



Research article

Gregarious flowering in *Dendrocalamus strictus* (Roxb.) Nees (Poaceae: Bambusoidae) in Tadoba Andhari Tiger Reserve, Maharashtra, India

Narendra G. Chandewar

Maharashtra Bamboo Development Board, Forest Department,
Government of Maharashtra, India

Corresponding Author: ngc609@gmail.com

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Abstract: Tadoba Andhari Tiger Reserve (TATR), located in Chandrapur District, Maharashtra, India, is a renowned protected area known for its rich biodiversity and diverse flora and fauna. Bamboo flowering in Tadoba Andhari Tiger Reserve took place in 1982 and next bamboo flowering of *Dendrocalamus strictus*, may take place after 35–40 years of last flowering. This is the third flowering report from the TATR area, Maharashtra. Description of primary information of floral morphology, phenology and botanical description of male bamboo and photographs of the species are provided in this present paper. Strategy in case of gregarious flowering as it will affect habitat, cover, forage and threat of fire must need.

Keywords: Bamboo - Flowering Cycle - Tadoba Andhari Tiger Reserve.

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INTRODUCTION

Bamboo has existed on Earth for about 200 million years. The earth is home to over 1,250 species of bamboo, which are distributed unevenly across the humid tropical, sub-tropical, and temperate regions of the world and these species belong to 75 different genera (Scurlock *et al.* 2000, Banik 2000, Banik 2016). Bamboo is a plant belonging to the grass family Poaceae (Gramineae) and having most primitive sub-family Bambusoidae and has a lifespan of hundreds of years. It is native to India, Myanmar, Thailand and the Malay Peninsula (Ramanayake & Weerawardene 2003). The total bamboo bearing area of India is estimated to be 15.69 million hectares (Tewari *et al.* 2019). They are distinguished by woody culms, complex branching, robust rhizome system, and infrequent flowering (Soderstrom & Calderon 1979).

In Maharashtra, this plant is mainly found in Konkan, Western Ghats, Khandesh and Vidarbha. Bamboo is most important source of nature which is strong, versatile and highly renewable plant. This plant species is widely distributed across the world, primarily in forest areas that are characterized by moist deciduous, semi-evergreen, tropical, subtropical, and temperate climates. Other environmental factors such as latitude, altitude, and soils are also related to the growth of bamboo. The high temperatures promote bamboo growth and low temperatures inhibit the growth rate. Bamboos are distributed in the country differing from sea level to altitude of 3600 m. The most suitable conditions for the occurrence of bamboo; however, are found between 770–1080 meter above sea level (Tewari *et al.* 2019). The bamboo bearing area in Maharashtra is 1.6 million hectares, while pure bamboo- 51 km², dense bamboo- 3911 km², scattered bamboo- 7951 km², bamboo present but clumps completely hacked- 1389 km², regeneration crop is 2625 km² (FSI 2017). In India, clump-forming bamboo constitutes over 67% of the total growing stock, of which *Dendrocalamus strictus* (Roxb.) Nees is 45% alone. Aptly called the 'Poor Man's Timber', 'Green Gold', 'Bamboo, Friend of the People' and 'Cradle to Coffin Timber' due to its uses, they have a significant place in rural economy.

The Tadoba Andhari Tiger Reserve (TATR), located in Maharashtra, is one of India's 47 project tiger reserves and it is the oldest and largest national park in Maharashtra. TATR is second Tiger Reserve of the Maharashtra State under Project Tiger. The Government of India approved the composite area of 625.40 km² as

Tiger Reserve under Centrally Sponsored Scheme "Project Tiger", as per vide Notification No. I-2/53- PT, dated 21/12/1993. The state government declared this composite area as Tadoba Andhari Tiger Reserve as per vide Notification No. WLP-1054/CR-225/F-1, dated 23/2/1995. This includes Tadoba National Park, with an area of 116.55 km² (45.00 mi²) and Andhari Wildlife Sanctuary with an area of 508.85 km² (196.47 mi²). TATR is strategically located in Central India and is excellent tiger habitat in East Maharashtra. The TATR forests according to Champion and Seth's classification belong to the Subgroup 5A-C1-1B Southern Tropical Dry Deciduous Forests' having Teak as dominant species and bamboo as middle to lower canopy. The main associates of Teak are Ain, and Bamboo. Bamboos of this area flowered gregariously in the year 1982–83 and later Bamboos have regenerated in this area naturally and profusely. Next bamboo flowering of *Dendrocalamus strictus*, may take place after 35–40 years of last flowering.

