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THE DEVELOPMENT OF INVASIVE ALIEN PLANT SPECIES MANAGEMENT IN THE FRAMEWORK OF REHABILITATION OF INVADED ECOSYSTEMS AT GUNUNG GEDE AND PANGRANGO NATIONAL PARK

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ABSTRACT

THE DEVELOPMENT OF INVASIVE ALIEN PLANT SPECIES MANAGEMENT IN THE FRAMEWORK OF REHABILITATION OF INVADED ECOSYSTEMS AT GUNUNG GEDE AND PANGRANGO NATIONAL PARK

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Chimonobambusa quadrangularis (Franceschi) Makino, is an invasive alien bambu species, belonging to Poacae family , originated from China and Formosa (Suzuki 1978). However this species was introduced from Japan around 1920 to Cibodas Botanical Gardens (Widjaja 2001). It spreads vegetative via the belowground rhizome carrying bud in each nodes. Mutaqien *et al*. (2011) suggested that this bambu invaded Gunung Gede and Pangrango National Park, since this bambu has been utilised as the fence separating the Cibodas Botanical Garden area. Driven by this recommendation activities were organised and researches were designed to study the control and the eradication of this bambu. A factorial experimental design was carried out combining two factors, one was slashing of bambu culm consisting of 2 levels, i.e. slashing the culm by leaving (1) one nodes, and (2) slashing culm leaving 3 nodes. The second factor was tretments consisting of 4 levels, (1). Slashed at monthly interval, (2). after slashing the cut culms were immediatelly brushed with 10% triclopyr disolved in diesel oil, (3). 2 months after slashing the growing shoot were sprayed with equivalent glyphosate at 6 l/ha in 400 l water/ha with a knapsack sprayer, (4), slashing at 2 months interval. The experiment was carried out in GGPNP on an area dominated by bambu kersik under the trees of rasamala (Altingia exelsa). The combined treatments were 8 and replicated 3x tgiving a total of 24 plots. The plots were 2x 3 m2 delineated around by a ditch of 25 cm wide. *C.quadrangularis* (bambu kersik) is a strongly rhizomatous perennial bambu which proliferates well under the condition of mild environment of Pangrango Mountain. even under the shade of trees. Due to its rhizomatous growth form and intermingling of different genets, *C. quadrangularis* genets are very difficult to identify in the field. The bambu culm density in plot varied from 26 -62 culms/plot, statistically they were not different significantly with the mean 39.29 ±9.9 culms/plot. slashing followed by brushing with triclopyr at 10% disolved in diesel oil was good enough to control the growth of bambu culm, Two months after treatments, analysis of Variance on data of total living bamboo culms in each plots indicated no interactions among the factors, but each factors affected the number of living bambu culms significantly. The mechanism of expansion was deliberatly proposed. Another set of observation was done at another location to have a duplicate. Three bambu kersik community sites of different ages are to be identified, and selected as plots, these plots shall be widely apart and the sampling metods will be carried out as the following: 1. Two line transect of 50 m are laid randomly in each plot. 2. A single bambu kersik culm along the tansect will be selected at random and a kuadrat of 1 x 1 m is laid perpendicular to the transectat an interval of 10 m. 3. The sampling will be carried out from August to October each month to obtain a representative distribution of ramet, rhizome, bud and tillers.

Keywords : *Chimonobambusa quadrangularis,* invaded ecosystem, Invasive species.

1. INTRODUCTION

Chimonobambusa quadrangularis (Franceschi) Makino, is an invasive alien bambu species, belonging to Poacae family , originated from China and Formosa (Suzuki 1978). However this species was introduced from Japan around 1920 to Cibodas Botanical Gardens (Widjaja 2001). Bruggeman (1927) reported several species of Japanese bamboo has been brought into the garden that might included this species. Dakkus (1930) mentioned that *Phyllostachys quadrangularis* was grown at P block (P 56). Later, this plant were being re-identified as *Tetragonocalamus quadrangularis* (Nasution 1963) as *Bambusa angulata (*Roemantyo *et al*. (1988), and was officially named by SINDATA (2017) as *Chimonobambusa quadrangularis* . (Fig. 1). Widjaja *et al*. (2014) confirmed that this plant was most likely the one that being introduced around the 1920s from Japan.

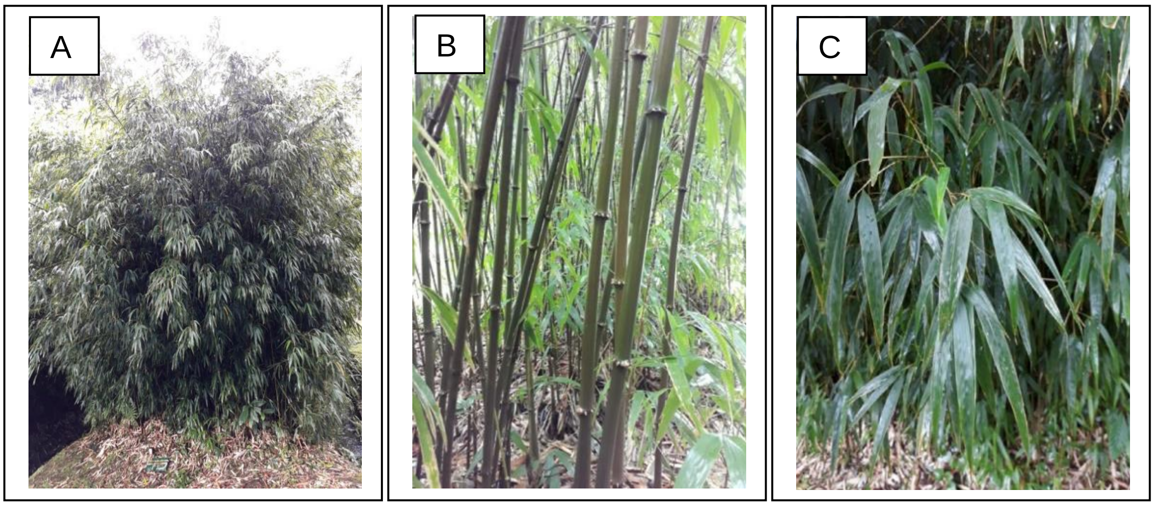

Figure 1 Chimonobambusa quadrangularis collection of Cibodas Botanical Garden. A. Habit, B. Culm, C. Leafy branch (Photos: Muhamad Muhaimin 2017).

