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BAMBOO RESOURCES, CULTURAL VALUES, AND EX-SITU CONSERVATION IN BALI, INDONESIA

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ABSTRACT

SUJARWO, W. 2018. Bamboo resources, cultural values, and ex-situ conservation in Bali, Indonesia. Reinwardtia 17 (1): 67–75 — This present study describes the diversity of bamboo resources, based on Bali Botanic Garden’s bamboo collections, and its unusual uses, including complementary information on floristic region, and ex-situ conservation of bamboo resources on the island of Bali, Indonesia. Bamboo resources have played an important role in the economics and culture of rural communities in Bali. Bali Botanic Garden, Indonesian Institute of Sciences (LIPI), started to introduce bamboo species in 1982 and established the ex-situ conservation compartment (2 ha) of bamboo in the same year. Up to now, 52 species in 11 genera collected from mostly the Malesian region (67.44%) and the Eastern Asiatic region (20.93%) have been planted in the bamboo compartment, of which 5.77% bamboo species are woody climbers.

Key words: Bali, bamboo resources, ethnobotany, ex-situ conservation.

INTRODUCTION

There are more than 1,250 bamboo species distributed in the humid tropical, sub-tropical and temperate regions of the world (Sharma, 1980; Dransfield, 1981; Qing et al., 2008). The islands in the Malesian region have a rich diversity of plants and not all of those plants have been identified. Indonesia has approximately 17,000 islands; one of those is Bali. The country, with over 100 bamboo species, has rich bamboo diversity, third in the world only to China and India (Dransfield & Widjaja, 1995). Bamboo is an amazing grass in the Poaceae family (Wong, 2004), and generates off-spring by a complex robust rhizome system with woody culms and branches (Soderstrom et al., 1979). Bamboo is very adaptable, as it grows from lowland to highland. Its uses in construction, pulp and paper, for handicrafts and household utensils are well known by many people, but its cultural values are less known.

There is a uniqueness of bamboo on the island of Bali. Bamboo represents one of three living philosophies of the Balinese. Bamboo is an integral part of Bali life, particularly in the rural populations. The coconut and banana are also used, but less commonly. The people of Bali depend upon bamboo for every aspect of life from birth to death. For instance, Balinese utilise the bamboo as a knife to cut the navel when a baby is born, and bamboo is used to transport the body of an individual to the cemetery upon his demise (Sujarwo et al., 2012).

Bali Botanic Garden (BBG) has become one of the plant conservation centres in Indonesia, situated on the east slope of Bukit Tapak Hill, at an elevation of 1,250-1,400 m asl, adjacent to the Batukaru Nature Reserve (15,390 ha). The total area of BBG is 157.5 ha (Lugrayasa et al., 2009). By December 2015, BBG had 2,386 species in its collection, consisting of 241 families, 1,069 genera and including 52 species of bamboo and 213 species of ceremonial flora (Kebun Raya Bali, 2015).

Learning the indigenous knowledge in every region about utilisation of bamboo will be useful for understanding the cultural values. Even for the same bamboo species, the parts that are used and the preparation and application methods are not the same in every region. These depend upon the local wisdom and culture in every region (Sujarwo et al., 2014). Considering the diversity of bamboo,
discovering its unusual uses could be valuable, not only in Bali, and many scientists could take a role in this. It is possible that bamboo could become an industry worth millions of dollars, because of its rapid productivity and ease of cultivation in many environments. Therefore, the aims of this present study are to discuss and to analyse the diversity of bamboo resources in Bali Botanic Garden and its unusual uses, especially related to Balinese culture, including their floristic region, and conservation efforts.

MATERIAL AND METHODS

Study area

The study was conducted in Bali Botanic Garden (8°16'20"S, 115°9’7” E) in the middle part of Bali island, Indonesia. The island of Bali is located at the westernmost end of the Lesser Sunda Islands (Indonesia), between Java to the west and Lombok to the east (Fig. 1.). Altitude varies from 0 m at the coast line to 3,142 m at the top of highest mountain (Mount Agung) (Badan Pusat Statistik, 2015).

