【Article】

Conservation Ecology of *Gigantochloa Manggong*: an Endemic Bamboo at Java, Indonesia

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Abstract

Ecological study of *Gigantochloa manggong*, one of the endemic bamboo species at Java was done in the secondary tropical forest of Meru Betiri National Park, East Java, Indonesia. Distribution was limited in eastern part of the national park. In general, *G. manggong* grows well in lowland secondary forest patches at altitudes 5 - 50 m on the clay loam soil. Absence of large trees caused canopy gaps which made bamboo grows well and spread. There were several associate species such as *Callamus* sp., *Erioglussum rubiginosum*, *Voacanga grandifolia*, *Pleomele* sp., and *Ficus* sp. Throughout the field observation, its sexual reproduction was not found. However, vegetative reproduction by developing new culms was found in all of the quadrats. Bamboo harvesting in Sukamade forest by villagers was the threats of *G. manggong* population at the wild habitat. Furthermore, our study showed that the range of the species distribution has contracted substantially from that recorded in 1987, and this has led to its assessment as an endangered species. Unsustainable exploitation and habitat loss might be important factors toward the extinction of *G. manggong* in the natural habitat.

Keywords: Bamboo; conservation; endemic; *Gigantoehloa manggong*; Java.

1. Introduction

Bamboo is very important in Indonesia. Bamboo culms commonly are used as construction material on the households in rural area, for making various types of baskets, as a source of raw material for making paper, for musical instrument and handicrafts. Millions of bamboo culms are harvested annually and it seems in term of socio economic roles of bamboo in Indonesia is significantly viable. There are about 125 bamboos species belonging to 19 genera in which 24 species was endemic in the Indonesia archipelago (Dransfield and Widjaja, 1995; Nasendi, 1995; Widjaja, 1998). The highest number of endemic bamboos is found in Sumatra (51 %) and followed by Irian Jaya (18 %) (Suhirman *et al*., 1994). However, Java Island, one of the main island in the archipelago, where the population is dense and high deforestation occur is the habitats of bamboo. It was estimated that Java has about 60 bamboo species, in which 9 species are endemic in Java, such as *Bambusa cornuta, B. Jacobsi, Dendrocalamus asper, Dinochloa matmat, D. scandens, Gigantochloa atroviolacea, G. manggong, Nastus elegantissimus* and *Schizostachyum biflorum*. Distribution of endemism in Java Island is unique since some of species are limited on the certain part of this island (Widjaja,1987).

Biosystematically, *Gigantochloa manggong* was described by Widjaja (1987) in the Revision of Malesian Gigantochloa (Poaceae - Bambusoideae). *Gigantochloa manggong* is a sympodial bamboo. Culms up to 10 to 15 m tall, 5-7 cm in diameter, internodes up to 34 - 40 cm in long, smooth, green turning yellowish. Culms sheath appressed with truncate but centrally slightly raised apex, 30-33 cm long, dull yellow. Leaf blade lanceolate, 27-29 cm × 3-4 cm, glabrous and thick. Local people at Banyuwangi district, East Java, called this bamboo *Pring manggong* (Javanese), means Manggong bamboo. *G. manggong* occurs in a tropical climate, with average annual rainfall of 1400 mm, from sea level up to 1500 m in altitude. It grows on riverbank, mountain slopes and even steep cliffs. It was reported that culms of *G. manggong* was used for construction, scaffolding and other small-scale household uses, but possibly due to their limited distribution, they are considered inferior to those of *Gigantohloa apus* (Dransfield and Widjaja, 1995; Widjaja, 1987).

The conservation of bamboo resources is absolutely fundamental to the long term of biodiversity conservation. Bamboo conservation in Java therefore was implemented both *in situ* and *ex situ*. The *ex situ* conservation of *G. manggong* have been done in Purwodadi Botanical Garden at East Java, whereas *in situ* conservation was done in the protected area such as Nature Reserve, Forest Park and National Park. It was estimated that more than 75 % of the native Indonesian bamboo species grow naturally in the protected areas and wild habitats such rural forest (Widjaja, 1998). However, few attention was paid on the bamboo conservation. A bamboo species, *G. manggong* conservation management is discussed from the viewpoint of their ecology in this paper.

2. Study site

The field study was done in Meru Betiri National Park (MBNP). It was located at southeast of Jember district and southwest of Banyuwangi district, East Java, Indonesia (**Figure 1**). Geographically, MBNP locates from 8º 22' 16'' S to 8º 32' 05'' S and 113º 37' 51'' E to 113º 57' 06'' E. The parks cover an area about 58,000 ha of lowland tropical monsoon forest (Bakorsurtanal, 1997; TNMB, 2000).

Most of the forest is the moist deciduous type. Before the World War II Meru Betiri forest was continuous with Alas Purwo forest (recently known as Alas Purwo National Park) to the east, but agriculture developments cut this continuously. Although, the larger trees present such as *Bischofia javanica, Planchonia valida, Kleinhovia hospita, Langerstroemia flos-reginae, Pterospermum javanicum, Spondias pinnata, Sterculia* sp., *Ficus benjamina, Ficus variegata* and *Anthocarpus elacticus* have survived, they rarely form a continuous close canopy. *Gigantochloa manggong, Balanophora fungosa, Raflesia zollingeriana* and several orchids were endemic plant species to MBNP. The park is also a habitat for 181 rare and protected animals species of reptiles, birds and mammals (TNMB, 2000)

The topography is wavy, hilly to mountainous and some are steep. The peaks are Mt. Permisan (568