The report on "Establishing Computerized Wildlife Database for Conservation, Monitoring and Evaluation" in Tadoba-Andhari Tiger Reserve, Maharashtra (1994–1998) by Shri. Yogesh Dubey and Dr. V. B. Mathur classified the vegetation into 11 types of association out of them Miscellaneous Bamboo I (MB-I), Teak Miscellaneous Bamboo (TMB) and Miscellaneous Bamboo II (MB II) emerged as the most dominant vegetation types covering 25.27%, 21.65% and 21.01% respectively of the total area.

The major tree species are Teak (*Tectona grandis* L.f.), Tendu (*Diospyros melonoxydon* Roxb.), Ain (*Terminalia tomentosa* Wight & Arn.), Dhavda (*Anogeissus latifolia* (Roxb.ex. DC.) Wall. ex. Bedd.), Bija (*Pterocarpus marsupium* Roxb.), Haldu (*Adina cordifolia* (Roxb.) Brandis), Salai (*Boswellia serrata* Roxb. ex. Colebr.), Mahuwa (*Madhuca longifolia* Koenig.), Bahawa (*Cassia fistula* L.), Karu (*Sterculia urens* Roxb.), Jamun (*Syzygium cumini* L.), Mango (*Mangifera indica* L.), Arjun (*Terminalia arjuna* (Roxb.) Wight & Arn.), Kumbhi (*Careya arborea* Roxb.), Char (*Buchanania lanzan* Spreng.), Bhirra (*Chloroxylon swietenia* (Roxb.) DC.). Besides the tiger, the major wild animal is leopard, dhole, sloth bear, hyena, golden jackal, gaur, and sambar, chital, nilgai, barking deer, four-horned antelope, langur, rhesus macaque and wild pig. The smaller mammals include Indian pangolin, Indian porcupine, honey badger, Asiatic wild cat, jungle cat; Rusty-spotted cat, Indian fox, mouse deer, Indian grey mongoose, Ruddy mongoose, Indian hare, palm civet, small Indian civet and the giant flying squirrel.

The tract is mostly undulating and hilly in the North, interspersed with open grasslands and wooded areas. The other part of the tract is mostly in plains. The average elevation is 284.07 meter above M.S.L. The climate of the area is characterized by a hot summer, well-distributed rainfall during the South-West Monsoon season and general dryness except in the rainy season. The rainy season is hot and humid. The bulk of rainfall is, received in the period from June to September. The average annual rainfall is 1175 mm. The air is generally dry, except during the South-West Monsoon, when the humidity exceeds 70 %. The summer months are the driest when the relative humidity in the afternoon is between 20-25 %.

MATERIAL AND METHODS

Study area

Situation and limits of Tadoba Andhari Tiger Reserve (TATR) located in Chandrapur district and lies between Longitude- 79° 13' 13" E and 79° 33' 34" E and Latitude- 20° 4' 53" N and 20° 25' 51" N. The area has been covered with heterogeneous landscape and beautiful forest with some hilly area (Figs. 1 & 2).

Survey

Different places of TATR were surveyed during the month of November 2023 and gregarious flowering of *Dendrocalamus strictus* was observed in Core and Buffer of Tiger Reserve. The seed setting can be expected by the month of March–April 2024. Photographs taken and make depositary of images. Primary study of Bamboo flowering, floral morphology, phenology studied (Fig. 3).

Review of Literature

D. strictus, bamboo species flowers gregariously in Indian bamboo forest. It is the most widely distributed species in India and used extensively in paper pulp manufacture. In this species some cohorts have different inter mast periods of 25 years in South India, 40 to 45 years in North East and Central India, 45 years in Bangladesh and 65 years in West India (Banik 1994). The species also flowers sporadically and seeds are available annually (Ramanayake 2006).

