



RESEARCH ARTICLE

Field Study of Gregarious Flowering and Use of ENM in Conservation Strategies for *Gigantochloa andamanica* (Kurz) Kurz in Andaman Islands (India)

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ABSTRACT

Gregarious flowering in bamboo species is a periodic event which affects the habitat's ecology, since the whole population die within same time frame. The phenomenon sets effects on the social economy too as bamboo is one of the most important natural resources people depends on. In this paper gregarious flowering and mass seeding in *Gigantochloa andamanica* (Kurz) Kurz, an economically important bamboo species of Andaman Islands have been reported with effective conservation strategies to balance the population in natural habitat. This also includes the description, illustration, photo plates of the species for the easy identification, the ENM map based on the GPS data collected for the distribution area and data relevant to traditional and economic uses of the species. This study more importantly shows the application of ENM for the identification of suitable sites for field reintroduction of the seedlings in natural habitats aimed at their better growth and survival.

Keywords: *Gigantochloa andamanica*, gregarious flowering, seedlings, economic value, ENM, Andaman Islands.

INTRODUCTION

Bamboo plays a significant role in environmental protection besides its economic values. The flowering cycle in bamboo has been a matter of much popular interest and speculation. Their flowering nature is usually of long interval and rare so that their identification is mostly done with their vegetative character. However for their correct generic placement floral characters are essential. Flowering records of a species reveal their flowering nature, pattern, time period, effect on ecosystem and many more. An event of massive flowering and seedling at intermittent intervals over a large area is common in woody bamboos. Flowering in bamboos may be sporadic or gregarious and vary from one species to another, generally it takes about 20 – 60 years, sometimes even 120 years (McClure, 1966). The factors that determine gregarious flowering are not yet understood. Certain evidence points to the probability that a short rainy season followed by a spell of severe drought stimulates flowering (Gupta, 1952). In mass flowering, all members of a cohort (plants from seeds of common origin) or even an individual entering their productive phase simultaneously and subsequently die.

Gigantochloa andamanica (Kurz) Kurz is most utilised commercial bamboo found in many areas of Andaman Islands. During the year 2013 – 2019 flowering has been noticed in continuous range of occurrence of the species all over North to South Andaman. The clumps flower gregariously right through on the large area of its occurrence and finally die off altogether (Plate 2). This periodic flowering of bamboos once in a life span and its mass death event afterwards cause ecological disaster. This probably also explains why bamboo flowering is commonly associated with local feminine. The belief that flowering of bamboo omens disasters like famine and natural calamities has compelled the rural people to destroy the cohorts/clumps after or during blooming. Furthermore, the over-exploitation of the bamboo plants added with mass scale death after gregarious flowering also enhance the extinction rate of the species, unless effective measures are taken for their conservation.

The systematic conservation of biodiversity requires knowledge of the spatial distribution of resources (Margules and Pressey, 2000). Field information on conservation aspects such as distribution, population status, habitat types, regeneration potential, causes of depletion of population size, and the level of disturbance to which the species is exposed to are fundamental. Ground surveys covering the entire study areas are much time consuming or not possible in most of the cases. However, knowledge of the areas where appropriate environmental conditions exist to

sustain the species is a pre-requisite for species conservation. Thus, characterization of niche of species is fundamental to conservation biology. New Geographical Information System (GIS) approaches called Ecological Niche Modelling (ENM) are being used for the purpose which produces the potential distributional maps using maximum entropy modelling (MaxEnt 3.3.3e).

MaxEnt estimates the maximum entropy probability distribution function to predict the geographic location of a species based on environmental variables and reconstructs the boundaries of the ecological niche by placing constraints on the probability distribution based on the environmental parameters of the grid-cell presence record (Phillips *et al.*, 2006). Ecological Niche Modelling was used for this study to construct the potential distribution of *G. andamanica* all over the Andaman Islands.

The area of study for this flowering event includes - North Andaman (Deshbandhu Gram, Kalara, Nabagram, Sitapur, Parangarah, Mohanpur); North-Middle Andaman (Mayabunder, Bamboonalah, Nimbutala); Middle Andaman (Rangat, Nimbutala, Bakultala, Panchvati, Parlobjig, Kadamtala, Shantanu); Middle-South Andaman (Jarawa creek, Mud volcano, Nayadera, Krishnanagar, Middle Straight); South Andaman (Middle Straight to Jirkatang, Pongibalu, Mount Harriet, Maanpur, Sholbay).

