Assessment of Subsistence Plant Resource of the Mangrove Forest in the Ayeyarwady Delta, Myanmar

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Abstract

An ethnobotanical study on the plant resources of mangrove forests was conducted in the village of Ashe Mayan in the Ayeyarwady Delta, Myanmar. Among 82 species of mangrove flora, 54 species including 19 mangrove plants, 20 mangrove associates and 15 non-mangrove plants were inventoried as useful plants for local subsistence. The cumulative number of plant resources stood at 119 species, consisting of 28 species applied for medical purposes or as poison, 22 species used in crafts, 19 edible species, fourteen species providing construction materials, ten species used for tying, seven species used for fuel, one species used in roofs and walls and 18 species with other purposes. Examining the meteorological and geographical environment, plant features and requisites for life, we assessed that utilization of plant resources of mangrove forests is harmonized with the endemic life culture.

Key words: ethnobotanical study, inventory, mangroves, useful plants, subsistence use

1. Introduction

In the late 19th century, the British colonial government transferred the inhabitants of Bamar from the central dry plains to the Ayeyarwady (AYWD) Delta, which had been an almost uninhabited wilderness with forests and swamps until then (Saito, 1962; Tamura, 1997). Mangroves were a major forest resource in the coastal lowlands for the settlers, and the people have benefited from the mangrove forests since that time. As large volumes of woody resources have been supplied to the cities (Ohn, 1992) however, the distribution of the mangrove forests has dwindled since the 1970s. The subsequent depression and degradation of mangrove ecosystems have put the traditional life of the local people in jeopardy. Conservation of mangrove forests has become a critical issue in the AYWD Delta, as well as in other coastal areas in the tropics.

Because groups of indigenous people regard natural resources as essential to their culture and well-being, they should be given particular attention in any kind of conservation programs (McNeely *et al*., 1990). However the reliance of rural people on ecosystems is rarely examined and thus typically overlooked in national politics and economics, resulting in inappropriate strategies that do not take into account the role of the environment (Millennium Ecosystem Assessment, 2005).

To contribute an alternative viewpoint to mangrove conservation, the subsistence value of mangrove plants has been investigated in each country over time (*e.g*., Taylor, 1982 [Thailand & Malaysia]; Chan & Salleh, 1987 [Malaysia]; Siddiqi, 1994 [Bangladesh]; Dahdouh-Guebas *et al*., 2000 [Kenya]), and this information has been compiled (*e.g*., Tomlinson, 1986; Field, 1995; Bandaranayake, 1998; Spalding *et al*., 2010). However, in Myanmar, assessment of the subsistence value of mangroves based on field work has been limited, and besides, the natural environment and species composition are unique compared to typical mangrove forests in Southeast Asia (*e.g*., Yamada, 1984; Maung Maung Than, 2006), thus the local use of plants may be different.

Therefore, the purpose of this study was to elucidate the subsistence value of mangrove forests in the AYWD Delta in the local context, based on field inventory work on useful plants.

2. Site Description

The AYWD Delta is situated in the southern part of Myanmar, between the latitudes of 15° and 18° north, and longitudes of 94° and 96° east. The delta faces the Bay of Bengal, to the south and southwest (Fig. 1a). This megadelta is approximately 20,600–35,000 km^2 in area, and its extensive mangroves cover 652 km^2 as of 2007, down