Under the condition at Cibodas Botanical Garden it grows prolifically reaching 6 m height (Tjitrosoedirdjo et al, 2016) even under the shade of trees, however it does not flower at all. It spreads vegetatively via the belowground rhizome carrying bud in each nodes. Mutaqien *et al*. (2011) suggested that this bambu invaded Gunung Gede and Pangrango National Park, since this bambu has been utilised as the fence separating the Cibodas Botanical Garden area. From this fence rhizomes grew into gaps sending culms to grow between trees and spreaded rapidly to reach an area called *Pasarean*. No attempt was taken to eradicate this species. It was reported a colony of *C.quadrangularis* detected in *Topos* and considered as an invasive species (Tjitrosoedirdjo *et al*. 2016b).

During the workshop on Harmonizing Methods in Risk Assesment and Management of Forest Invasive Alien Plant Species in Southeast Asia, organised by BIOTROP in 2-5

December 2014 (Fernandez, et al., 2015) *C.quadrangularis* obtained a recommendation to be eradicated. The consideration was heavily influenced by the fact that the distribution of this bambu was still limited, covering a few hectar, i.e. small patch near the education center, a wider area from the fence to Pasarean area, while another patch was observed in Topos suspected was initiated by a visitor using a piece of bambu culm as a walking stict and inadvertedly left behind sticked to the ground and proliferated, to invade the surroundung area. Driven by this recommendation activities were organised and researches were designed to study the control and the eradication of this bambu. A factorial experimental design was carried out combining two factors, one was slashing of bambu culm consisting of 2 levels, i.e. slashing the culm by leaving (1) one nodes, and (2) slashing culm leaving 3 nodes. The second factor was tretments consisting of 4 levels, (1). Slashed at monthly interval, (2). after slashing the cut culms were immediatelly brushed with 10% triclopyr disolved in diesel oil, (3). 2 months after slashing the growing shoot were sprayed with equivalent glyphosate at 6 l/ha in 400 l water/ha with a knapsack sprayer, (4), salshing at 2 months interval. The experiment was carried out in GGPNP on an area dominated by bambu kersik under the trees of rasamala (*Altingia exelsa*). The combined treatments were 8 and replicated 3x tgiving a total of 24 plots. The plots were 2x 3 m2 delineated around by a ditch of 25 cm wide.

The density of bambu culms were presented in Table 1. The bambu culm density in plot varied from 26 -62 culms/plot, statistically they were not different significantly with the mean 39.29 ±9.9 culms/plot.

Table 1. The population of bambu culms in 2x3 m2 experimental plot

N0	Treatments combinations		Replications			
	Cutting	treatment	1	2	3	Mean
1	1 internode	Cut once	31	30	62	41.00
2		Cut 2 monthly	26	33	48	35.67
3		Brushed 10% GARLON	33	39	51	41.00
4		Sprayed Glyphosate	30	32	27	29.67
5	3 internodes	Cut once	38	55	52	48.33
6		Cut 2 monthly	34	35	50	39.67
7		Brushed 10% GARLON	37	49	43	43.00
8		Sprayed Glyphosate	41	30	37	36.00
	General mean					39.29 ± 9.9

Two months after treatments, analysis of Varince on data of total living bambu culms in each plots indicated no interactions among the factors, but each factors affected the number of living bambu culms significantly (Tabel. 2)

Table 2 . The mean umber of living bambu plants 2 months after treatments

No	Treatments	No of living culms
1	Cut montly	31.883[b]
4	Cut 2 monthly	24.500[b]
2	Brushed 10% GARLON	6.500[a]
3	Sprayed Glyphosate	23.333[b]

NB. Numbers followed by the same letter do not differ significantly

Looking at the data presented in Tbl 2, slashing followed by brushing with triclopyr at 10% disolved in diesel oil was good enough to control the growth of bambu culm.

Up to six months after treatment, slashing followed by brushing with triclopyr at 10% showed a consistant good result, reducing thr regrowth of buds (Tbl. 3)

Table 3 The mean umber of emerging bambu buds plants 6 months after treatments

No	Treatments	No of living culms
1	Cut montly	7.328 [b]
4	Cut 2 monthly	1.994[a]
2	Brushed 10% GARLON	4.753[b]
3	Sprayed Glyphosate	4.444[b]

NB. Numbers followed by the same letter do not differ significantly

The effect of triclopyr was consistant in redusing the growth of bud, however the application of herbicides was not accepted by the policy makers, therefore, the experiment was terminated. Another way may be developed to catch up with the recommendation of the workshop to eradicate bambu kersik. The objective of the study was shifted from eradication into studying its biology, how this plant was selected by the botanist at CBG as collected plant, it may have somethings useful.

