TAXONOMIC IDENTITY, ECOLOGICAL NICHE AND DISTRIBUTION OF TWO RESTRICTED RANGE BAMBOO SPECIES OF MEGHALAYA – *PHYLLOSTACHYS MANNII* GAMBLE AND *SINARUNDINARIA GRIFFITHIANA* (MUNRO) C.S. CHAO & RENVOIZE

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Introduction

Establishing correct taxonomic identity of many species under family Poaceae has been one of the biggest challenges for the taxonomists world-wide. Since flowers are difficult to get because of long and variable flowering cycle, and seemingly less economic importance of bamboos, the taxonomy of bamboo remained a neglected area of research till the current decade. In view of the absence of flower in most herbaria, localized distribution of species and high morphological variations, the same bamboo species are often named differently by different workers, working in different parts of the world, creating taxonomic ambiguity. Every taxonomist would have their own view and disagree upon which groups to give a separate generic name to and which to merge (Stapleton, 1990). Unfortunately, most references relating to bamboo taxonomy are contradictory to each other and express divergent views on several species making it difficult for establishing a firm taxonomic identity. *Sinarundinaria griffithiana* (Munro) Chao & Renvoize is one such example, which was confused and placed under four different genera at different times such as *Arundinaria, Chimonobambusa* and *Chimonocalamus* (Newman *et al.*, 2007). Similar taxonomic controversies at species level are observed in case of *Phyllostachys mannii,* which has always been confused with *P. assamica* and *P. bambusoides.* In absence of correct and firm taxonomic identity, any further work on any of the aspect of the species biology either becomes futile or misleading. For instance, the inclusion of *Phyllostachys mannii* in the IUCN Red List is difficult to justify given its broad distribution range, after merging all the species complex together (Chao and Renvoize, 1989).

Both *Phyllostachys mannii* and *Sinarundinaria griffithiana* have restricted range of distribution in Meghalaya and have considerable economic importance in local handicraft industry. However, both the species continue to grow in a restricted range, making it difficult to get adequate quantity of bamboos for expanding handicraft industry. In order to increase the area of occupation of any species, it is essential to

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characterize the niche of the species for its successful introduction to new areas. The knowledge on the regeneration niche of the species ensures its successful propagation. As discussed earlier, in order to understand and proceed with further studies for any species, it is important to have a correct taxonomic identity to avoid confusion. Therefore, the present study aims to provide :

(i) a comprehensive account on taxonomic identity,
(ii) characterization of the ecological niche, and
(iii) distribution pattern of the two important bamboo species.

Material and Methods

The two bamboo species viz., *Phyllostachys mannii* Gamble and *Sinarundinaria griffithiana* (Munro) Chao & Renvoize, were selected for the study grown in the sub-tropical climate in the altitudinal range of 1,000 m - 1,900 m.

Phyllostachys mannii Gamble is a shrubby or arborescent leptomorph bamboo with running underground stems. The culm is yellow-green or green in colour, having smooth surface and flattened on one side in alternate nodes. The nodes are not so prominent, internodes short and branches 2-3, alternating at the nodes. Culm-sheaths are papyraceous and tessellated, green or green-purple to purple, with pale yellow or yellow-green stripes, usually with sparse, small, dark spots. Leaves articulate on the sheath; sheaths loose and smooth. This species is used for various purpose such as weaving mats and various articles, walking sticks, poles and fencing. Young shoots are edible and leaves are used as fodder for cattle and goat. Branches are used as broom sticks and supporting materials for tendril climber vegetables. The flowering record of this species is not known till date.

Sinarundinaria griffithiana (Munro) Chao & Renvoize is a shrubby, pachymorph bamboo having short neck rhizomes. The culm is glaucous green in colour. The nodes are prominent bearing a circle of conical stout short spines with a basal ring of tawny hairs. The internodes are short yellow green, distally pilose and hollow. Culm sheaths are longer than internode, gradually attenuate upward, papery, striate, base with a thick belt of soft tawny hairs, margins ciliate, auricles tiny. This species is used for thatching houses, firewood and fencing, besides using in local handicraft industry. The flowering record of this species was reported from Assam in 1833, Meghalaya in 1894 and Mizoram in 1953 (Tewari, 1992).