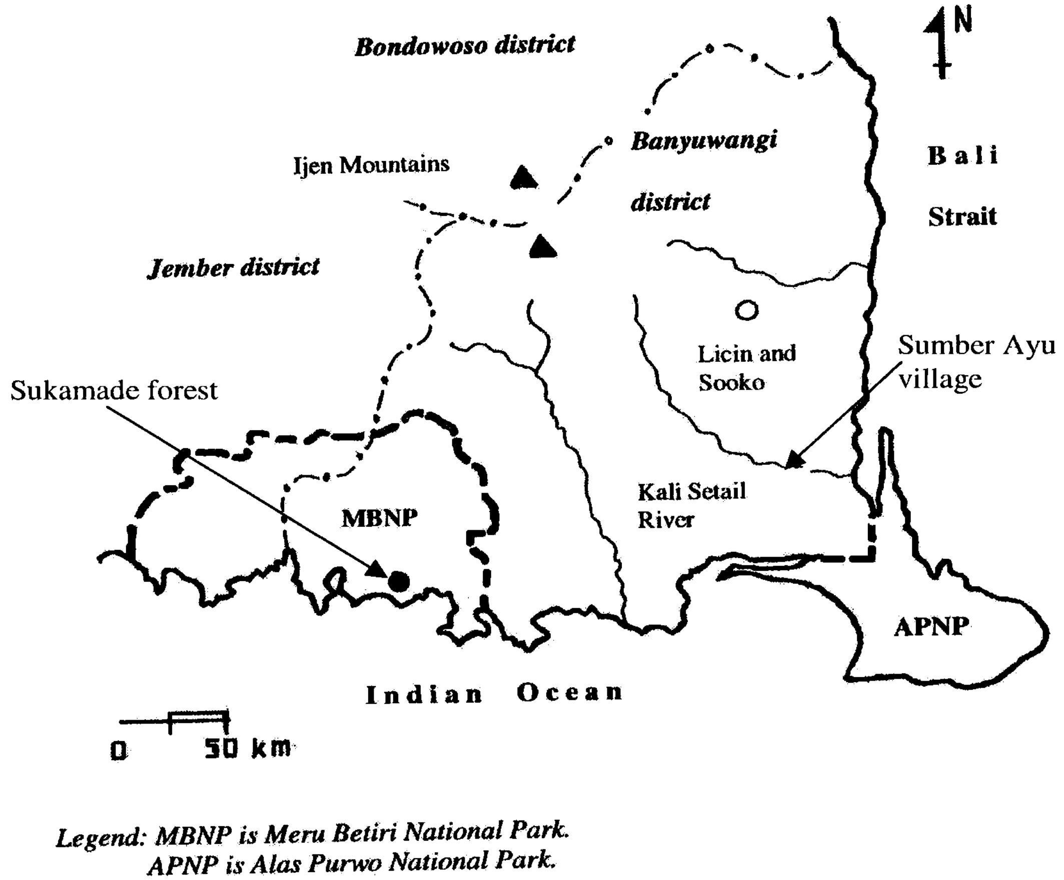

Figure 1. Eastern part of Java and the locations of study site.

m), Mt. Betiri (1,223 m), Mt. Sumbadadung (1,155 m), Mt. Mandilis (843 m), Mt.Sukamade (806 m) and Mt. Gedong (893 m). Two large rivers, Sukamade and Bande Alit rivers play an important role as water resource for wildlife during the dry season (Bakorsurtanal, 1997).

The southern zone of park consist of one of the large extensive areas of low land rain forest on Java Island, as well as mangrove and lowland swamp forest.

Following the Schmidt-Ferguson climate classification for Java and Bali, northern and central part of MBNP was classified as B category, with the climate type was slightly seasonal (Q=14-33%), and the southern part of the national park was classified C category, with the climate type was seasonal (Q = 33 - 60 %). The Q value shows the percentage of wet months to dry months. Annual rainfall means vary between 2,555 to 3,478 mm. Wet months were from November to March, whereas the dry period (dry months) were from April to October. Monthly rainfall along Sukamade forest was reported to be varying. The highest rainfall was occur in January (amount of rainfall 329 mm which rain day recorded was 21 days in January) and February (amount of rainfall 325 mm which rain day recorded was 25 days in February). However, there were some fluctuations of the distribution of the rainfall through out the years (Whitten *et al*., 1996; TNMB, 2000).

3. Methods

Research methods consist of four components. Firstly, range and distribution survey were conducted to provide information of range and distribution of *Gigantochloa manggong*. Secondly, vegetation analysis and environmental factors survey were conducted to provide relationship between plant species and their environment. Thirdly, population and vegetative reproductive ability of *G. manggong* were observed. Fourthly, threats to *G. manggong* populations in natural habitat were assessed to predict their future status.

Field works were conducted on February, March, August and September 2001 in MBNP. In this study, we focused on all of the *Pring manggong* (Manggong bamboo) in wild habitat with *G. manggong* bamboo planted in Purwodadi Botanical Garden. Taxonomically, it is very important because in wild habitat, diversity within *Pring manggong* is very high, and this is liable to cause errors in the recognition and identification of *G. manggong*.

3.1. Range and distribution of *Gigantochloa manggong*

To clarify *Gigantoehloa manggong* distribution at Java Island we used two data source, literature concerning of bamboos and field survey.

Data and information on the localities from which *G. manggong* have been recorded were collected systematically from international and regional journals, regional reports, and Annual Reports of Meru Betiri National Park. These journals related to biological conservation, plant taxonomy, plant ecology and biodiversity. Reports and archives were obtained from Department of Forestry, Indonesian Nature Conservation Agency, and Annual Reports of National Parks. Furthermore, some important publications related to the flora of Java were used during data collection. Since local people have a long interaction history with biological resources within park, we collected their information on the bamboo forest location and *G. manggong* distribution. Such information were used to estimate bamboo *G. manggong* distribution.

3.2. Analysis of vegetation and environmental factors

Vegetation analysis of bamboo forest was based on five quadrats by 25×50 m. Quadrats 1 and 2 lie around Sukamade guard post (4.0 to 5.0 km from village), quadrat 3 lies around Sukamade village (0 km) , quadrat 4 lies on northern part of plantation border (0.5 km from village) and quadrat 5 lies on core zone of national park (5.5 km from village).

