of streams. Male and hermaphrodite flowers are borne by separate individual trees. Altogether 28 mature trees were documented from nine populations. Of these, very few regenerating trees were found. This species regenerates only through seeds. The major constraints to natural regeneration are overharvesting of mature fruits, habitat destruction, grazing, predation of seeds by scatter-hoarding animals, poor percentage of seed germination due to their hard-waxy seed coats, and the lack of seed dispersal. Effective conservation initiatives should emphasize sustainable harvesting of mature pods, awareness among local people, and preservation of surviving individuals of the species. Nonetheless, reintroduction of the species to suitable ecological habitats is also recommended.

1. INTRODUCTION

Arunachal Pradesh, the Northeastern state of India, with the richest terrestrial biodiversity of the country is home to nearly half of India's flowering plants [1]. Arunachal's Eastern Himalayan region, a biodiversity hotspot, is home to numerous endemic, primitive, and endangered plant species of significance. Due to various natural and anthropogenic interference, the biodiversity of the region is under tremendous pressure and for this many species are on the verge of extinction. *Gymnocladus assamicus* Kanj. ex. P.C. Kanjilal is one such endemic and very rarely explored tree species of Northeast India with an extremely small population. The species was first described and documented from the Khasi Hills of Meghalaya in 1934 [2] and until now only two other records are available from Arunachal Pradesh [3] and Nagaland [4]. For its rarity, this species is categorized as critically endangered [5] and is also included in the prioritized list for national recovery programme in India [6]. However, information on its autecological details is not available for effective conservation initiatives. With this backdrop, an attempt is made to study the existing population of *G. assamicus* with special reference to its habitat characteristics, regeneration status, modes of regeneration, and the major constraints to its natural regeneration. A few conservation initiatives have also been suggested.

1.1. Background of the species

Gymnocladus is a small archaic genus of leguminoseae family with five species of which *G. angustifolius* occurs in Vietnam, *G. diocus* occurs in N. America and the remaining three species, namely, *G. chinensis*, *G. assamicus*, and *G. burmanicus* are confined to the trijunction of India, China, and Myanmar (Burma). The species *G. assamicus* and *G. chinensis* are found only in the Northeastern states of India [7]. Mature pods of *G. assamicus* yield soap material and they are used by local tribal people for their domestic use as well as in religious activities [8].

Gymnocladus assamicus is a medium-sized (ca. 15 m) deciduous tree (see Figure 1(a)) with bipinnate compound leaves. Flowers are 12.7–20.32 mm long with purplish corolla

Table 1: Distribution and current population status of *Gymnocladus assamicus* in Arunachal Pradesh.

Sl. no.	Location	Elevation (m)	Latitude (N)	Longitude (E)	Tree population size
1	Changfu Moon	1960	27°1′	92°4′	4
2	Dambla Basti	1723	27°3′	92°4′	7
3	Dirang Basti	1715	27°0′	92°5′	1
4	Jyotinagar	1724	27°2′	92°4′	1
5	Lishpa Village (Rama Camp)	1870	27°3′	92°3′	5
6	Lishpa Village II (Rama Camp)	1900	27°3′	92°3′	5
7	Moishing	2052	27°8′	92°4′	2
8	Runkung Village	1669	27°2′	92°5′	1
9	Yewang Village	1688	27°1′	92°4′	2

(a) (b)

Figure 1: (a) Habit of *Gymnocladus assamicus* and (b) of inflorescence.

borne on 7.5–18 cm shaggy racemes (see Figure 1(b)). The genus *Gymnocladus* has been described as dioecious [9] or polygamous [10] or as having unisexual flowers [11]. However, during the present study, we found the species bearing male and hermaphrodite flowers on separate trees. Pods are 10–16 × 2.5–4 cm in dimension having 4–8 extremely hard seeds. The pericarp is polished and mesocarp highly saponaceous. The tree remains leafless for a period of two month (January-February) and flowers during April. A generalized phenogram on the basis of regular observations to each population of *G. assamicus* is presented in Figure 2.