Bali has a tropical climate with a bimodal seasonality (dry season from May to October and rainy season from November to April). The total annual rainfall can vary across the island spanning from around 1,200 to around 3,700 mm. The average annual temperature also varies throughout the year, and ranges from 23 to 33°C. The soil is alluvial and dominated by latosol, regosol, and andosol (Badan Pusat Statistik, 2015; Sujarwo & Caneva, 2015). Bali has also rich biological diversity. The flora of Bali is characterised by 1595 species of Spermatophyta, 173 species of Pteridophyta, and 169 species of Bryophyta (Girmansyah et al., 2013).

Data collection

Information on the number of bamboo resources was obtained through Bali Botanic Garden’s catalogue (Lugrayasa et al., 2009; Kebun Raya Bali, 2015), and their floristic regions were obtained through the book of floristic region of the world, written by Armen Takhtajan (1986). That is important information to understand the origin/distribution of bamboo resources. For each species of bamboo, the author reviewed available literature for utilisation and cultural values using scientific databases (such as Science Direct, Google Scholar). Scientific names of the bamboo species were verified using online sources (e.g. The Plant List, 2018).

RESULTS

This present study recorded 52 bamboo species belonging to 11 genera as being collected by Bali Botanic Garden, of which 5.77% bamboo species are woody climbers. The most common genera are Gigantochloa (20 species), Bambusa (11 species), and Schizostachyum (8 species). However, nine bamboo species are still unidentified. The native floristic region of the 52 recorded bamboo species covers Malesian (67.44%), Eastern Asiatic (20.93%), Indochinese (4.65%), and other tropical and sub-tropical Asian (6.98%) regions. In total,
only three bamboo species are not native to the tropical and sub-tropical areas of Asia. A list of bamboo species together with their floristic region is provided in Table 1. This present study also recorded cultural values and ex-situ conservation of bamboo resources on the island of Bali, Indonesia.

DISCUSSION

Bamboo resources and their floristic region

Dransfield (1981) estimated that sixty-four percent of world bamboo species are native to Southeast Asia, thirty-three percent grows in Central and South America, and the rest is in Africa and Oceania. In Indonesia, over 100 bamboo species are mostly distributed in Sumatra, Java, Bali and the Lesser Sunda Islands (Dransfield & Widjaja, 1995; Widjaja, 2001; Widjaja et al., 2005).

The floristic region of this present study covers Malesian (67.44%), Eastern Asiatic (20.93%), Indochinese (4.65%), and other tropical and sub-tropical Asian (6.98%) regions. This geographical derivation might be strongly in connection with cultural influences within the tropical and sub-tropical Asiatic region. Pringle (2004) and Suwarjo & Caneva (2016) mentioned that the island of Bali is not only a species-rich tropical area, but also its people have a rich cultural history. On the contrary, the arrival in Indonesia of plants native to Central and South America was made by seed exchange among botanic gardens, and might have been introduced by the Dutch starting in the 16th century (Simmonds, 1976).

Even though the surface area of Bali Island is around 5,780 km², and only 0.2% of the whole area of Indonesia, six bamboo species were identified native to the island. They are Bambusa ooh Widjaja & Astuti, Dinochloa sepang Widjaja & Astuti, Gigantochloa aya Widjaja & Astuti, Gigantochloa baliana Widjaja & Astuti, Gigantochloa taluh Widjaja & Astuti, and Schizostachyum castaneum Widjaja (Arinasa et al., 2015). Arinasa & Peneng (2013) stated not all bamboo species on the island have been identified. In Bali, bamboo generally grows in the natural forests and home gardens. One of the well-known bamboo forests is situated in Penglipuran traditional village, a large area of bamboo belongs to the local communities and individual landowners, and it varies between 40 and 50 hectares (Suwarjo, 2016).