Community similarity among quadrats was quantified using Sørensen coefficient. This coefficient of similarity (*Ss*) was defined using the formula:

$$Ss = 2a/(2a + b + c)$$

where Ss = Sørensen similarity coefficient

a = number of species common to both quadrat

b = number of species in quadrat 1

c = number of species in quadrat 2

(Kent and Coker, 1992)

Species diversity among quadrats community was calculated using the formula given by Shannon and Wiener. Epiphyte, fungus and tree seedlings were excepted in this calculation. The Shannon diversity index (*H*') was calculated from the formula:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

where *H'* = the Shannon index of general diversity,
s = the number of species
pi = the proportion of individuals or the abundance of the *i*th species expressed as a proportion of total cover
ln = log base n
(Kent and Coker, 1992)

Association among *G. manggong* and woody tree was calculated using the formula given by Jaccard. The Jaccard index of species association (*IA*) based on presence (*p*) is:

$$IAp = [\, a / (a + b + c) \,] \times 100.$$

where *IAp* = Jaccard index
a = number of quadrat in which the two species under comparison occur together
b = number of quadrat in which one of the two species occur alone
c = the number of quadrat in which the other species is found alone (Mueller-Dombois and Ellenberg, 1974)

All of the *G. manggong* clump grows in the protected area. Considering the government law and the limited population size we decided not to harm or kill bamboo throughout the study. For this reason, the bamboo biomass was not measured.

Soil samples were taken from the top 10 cm of soil from all quadrats. Soils were collected in plastic bag and analyzed for texture and pH. The pH of soil was determined electrochemically in a soil-water suspension (1: 2.5 by weigh) using a glass electrode.

Temperature and humidity were recorded in two seasons: rainy season in February and March, and dry season in August and September in all quadrats. Temperature was recorded using thermometer, whereas temperature data were taken at day time, twice a week per month. Humidity data were recorded following the same techniques using hygrometer.

3.3. Population size and reproductive ability

To clarify the size structure of the bamboo population, we decided to classify bamboo clump into 3 categories base on circumference size. Class A was less than 5 m in circumference, class B = 5 -10 m, and class C is over 10 m.

Population size was counted based on number of culms in all of the quadrats observation, whereas reproductive ability of *Gigantochloa manggong* was examined by measuring number of new developing culms. This was carried out in August when the young culms develop from bud (youngest rhizomes). To compare the vegetative reproductive ability of *G. manggong* among class, number of new culms were counted. Generative ability was not recorded due to this observation there were no flowering bamboo.

3.4. Threat to populations

Description of the threats on *Gigantochloa manggong* population in the wild was based on the bamboo exploitation by local people. This threat caused a decline in bamboo population in natural habitat. Decline and disturbance of *G. manggong* population caused by anthropogenic factor were measured by culms harvested illegally by local people.

To clarify the bamboo culms harvesting trends, we classified the bamboo culms into five categories by measuring the diameter at 1 m above ground surface. These categories were: category 1 (2 cm to 2.99 cm in diameter); category 2 (3 to 3.99 cm in diameter); category 3 (4 to 4.99 cm in diameter); category 4 (5 to 5.99 cm in diameter), and category 5 (6 cm to 6.99 cm). Clump disturbance and culms harvesting were counted in each quadrate analyzed. Data was analyzed using SPSS (10.0 version) statistical package. Furthermore, to estimate habitat loss, we examine past and present forest covers in East Java from several literatures and reports.

4. Results

4.1. Current distribution of *Gigantochloa manggong*

Throughout the research period, only Reinwarditia (an international journal published by Bogor Botanical Garden in 1987) has published about the distribution of *G. manggong*. Furthermore, some local reports, such as Annual Report of Meru Betiri National Park (TNMB, 2000), Flora and Fauna of Alas Purwo National Park (BTNAP, 1999), and a textbook by Dransfield and Widjaja (1995) have discussed the distribution of *G. manggong* in the wild. These papers show that, *G. manggong* was distributed at Sooko, Licin, Kali Setail River, and Sukamade forest. However, our results of the revisits showed the distribution is decrease (**Table 1**). It shows that *G. manggong* population was not found in Sooko and Licin villages. Along river sides of Kali Setail river (about 450 km long) there was a dense population of bamboo, however only two clumps of *G. manggong* were found in Sumber Ayu during this trace.

We found that there is a certain patch of bamboo forest within national park, namely Sukamade forest in MBNP. The area size is 5,000 ha. which was planted with coffee, rubber tree and cocoa as main plantation trees. Several bamboo forests of *G. manggong* were found surrounding plantation. However, the

Table 1. Past and current distribution of *Gigantochloa manggong* population in natural habitat. Administratively, the entire locations belong to Banyuwangi District, the eastern district in East Java province. MBNP is Meru Betiri National Park and APNP is Alas Purwo National Park

Previous reports	Current finding
Sooko (Widjaja, 1987)	No population was found.
Licin (Widjaja, 1987)	No Population was found.
Kali Setail River (Widjaja, 1987)	Two clumps were found in Sumber Ayu vilage
MBNP (Widjaja,1987)	Limited population grows in eastern part of park, namely Sukamade forest
APNP (BTNAP, 1999)	Since the young shoot morphology was different with the Purwodadi Botanical Garden , we ignore these populations in this study.

densest population of *G. manggong* were found in south east of the Sukamade river valley (close to coastal forest) and in north west of Sukamade river valley. Several populations were also found around the village and plantation area, however their population quite rare and limited in number.

4.2. Vegetation and environmental features

Based on the Sørensen coefficient, highest similarity of forest vegetation was found between quadrats 1 and 2. Some valuable vegetation such as *Kleinhovia hospita*, *Ficus benjamina* and *Areca catecu* were found. Understory of tree canopy, *G. manggong* grows together with *Streblus asper*, *Alpinia striata*, *Voacanga grandifolia*, *Macaranga* sp. and *Baringtonoa asiatica*.