Taxonomic identity and distribution

Information about the occurrence of the species was collected from published literature all over the world, herbarium data collected from Botanical Survey of India, Eastern Circle, Shillong and Botany Department, North-Eastern Hill University, Shillong. Intensive field visits were undertaken for documenting the distribution of the two species in Meghalaya. Life specimens were collected, identified and compared with the help of herbarium at Botanical Survey of India, North Eastern Circle, Shillong. The voucher specimens have been deposited at the herbarium in the Department of Botany, North-Eastern Hill University, Shillong. The distribution of the two bamboo species were mapped using a GPS.

Niche characterization

After thorough field survey, Mylliem (25°29.67' to 25°29.71'N lat. and 91°49.04' to 91°48.95'E long.) area was selected for the study of *Phyllostachys mannii* and Mawsynram (25°19.41' to 25°20.49'N lat. and 91°35.75' to 91°36.02'E long.) area for *Sinarundinaria griffithiana*. The sites were selected based on the higher population size of the respective species. Mylliem is about 20 km South of Shillong. Its altitude varies between 1,680 and 1,700 m amsl. Mawsynram is about 75 km from Shillong with altitude ranging between 1,910 and 1,975 m amsl.

For characterizing the ecological niche of the two bamboo species, data on various micro-environmental parameters prevailing in the stands were collected.

Forest stand micro-climate : The micro-climatic conditions prevailing inside the stand were studied for a period of two years from 2006-2008. The micro-climatic factors studied were, light intensity, air temperature and relative humidity, which were measured close to the forest floor on a particular day at monthly interval. The measurements were taken at 4 hourly intervals at ten random points in each stand on the day of microclimate measurement. Light intensity was measured by a Digital Luxmeter (TES 1332A), air temperature and relative humidity by a Thermo hygrometer TH-103 (Mex-therm).

Physico-chemical properties of soil : Physical and chemical properties of the surface soil layer i.e. up to 20 cm depth were analyzed. The parameters were soil pH, soil texture, water holding capacity, bulk density and organic carbon. The analyses were done following the methods outlined by Allen *et al.* (1974) and Anderson and Ingram (1993). Soil temperature was measured by a soil thermometer (Multi-Thermometer).

Results and Discussion

Establishing taxonomic identity

Since its first description in 1989 by Chao and Renvoize in China, the species *Sinarundinaria griffithiana* has been placed in four different genera including *Arundinaria, Chimonobambusa* and *Chimonocalamus* due to the similarities in the inflorescence type, structure of spikelet, floret and rhizome type. Seethalakshmi and Kumar (1998) put all the Indian species of the genera, *Arundinaria, Chimonobambusa, Drepanostachyum, Indocalamus, Semiarundinaria* and *Sinobambusa* under *Sinarundinaria*. Approximately 50 species are distributed worldwide under the genera *Sinarundinaria*, of which two are in Central America, three in Africa and Madagascar, and the rests are in Asia (Chao and Renvoize, 1989).

Phyllostachys mannii Gamble has always been confused with *P. assamica* and *P. bambusoides* and has given rise to much controversy due to taxonomic ambiguity bearing different species name such as *P. assamica* Gamble ex Brandis, *P. bawa* E.G. Camus, *P. decora* McClure and *P. bambusoides* auct. non Sieb. ex Zucc. (Fig. 1). Many authors have treated these species as independent species (Gamble, 1896; Bor, 1940; Seethalakshmi and Kumar, 1998; Tewari, 1992). However, it is now believed that all these species are synonyms of *Phyllostachys mannii* (Chao and Renvoize, 1989).