2. BIOLOGICAL STUDIES OF BAMBU KERSIK

When the chemical control using herbicides was not accepted as a mean of controlling bambu kersik, biological studies were designed to find other ways of controlling it. Preliminary study was carried out under the green house condition at BIOTROP about 250 m asl. Observing the performance of bambu kersik at BIOTROP under greenhouse condition turned out to be markedly different from that of bambu kersik in GNPNP area. It grows shorter, hardly reaches 50 cm; despite its dwarf performance the architectural structure remains Tbl.4).

Table 4 . The performance of rhizomes, culms and tillers from *C.quadrangularis* grown in BIOTROP campus under the greehouse condition

		Sum	Length (cm)	Total nodes
Rhizomes	Primary	7	846	504
	Secondary	22	818.8	431
	Tertiary	17	620	327
	Quarterly	3	27	17
Total		49	2311.8	1279
		Sum	Length (cm)	Total nodes
Culm +tillers	Primary rhizome	33	1408	624
	Secondary rhizome	7	413	141
Total		40	1821	765

The length of rhizome, 2311.8 cm when compared against that of culms and tillers, 1821 cm was much longer; the number of nodes of rhizomes, 1279 is also much bigger than that of culm and tiller, 765. The whole colony in plastic pot is shown as Fig. 2. It seems this bambu produces a considerablw rhizome, supporting a rapid growth in the process of invasion.

Figure 2 . A colony of bambu kersik A. in pot, B stretches on the floor

3. OBJECTIVES

1. To study the growth of *C.quadrangularis* in the field term of resource allocation among the organ below and above ground
2. To study the process of biological invasion
3. To find the benefit of its biological characters

4. LITERATURE REVIEW

4.1. DISTIBUTION

Chimonobambusa quadrangularis (Franceschi) Makino, was also reported from Sibolangit Tourist Park, North Sumatra since 1975. Damayanto & Muhaimin (2017) during their investigation in Herbarium Bogoriense (BO) , noticed that on the first specimen they investigated they found written information that this bambu occupied a large area of the garden in Sibolangit. They considered then that the above record provided a legal prove as first report of *C. quadrangularis* being an invasive species. Maryanto *et al*. (2013) & Widjaja *et al*. (2014) reported that *C. quadrangularis* was found also in Mt. Sibayak. It is only natural to find *C.guadeangularis* invades the nearby areas.

Based on Taihui (1994) *C. quadrangularis* in the sub-tropics are found growing at an altitude 1,000– 2,000 m, with average annual rainfall 1,000–1,400 mm, temperature of 8–16ºC with extreme low temperature of -14ºC, and air humidity of 70–80%. The performance of *C.quadrangulasi* at Cibodas Botanical Garden has been spectacular reaching the height of 6 m under an average annual rainfall 2,950 mm, temperature of 20.06ºC (KRC 2017, Junaedi 2014), while Sibolangit Nature reserve and park lies at altitude 550 with average annual rainfall 3,000–4,000 mm, temperature 13ºC–28ºC and air humidity above 90 % (DEPHUT 2002, Ginting 2011). Damayanto & Muhaimin (2017) descriped *C.quadrangulasi* having leptomorph rhizomes up to 4 m, easily rising to the ground surface or rock gap. *Shoot* purplish green with scattered brown hairs particularly near the nodes. The shoot can grow far from the main clump. *Culm* green, straight, erect to tip, 2–4 m tall, 2–3 cm in diameter, internode 20–25 cm, quadrangular but cylindrical in the upper part, rough with the scattered small white spine (less than 1 mm long).

C. quadrangularis in its natural environment as reported by You *et al* (2014) even under the tree forest of *Davidia involucrata* it forms a very intensive coverage. You et al (2014) in studying the endangered *Davidia involucrata* forest in China described one of the 15 communities under *Davidia involucrata* forest as community J.

This short wooded community is situated at altitude ranging from 1570 m to 1700 m in the Kuankuoshui forest area of Guizhou. The diagnostic species are *Chimonobambusa quadrangularis*, *Sassafras tzumu*, *Morus mongolica*, *Yulania sprengerii*, *Eurya japonica*, and *Rubus irenaeus*. Stratification shows usually four layers with two tree sub-layers. The upper canopy reaches 10 - 15 m and is dominated by *Davidia involucrata*, mixed with *Pterostyrax psilophylla*, *Toxicodendron succedaneum*, *Cyclobalanopsis multinervis*, *Magnolia sprengeri*, *Aesculus wilsonii*, *Sassafras tzumu*, *Fagus longipetiolata*, etc. The lower tree layer attains 3 - 8 m, and the main species include *Litsea euosma*, *Weigela japonica* var. *sinica*, *Morus mongolica*, *Eurya japonica*, *Ilex chinensis*, *Rhododendron stamineum*, *Lindera glauca*, etc. The shrub layer (1 m) is a dense cover (80% - 90%) of dominant *Chimonobambusa quadrangularis*.

4.2 RHIZOMES

Although rhizomes are not the most accessible parts of the plant, rhizomes are particularly important in the bambus, both ecologically and horticulturally. They control when the culms develop and how they spread, and they also dictate vegetative propagation techniques.

There are two problems related to rhizomes. The first problem is the difficulties in appreciating the important roles of rhizome carried out for the life of bambus; rhizomes are experiencing evolutions to support the survival of bambus, therefore they are different one from the other depending upon the evolution history. It is now accepted that rhizome form, in conjunction with other characters, is very useful for the separation of bamboo genera. The second problem is that the researchers have developed terminologies that are not compatable one with the others, creating a great deal of confusion as to which terminology is appropriate for bambus with particular forms of rhizomes, and how the different terminologies relate.