The lowest similarity of vegetation between quadrats were found among quadrats 2 and 5. Although both of the quadrats were classified as low land forest, however vegetation in quadrat 2 was influenced by coastal vegetation whereas quadrat 5 lacking coastal flora since the location of quadrat 5 was far for the seashore.

On the basis of Shannon index (*H*'), quadrat 1 (*H*'= 2.49) was more diverse, following quadrat 2 (*H*'= 2.28). Shannon index of quadrat 3 was 1.78, quadrat 4 was 2.00 and quadrat 5 was 2.13. Bamboo basal coverage indicated the species dominance in the quadrats. Bamboo basal coverage was 332.90 m^2 in quadrat 1; 337.35 m^2 in quadrat 2; 370.10 m^2 in quadrat 3; 524.95 m^2 in quadrat 4; and 448.15 m^2 in quadrat 5. The scatter diagram in **Figure 2** shows negative relationship between Shannon index values and bamboo basal area at all quadrats with the correlation value r = -0.443, p = 0.455.

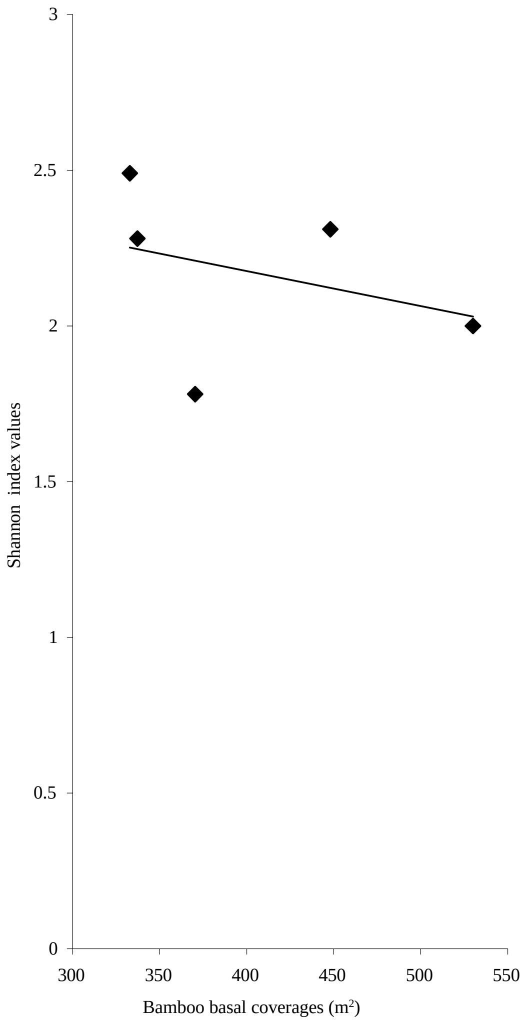

Figure 2. Correlation between species diversity (Shannon index) and bamboo basal coverage. R=-0.443 (p=0.455).

In the Meru Betiri forest, *G. manggong* grows on secondary forest mixed with several trees species. In the quadrats surveyed, it was clear that *Calamus* sp. and *Erioglussum rubiginosum* have high association with *G. manggong* (*IAp* = 100 %). Both of the plants were found growing together with *G. manggong* in all of the quadrats. Some species such as *Licuala paludosa, Caryota mytis, Planchonia valida , Cassia timorensis, Baringtonia asiatica and Pterospermum javanicum* have less association with *G. manggong* (*IAp* = 20 %).

Based on the soil examination, soil samples were classified as clay loam soil class. Measurement of soil pH about 5.90 in quadrat 3; 6.00 in quadrat 2; 6.05 in quadrate 5; and 6.10 in quadrats 1 and 4.