There are various reports of gregarious flowering of different bamboo species in different parts of India, but there are few reports of gregarious bamboo flowering of *Dendrocalamus strictus* in Maharashtra. In 2015, *Dendrocalamus strictus* flowered in the foothills of Nainital district in Ramnagar forest division of Kumaon zone in Uttarakhand. In the years 2019 and 2020, ringal flowering was observed in Mussoorie and its www.tropicalplantresearch.com

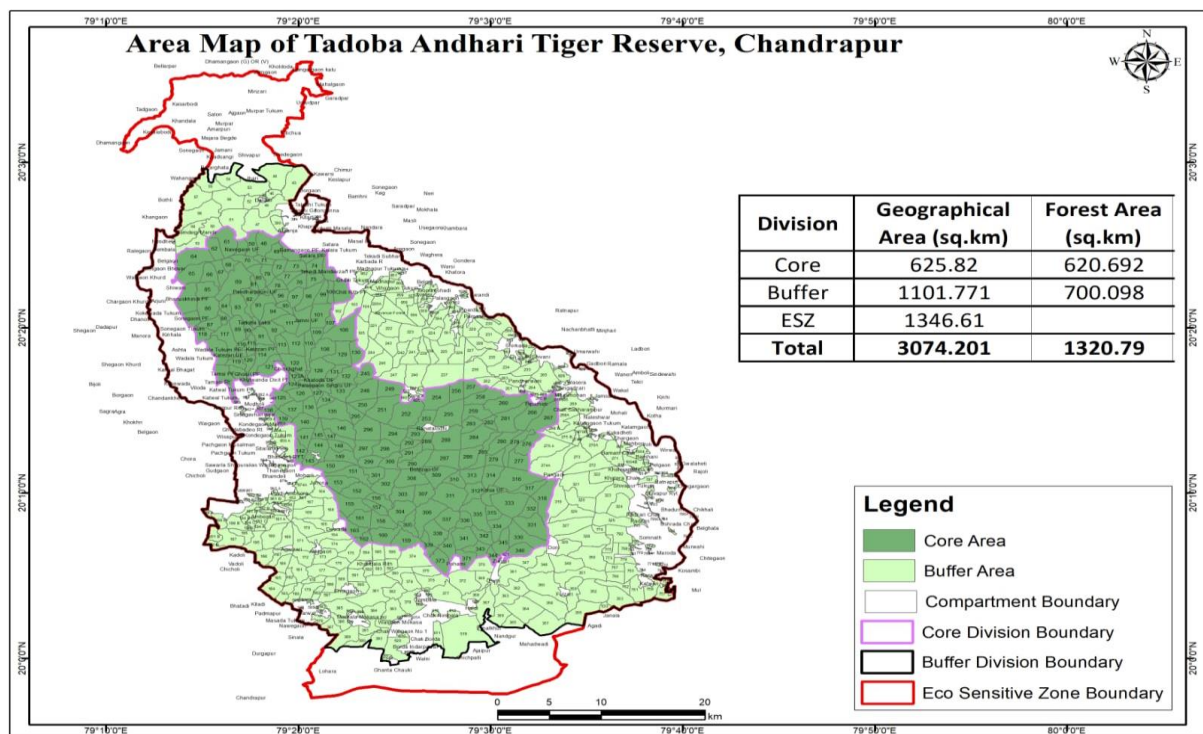


Figure 1. Map showing vegetative data and area of Tadoba Andhari Tiger Reserve (TATR).