2. STUDY AREA AND METHODOLOGY

The study was conducted in Dirang forest range (altitudinal range 1500–2000 m) located in the West Kameng district of Arunachal Pradesh, Northeast India (see Figure 3). The area of the forest range is 892.23 km^2 and is surrounded by higher elevation terrain (2800 m to 3400 m) of Bomdila and Tawang. Climate is subtropical with 2031 mm mean annual rainfall of which the maximum (75%) is received between May and September (rainy season). Average monthly temperature ranges from 0°C during winter (November–February) to 34°C during summer (May-June). Three *G. assamicus* populations viz. Moishing, Changfu Moon, and Dambla Basti were selected for detailed study. The study sites are facing acute threat of land degradation due mainly to extensive agriculture activities and road construction that is engulfing a chunk of forest vegetation along the hill slopes.

Table 2: Associated indigenous woody plants where *Gymnocladus assamicus* occurs (three representative localities).

Species	Moishing	Dambla Basti	Changfu Moon
Alnus nepalensis	−	+	+
Alstonia neriifolia	−	+	+
Erythrina stricta	+	+	−
Ficus sp	−	+	−
Ilex fragilis	−	+	+
Illicium griffithii	+	−	+
Juglans regia	−	+	+
Phylostachys manii	+	+	−
Pinus roxburgii	−	−	+
Pyrus pashia	−	−	+
Quercus griffithii	+	+	+
Rhododendron arboreum	+	−	+
Rhus wallichii	+	+	+
Rinorea bengalensis	−	+	+
Schima khasiana	−	+	+

These anthropogenic threats affect the regeneration of several species including *G. assamicus*.

The population status of *Gymnocladus assamicus* was documented through extensive field survey and all the trees were counted in each population during 2004–2007 and they were geographically marked with global positioning system (GPS). Phenological observations were made according to [12] and notes were compiled on vegetative as well as reproductive events. Twenty quadrats of 10 m × 10 m size (covering 0.2 ha area) were laid randomly in and around *G. assamicus* individuals in the three major populations for recording associated woody plants. In order to understand the regeneration status, population size of seedlings, saplings, trees, and sprout/coppice shoots were ascertained [13]. Seed dispersal and seedling survival in relation to distance from the mother plant was ascertained by counting the number of seedlings and saplings with respect to the increase in the radial diameter from the mother plant [14]. Five-hundred freshly collected mature seeds were germinated in polythene bags filled with farmyard soil kept in mist chamber under regular watering. Germination was defined as the emergence of radicle from the seedcoat.

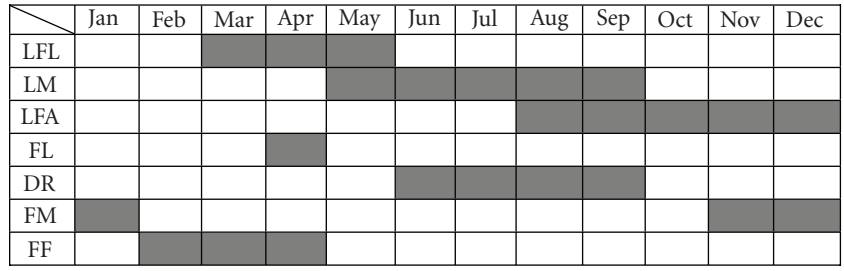

Figure 2: Phenogram of *Gymnocladus assamicus.*

3. RESULTS AND DISCUSSION

3.1. Distribution

During the present study, nine populations with 28 mature trees were documented from Dirang forest range (Table 1). The populations are distributed in and around a 10 km^2 area. The number of mature trees per population ranges from one to six and only two populations (Moishing and Dambla) had seedlings and saplings. The species is mostly distributed on the hill slopes and along the banks of streams. *Quercus griffithii* and *Rhus wallichii* were the most common trees growing with *G. assamicus* in the three studied sites. Other associated woody species were *Alnus nepalensis, Illicium griffithii, Juglans regia, Rhododendron arboreum,* and so forth, (Table 2).

3.2. Population structure and regeneration status

Observations revealed that the percentage of mature tree populations was higher than that of sapling/seedling populations in all the sites except in Moishing. Largest seedling (160) and sapling (11) populations were recorded from Moishing, while only one sapling was found in Dambla site (Table 3). 55 percent seedlings occurred within 4 to 8 m radial distance of the mother tree. The density and survival of saplings was recorded only at 8 to 12 m radial distance from the crown of mother tree. There was no seedling or sapling population beyond 12 m radius which suggests that seed dispersal of *G. assamicus* is very poor and may act as a major regeneration constraint. Results of the demographic survey of three *G. assamicus* populations are summarized in Table 3. Other possible reasons for very poor regeneration in Changfu Moon and Dambla sites may be due to anthropogenic activities (over harvesting of mature pods, disturbance, and grazing) because of their locations nearby human settlements, while, such disturbances are almost nil at Moishing site.