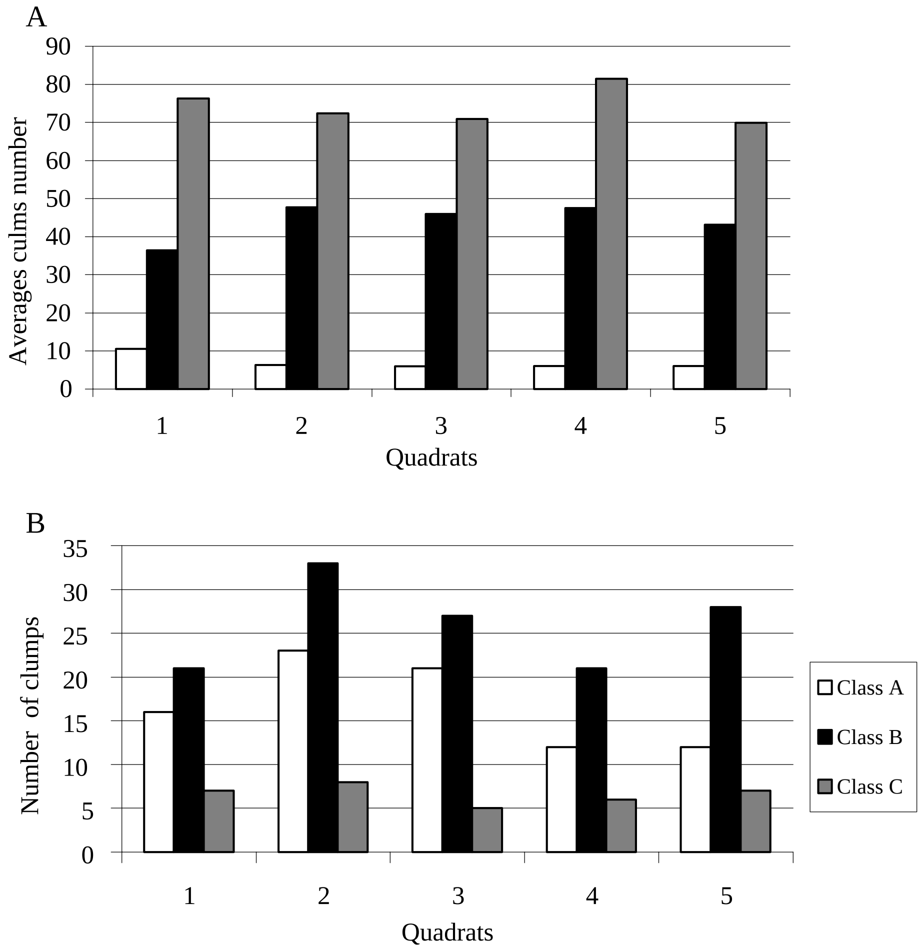

Figure 3. Averages culms number in class A, class B and class C in all quadrats (A), and number of clumps in class A, class B, and class C in all quadrats (B).

Our study recorded that respectively temperature averages was 25ºC in quadrats 1 ,2 and 5, whereas in quadrats 3 and 4 averages temperature about 26ºC. Mean humidity ranges from 60 % to 69 %.

Through this study, all of the population occurs between 5 to 150 m above sea level. No population records refers bellow 5 m or above 150 m although previous study reported some population were found in Licin (elevation 500 m above sea level).

4.3. Population and reproductive ability

4.3.1. Population size

In this study we classified all of *Gigantochloa manggong* clumps into three categories based on bamboo clumps circumferences. The smallest number per clump of bamboo culms in all quadrats was found in sapling categories (class A). The number of culms was increase in class B and then following by class C (**Figure 3A**). This is reflecting that large size circumference bear larger number of culms.

Table 2. Percentage of new culms production in all quadrats.

Quadrat	class A (%)c	lass B (%)	class C (%)
1	39	69	47
2	35	65	42
3	40	67	50
4	22	65	56
5	28	63	45

Distribution of bamboo clumps was given in **Figure 3B**. The highest number of clumps was found in clumps with 5-10 in circumference in all quadrats (class B), following by class A and then class C.

4.3.2. Vegetative reproduction ability

Vegetative reproductions were developed by new culms. The percentage of new culms productions were given in **Table 2**. Furthermore, the new culms production was tested by Kruskal-Wallis test. The new culms production was significantly different among the classes ($p < 0.05$. Kruskal-Wallis test).

4.4. Treat to *Gigantochloa manggong* population

Human disturbance by culms cutting in all of the clumps categories were shown in **Figure 4**. Quadrats 3 and 4 were highly harvested by humans and followed by quadrat 5. Number of culms harvested in quadrats 1 and 2 were less than other since the locations were situated closed to the national park guard post. It seems bamboo sapling (class A) was not harvested by humans in all of quadrats. Furthermore, the highest disturbance occurs in class B and followed by class C. Trends to culms disturbance based on the culms diameter was shown in **Figure 5**. It was shown that bamboo which diameter 5

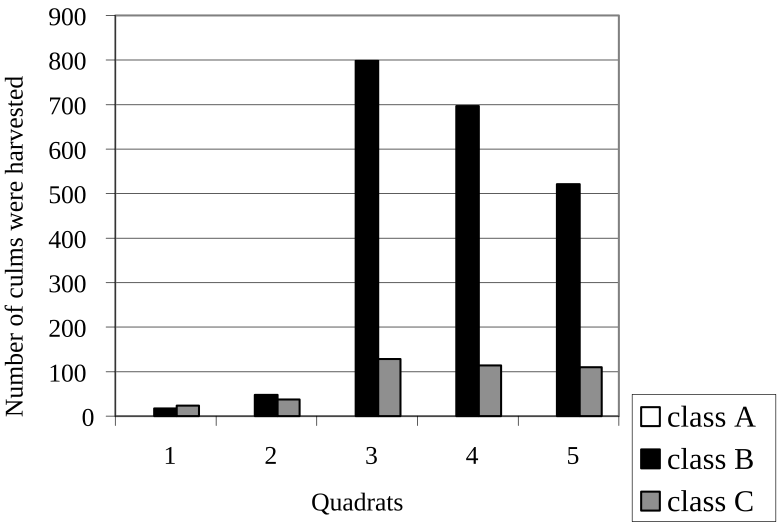

Figure 4. Number of bamboo culms were harvested by local people in all quadrats.

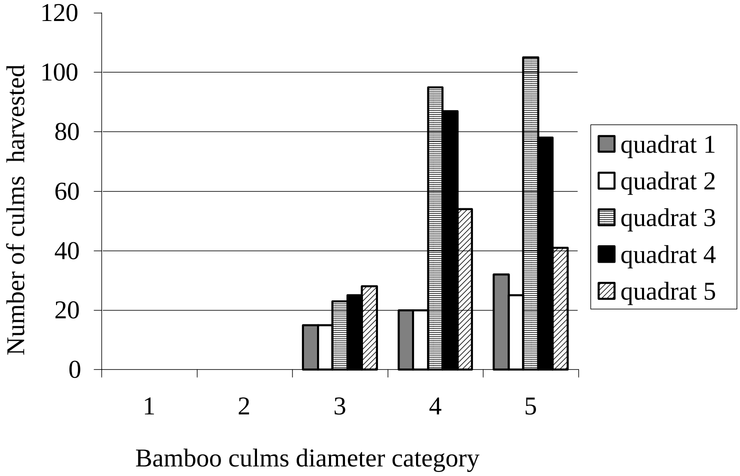

Figure 5. Number of culms were harvested based on bamboo culms diameter.

to 5.99 cm (category 4), and diameter 6 cm more (category 5) is main target of harvesting.