The above three species have been differentiated based on the culm height, sheath and diameter. In the literature, the culm height of *Phyllostachys mannii* is stated to be ranged between 4.5 and 10 m with a culm diameter ranging from 2.5 - 6.0 cm (Shukla, 1996; Gamble, 1896; Bor, 1940; Tewari, 1992; Seethalakshmi and Kumar, 1998; Zhengyi, 2006), in *Phyllostachys assamica* height ranges from 10 - 12 m with a culm diameter of 20 cm (Shukla; 1996; Bor, 1940; Tewari, 1992), and in case of *Phyllostachys bambusoides,* the height ranged from 2 - 22 m with a culm diameter of 1 - 15 cm (Seethalakshmi and Kumar, 1998; Tewari, 1992; Gamble, 1896). During the present study, the culm height in *Phyllostachys mannii* ranged between 6 and 16 m with a culm diameter of 1.5 - 6.0 cm; hence conforming to the synonymous identity with *Phyllostachys assamica* and *Phyllostachys bambusoides.* The culm sheath, one of the most important identification characters of bamboo species, however varies among the three synonyms. In fact, several workers have reported variable size and form of the culm sheaths in the genus *Phyllostachys* (Chao and Renvoize, 1988). In the present study, the culm sheaths of *Phyllostachys mannii* were found to be variable even within the same species depending upon the height and diameter of the culm. The young shoots and the lower sheaths of the mature shoots are without auricles or have only a small protuberance. But the middle culm sheaths of the mature shoots always have falcate auricles. The young lower sheath can range from 10 - 35 cm long and 2 - 15 cm broad and the middle culm sheath 10 - 45 cm long and 3 - 15 cm broad. The blade is also varied, from triangular or lanceolate to strap-like, depending on its position on the culm. But the ligule of the culm sheath is always purplish fimbriate at the apex. A pair of branches at each node is another important character for the genus *Phyllostachys.* All these characteristics and variabilities are also found in *Phyllostachys assamica* and *P. bambusoides,* as are observed in *P. mannii.* Therefore, the authors firmly believe that *Phyllostachys assamica, P. bambusoides* and *P. mannii* are synonyms. Such a conclusion as made in this study is in conformity with the observations made in Flora of China (Zhengyi, 2006), where *P. assamica, P. bawa, P. decora* and *P. helva* were identified as the synonyms of *P. mannii* and is also more or less in agreement with Shukla (1996) who identified *P. bambusoides* as synonym of *P. assamica.* Gamble (1896) concluded that *P. megastachya, Bambusa reticulata* and *B. bifolia* were synonyms of *Phyllostachys bambusoides.* On the other hand *P. bambusoides* and *P. reticulata* were stated to be synonyms by Tewari (1992). Zhengyi (2006) reported that *Bambusa reticulata, Phyllostachys bambusoides, P. lithophila, P. megastachya, P. pinyanensis* and *P. quilioi* are synonyms of *P. reticulata* (Fig. 1). All these works although present divergent views about the identity of these species, some sort of similarity can be traced among them and hence, synonymity can be argued.

Niche characteristics

The micro-environmental variables and soil characteristics in *Phyllostachys mannii* and *Sinarundinaria griffithiana* stands were more or less similar. This shows that both the species have similar niche requirement for their survival and growth (Table 1). Both the species follow three-phase growth sequence. Firstly, a young shoot protected by numerous

Fig. 1

Species	Synonyms	Reference
***Phyllostachys mannii* Gamble**	*Phyllostachys assamica* Gamble ex Brandis *P. bawa* E.G. Camus *P. decora* McClure *P. helva* T.H. Wen	Zhengyi, 2006
***Phyllostachys assamica* Gamble ex Brandis**	*P. bambusoides* Sieb. ex Zucc.	Shukla, 1996
***P. bambusoides* Sieb. ex Zucc.**	*P. megastachya* Steudel *Bambusa reticulata* Rupr. *Bambusa bifolia* Sieo.	Gamble, 1896
***P. bambusoides* Sieb. ex Zucc.**	*P. reticulata* Sensu Koch	Tewari, 1992
***Phyllostachys reticulata* (Rupr.) K. Koch**	*Bambusa reticulata* Rupr. *P. bambusoides* Sieb. & Zucc. *P. lithophila* Hayata *P. megastachya* Steudel *P. pinyanensis* T.H. Wen *P. quilioi* Riviere & C. Riviere	Zhengyi, 2006