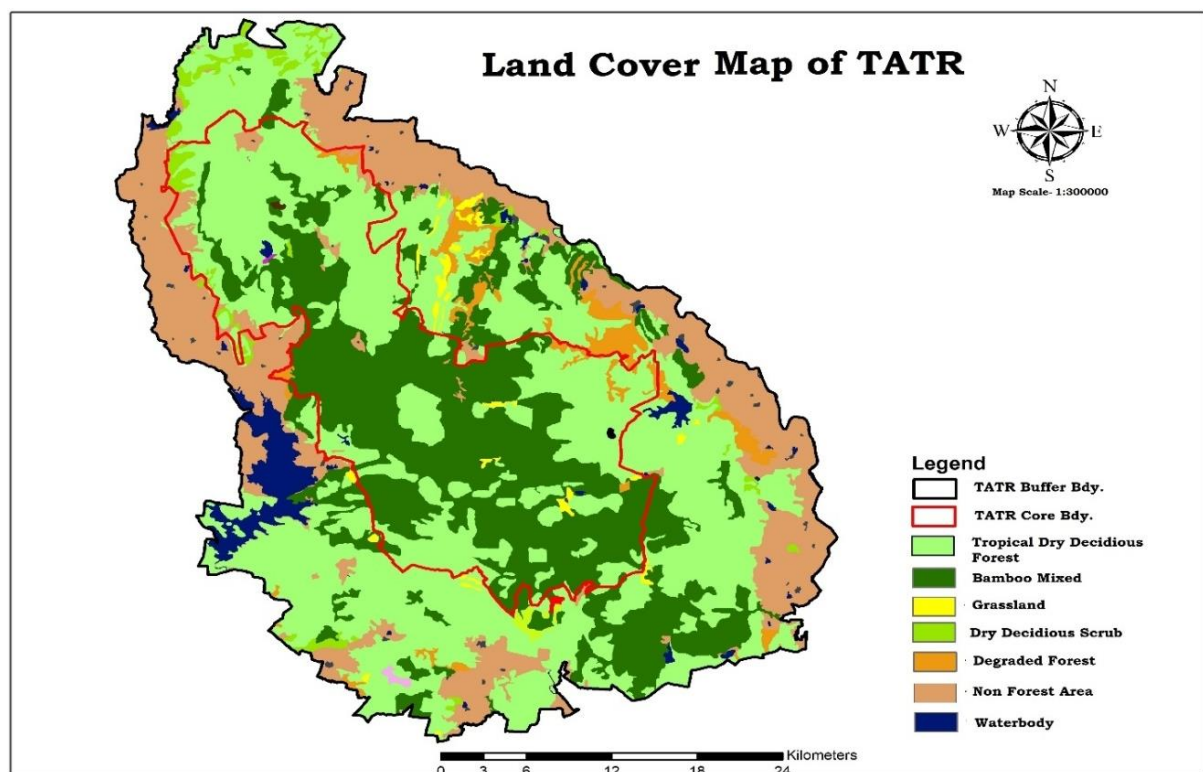


Figure 2. Map showing Bamboo Area in Tadoba Andhari Tiger Reserve (TATR).

surrounding areas. In the past, there were few reports of gregarious flowering in *D. strictus* was reported by Banik *et al.* (1981); Naithani & Pal (2001). Gregarious flowering in *D. strictus* observed in Angul forest Division (SenGupta 1939), Bihar (Sinha 1968), Hyderabad (Uppin 1978), Melghat, Maharashtra (Tatwawadi & Kali 1983), Bhandhavgad, Madhya Pradesh (Gopal 1989), Kurnool, Andhra Pradesh (Rao 1988), Shahdol, Madhya Pradesh (Debi & Dwivedi 1988), Haryana (Kaur 2001), Odisha (NMBA 2009), Mirzapur, Uttar Pradesh (NMBA 2009), Solan, Himachal Pradesh (NMBA 2009), Seoni and Balaghat (NMBA 2009), Mussoorie hills, Uttarakhand (Debi *et al.* 2021). In TATR, an attempt was made to seek records of previous gregarious bamboo flowering that occurred during 1981–84. But not much was available barring the exception of an article on the fires in the bamboo area worked in gregarious flowering of 1981–82. Second gregarious

flowering occurred in the core and buffer area forest compartments of TATR during 2020 have been extensively surveyed and studied (TATR-Management Plan 3/2021). Gregarious flowering was observed during this visit (November 2023) and took survey and studied bamboo flowering, phenology and floral morphology of *Dendrocalamus strictus*, in preliminary manner.