5. Discussion

At the present, distribution of *G. manggong* bamboo was limited in a certain area at eastern part of Java Island. Two clump of bamboo have been found in Sumber Ayu village along Kali Setail river during field work indicates that at the previous time some population of *G. manggong* grew around river side. It was supported by Dransfield and Widjaja (1995), and Widjaja (1998) in their reports. However, through literature reviews and information of this species are scare, perhaps no more studies have been done. Furthermore, it is difficult to assess the precise number of clump since there were no historical reports. For many species in tropical countries such as Indonesia, information on the pattern of distribution, population density and trends in population size was inadequate or entirely lacking (Soehartono and Newton, 2000; McGowan *et al*., 1998). Most of the population recently limited in the Meru Betiri National Park and seems that, the population was still grows well under the conservation act. Throughout this study, *G. manggong* population in Sooko and Licin villages apparently extinct. Recently, *Bambusa bamboo, Bambusa vulgaris, Gigantochloa atter* and *Gigantochloa apus* are dominant bamboo species and being cultivated in Sooko and Licin due to highly market demand. Herbarium data were perhaps the most reliable source of distributional information. Unfortunately, the number of herbarium sample of *G. manggong* encountered in this study was very limited. The herbarium sample of *G. manggong* were only found in Purwodadi Botanical Garden which were taken from Sukamade forest in 1985 (Dransfield and Widjaja, 1995; KRP, 2000). The range of the species distribution has contracted substantially from that recorded in the 1987, and this has led to its assessment as and endangered species in decline.

Most of the *G. manggong* in Meru betiri forest located at secondary forest which grow as understory vegetation. It is spread and abundance in mixed communities of lowland forest vegetation. This study shown if the number of *G. manggong* basal coverage increase, the number of plants diversity within

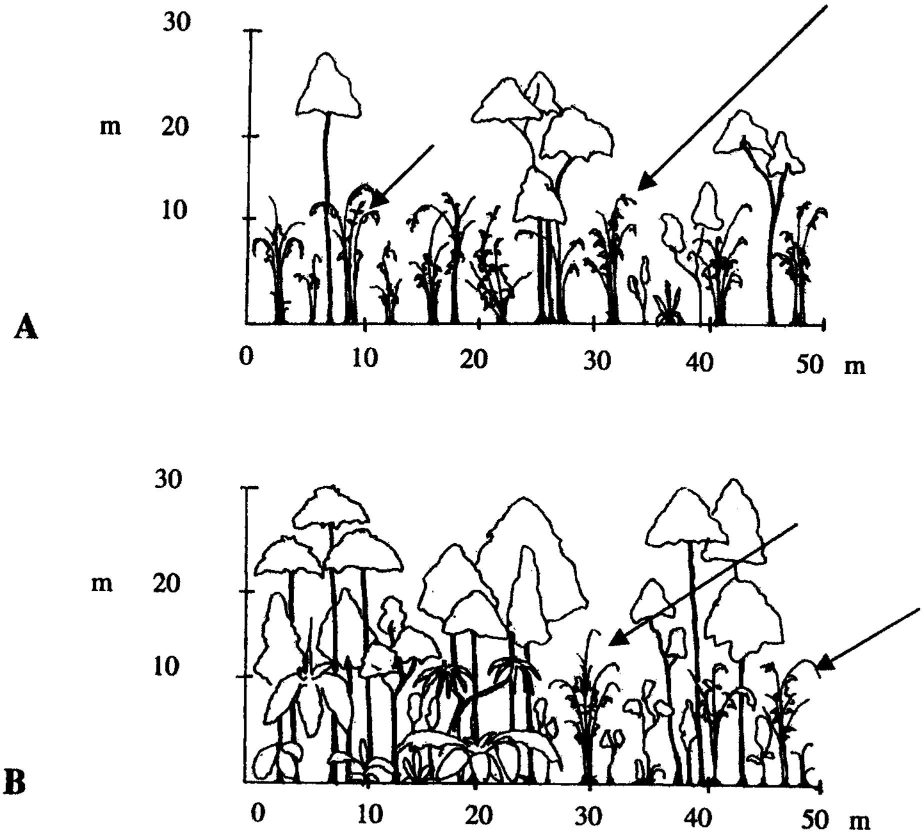

Figure 6. Cross sections through forest profile a bamboo vegetation in Meru Betiri lowland forest. In Figure 6A loss of canopy building allow bamboo grows strives, whereas in Figure 6B canopy dense is limitation factors toward *Gigantochloa manggong* grows. Arrows indicate *Gigantochloa manggong* clumps as understory vegetation.

quadrats decrease. This data indicates that loss of the tree and their canopy in the forest give chance for bamboo population to develop (**Figure 6-A, B**). Relationship of canopy gap due to natural disturbance or human destruction and spread of bamboo population in the forest community already conducted by several authors (Chandrashekara, 1996; Numata, 1979; Whitten *et al*.,1995). Higher Shannon index in quadrat 1 and quadrat 2 were influenced of the trees such as *Ptertospermum javanicum, Kleinhovia hospita,* and *Ficus benjamina*. In addition, a member of palm family such as *Calamus* sp, *Arenga pinata, Licuala paludosa and Litsea monocepala* was found in these quadrats. The entire species form dense canopy in these quadrats. As a result, bamboo and some understory vegetation were limited to grows. The highest bamboo basal coverage located at quadrat 4 (524.94 m^2) where the Shannon index was low (H' = 1.997) compared with quadrats 1, 2 and 5. The lowest species diversity lies at quadrat 3 (H' = 1.782) where the bamboo basal coverage was 370.10 m^2. Low diversity index and decrease of bamboo basal coverage were probably due to human impact in this forest patch. Recently, this quadrat was dominated by bamboo clumps in small number, and several woody trees such as *Ficus benjamina, F. glomer-*

ata, and *K. hospita*. Bamboo clumps disturbance in the site was shown in **Figure 4** and **5**. For this reason, both of Shannon index value and bamboo basal coverage were lower than others. The *Calamus* sp and *Erioglussum rubiginosum* had the highest association with the *G. manggong*. It seems that the main reason is since both of the plants are well known as colonizers where canopy gaps take place in the tropical forest.