A list of synonyms of *Phyllostachys mannii*, *P. assamica*, *P. bambusoides* and *P. reticulata*

sheaths emerges from the ground. This new shoot develops slowly at first, but elongates rapidly in the mid-phase and grows to full height after a slow down period. Finally, branches are unfolded and a culm is then established. However, the length of each phase varies from species to species (Table 2, Fig. 2), depending on the rhizome structure of the bamboo. There are two basic types of rhizomes: sympodial (clumping/pachymorph bamboo) and monopodial (running/leptomorph bamboo) (McClure 1993). Studies have shown that the monopodial bamboo sprouts and grows much quicker than the sympodial bamboo (Li, 2005). This holds true for *Phyllostachys mannii* having monopodial rhizome, where shoots emerges in spring and early summer within a short sprouting phase averaging 30 ± 10 days. Emerged shoots rapidly elongate and form a canopy of the stand within 40±15 days. *Sinarundinaria griffithiana* a clumping bamboo have much longer sprouting (115 ± 47 days) and elongation (120 ±37 days) phases (Table 2, Fig. 3).

Distribution

The distribution map of *Phyllostachys*

Table 1

Geographic range, macro-climatic, micro-environmental and soil characteristics in Phyllostachys mannii and Sinarundinaria griffithiana stands in Meghalaya.

	Phyllostachys mannii	*Sinarundinaria griffithiana*
Geographic range and macro-climatic conditions :		
Latitude	25°17.55'N - 25°29.71'N	25°15.03'N - 25°24.20'N
Longitude	91°12.64'E - 92°14.43'E	91°34.54'E - 92°09.22'E
Altitudinal range (m amsl)	1200 – 1900	1000 – 1800
Annual precipition (mm) – year 2005	10,754	10,754
Annual temperature (°C) – Year 2005	23.5	23.5
Microclimatic condition (Annual range) :		
Light (lux)	25000 - 61400	23000 - 119900
RH (°C)	45.0 - 88.0	44.0 - 92.0
Air (°C)	17.0 - 27.0	15.0 - 28.0
Soil physical properties (Annual range) :		
Soil Moisture Content	12.0 - 33.0	15.0 - 38.0
Soil temperature (°C)	11.0 - 23.0	10.0 - 23.0
Clay (%)	8.8 - 10.8	11.7 - 12.7
Silt (%)	1.0 - 3.0	1.0 - 3.0
Sand (%)	88.0 - 89.12	85.0 - 86.0
Textural class	Sandy	Sandy
WHC (%)	45 - 53	54 - 63
BD (g/cm^3)	0.39 - 0.45	0.40 - 0.47
SOC (%)	2.0 - 5.0	3.0 - 4.0
SOM (%)	3.5 - 8.0	5.0 - 8.0
NH_4-N (µg/g)	5.0 - 32.0	5.0 - 29.0
NO_3-N (µg/g)	9.0 - 38.0	6.0 - 36.0

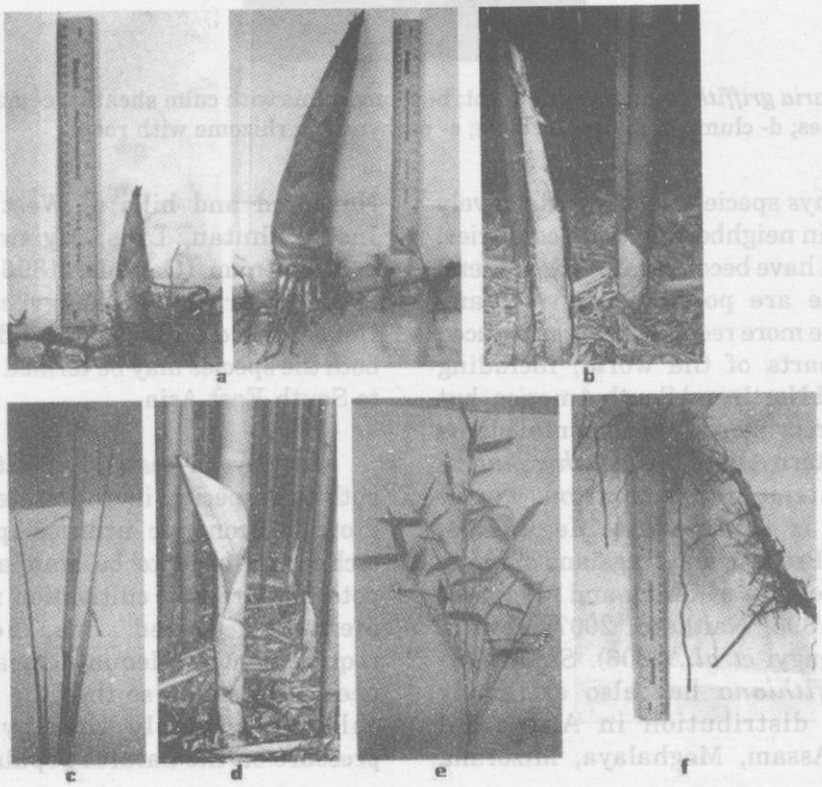
mannii and *Sinarundinaria griffithiana* in Meghalaya (Fig. 4) shows extremely restricted distribution in the state, mostly in Khasi Hills. The genus *Phyllostachys* is the most economically important group of the monopodial bamboos. It includes about 55 species, all of them native to China, although *P. bambusoides* Sieb. & Zucc. and *P. mannii* extend to India, Vietnam, Laos and Burma. Some species were introduced from China to Japan hundreds of years ago (Chao and Renvoize, 1988).