Cultural values of bamboo

History and folklore

In the past, Bambusa blumeana Schult.f. grew abundantly throughout the coastline of the northern part of Bali Island. It formed a natural barrier, which prevented the Dutch from entering the island when they wanted to colonise Singaraja (the former capital city of Bali) (Suwarjo, 2012). According to the ancestors, the Dutch threatened Singaraja many times, but they could not enter Singaraja due to Bambusa blumeana. Therefore, Singaraja could not be colonised by the Dutch for a long time. However, the Dutch were very smart and they were relentless in their quest to colonise Singaraja, so they were always devising new techniques to accomplish their goals. They came up with the idea of destroying the forest of B. blumeana, where it grew well and was sturdy. Many coins (money) were thrown by helicopter at the bamboo forest over a long period of time. Local people were overjoyed at this, because they did not have much money. As a result, they began to cut down all clumps of B. blumeana throughout the coastline in pursuit of these coins. The livelihood of the Balinese people living in Singaraja gradually began to change. Consequently, this provided an opportunity for the Dutch to clear the forest of B. blumeana. Once that had been removed from the coastline, it was vulnerable and the Dutch moved in easily. The Dutch used weaponry and warships to attack Singaraja. In the end they were able to colonise Singaraja. The local people were saddened by this, because they realised, after it was too late, that the Dutch had used this strategy to conquer them.

Folk feast

Galungan is one of the biggest feasts for Hindus in Bali, as are the Nyepi and Kuningan days. Bali’s Hindus celebrate Galungan twice a year, as well as Kuningan but Nyepi is held only once a year. A day before the day of Galungan, Balinese Hindus in celebration set Penjor in front of their own houses (Suwarjo, 2011).

Penjor is made from entire bamboo culms and the curved ends are garnished with an assortment of ornaments. Penjor is one of the most important tools in the Galungan’s ceremony. This has resulted in increasing demand of bamboo in Bali, which affects the selling price in the market. The meaning of Penjor is as gratitude for blessings that have been given and also an offering to God that is symbolised in all the crops used in it. Penjor is always installed the day before Galungan and is attached in front of the entrance to the house with its end facing the street. It is removed a month after the day of Galungan.

The types of bamboo that are often used to make Penjor are bambu bali (Gigantochloa bali-a-na), bambu tali (G. apus (Schult.) Kurz), bambu tabah (G. nigroclitata (Buse) Kurz), and bambu tamblang gading (Schizostachyum brachycladum (Schult.) Kurz) (Suwarjo, 2011). Bambu bali is Bali endemic species that has been developed in many local communities in Bali and has been
Table 1. The *ex-situ* conservation of Bamboo in Bali Botanic Garden