Human impact on a certain habitat such as tropical forest is responsible for the spread of bamboo that are able to strives under disturbed conditions (Numata, 1979; Widmer, 1997).

Recently, most of the population grows in lowland forest at 5 - 100 m altitude, with temperature generally from 25 -26ºC, and humidity 60-68%. They grows in clay loam soil at soil pH from 5.90 - 6.10. Chandrashekara (1996) shows that, saline soil is not suitable for bamboo growth. It was also reported that bamboo grows well in clay loam and sandy loam soil. The results shows that *Gigantochloa manggong* has no extreme features compared with other Gigantochloa bamboo such as *Gigantochloa atter and Gigantochloa apus* which grows at Java Island, which the average temperature was 19-30ºC, and humidity range from 60-75%. This finding indicate that altitude, temperature, pH and humidity were not main limitation factors of *G. manggong* distribution. According to Dransfield and Widjaja (1995), Gigantochloa with about 24 species was native bamboo to tropical Asia and it was mainly confined to the area from Burma, Indo-China to Peninsular Malaysia.

The averages of bamboo culms number vary among classes (**Figure 3A**). In all of quadrats the highest number of culms were found in classes C, following by classes B and classes A (saplings). Distribution of bamboo clumps among quadrats (**Figure 3B**) shows clumps number was varying among quadrate. However, there are clear that class B has the highest clump number, followed by class A, then class C in all quadrats. Growth of bamboo sapling was a former evidence of bamboo seedlings recruitment that seems to have occurred in the past. However, absent of bamboo seedling in this study indicates that the establishment of seedlings was difficult in the present community. Probably, absent of generative reproduction event and long drought in the past years was the main inhibitors of bamboo seedling. Nevertheless, vegetative reproduction by producing new culms was able to sustain patches of *G. manggong* on wild habitat for at least several and perhaps many years.

Based on the Kruskal-Wallis test, culms production was significantly different among classes. Lowest culms production in class A reflected that this class was sapling categories whereas new culms was produced in limited number. According to Dransfield and Widjaja (1995), new culms production in sapling category was low and will be increase gradually in the next years. Class B was develop culms stage whereas culms production was high compared with class A. Throughout field observation, the site of new culms production site in C class were vary among quadrats. Most of the new culms grows on the outside of clump in classes A, B and C. However, some new culms in the class C grows on the center of clumps. It seems that density of culms within bamboo clumps affect the site of new culms production. Abundance of culms and culms debris in the center of clumps might be inhabit culms grows in the center of clumps, but absence of culms debris in the center of clumps will be allow the new culms growing in the center of bamboo clumps. Compared with culms production in previous study, *G. manggong* culms production in the wild was high (*Farggesia spathesia* 8.2 % ,*Fargesia scabrida* 13.7 %, and 10.6 - 12.3 % recruitment in a mature *Dendrocalamus strictus*) (Singh and Singh, 1999). High precipitations throughout wet season in this forest apparently act an important role and influence the shoots and new culms production. However, not all of this new culms become mature culms. Naturally, factors such as nutrient competition and diseases form as a limitation factors for newly culms development into mature culms. Bamboo culms were often injured by fungous diseases and insect (Numata, 1979), especially in tropical region where humidity was high.

Bamboo harvesting in Sukamade forest by villagers is the threat of *G. manggong* population at the wild habitat. Previously, it was reported that the relationship between national park resources and local people was often reported has been likened parasitism (Beatley, 1996; TNMB, 2000; Whithen *et al.*, 1996). Local people have use Meru Betiri forest and its resource to support their daily live and gain benefits due to bamboo exploitation where national park was losing the bamboo forest. However, there were no efforts exerted to re-establish the bamboo population in the wild. Bamboo culms harvesting within national park by villagers in each quadrate was shown by **Figure 4.** Clearly, indicate that highest disturbance of the bamboo forest take place on quadrats 3 and 4, which related to the location of Sukamade village, and following by quadrat 5. Harvested bamboo in quadrat 5 was evidence that the villagers penetrate the core zone of national park, which is protected by National Park Laws. Mature culms were main target of local people harvesting. It is shown in **Figure 5** that the highest harvesting was occurs in category 4 (5 to 5.99 cm in diameter) and category 5 (6 cm and more in diameter). These diameters were useful for agriculture equipment and building material (Dransfield and Widjaja, 1995; Widjaja, 1998).

Furthermore, population growth and agriculture development change the wild habitat of bamboo into settlement and paddy field was a serious threats. Habitat loss and land-use change might have contributed to the extinction of *G. manggong* in the rural habitat. East Java part had lost its several forest patches where this bamboo species grows wild. Decline of *G. manggong* in natural habitat apparently occur during forest lost in eastern Java. Destruction of native forest probably played a role in the historic decline of endemic and most of the threatened species. Some endemic orchid species of Java Island such as *Habenaria giriensis*, *Liparis lauterbachii*, *Plocoglotis latifolia* and *Zeuxine tjiampeana* apparently extinct (Whitten *et al.*, 1996) due to habitat loss. It was reported that rate of deforestation in Indonesia from 1985-1997 was high, 1,871.716 ha per year and Java has already lost considerable amount of biological diversity in this century, as a result of habitat lost (Dephutbun, 2001). **Figure 7** shows a result of deforestation during 1891 to 1987 in Java Island, where *G. manggong* habitat in eastern part was disappear. Decline in the natural population size of *G. manggong* therefore likely to have occurred through this years. However, the trends were difficult to estimate with precision.