Table 2

Growth parameters of two bamboo species in Mylliem and Mawsynram stands in Meghalaya.

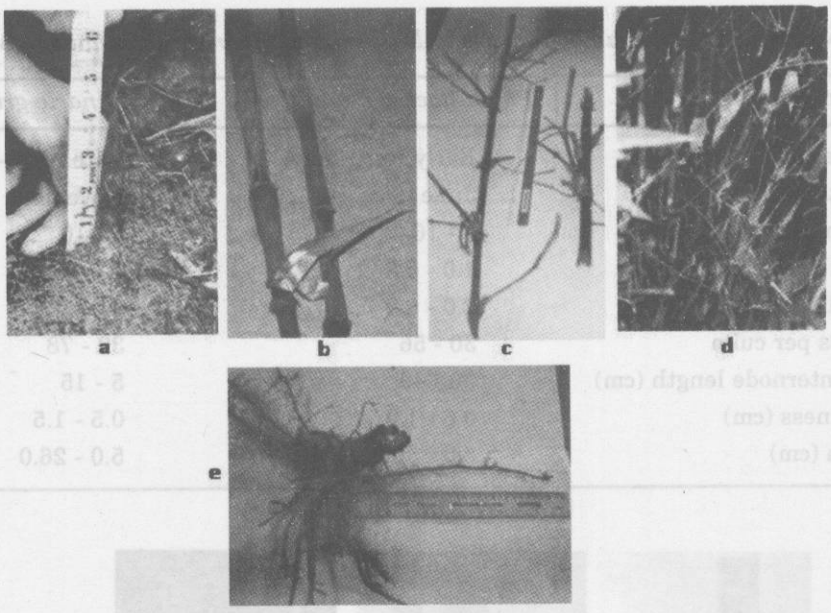
Growth parameters	*Phyllostachys mannii*	*Sinarundinaria griffithiana*
Shooting period	Early April-May	Late April-July
Peak growth period	June	November
Culm height (m)	8 - 16	5 - 10
Basal culm dia. (cm)	1.0 - 6.8	1.5 - 6.0
Mid culm dia. (cm)	2.0 - 6.0	1.0 - 4.7
No. of nodes per culm	30 - 56	30 - 78
Mid-culm internode length (cm)	30 - 49	5 - 15
Culm thickness (cm)	0.5 - 1.0	0.5 - 1.5
Root length (cm)	5.0 - 30.0	5.0 - 26.0

Fig. 2



Phyllostachys mannii: a- young shoots; b- young shoots with culm sheaths; c- young culms with new branches; d- matured culms with lower culm sheaths; e- branches with leaves; f- leptomorph rhizome with roots.