<table>
<thead>
<tr>
<th>Species of bamboo</th>
<th>Life form</th>
<th>Collected from</th>
<th>Number of specimen (clump)</th>
<th>Floristic region</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bambusa</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Bambusa blumeana</em> Schult.f.</td>
<td>Tree</td>
<td>Bali</td>
<td>5</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Bambusa maculata</em> Widjaja</td>
<td>Tree</td>
<td>Bali</td>
<td>5</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Bambusa multiplex</em> (Lour.) Raeusch. ex Schult.</td>
<td>Tree</td>
<td>Bali</td>
<td>16</td>
<td>Eastern Asiatic</td>
</tr>
<tr>
<td><em>Bambusa ooh</em> Widjaja &amp; Astuti</td>
<td>Tree</td>
<td>Bali</td>
<td>9</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Bambusa tuloides</em> Munro</td>
<td>Tree</td>
<td>Bali</td>
<td>6</td>
<td>Eastern Asiatic</td>
</tr>
<tr>
<td><em>Bambusa vulgaris</em> Schrad.</td>
<td>Tree</td>
<td>Bali</td>
<td>11</td>
<td>Eastern Asiatic</td>
</tr>
<tr>
<td><em>Bambusa vulgaris</em> var. <em>striata</em> (Lodd. ex Lindl.) Gamble</td>
<td>Tree</td>
<td>Bali</td>
<td>7</td>
<td>Eastern Asiatic</td>
</tr>
<tr>
<td><em>Bambusa vulgaris</em> f. <em>waminii</em> T.H. Wen</td>
<td>Tree</td>
<td>Bali</td>
<td>11</td>
<td>Eastern Asiatic</td>
</tr>
<tr>
<td><em>Bambusa sp.1</em></td>
<td>Tree</td>
<td>Bali</td>
<td>5</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Bambusa sp.2</em></td>
<td>Tree</td>
<td>Bali</td>
<td>12</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Bambusa sp.3</em></td>
<td>Tree</td>
<td>Bali</td>
<td>2</td>
<td>Malesian</td>
</tr>
<tr>
<td><strong>Dendrocalamus</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Dendrocalamus asper</em> (Schult.) Backer</td>
<td>Tree</td>
<td>Bali</td>
<td>23</td>
<td>Indochinese</td>
</tr>
<tr>
<td><em>Dendrocalamus sp.</em></td>
<td>Tree</td>
<td>Bali</td>
<td>6</td>
<td>Malesian</td>
</tr>
<tr>
<td><strong>Dinochloa</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Dinochloa kostermansiana</em> S.Dransf.</td>
<td>Woody Climber</td>
<td>Bali</td>
<td>1</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Dinochloa sepang</em> Widjaja &amp; Astuti</td>
<td>Woody Climber</td>
<td>Bali</td>
<td>3</td>
<td>Malesian</td>
</tr>
<tr>
<td><strong>Gigantochloa</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Gigantochloa apus</em> (Schult.) Kurz</td>
<td>Tree</td>
<td>Bali</td>
<td>42</td>
<td>Indochinese</td>
</tr>
<tr>
<td><em>Gigantochloa atter</em> (Hassk.) Kurz</td>
<td>Tree</td>
<td>Bali</td>
<td>4</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Gigantochloa atroviolacea</em> Widjaja</td>
<td>Tree</td>
<td>Bali</td>
<td>4</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Gigantochloa aya</em> Widjaja &amp; Astuti</td>
<td>Tree</td>
<td>Bali</td>
<td>13</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Gigantochloa baliana</em> Widjaja &amp; Astuti</td>
<td>Tree</td>
<td>Bali</td>
<td>1</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Gigantochloa manggong</em> Widjaja</td>
<td>Tree</td>
<td>Bali</td>
<td>12</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Gigantochloa hasskarliana</em> (Kurz) Backer</td>
<td>Tree</td>
<td>Bali</td>
<td>4</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Gigantochloa kuring</em> Widjaja</td>
<td>Tree</td>
<td>Bali</td>
<td>7</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Gigantochloa luteostriata</em> Widjaja</td>
<td>Tree</td>
<td>Bali</td>
<td>3</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Gigantochloa magentea</em> Widjaja</td>
<td>Tree</td>
<td>Bali</td>
<td>1</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Gigantochloa nigrociliata</em> (Buse) Kurz.</td>
<td>Tree</td>
<td>Bali</td>
<td>5</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Gigantochloa pubinervis</em> Widjaja</td>
<td>Tree</td>
<td>Bali</td>
<td>9</td>
<td>Malesian</td>
</tr>
<tr>
<td><em>Gigantochloa pubipetiolata</em> Widjaja</td>
<td>Tree</td>
<td>Bali</td>
<td>1</td>
<td>Malesian</td>
</tr>
</tbody>
</table>
Table 1. The ex-situ conservation of Bamboo in Bali Botanic Garden (continued)