McClure (1966) gave a very detailed and perceptive description of the bambu rhizome. He separated two distinct forms, now most commonly known as the pachymorph (or sympodial) form, and the leptomorph (or monopodial) form, he was the first to describe the two different forms of rhizome, applying the terms sympodial and monopodial in his first publication (McClure, 1925). This distinction is well understood by most of those who have any experience of handling bambus. However, several terms have been coined for these two forms of rhizome, and this has caused confusion. The problem is compounded when ambiguous terminology is introduced, especially the term amphipodial, which blurs the distinction unnecessarily. McClure (1966) gave an illustration of *Chusquea fendleri* Munro, in which leptomorph rhizomes produce very swollen tillering culm bases, some having marked horizontal growth, and appearing very similar to pachymorph rhizomes. The rhizomes of such bamboos have been described as amphimorph or amphipodial. The use of these terms may be rather misleading, however. They clearly imply possession of both leptomorph and pachymorph rhizomes in a single plant, but so much depends upon how a rhizome is defined. In a segmented plant such as a bamboo, with all axes based simply upon nodes and internodes, it is difficult to produce a watertight definition of a rhizome or any other class of axis. When does a rooting culm base or branch base become a rhizome? In a plant such as *Chusquea fendleri* in which the mature leptomorph rhizome axes are so well differentiated from all other axes, it could be asked whether it is correct to describe any other part of the plant as rhizome as well.

4.3 Rhizome terminology

There are two types of bamboo rhizomes,i.e. (1) indefinite apical growth and have monopodial branching (Fig. 3A). (2). structure known as a sympodium (Fig. 3B), where an axis (the rhizome) is actually composed of many sections of separate axes that have branched repeatedly. This is why such rhizomes are said to have sympodial branching. In fact a single axis as portrayed in Fig. 3B is rarely produced, and a much more complex ramification is usual, without any clearly defined sympodium, so that the term sympodial is being applied rather loosely.

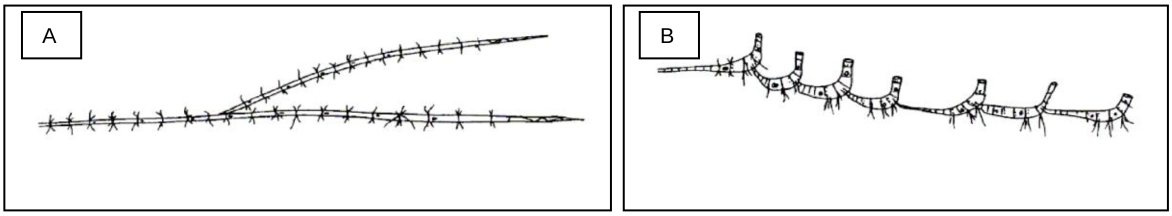

Figure 3 Rhizome branching pattern known as monopodial.

a . The rhizome is leptomorph with monopodial branching, and indeterminate growth. The culms may be diffuse or pluricaespitose, according to the degree of tillering at the culm base

b. Rhizome branching pattern known as sympodial.
The rhizome is pachymorph, with sympodial branching, and determinate growth. The culms may be unicaespitose, pluricaespitose, or diffuse according to the neck length and variability.

The growth of the rhizome can also be described as determinate or indeterminate, and this distinction reflects an important difference in the longevity of their apical meristems, but these terms are now rarely used for the rhizome. Determinate is equivalent to sympodial, and indeterminate to monopodial. There are also two forms of rhizome appearance. The internodes are usually either thickened somewhere along the rhizome (pachymorph) or uniformly thin (leptomorph), relative to the culm. Fortunately monopodial rhizomes are always leptomorph, and sympodial rhizomes are always pachymorph. Thus all these terms are synonymous: monopodial = leptomorph = indeterminate, and sympodial = pachymorph = determinate.

McClure in his final glossary (1973) used the terms pachymorph and leptomorph in preference to all other terminology, but in the Chinese taxonomic literature the terms mono podial, sympodial, and amphipodial reign supreme. In popular accounts a variety of termino logies are applied, and in one account ('Bamboos of China': Wang & Shen, 1987) their use seems difficult to understand at all unless the captions to the figures have become juxtaposed.

The term amphipodial is widely used for bamboos that tiller from the base of culms arising from leptomorph rhizomes (Fig.4). As stated before, the term amphipodial implies possession of both monopodial and sympodial rhizomes. However, the tillering culm bases are not usually as thickened as a normal pachymorph rhizome, and they do not usually have a pronounced horizontal growth habit (diageotropic growth). Given the disparity between culm Rhizome leptomorph with monopodial branching and indeterminate growth, with tillering culms giving a pluricaespitose habit. This is often known as an amphipodial rhizome and leptomorph rhizome in such plants it is hard to consider these culm bases to be rhizome at all.

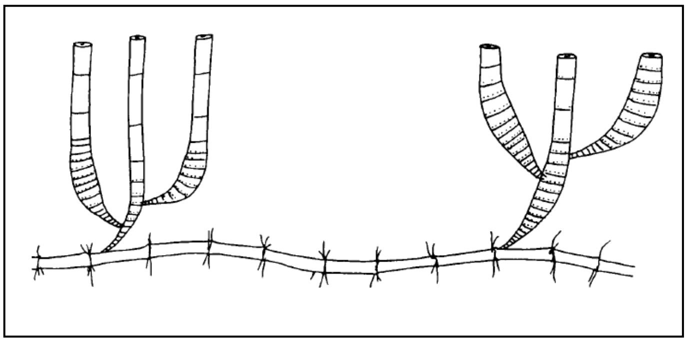

Figure 4 . Rhizome leptomorph with monopodial branching and indeterminate growth, with tillering culms giving a pluricaespitose habit. This is often known as an amphipodial rhizome