A near-future land use changes were predicted by Vernburg *et al.* (1999). The scenario between 1994 to 2010 allow that for the future land use change mainly will occur in Java's lowland forest. According to prediction, Meru Betiri forest might change to several categories due to land uses changes. It was predicted that housing and surrounding area will slightly increase. Enclave zones within national park give a rational reason of the increase of housing. It means that the area of *G. manggong* habitat in Sukamade forest has high possibility to change into settlement and agriculture or plantation development.

6. Conclusion and recommendations

This study found that current distribution of *Gigantochloa manggong* limited on the eastern part of MBNP and few population in rural village near the national park, namely Sumber Ayu villages along Kali Setail river. However, additional surveys is needed to find a more solitary population or small populations in other area in forest park. Area in eastern Raung Mountain slope areas is needed to be surveyed since a large bamboo forest was found in this region. Such study is important to assess their his-

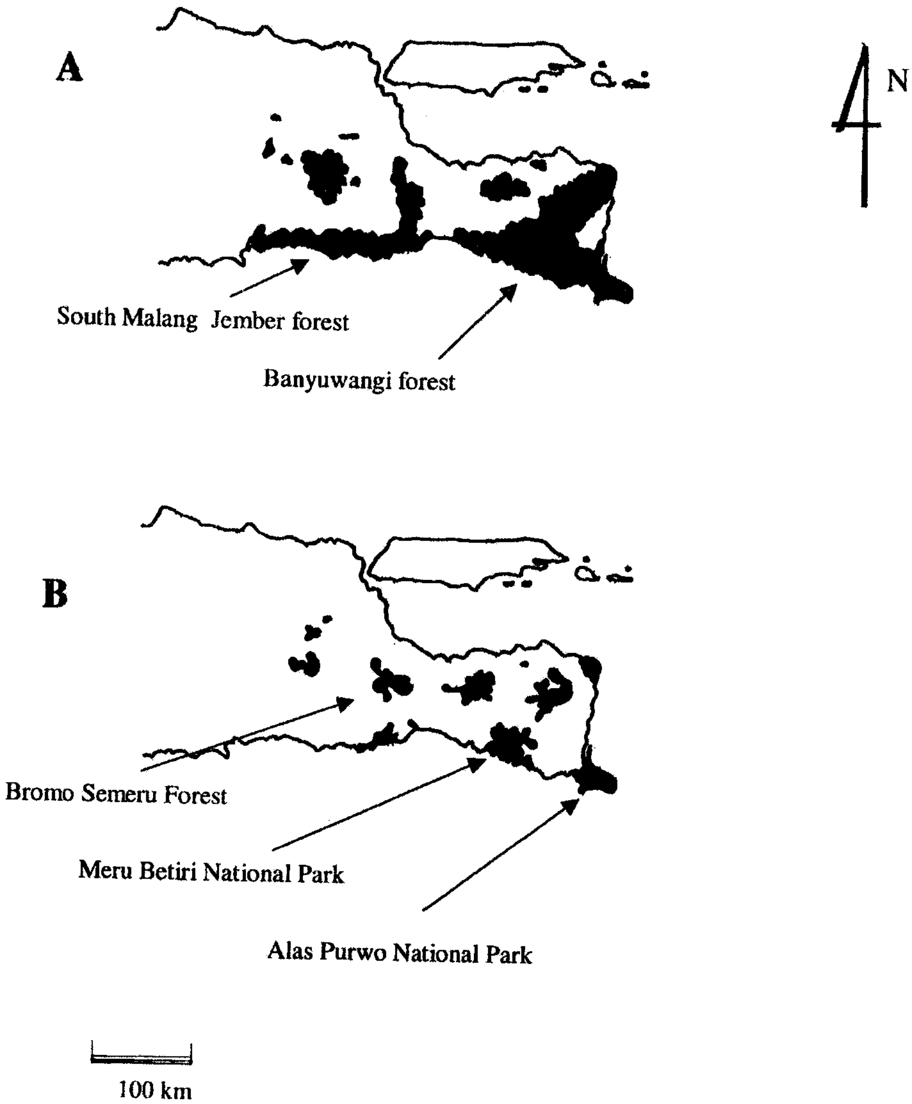

Figure 7. Forest cover (black) reduction in eastern part of Java Island. A in 1891 and B in 1987 (Whitten *et al.*,1996)

torical distribution and decline factors.

Since the *G. manggong* is an endemic species where in the nature their distribution limited on eastern part of the MBNP, *in situ* conservation strategy of *G. manggong* have played an important role to maintained their population in wild habitat. There was benefits of *in situ* conservation such as conserve the processes of evolution and adaptation of bamboo to their environments, and also to conserve genetic biodiversity of *G. manggong* bamboo. Since the reason, preserving endemic species where their distribution was limited such as *G. manggong* in Sukamade forest is important. The management and protection of the Sukamade zone have to promote immediately to ensure habitat of *G. manggong* is available. Since bamboo forest in certain part of national forest was infected by villagers activities, recovery efforts of *G. manggong* bamboo forest should be focused on preventing or reducing harvesting by local people, with the ultimate goal to reestablishing viable population on certain forest that closed to village. Several agreements with villagers are very important on preventing or reducing harvesting bamboo in natural habitat. Rural participatory can be harnessed as a useful method of securing protection for a wide range of ecosystem.

There was relationship of forest canopy and bamboo vegetations (Widmer, 1997; Chandrashekara,1996; Shoderstorm and Calderon, 1979). It is clear that absent of canopy give chance to bamboo to grow. Study on the value assessment of *G. manggong* and tree that forming canopy should be done previously to minimize to conservation conflict in the future. Conservation programs in this zone should be clear whether priority of forest recovery is maintaining *G. manggong* bamboo forest or reestablishing primary forest in this quadrate.

For the conservation of genetic diversity of natural populations of bamboo, understanding the genetic structure in species is a prerequisite. In addition, genetic analysis should be done to assess the gene pool among *G. manggong* forest patch within park, whether isolation of population in fragmented habitat occur or not. This information is very useful to design *in situ* conservation strategies.

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