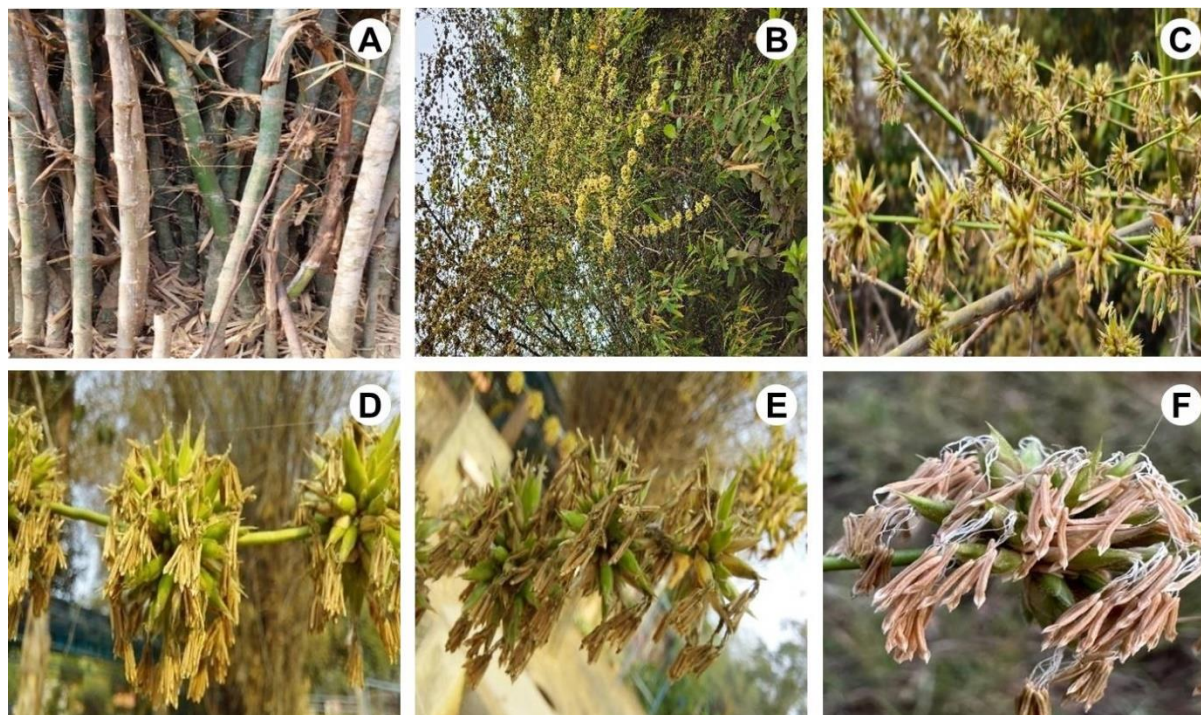


Figure 3. *Dendrocalamus strictus* (Roxb.) Nees: **A**, Bamboo Clump; **B**, Flowering Clump; **C**, Flowering twig and development of flower; **D–F**, Flowering twig bearing florets at anthesis with anthers exerted.

Botanical Classification

The grass family Poaceae has a subfamily called Bambusoideae, which consists of over 1,400 species belonging to about 116 genera. These species are distributed across tropical and temperate habitats around the world (Stevens 2012). The genus *Dendrocalamus* consists of over 40 species of tall, tree-like bamboos that are primarily found in subtropical and tropical regions of Asia (Flora of China Editorial Committee, 2015). In 1798, Roxburgh described this plant species as *Bambusa stricta*. Later, in 1853, Nees separated it into a new genus called *Dendrocalamus strictus*.