Pachymorph rhizomes are thickened at some point, but they may have long thin necks (long-necked pachymorph), which usually bear no roots. These long necks have also been termed pseudowhips (Keng, 1982) and rhizoids (Wen, 1985). In some bamboos with longnecked pachymorph rhizomes, such as *Melocanna baccifera* Kurz and *Guadua angustifolia* Kunth, the neck length is fairly uniform. In others, such as *Yushania* species, the length of the neck varies greatly. The thickened portion of the rhizome has several buds, from which new rhizomes can grow. In *Yushania* new rhizomes that arise from buds at nodes lower down and closer to the neck of the parent rhizome will themselves have long necks. New rhizomes that arise from buds at nodes higher up the parent rhizome and closer to the culm have progressively shorter necks, the highest nodes giving the shortest rhizomes. In this way each rhizome gives birth to an array of daughter rhizomes with different neck lengths (see Fig.5)

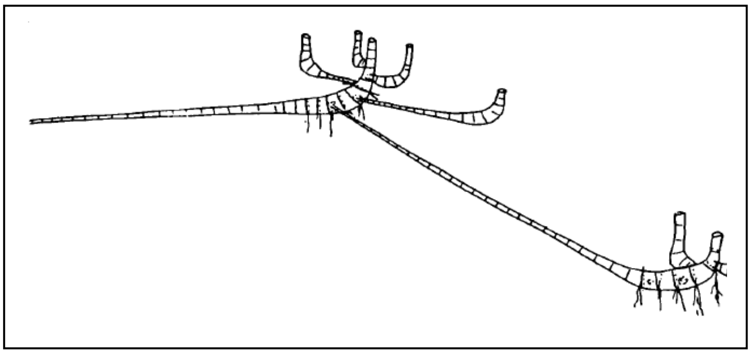

Figure 5 . Pachymorph rhizome of Yushania with variable neck length, giving a pluricaespitose culm arrangement

4.4 Clum and Culm Terminology

How the culms arise from the rhizome is also very important. Therefore a description is very useful for the culm or clumping habit, and fortunately the terminology for this is not as complicated as rhizome terminology.

The culms of a bambu may arise in a consistently well-separated fashion from vigorous leptomorph rhizomes. In such a pattern of growth we can simply call the culms diffuse, arising singly, or isolated. The culms of bambus with pachymorph rhizomes without long necks arise in a clump and are caespitose (strictly unicaespitose, alternative spellings cespitose, unicespitose, etc.), and always arise together in a clump. In bambus with consistently longnecked pachymorph rhizomes, the culms may also arise singly in an isolated fashion, as in *Melocanna baccifera*. In bamboos in which the neck length varies, such as species of *Yushania* series of small separate clumps is produced. Such culms are pluricaespitose (also sometimes called multicaespitose or compound-caespitose). The culms of many bamboos with leptomorph rhizomes will often tiller at the base giving small separated clumps of culms. These are indistinguishable from the small separated clumps of culms arising from bambus with longnecked pachymorph rhizomes, and their culms can also be called pluricaespitose. It is felt that ‘rhizomes leptomorph; culms pluricaespitose’ is a better way to describe these bambus than referring to their rhizomes as amphipodial.

The rhizomes and culms of some bamboos are well known for their different behaviour under different environmental conditions, and in juvenile and mature stages of growth. This usually applies to those bamboos that have leptomorph rhizomes when they are mature and growing vigorously. They can at times produce tillering clumps of culms with no real rhizome development. This can easily cause confusion in young plants or in plants growing away from their natural habitat. This variation in habit is one argument against the use of the term amphipodial. It leads to great overlap between the terms monopodial and amphipodial in the bamboos with leptomorph rhizomes at maturity, making the terms very difficult to define accurately or consistently.

Thus it seems accurate and quite adequate in presently known bambus to describe the rhizome and culm habit of a bamboo according to whether the mature rhizomes are thickened (pachymorph) or uniformly thin (leptomorph); if thickened then either short or long (with or without elongated necks); and whether the culms arise singly (diffuse), in one large clump (unicaespitose), or in many small clumps (pluricaespitose). Combinations of these characteristics can be used in cases where they are variable. Leptomorph and pachymorph seem more appropriate than monopodial and sympodial, and amphipodial or amphimorph seem to be rather ambiguous and potentially misleading. As it is now becoming customary in definitions of bamboo rhizome terminology to give one’s own preferred names for the four classic illustrations we follow that of Stapleton (1998). See Fig.6