Fig. 3

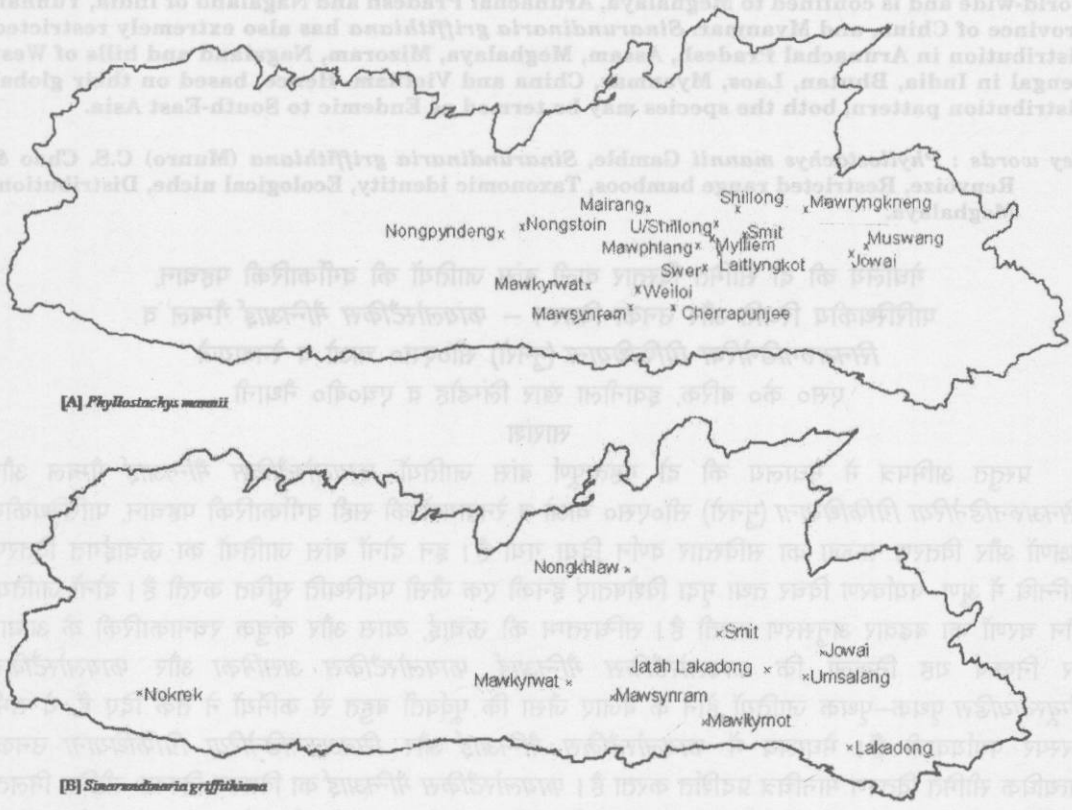


Sinarundinaria griffithiana: a- young shoot; b- young culms with culm sheaths; c- matured culms with branches; d- clump of matured culms; e- pachymorph rhizome with roots.

Phyllostachys species are now extensively cultivated in neighboring Asian countries, and several have become naturalized there, while some are possibly native. Many species have more recently been introduced to other parts of the world, including Europe and North and South America, but they remain principally ornamental plants outside eastern Asia. *Phyllostachys mannii* has a restricted distribution world-wide and is confined to Meghalaya, Arunachal Pradesh and Nagaland of India, Yunnan province of China and Myanmar (Gamble, 1896; Naithani, 2007; Tewari, 1992; Zhengyi *et al.*, 2006). *Sinarundinaria griffithiana* has also extremely restricted distribution in Arunachal Pradesh, Assam, Meghalaya, Mizoram, Nagaland and hills of West Bengal in India, Bhutan, Laos, Myanmar, China and Vietnam (Gamble, 1896; Naithani, 2007; Tewari, 1992; Zhengyi *et al.*, 2006). Hence, based on their global distribution, both the species may be termed as Endemic to South-East Asia.

In view of restricted distribution of both the species in the state and their growing economic utilities, propagation techniques need to be standardized and potential areas of cultivation needs to be identified based on their niche requirements. Adequate measures also need to be taken so that the species are cultivated widely thereby reducing pressure on the natural populations.

Fig. 4



Distribution map of *Phyllostachys mannii* (A) and *Sinarundinaria griffithiana* (B) in Meghalaya.