Domain:	Eukaryota
Kingdom:	Plantae
Phylum:	Spermatophyta
Subphylum:	Angiospermae
Class:	Monocotyledonae
Order:	Cyperales
Family:	Poaceae
Genus:	<i>Dendrocalamus</i>
Species:	<i>strictus</i>

RESULT AND DISCUSSION

Description of Inflorescence

Dendrocalamus strictus, is a sympodial, monocarpic, caespitose, medium-sized evergreen bamboo species with culms of about 8–20 m tall and 2.5–8.0 cm in diameter. The internodes are 30–45 cm in length and thick-walled. Its nodes are some extent swollen and basal nodes are frequently rooting. Culms are hollow when grow in humid conditions, and solid, when growing under dry conditions. During young, species has pale blue-green culms, and when mature, show dull green or yellow culms, sometimes zig-zag or crooked from the middle towards the top. Many groups of branches with one larger dominant branch. Alternate type simple leaves. They are lanceolate with entire margins and parallel venation Leaf size is changes between 5–25 cm long and 1–3 cm broad. The flowers are arranged in spikes (Fig. 4). The grasses produce caryopses. The flowers of Male Bamboo are unisexual and are borne on different culms (stems). The male flowers are pale yellow and clustered together

in spikelets. Female flowers are smaller and often hidden within the culm nodes. The seeds of Male Bamboo are small and typically have a hard outer covering. They are dispersed by wind or water (Roxburgh 1798, Nees 1753, Nadgauda *et al.* 1993).