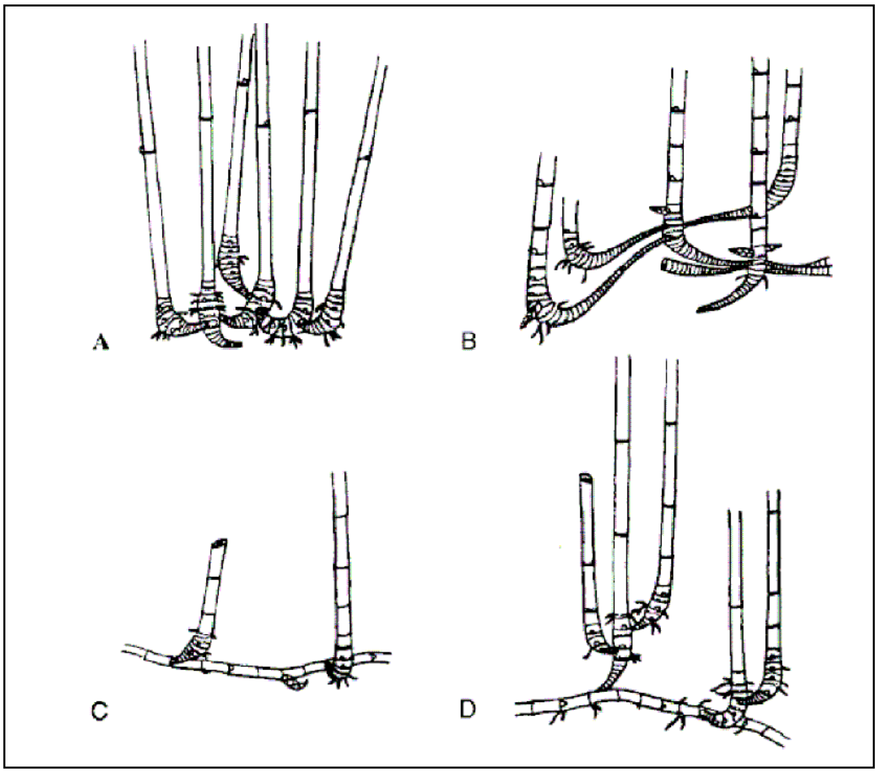

Figure 6 . This terminology will be followedin Kew's World Grasses Database, and in morphological and cladistic analyses undertaken at Kew.

A – Rhizome pachymorph with short necks, culms unicaespitose.

B – Rhizome pachymorph with consistently long necks, culms diffuse.

C – Rhizome leptomorph, culms diffuse.

D – Rhizome leptomorph, culms pluricaespitose

4.5 **Function of Different Rhizome and Clump Forms**

The rhizome is a crucial component of the bamboo plant, and it has several different functions. The balance between these functions can be related to different habitats under which bamboos with different classes of rhizome grow, and a few interesting forms of rhizome development can probably be attributed to adaptation to particular environments.

In *Yushania microphylla* (Munro) R.B. Majumdar the elongated rhizomes necks are completely hollow, even at the nodes, forming long uninterrupted tubes, and this may be related to the seasonally waterlogged sites in which this species is usually found. Hollow rhizomes may have developed from solid rhizomes, as an adaptation allowing transport of air to culms growing in wetter locations, or just to allow the rhizomes to grow further through soft soil. On the other hand, it may be that solid rhizomes have evolved from weaker, hollow rhizomes, in order to break through drier soil. McClure (1973) described small hollow rhizome canals in *Arundinaria gigantea* (Walter) Muhlenberg, which also often grows in seasonally waterlogged conditions.

It is not quite so easy to postulate why leptomorph and pachymorph rhizomes have developed, but their distribution is certainly interesting. In the Himalayas there are only two species with leptomorph rhizomes, *Arundinaria racemosa* Munro and *Chimonobambusa callosa* (Munro) Nakai. These species are restricted to the eastern end of the mountain chain, where rainfall is highest. The endemic species with long-necked pachymorph rhizomes, such as *Yushania maling* (Gamble) R.B. Majumdar, extend further west to areas where the rainfall is only moderate. They are also found at the western end of the Himalayas, where although the rainfall is lower, it is more evenly distributed, with more winter rain. In the central Himalayas, where spring rainfall is lowest, there are only unicaespitose bambus.

This variation in distribution could be related to the ability of long rhizomes to penetrate through very dry soil during a spring drought. To reach up to several metres underground as well as producing tall culms, spreading bambu rhizomes require a longer period during which growth is possible. Thus the unicaespitose habit as seen in most Himalayan genera such as *Bambusa* Schreb. and *Drepanostachyum* Keng f. could be an adaptation to the driest conditions under which bamboos can grow. The pluricaespitose habit in pachymorph bamboos, as exemplified by *Yushania*, could reflect a combination of the ability to consolidate in one location when spreading is not possible, with the ability to spread when conditions are more suitable. The pluricaespitose habit in leptomorph bambus, as seen in *Chimonobambusa* Makino and *Arundinaria* Michx., leads to an emphasis on spreading rather than consolidation, but is possible only when spring rainfall is more reliable. The true diffuse monopodial habit, as exemplified by the leptomorph rhizomes of many species of *Phyllostachys* Sieb. & Zucc. in their natural environments, is not indigenous to the monsoonal Himalayas, and may only occur where conditions are most favourable, in areas with ample rainfall more evenly distributed throughout the year, allowing sustained growth through spring, summer, and autumn.

The advantages of spreading bambus over non-spreading types in suitable locations are apparent. Quick colonisation of new sites is possible, and the sharp rhizomes can also penetrate the rooting systems of existing vegetation, with vigorous shoots benefiting from photosynthesis occurring elsewhere while they grow up to overshadow the vegetation at a different site. Such an effective vegetative dispersal mechanism may have implications for aspects of reproductive biology, for example length of flowering cycles, and the ability to survive flowering. Longer flowering cycles might be expected in spreading bamboos, with a reduced tendency for the plant to exhaust all reserves and die after producing too much seed. In addition, spacing of the culms may reduce parental competition and the benefits to seedlings of parental death, further encouraging polycarpy.

In the unicaespitose bambus with pachymorph rhizomes dispersal is more reliant upon successful seed production. Short rhizomes cannot transport the plant very far. Dispersal can sometimes be effected above the ground by the rooting of branch bases when older culms fall down or arch across a stream. This may be one reason why the unicaespitose bamboos have retained relatively primitive, heavy branch architectures, while spreading genera such as *Phyllostachys* have developed more sophisticated and more efficient arrangements of their branches and foliage. The thickening of the pachymorph rhizome definitely allows greater storage potential, however, especially in those tropical bambus that lose most of their leaves in an annual drought, and in these bambus this is certainly a more important function of the rhizome than dispersal. Overall, as a broad generalisation, pachymorph rhizomes clearlyrepresent a better adaptation to relatively dry conditions, with hard soils and periodic droughts.