The GPS data of the collection sites are: North Andaman, Kalara, Lat. N13°06'39.7" Long. E092°58'31.5", 28-12-2013; Middle Andaman, Khesredera, Lat. N12°23'24.2" Long. E092°46'46.5", 09-02-2014; South Andaman, Mount Harriet, Lat. N11°45'07.1" Long. E092°45'07.1", 20-02-2014; South Andaman, Pongibalu, Lat. N11°31'31.2" Long. E092°36'39.4", 04-03-2014; South Andaman, Maanpur, Lat. N11°40'09.1" Long. E092°36'39.4", 06-03-2014; North Andaman, Kalara, Lat. N13°10'36.7" Long. E092°55'54.4", 07-04-2015; Middle-South Andaman, Mud volcano (Baratang), Lat. N12°05'45.6" Long. E092°44'39.2", 22-03-2015; South Andaman, Jirkatang, Lat. N12°23'52.8" Long. E092°46'33.8", 22-03-2015; South Andaman, Sholbay, Lat. N11°51'31.8" Long. E092°44'07.9", 28-12-2016; North Middle Andaman, Mayabunder, Lat. 12°53'1.27" Long. 92°52'24.3", 18-12-2018; North Andaman, Parangarah, Lat. 13°8'40.24" Long. 92°52'43.6", 05-12-2018.

MATERIALS AND METHODS

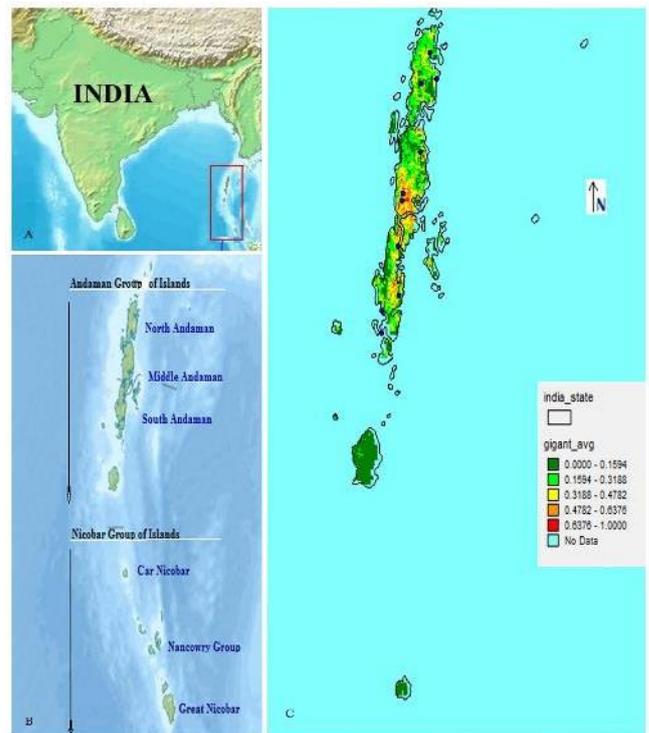
Specimens were collected and identified on the basis of their vegetative and reproductive characters and authenticated with available literature and herbarium. The illustrations for the morphological characters of the species have been done by examination of the live materials collected during the study and the description has been made with the help of the

field notes taken as per the standard format used for bamboo collection and study of the samples under microscope in the laboratory. Flowering period of the species have been reported with the continuous field surveys in the distribution area, herbarium records and literature for earlier reports of flowering. Information of seedling growth and development were collected by observation and data recorded in the nursery, while that of economic value of the species has been brought out from the survey of local markets, tribal and the local inhabitant.

The conservation status through macro-proliferation and field reintroduction is under observation which is expected to be more than 60 percent. Distributional pattern of flowering and reintroduction sites is shown through ENM mapping (Map1). The method of Ecological Niche Modelling (ENM) map is applied by using the modelling algorithms of DIVA-GIS and MAXENT. Nineteen bioclimatic variables are used as environmental variables for modeling, which includes Annual Mean Temperature, Mean Diurnal Range, Isothermality, Temperature Seasonality, Maximum Temperature of Warmest Month, Minimum Temperature of Coldest Month, Temperature Annual Range, Mean Temperature of Wettest Quarter, Mean Temperature of Driest Quarter, Mean Temperature of Warmest Quarter, Mean Temperature of Coldest Quarter, Annual Precipitation, Precipitation of Wettest Month, Precipitation of Driest Month, Precipitation of Seasonality, Precipitation of Wettest Quarter, Precipitation of Driest Quarter, Precipitation of Warmest Quarter, Precipitation of Coldest Quarter etc. Through this modelling, the potential area of occurrences of the species and their reintroduction were done [Map 1].