Table 3: Population status of three *G. assamicus* populations determined from all individuals located during the study.

	Moishing	Dambla Basti	Changfu Moon
n	173	8	4
% mature tree	1.16	87.50	100
% saplings (10 ≥ 20 cm cd at base and >30 cm height)	6.36	12.50	—
% seedlings (≤10 cm cd at base and <30 cm height)	92.49	—	—

cd = collar diameter

4. MODES OF REGENERATION

G. assamicus regenerates only through seeds. Freshly collected seeds had 42% germinability and they retain a viability of 6.7% even after 12 months of storage under normal laboratory conditions. Germination takes place within 10–12 days from the day of sowing, however, some seeds germinated even after 12-13 months of sowing.

4.1. Major constraints to natural regeneration

Though fruit set seems to be sufficient (Prof. Amots Dafni, personal communication), other extrinsic and intrinsic constraints to natural regeneration were identified in *G. assamicus.* Major threats to natural habitats are expansion of agricultural activities in forest land and construction of roads and houses in and around forest areas. Such activities may be adversely affecting population of seedlings and saplings in Changfu Moon and Dambla Basti (Table 3). A few specific threats to *G. assamicus* are overharvesting of mature pods for domestic use, grazing, predation of seeds by scatterhoarding animals, and fungal damage to seeds [15]. Other intrinsic constraints are lack of dispersal and a hard-waxy seed coat. Seed dispersal necessary for the survival of the offspring, farther from the mother tree, [16] was not observed in *G. assamicus.* Also a very limited number of fruiting (hermaphrodite) trees may also be a natural constraint.

4.2. Conservation status

Present investigation revealed that the population of *G. assamicus* is extremely small and the total number of reproducing individuals is far less than fifty. Therefore, the species may

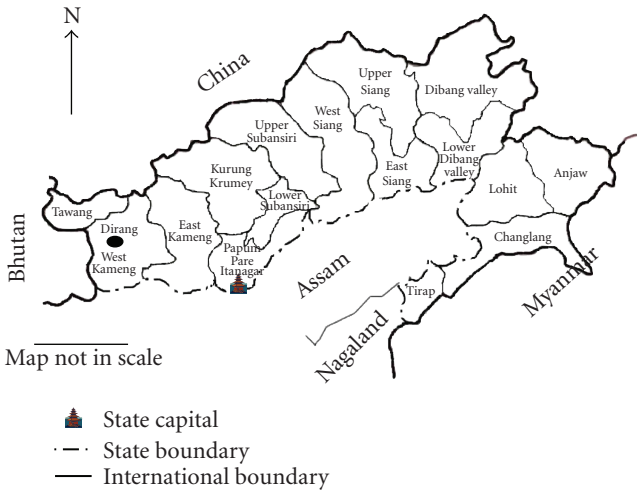

Figure 3: Map of Arunachal Pradesh showing study site (Dirang).

be designated as "critically endangered" [17]. Hence, active protection measures and continuous monitoring of the existing populations should be given top priority. As the numbers of mature trees are very limited (Table 1), all the populations should be preserved. Rare and endangered taxa often exist as relatively small populations [18] and are subject to population bottlenecks [19]. Thus, a short-term conservation goal should be adopted to ensure that the vigor of a population is maintained or restored in the face of inbreeding through appropriate manipulation of the remaining genetic variations [20]. According to the demographic characteristics of this species, it is found that the seedling and sapling populations do not contribute to the maintenance of natural regeneration stock. Thus, an artificial introduction of the species in suitable ecological habitats may be one of the options to restore the populations of *G. assamicus.* Population restoration by supplementary regeneration could be an adaptive strategy to combat the declining populations by introducing nursery-grown seedlings to compensate the lack of natural regeneration. Since major threats to *G. assamicus* are habitat degradation and overharvesting of mature pods, awareness among local people, preservation of existing reproducing individuals, and sustainable harvest of mature pods may be effective in successful preservation of the species. Government agencies such as State Forest Department, NGOs, and other conservation agencies may take initiatives in developing, distributing, as well as planting nursery-grown seedlings of *G. assamicus* in suitable habitats. Plantation of seedlings in homegardens, along traditional agricultural land or in wayside plantations are also recommended. Such locations are generally protected and for this growth and survival of seedlings may be ensured.

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