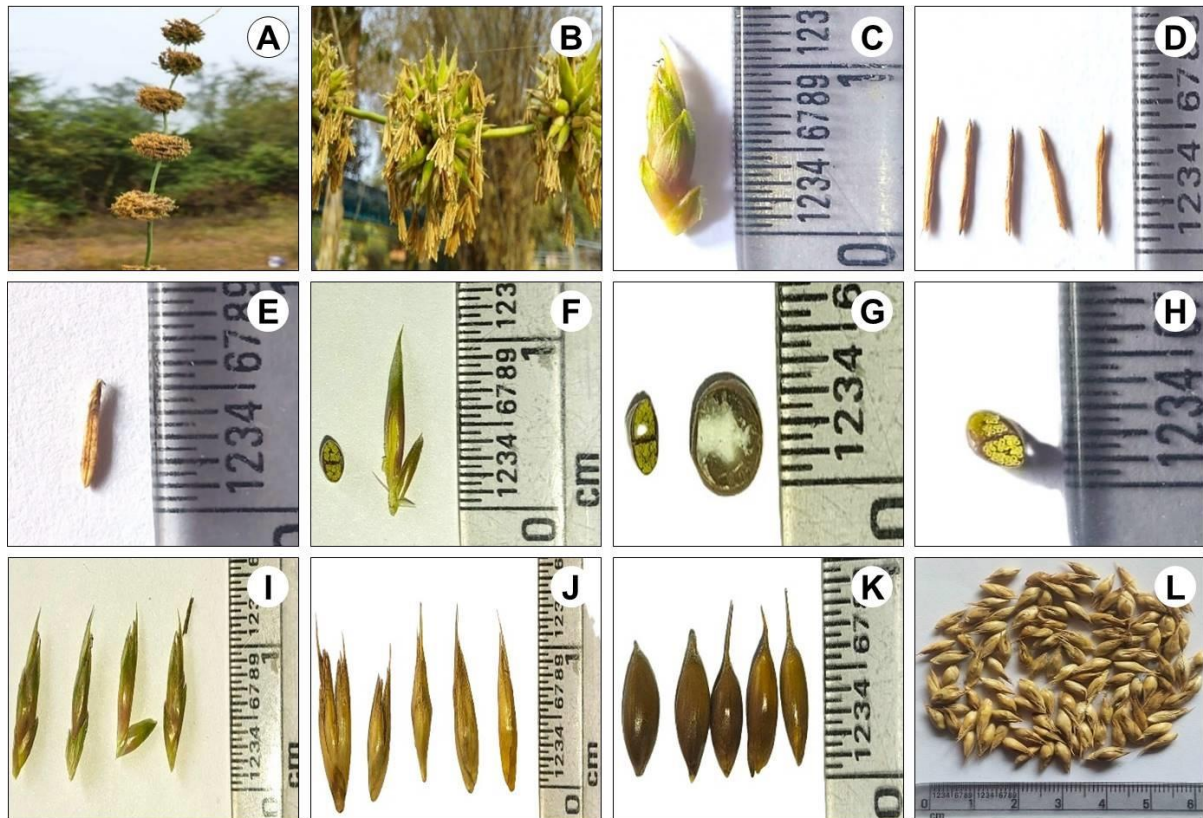


Figure 4. Floral parts and seed of *Dendrocalamus strictus* (Roxb.) Nees: **A**, Inflorescence; **B**, Spikelets; **C**, Spikelets with glume, Lemma and Pales; **D**, Diff. sizes of Anther; **E**, Anther; **F**, L.S. and T.S. of spikelet; **G**, T.S. of seed; **H**, TS of immature seed; **I**, Diff. sizes of spikelet; **J**, Seed with Husk case; **K**, Seed without Husk case; **L**, Mature Seed.

Bamboo Flowering in Male Bamboo

There are two bamboo flowering found in male bamboo: Gregarious and sporadic with flowering cycle of 25–45 years (Debi & Dwivedi 1988). Bamboo flowers only once and die afterwards (Janzen 1976). In bamboo plants, flowering may start sporadically but eventually becomes gregarious, spreading like a wave in a specific direction over the entire forest area (Thapliyal 2011). Verma & Bahadur (1980) reported the flowering cycle of *Dendrocalamus strictus* is about 20–65 years. Gregarious flowering refers to large-scale simultaneous flowering across an entire bamboo population, while sporadic flowering occurs in isolated patches or individuals (Ramanayake & Yakandawala 1995). TATR has experienced both types of flowering events. Some bamboo species exhibit a unique flowering pattern where they remain in a state of constant sterility or constant flowering for long periods of vegetative growth, which can last up to 120 years (Ramanayake 2006). Sometimes during gregarious flowering in bamboo, a few clumps may remain in a state of vegetative growth for no known reason. At the same time these species may also show sporadic flowering in some clumps within populations during the intermast period and also set seeds (Ramanayake 2006).

Bamboo flowering, although a natural phenomenon, has both advantages and disadvantages. Advantages include increased bamboo seed production, which can result in a higher number of bamboo shoots, providing food for animals and promoting forest regeneration. However, the excessive abundance of bamboo seeds during flowering can result in a sudden saturation of the seedbed, leading to both ecological imbalances and agricultural challenges for nearby communities. Bamboo flowering events often spur research and conservation efforts. Tissue culture systems (Ramanayake *et al.* 2006), including micropropagation techniques, have been used to propagate bamboo species, providing an avenue for conservation, reforestation, and sustainable management during and after flowering events. Such initiatives aid in preserving bamboo genetic diversity and mitigating the impact of bamboo die-off after flowering.

CONCLUSION

Dendrocalamus strictus is an industrially, socially, and economically important bamboo species. Periodic
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flowering of this bamboo species, collection of data on the flowering area, the botanical study of bamboo flowers, collection of viable seeds for breeding and afforestation, seed storage and research on factors behind such phenomena and there is an urgent need to study. Studies of bamboo flowering, flowering area, and floral biology provide useful information to fill gaps in knowledge and research on bamboo flowering aggregates, area, and distribution. It is necessary to study the socio-economic aspects of bamboo species for the economic benefit of the rural community in the villages adjacent to the TATR as well as in the buffer zone of Chandrapur district. Employment generation from bamboo, cottage industries like bamboo rice, bamboo furniture, decorative articles, and bamboo plant production should also be emphasized. The bamboo seed is allowed to fall on the ground and regenerate naturally to form the food for the herbivores when there is a likelihood lack of other palatable vegetation of fall of bamboo clumps on the forest floor. The fresh bamboo regeneration will act as an alternate food option and ensure food security. The seed collection activity is labor intensive and if seed collection is permitted within buffer, it will supply employment to the villagers. The human activity in core area can invite man-animal conflict and may eventually result in human deaths. Therefore for the safety reasons the seed collection within core area is not recommended. The bamboo seed being of the Gramineae family is highly susceptible to rodent, ant damage and fungus infection. Hence, proper storage to ward off the damage shall be ensured.

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