Taxonomic identity of the species was confirmed with help of type, protologue, available herbarium specimens and the fresh samples collected from the field. All vegetative and reproductive parts of the plant were collected over a long period of time by visiting same locations in different seasons. This well-established species from Andaman Islands has been invalidly synonymized with another species of *Gigantochloa* in different works (Seethalakshmi and Kumar, 1998; Widjaja, 1987). Even the recently published work has treated this species under synonymy (Vorontsova *et al.*, 2016). After critical and complete morphological study of all the parts of the species this is hereby retained as a taxonomic sound species.

Gigantochloa andamanica (Kurz) Kurz, Prelim. Rep. For. Pegu, 1875; Kurz, For. Fl. British Burma 2: 556. 1977. *Bambusa andamanica* Kurz in J. Asiat. Soc. Bengal n.s. 39(2): 88. 1870; The Bamboos of the world, Ohrnberger, 252. 1999. **Vernacular name:** 'Chataai bamboo'; 'Tennang'(Jarawas). [Fig. 1 & Plate 1].



Map 1 : A. India map showing Andaman & Nicobar Islands; B. Andaman & Nicobar Islands; C. ENM map, warmer colours shows potential area of flowering, blue dots shows seedlings planted in habitats.

An evergreen densely clumped erect bamboo drooping above. Rhizome pachymorph. Culm 8 – 17 m tall, 4.5 – 6.5 cm in diameter, dark green when young, yellowish green when mature; nodal ring prominent; internodes 30 – 50 cm long, thin-walled, sometimes with longitudinal white stripes from base to middle; bud broadly ovate; branching in triplets, 3 – 12 from upper nodes. Culm sheaths late deciduous, elongated, shorter than internodes, brown, thin, crustaceous; sheath proper 12 – 32 cm × 6 – 8 cm with appressed brownish black hair on outer surface, ciliate at upper margin; imperfect blade 3 – 5 cm long, lanceolate, shorter than sheath proper, pubescent within, deciduous; auricles elliptical, pointed, glabrous; ligule 2 – 3 mm, entire. Leaves 6 – 16 per twig, leaf blade 12 – 30 × 4 – 6 cm, broadly lanceolate, rounded to attenuate at base, acuminate at apex, glabrous, at times sparsely hairy on upper surface; midrib prominently raised, shining, glabrous, secondary veins 8 – 12, tertiary veins 5 – 7, no cross veins; margins minutely serrulate, ciliolate towards base; pseudopetiole 3 – 5 mm long, twisted at base, with few translucent hairs on adaxial side; leaf sheath prominently keeled, striate, appressed hairy, glabrous afterwards, ciliate margins, ending in 0.2 – 0.3 mm, smooth callus; auricle oblong, prominently seen on one side, obscure on other side; ligule 0.3 – 0.5 mm long, entire, glabrous. Inflorescence panicle of spicate verticillis. Spikelets oval lanceolate, 3-flowered, bisexual, 1.5 – 2.5 cm × 2 – 3 mm; empty glumes 3 – 4, 4 – 8 mm long, broadly lanceolate or ovate, coriaceous yellowish brown, multi-veined, apex acute

or shortly mucronate, margins ciliate, cilia golden brown; lemma 5 mm – 2.3 cm long, lanceolate, coriaceous, yellowish brown, multi-veined, apex acuminate or mucronate, margins ciliate, cilia dark brown; palea 4 mm – 1.2 cm long, linear-lanceolate, apex bifid, 2-keeled, ciliate on keels, dorsal surface faintly pubescent, margins ciliate; anthers 6, 2.8 – 8 mm long, dark purple to pinkish purple, with hairy apex, filaments fused to form a 2 – 5 mm tube; ovary ovate, 1 – 2 mm long, style 5 mm – 1 cm long, stigma solitary, 1 – 2.5 mm; caryopsis 1.2 – 1.5 cm, elongate, golden brown, with persistent style.

Flowering cycle: The earlier available flowering evidence of this species is from Sundargarh, Baratang, South Middle Andaman in July 1977. Thus the estimated flowering cycle may be predicted as 38 – 40 years for this species.

Distribution: **India:** Andaman Islands; **Myanmar, China, Hongkong, W. Malaysia** (Ohmberger, 1999; Vorontsova *et al.*, 2016).

Growth and Development of Seedlings

Studies on the patches of flowering area reported during first rain, after 8 – 9 month of flowering, germination of seeds started and just below the flowering mother clump, small seedlings could be seen. Seedlings with 6.39±1.08 cm shoot height were collected at 2 to 3 leaves stage without damaging the rhizome since, damaged rhizome leads to failure of propagation (Table 1).