It has been conventional to treat pachymorph rhizomes as more primitive and ancestral, consequently considering leptomorph rhizomes to be relatively derived. Today's leptomorph and pachymorph rhizomes may both be sophisticated modifications of ancestral rhizome forms. Comprehensive morphological and molecular phylogenetic analyses are required before any firm conclusions could be drawn.

MATERIALS AND METHODS

1. Site description

The study will be conducted from September to November 2019 in Pasrean area inside GGPNP (3,914 ha) at elevation of 1,200-1,400 m meter above sea level (asl), average annual rainfall 2,950 mm, average temperature 20^0 C, and Relative Humidity of 80%. The area has been deforrested representing a disturbed lower mountainous Java rainforest. The original tree forest composition were consisted of *Lithocarpus, Quercus, Castanopsis* and other species of Fagaceae Lauraceae, Magnoliaceae, Hammamelidaceae and Podocarpaceae (Whitten 1996; van Steenis 2006). The domination of Fagaceae family at tree category was supported by its rapid growth and avoided by illegal logger, due its low timber quality. (Yoneda 2006).

This disturbed lauriphyll forest were invaded by at least 15 invasive alien plant species. Notably *C.quadrangularis* thrives even under the shade of trees, threatening regenration of this remnant tropical rain forest in CBG.

2. Field Samplings

C.quadrangularis (bambu kersik) is a strongly rhizomatous perennial bambu which proliferates well under the condition of mild environment of Pangrango Mountain. even under the shade of trees. Due to its rhizomatous growth form and intermingling of different genets, *C.quadrangularis* genets are very difficult to identify in the field.

Unexpectedly there was a new colony of bambu kersik, in the area where the sapplings of local species was planted. The colony of bambu kersik was dismantled, all rhizomes were dug out exposing all the buds, and the position of culms on the rhizome were recorded. The rhizomes were inspected, the length was measured, the buds were inspected and counted, and the nodes where culm emerged were also noted, and appropriate numbers were allocated. The mechanism of expansion was deliberatly proposed. Another set of observation was done at another location to have a duplicate.

Three bambu kersik community sites of different ages are to be identified, and selected as plots, these plots shall be widely apart and the sampling metods will be carried out as the following:

1. Two line transect of 50 m are laid randomly in each plot.
2. A single bambu kersik culm along the tansect will be selected at random and a kuadrat of 1 x 1 m is laid perpendicular to the transectat an interval of 10 m.
3. The sampling will be carried out from August to October each month to obtain a representative distribution of ramet, rhizome, bud and tillers .

RESUTS AND DISCUSSION

1. **The growth and expansion of bambu kersik rhizome**

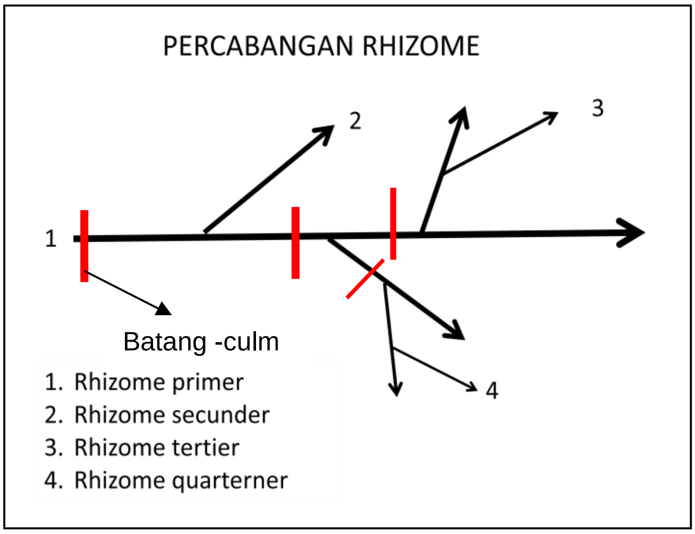

Figure 7. Hyphotetical diagram of rhizome growth of C. quadrangularis

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Every culm supplies energy to growing rhizome with at least two tips, but they can grow very long with a bud on each nodes. When a bud is damaged or killed , with any one of so many reasons, that meristem of rhizome tip will continuw to grow to replace the dead nodes, on the next nodes,

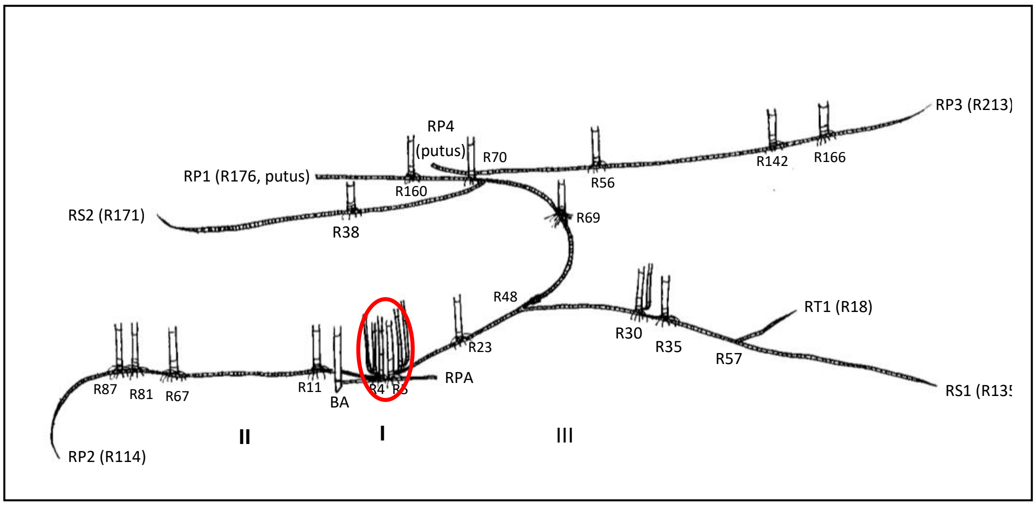

Figure 8 . Diagram of a *C. quadrangularis* colony Originating from a piece of bambu kersik culm inadvertently sticked to the ground survived and grew to form a colony of bambu kersik, recorded from Mandalawangi area inside Gunung Gede Pangrango National Park