<table>
<thead>
<tr>
<th>Species of bamboo</th>
<th>Life form</th>
<th>Collected from</th>
<th>Number of specimen (clump)</th>
<th>Floristic region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gigantochloa robusta Kurz</td>
<td>Tree</td>
<td>Bali</td>
<td>2</td>
<td>Malesian</td>
</tr>
<tr>
<td>Gigantochloa serik Widjaja</td>
<td>Tree</td>
<td>Bali</td>
<td>1</td>
<td>Malesian</td>
</tr>
<tr>
<td>Gigantochloa taluh Widjaja &amp; Astuti</td>
<td>Tree</td>
<td>Bali</td>
<td>5</td>
<td>Malesian</td>
</tr>
<tr>
<td>Gigantochloa thoi K.M.Wong</td>
<td>Tree</td>
<td>Bali</td>
<td>1</td>
<td>Malesian</td>
</tr>
<tr>
<td>Gigantochloa velutina Widjaja</td>
<td>Tree</td>
<td>Bali</td>
<td>3</td>
<td>Malesian</td>
</tr>
<tr>
<td>Gigantochloa sp.1</td>
<td>Tree</td>
<td>Bali</td>
<td>47</td>
<td>Malesian</td>
</tr>
<tr>
<td>Gigantochloa sp.2</td>
<td>Tree</td>
<td>Bali</td>
<td>61</td>
<td>Malesian</td>
</tr>
</tbody>
</table>

Guadua

Guadua chacoensis (Rojas Acosta) Londoño & P.M.Peterson

Neololeba

Neololeba atra (Lindl.) Widjaja

Otatea

Otatea acuminata (Munro) C.E.Calderón ex Soderstr.

Phyllostachys

Phyllostachys aurea Rivièr & C.Rivièr

Phyllostachys nigra (Lodd. ex Lindl.) Munro

Phyllostachys sp.1

Schizostachyum

Schizostachyum brachycladum (Kurz) Kurz

Schizostachyum castaneum Widjaja

Schizostachyum caudatum Backer ex K.Heyne

Schizostachyum cuspidatum Widjaja

Schizostachyum lima (Blanco) Merr.

Schizostachyum silicatum Widjaja

Schizostachyum zollingeri Steud.

Schizostachyum sp.1

Shibataeae

Shibataea kumasasa (Steu.) Makino

Thyrsostachys

Thyrsostachys siamensis Gamble

Abbreviations. C. Sulawesi = Central Sulawesi; E. Java = East Java; E. Nusa Tenggara = East Nusa Tenggara; N. Sulawesi = North Sulawesi; S. Sulawesi = South Sulawesi; S.E. Sulawesi = South East Sulawesi; W. Nusa Tenggara = West Nusa Tenggara; W. Papua = West Papua.
conserved in the Bali Botanic Garden.

Bamboo and myths

*Bambu pingit* (Gigantochloa hasskarliana (Kurz) Backer) is well known to the indigenous people in eastern parts of Bali (Sujarwo, 2010b). It is found there only in the holy area of the Lempuyang Luhur temple, which is one of the biggest temples in Bali. It is located on the mountain Lempuyang Luhur, which is 1,200 m asl. The local people in this area believe that this bamboo can cure breast cancer, insomnia, and heart problems. A Hindu priest at the temple says that the water inside the culms of this bamboo can cure those diseases. Local people say that many have been healed by drinking the water from inside the culm (Sujarwo et al., 2010a). In addition to being used as a medicine, the water inside the culm is used as holy water by Hindu people in Bali (Sujarwo, 2010b). This is an example of local indigenous knowledge. On top of this mountain five clumps of *bambu pingit* are growing. While bamboos can grow from the lowlands to the highlands, this bamboo is growing only on top of this mountain.

The roof of Balinese traditional buildings

Most Balinese have known that clay was usually used as raw material for the roof. But, in Penglipuran traditional village in Bali the roof is unique. In that village bamboo is used. The roof is made from laths of bamboos (*Gigantochloa aya*, *G. taluh* and *G. apus*) with the dimensions of 5–7 cm wide, 25–54 cm long, and 0.5–1.2 cm thick respectively.

In Penglipuran, most holy buildings such as pura (temple), bale gong, bale piasan, bale kuluk and bale paruman (these holy buildings are parts of the Hindu temple) have bamboo roofs. Besides holy buildings, houses, kitchens, and angkul-angkul (private entrance gates) also use bamboo for roofs especially from *bambu aya* (*G. aya*).