Collected seedlings (200 nos.) were transferred to the nursery for macro-proliferation / multiplication. Seedlings were transplanted into 40 × 50 cm polythene bag with proper hole containing mixture of manure, soil and sand in the ratio of 1:2:1 and were carefully kept under agro net shade house. Seedlings were watered regularly with sprinklers for providing suitable warm and humid atmosphere.

Seedlings kept under direct sunlight died. Regular measurement notes of saplings were taken to observe its growth. To execute the mean and standard deviation, 25 seedlings were taken for root and shoot growth observation. In between 8 – 9 months, seedlings with 92.59±13.40 cm shoot height were taken for macro-proliferation.

Each seedling was individually separated carefully with rhizome and root, and transplanted into polythene bag containing the same mixture as stipulated. These separated seedlings were kept for another 6 months under maintenance for healthy growth and then transplanted in the natural habitat (Plate 2).

Table 1. Shoot height and root length of *Gigantochloa andamanica* (Kurz) Kurz seedlings in different stages.

Seedlings age in Months	Seed collected from wild for propagation (Shoot height) Mean±SD	Shoot height (25 nos.) In cm	Seed collected from wild for propagation (Root length) Mean±SD	Root length (25 nos.) In cm
About 1	6.39±1.08	5 – 8	5.01±1.54	3 – 6
3 – 8	18.03±3.01	14 – 28	5.6 ± 1.55	4 – 8
5 – 8	36.03±6.68	28 – 45	7.20±2.51	3 – 10
(Macro- proliferation stage)				
8 – 10	46.95±1.77	45 – 50	8.88±2.71	4 – 13
12 – 14	48.9±2.85	45 – 54	9.68±4.38	3 – 15
16 – 22	66.47±9.16	50 – 75	13.15±5.01	4 – 20

Economic value

Gigantochloa andamanica (Kurz) Kurz is well known for its commercial value. This bamboo is mostly used by tribal especially *Jarawas* and also by local peoples and Small Scale Industries in Andaman Islands. *Jarawas* are completely dependent on forest for their livelihood. Each and every product made by them is either from forest or from sea resource. Their artistic and sharp skills are not easy to compete in utilizing bamboos. Bamboo is very much useful in their day to day life. These bamboos are available easily and in finest ways for their daily use.

Leaves of bamboos are used as fodder for elephants and also for thatching. Bamboos are transported from inter-island by using ferry's and truck to small scale industries permitted by Department of Forest Andaman and Nicobar Islands. More than 80 small scale industries are engaged in bamboo works for their livelihood. The range and quantity of bamboos used by small scale industries are permitted in 1500 Nos., 1800 Nos., 2000 Nos., 2400 Nos., 3000 Nos., 3500 Nos., and 5000 Nos. (Anon, 2005). It is often seen that in small scale industries mostly the family members are engaged as employees to make handicrafts. This bamboo is used not only for handicrafts or making household items but also as edibles. It is used as medicine for various ailments by the local people.

RESULTS AND DISCUSSION

G. andamanica is growing luxuriantly in the Andaman Islands. Economically this is one of the most valued species in these islands. Recently, due to gregarious flowering, entire clumps in large patches died and a huge population of bamboos is destroyed all over. Seed germination in the natural habitat is good but seedlings survival and growth is nearly 10 – 20 percent. And thus the species needs to be conserved through special human attention. Every year in several forest divisions, nurseries are being maintained properly by regular propagation of cuttings, seedlings and then transplanted in the natural habitat. This process continues to balance the population of the species.

During this study the weaker seedlings which were supposed to die in the habitat were collected and planted in polybags in a mixture of Soil: Sand: FYM (2:1:1). These were maintained under controlled shade and rain for their better survival and growth in the polyhouse. By the process of macro proliferation of seedlings, a good numbers of seedlings were multiplied to transplant in the forest with the help and participation of forest department, and the local people. The planted seedlings are monitored frequently and the current survival report estimates 50 – 60 percent establishment of the seedlings.

As per our survey, ENM has predicted the accurate distribution of the species. ENM maps locate large patches of flowering in Middle and South-Middle Andaman of high potential area and it is entirely absent in Little Andaman. As per forest statistics, the supply of this bamboo is mainly from Middle and South-Middle only. Due to this event of flowering, it may result in resource deficiency. So, there may be a chance for illegal supply of the resource. Considering the importance of the species, necessary action must be taken by the forest department for the balance of the species regarding conservation and utilization.