I. Original Piece Of Bambu Kersik Culm

The data from the young colony of *C.quadrangularis* revealed interestings information on bambu kersik characters,

In the field, the original piece of culm was identified that ianadvertently planted on the ground. That piece of culm survived and grew sending a rhizome from the its first culm node, underground; the rhizome was thin and uniform, **leptomorph typ**e of rhizome . The bud on the node no 4 of the first rhizome grew into a culm in a **diffuse** way. This culm produced a tiller and rhizome with buds on every nodes. Unfortunately some buds were damaged requiring a bud replacement, therefore this rhizome kept on growing, to replace the dead buds.. The original rhizome was also damaged and dead. It was interesting phenomenon here there was an apical doimance shift from the tip of the growing rhizome into a bud behind the tip of the rhizome on the node that was still alive to grow into a culm, diffusely. This is of practical significant as a possible way of generating culm (therefore young bambu shoot) from growing rhizome into growing culm. Further works will be needed to specify at what position that a growing rhizome dan be affected to revert bach into growing culm. From field observation for example it was noticed that a living rhizome besring growing culms if the living rhizome is cut at the node of younger culm, then behind that cut end one of the bud is recruited into a growing culm. This culm grew strongly also produced a tiller. So in a single rhizome culms grew diffusely and tillers were also produced. so *C.quadrangularis* may be called a bambu plant propogating with **pluricaespitose** way.

II. The development of rhizomateous parts from the 4th node

As mentioned above the rhizome from culm at the 4th node grew also produced a tiller. But some its buds were damaged, and dead, putting a heavy pressure on the culm and its tiller to replace

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Table 5 The distribution of culms, rhizomes, nodes along the rhizomes and no number the culms recorded, the position of nodes where culms were found and the length of rhizome in term of node numbers

No	First colony					
	Rhizome (nodes)	Culm at	Position at nodes no	Distance (nodes)	Dead Buds	Living buds
1	114	11	4-11	7	3	8
2		67	11-67	56	19	37
3		81	67-81	14	4	10
4		87	81-87	6	0	6
5			87-114	27	6	21
	Total				32	82

The damaged buds were quite high about 28.1%, it mpacted on the culm recruitment, after producing rhizome with 114 nodes 32 buds were damaged. This condition produced only 4 culms, because the nergy was utilised to replaced the damaged buds. It was also interesting to note that when the environment was good for this bambu kersik, no damage to the buds on nodes of rhizome, bambu kersik has been backed itself up through evolution to spare only 6 buds to recruit a bud into a culm (no 4 of Tbl. 1). This particluar environment while capable of supplaying an excellent water supplay, nutrients, carbondioxide as well as sunlight, and probably also tempertature, it is still adapting to the condition especially on herbivores attacking its buds

III. The development of rhizomateous from the fifth node

The development of this culm from the 5th node rhizome was exhibiting

Table 6 The distribution of culms, rhizomes, nodes along the rhizomes and no number the culms recorded, the position of nodes where culms were found and the length of rhizome in term of node numbers

No	First colony					
	Rhizome (nodes)	Culm at	Position at nodes no	Distance (nodes)	Dead Buds	Living buds
1	171	23	5-23	23	2	21
2			23-48	25	5	20
3			48-30	18	3	15
4		30	30-35	5	0	5
5		35	35-57	22	4	18
6			57-135	78	16	62 (12)
				171	30	141

In this area the growth of rhizome was very extensive, the damaged was only 17.5% although only 3 culms were recruited. The extensive performance of rhizome was obvious, because the data were recorded during the dry season, however approaching a wet season, i.e. September. The portion from node 57 to 135 a high bud damageds were recorded, but about 12 buds showed a preparation of recruitment into culms. It is interesting to see the condition of data where when the buds are not damaged after 6 healthy buds the culm will be recruited. This are was partly heavily shaded, but section number 6 was growing on an open patch; a long rhizome was dug and recorded, if not those 12 buds would have recruited into culms. The invasive expansion of ths bambu kersik is apt to be called guirrelia types, a decribed by

CONCLUSIONS

1. Bambu kersik (*C.quadrangularis*) was originated from China, in Indonesia was distributed not only in the Cibodas Botanical Garden area , and Gunung Gede and Pangrango National Park are , West Java but also in Sibilangit National Park and Mt Sibayak area North Sumatera,
2. *C.quadrangularis* has leptomorph rhizome, and recruited culm from buds on the node of rhizome diffusely producing pluricaespitose mode of propogation. The propogation was considered rapid following guirellia type of expansion. It is believed conventionally to be more modern than pachymorph type of rhizome whish is considered as primitive.
3. The recruitment of a bud on nodes of rhizome onto culms are effected by many factors, such as shift in apical dominance. It may be a good way of indducing bambu kersik to recruit culm, therefore, bambu shoot
4. The death of buds prevents the recruitment of culm from buds, when the environment are favourable culm with tillers will induce culm recruitment at around the node number 5 from the culm.
5. The growth of rhizome is crucial for the expansion of bambu kersik, slashing of culms, leaving onlt one node on culm reduced the emergence of culm recruitment,
6. Bambu kersik stores its resourches in rhizome biomass especially during the dry season. It may be a good time to control bambu kersik manually.

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