The utilisation of bamboo for roofs is found not only in Penglipuran (Bangli regency), but also in other villages in Bali such as Tigawasa and Sidatapa villages (Bulleleng regency), Angsri and Wongaya Gede villages (Tabanan regency), Pemapatan and Tenganan villages (Karangasem regency). Arinasa & Peneng (2013) stated that, in recent times, restaurants, hotels and houses in Bali have utilised the laths of bamboo for the roof.

Making and preserving bamboo laths is simple. Although the bamboo roof is made traditionally and without preservative, many people began to like it, because it gives freshness. The air circulation is better. Also, the bamboo roof has been reported as lasting 25-30 years or more.

Bamboo charcoal

In Bangli regency, 18 species of bamboo grow. These include *Gigantochloa aya*, *G. taluh*, *G. apus*, and *Dendrocalamus asper* (Schult.) Backer. Those bamboos have been utilised by traditional charcoal makers to produce charcoal. This is a product that has been developed as a sustainable product. It could be made from all parts of bamboo, but the traditional charcoal maker uses only bamboo waste. This includes rhizomes, internodes, small branches and waste from the bamboo home industry (Astuti & Arinasa, 2002).

A few iron makers still exist in Bali. They burn bamboo charcoal to make knives, sickles etc. They said that bamboo charcoal yields higher heat than other kinds, such as that made from coconut shells. This may be due the high silica content in bamboo. Bamboo has a significant impact and is used in many aspects of the lives of local people, particularly in the Bangli regency.

Based on local people information, bamboo charcoal usually sells for 60,000 IDR per sack (1 USD = 13,200 IDR). Traditional charcoal makers can make five sacks in two days, for which they will get IDR 300,000. However, they must buy the bamboo waste from craftsmen for IDR 30,000 for one sack of bamboo waste. So the traditional charcoal makers get only IDR 150,000 for two days or IDR 75,000 for one day. They do not earn much, although this is a bit higher than for day workers, because labour pay is usually about IDR 50,000 to IDR 60,000 per day.

Bamboo and medicine

The use of modern medicines and pharmaceuticals has spoiled humans, so that the knowledge of ancestral traditional medicines has been slightly overlooked. One potential alternative medicine material is bamboo.

Bamboo is well known, but its utilisation as medicine is less known. Previously, the shoots of *bambu kuning* (*Bambusa vulgaris* Schrad.) were used to heal liver problems (Sujarwo et al., 2012). Balinese ancestors used the water in *Dinochloa scandens* (Blume ex Nees) Kuntze as medicinal eyewash and for tuberculosis (Tengah et al., 1995). Sujarwo et al. (2012) mentioned that some indigenous knowledge of bamboo was found through interviews with Balian Usada, an indigenous medical practitioner who is knowledgeable on plant uses, and eight species were found as medicine. The eight species of bamboo and their medicinal uses were: shoots of *D. asper*, used to reduce hypertension; shoots of *Gigantochloa nigrociliata*, used to relax muscle and for heartburn; roots of *G. aya*, used to reduce fever; culms of *Bambusa vulgaris* var. *vulgaris*, used to cure liver problem; shoots of *Schizostachyum lima* (Blanco) Merr. used to increase memory; shoots of *Bambusa vulgaris* var. *vulgaris*.
Besides holy buildings, houses, kitchens, and of the Hindu temple) have bamboo roofs. Many have been reported as lasting 25 years or more. Also, the bamboo roof has better circulation. Although the bamboo roof is made traditionally in recent times, restaurants, hotels and houses in Bali (Tabanan regency), Wongaya Gede villages (Tabanan regency), Sidatapa villages (Buleleng regency), Angsri and only in Penglipuran (Bangli regency), but also in some other places because labour pay is usually about IDR 50,000 to 100,000 (1 USD = 13,200 IDR). Traditional charcoal makers will get IDR 300,000. However, they must buy the bamboo charcoal to make knives, sickles and thatched roofs for IDR 50,000. This is less costly than making charcoal from hardwood. Bamboo has a significant impact and is used in many ways. This may be due to the high silica content in bamboo. The local people have long used bamboo as a rope substitute, fishing net, basket, and animal harness. The bamboo charcoal yields higher heat than coal. The traditional charcoal maker uses only bamboo waste. This includes rhizomes, inter Digitations, bamboo shoots and other parts. Bamboo is used in the form of donations and index seminum among botanic gardens. Exploration is carried out in the form of donations and index seminum among the local Balinese communities, and bamboo lovers. In the last ten years, BBG’ botanists have conserved at least 30 new bamboo species in the garden. On the basis of studies conducted by Arinasa & Peneng (2013) and Sujarwo (2015b), the local inhabitants in several traditional villages in Bali, such as Aengsri Village in Tabanan regency, and Tigawasa Village in Bulleleng regency, believe that the bamboo forests that had been hundreds of years can create a new water spring. Such villages could be a model, how a strong tradition of local communities which has been passed down through generations of ancestors can maintain bamboo forests for hundreds of years. The bamboo forests in such villages are mostly owned by indigenous communities, and only a small quantity is owned by individuals. Local people only take a little direct benefit from selling bamboo culms, because they believe that the soil and water conservation is much more important than the direct value of bamboo culms itself.