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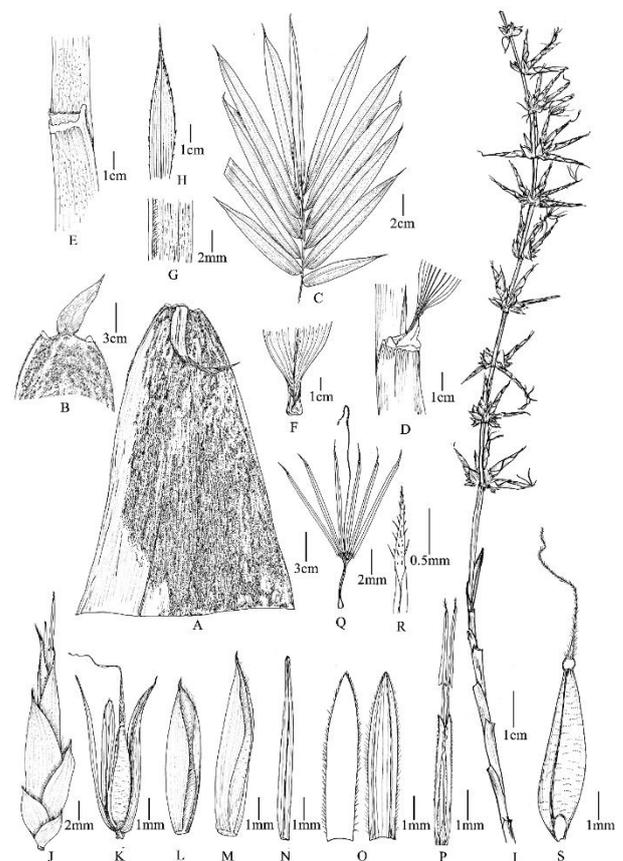


Fig. 1. *Gigantochloa andamanica* (Kurz) Kurz: A & B. Culm sheath; C. Leaf twig; D & E. Leaf sheath; F. Leaf base; G. Abaxial leaf surface; H. Leaf apex; I. Inflorescence; J. Spikelet; K. Single floret; L & M. Glumes; N. Lemma; O. Palea (dorsal & ventral); P. Anthers attached with palea; Q. Stamens and pistil; R. Anther apex; S. Caryopsis.



Plate 1. *Gigantochloa andamanica* (Kurz) Kurz: A. Clump; B. New shoot; C, D. Culm sheath; E. Culm sheath ligule; F. Nodal bud; G. Branching pattern; H. Leaf sheath & leaf margin; I. Hair on leaf upper surface; J. Inflorescence; K. Anthers.

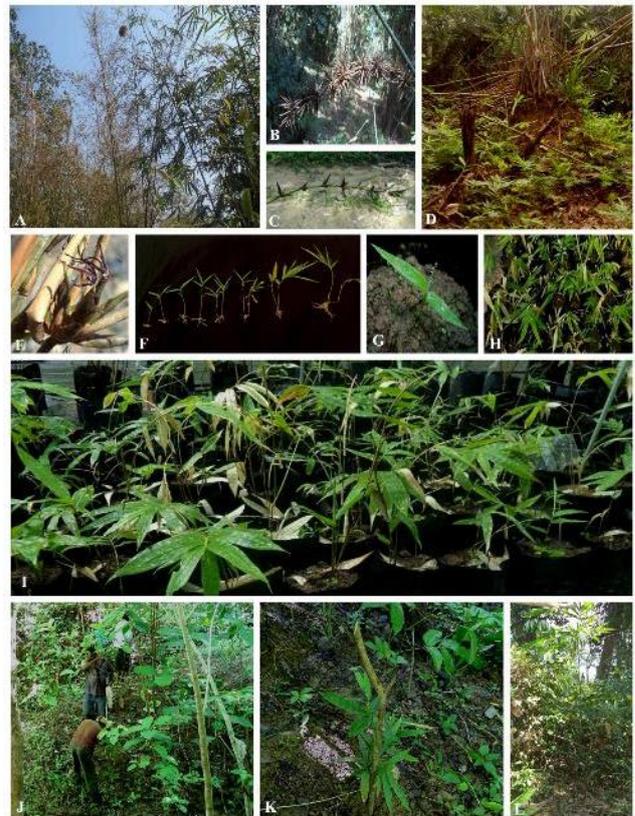


Plate 2. *Gigantochloa andamanica* (Kurz) Kurz: A. Flowering clumps; B & C. Inflorescence; D. Wild seedling growing under dead clumps; E. Spikelet; F. Different seedling stages; G & H. Wild seedlings transferred in polybags; I. Saplings splitted and planted in polybags; J. Reintroduction of saplings in natural habitats; K & L. Established saplings.