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SUMMARY

The paper presents a comprehensive account on taxonomic identity, niche characteristics and distribution pattern of two important bamboo species of Meghalaya viz., *Phyllostachys mannii* Gamble and *Sinarundinaria griffithiana* (Munro) C.S. Chao & Renvoize. The altitudinal distribution of both the species, and stand micro-environmental variables and soil characteristics indicate similar niche of the species. Both the species follow three-phase growth sequence. Based on the culm height, diameter and sheath morphology, it was concluded that *Phyllostachys mannii*, *Phyllostachys assamica* and *Phyllostachys bambusoides* are synonyms instead of being independent species as has been argued by many earlier workers. The distribution map of *Phyllostachys mannii* and *Sinarundinaria griffithiana* in Meghalaya

shows extremely restricted distribution. *Phyllostachys mannii* has a restricted distribution world-wide and is confined to Meghalaya, Arunachal Pradesh and Nagaland of India, Yunnan province of China, and Myanmar. *Sinarundinaria griffithiana* has also extremely restricted distribution in Arunachal Pradesh, Assam, Meghalaya, Mizoram, Nagaland and hills of West Bengal in India, Bhutan, Laos, Myanmar, China and Vietnam. Hence, based on their global distribution pattern, both the species may be termed as Endemic to South-East Asia.

***Key words* : *Phyllostachys mannii* Gamble, *Sinarundinaria griffithiana* (Munro) C.S. Chao & Renvoize, Restricted range bamboos, Taxonomic identity, Ecological niche, Distribution, Meghalaya.**

मेघालय की दो सीमित विस्तार वाली बांस जातियों की वर्गीकारिकी पहचान, पारिस्थिकीय स्थिति और उनका वितरण – *फायलोस्टैकिस मैन्निआई* गैम्बल व *सिनअरुनडिनेरिया ग्रिफिथियाना* (मुनरो) सी०एस० चाओ व रेनवायजे

एस० के० बरिक, इवानीला खार लिंग्डोह व एच०बी० नैथानी

सारांश

प्रस्तुत अभिपत्र में मेघालय की दो महत्वपूर्ण बांस जातियों *फायलोस्टैकिस मैन्निआई* गैम्बल और *सिनअरुनडिनेरिया ग्रिफिथियाना* (मुनरो) सी०एस० चाओ व रेनवायजे की सही वर्गीकारिकी पहचान, पारिस्थिकीय लक्षणों और वितरण सज्जा का सविस्तार वर्णन दिया गया है। इन दोनों बांस जातियों का ऊंचाईगत वितरण सन्निधि में अुण–पर्यावरण विचर तथा मृदा विशेषताएं इनकी एक जैसी पदस्थिति सूचित करती है। दोनों जातियां तीन चरणों का बढ़वार अनुसरण करती है। सन्धिस्तम्भ की ऊंचाई, व्यास और कंचुक रचनाकारिकी के आधार पर निष्कर्ष यह निकला कि *फायलोस्टैकिस मैन्निआई, फायलोस्टैकिस असमिका* और *फायलोस्टैकिस बैम्बूस्वायडिस* पृथक–पृथक जातियों होने के बजाए जैसा कि पूर्ववर्ती बहुत से कर्मियों ने तर्क दिए हैं, ये सभी परस्पर पर्यायवाची हैं। मेघालय में *फायलोस्टैकिस मैन्निआई* और *सिनअरुनडिनेरिया ग्रिफिथियाना* उनका अत्यधिक सीमित वितरण मानचित्र प्रदर्शित करता है। *फायलोस्टैकिस मैन्निआई* का वितरण विश्वतः सीमित मिलता है तथा यह केवल भारत के मेघालय, अरुणाचल प्रदेश और नागालैण्ड राज्यों, चीन के यून्नान प्रात और म्यांमार में ही सीमित है। *सिनअरुनडिनेरिया ग्रिफिथियाना* का अत्यधिक सीमित वितरण भारत में अरुणाचल प्रदेश, असम, मेघालय, मिजोरम, नागालैण्ड राज्यों, पश्चिम बंगाल की पहाडियों, भूटान, लाओस, म्यांमार, चीन और विएतनाम में ही मिलता है। अतः इन दोनों बांस जातियों को दक्षिण–पूर्व एशिया में ही स्थानसीमित जाति कहा जा सकता है।

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