Creating a new water spring

On the basis of bamboo collection activities until the end of 2015, the garden has collected as many as 52 bamboo species that represent 11 genera, including six endemic bamboos. Arinasa & Sujarwo (2015) mentioned that in their wild habitat, five types of endemic bamboo can be found in either bamboo forests or home gardens, and one type, D. sepang, is only found in a protected forest area. It is possible that more endemic bamboo species in Bali will be discovered, because many types of bamboo can be found in Bali. Bali Botanic Garden has not completely collected herbarium vouchers, especially in the genus Gigantochloa. Field exploration is expected to be able to increase the number of new collection, including discovering new endemic bamboo species.

CONCLUSIONS

The number of species of bamboos in Bali island is similar to that throughout the Malesian region, and the island has six endemic bamboo species, indicating that Bali is one of the richest areas of bamboo in Indonesia. Until recently, Bali Botanic Garden has collected 52 species with 11 genera from mostly the Malesian region and the Eastern Asiatic region. These bamboo collections

region increases after a few years of planting bamboo and in some cases new springs appear (Bamboo Central, 2015). This is not surprising, considering the bamboo is a C3 plant and very effective in water conservation. As a comparison, trees absorb an average of 35-40% rainwater, while the bamboo can absorb up to 90%. That is the reason people in Colombia said that they planted water when they grow bamboo.

Ex-situ bamboo conservation

Ex-situ bamboo conservation by Bali Botanic Garden has been conducted since the 1980s. By 2015, the garden had managed to collect a total of 52 bamboo species or 30% of the total bamboo found in Indonesia. Nearly 33% of the present collection is a kind of introduced species native to outside the Malesian region (Kebun Raya Bali, 2015). Efforts to increase the types of bamboo received great attention as a multi-purpose function. Increasing the bamboo collection can be done by exploration, and exchange of material in the form of donations and index seminum among botanic gardens. Exploration is carried out in the rural areas and protected forests of Bali and eastern parts of Indonesia, including Lesser Sunda Islands, Sulawesi, Moluccas and Papua, while material exchange is performed by governments and private institutions, Botanic gardens, bamboo communities, and bamboo lovers. In the last ten years, BBG’ botanists have conserved at least 30 new bamboo species in the garden.

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are planted in a bamboo compartment with an area of two hectares. Bamboo has out-standing cultural values for Balinese people, and has a promising prospect to be developed into a large scale industry. With an increasing human population expanding its demands on bamboo resources, more approaches are required for conserving and managing bamboo resources. Scientific approaches have to be conducted toward a better understanding of the distribution and propagation techniques of bamboo. Establishing new botanic gardens should be strongly fostered to conserve more bamboo resources.

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