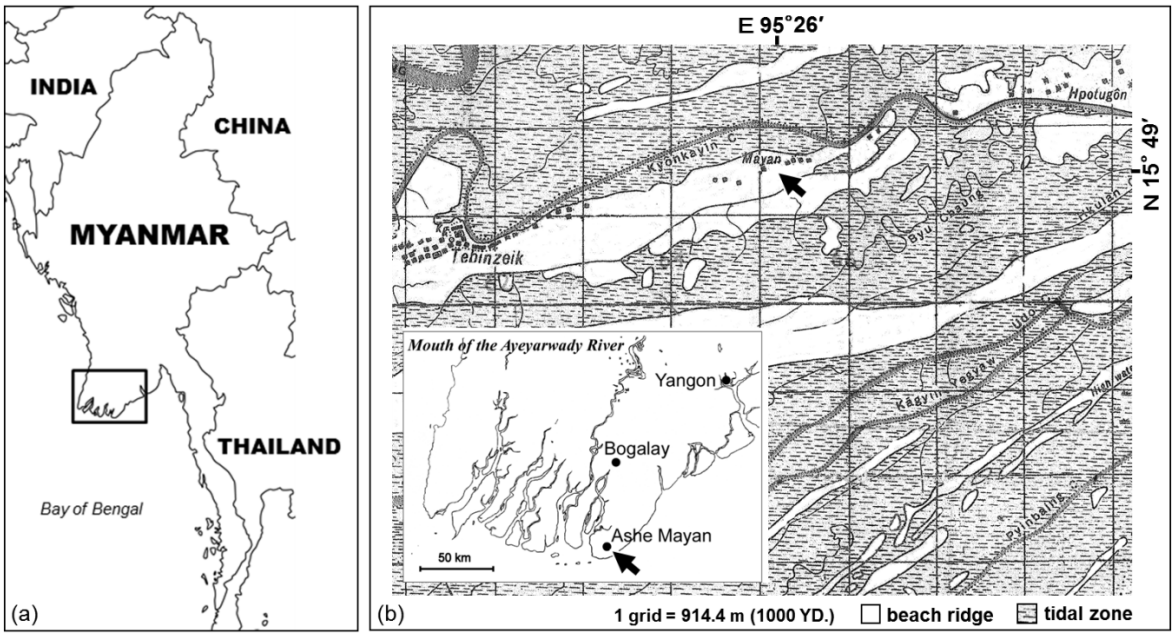

Fig. 1 The Study site. (a) The square shows the mouth of the Ayeyarwady River which is magnified in 1b. (b) The arrow indicates Ashe Mayan village. It is located in a mangrove swamp area, approximately 60 km south of the nearest town, Bogalay.

from 2,532 km^2 in 1924. The area is influenced by a tropical monsoon climate with high temperatures and abundant rainfall, and is characterized by three seasons: the rainy, cold, and summer seasons. The average annual rainfall is over 3,200 mm, and almost all precipitation comes during the rainy season from May to October (Toe Toe Aung *et al*., 2010).

The natural environment of the AYWD mangrove area is characterized by low salinity water of its streams (Myint Aung, 2004) and by rather higher ground, marked at class-three to class-five of the Watson inundation index (Watson, 1928), occupying most of the tidal zone. Because of this particular environment, the mangrove *Heritiera fomes* broadly dominates, accompanied by species from freshwater swamps, to the extent that this tidal ecosystem is a completely different mangrove forest in terms of species composition.

Our study site was the village of Ashe Mayan, in the eastern part of the AYWD Delta. Houses and other buildings were scattered along a footpath of about three kilometers, on a sandy beach ridge between a small creek and a tidal marsh (Fig. 1b). The reasons this village was selected were: the village was far away from commercial zones, villagers needed to depend much more on forest resources in order to live; and it was thought that the rich mangrove vegetation around the village was sufficient for maintaining the villagers' traditional lifestyle (Fig. 2). The inhabitants were all Bamar. Their ancestors were considered to have been transferred from nearby villages in and after the 19th century. Nearly half of the households held their own land; and home gardens, rice cropping and nipa plantations have provided their main income sources. The landless families, on the other hand, relied on fishing and other small-scale works (Table 1).

Fig. 2 Gathering of plant resources from adjacent mangroves is routine for the local people, Ashe Mayan village.

3. Methodology

A flora list of 82 vascular plants in the surrounding mangrove forest was acquired through flora and vegetation surveys, which were carried out for more than thirty days in total from 2002 to 2005. An inventory of plant resources in the mangrove forests was compiled based on an interview survey and participatory observation, which were followed up for more than 60 days in all from 2005 to 2010. Useful plants were selected from the flora list, and then their subsistence uses were investigated. Local

Table 1 Basic data and information pertaining to the studied village; Ashe Mayan.

Establishment	Before late 19th century
Linear distance to the nearest town	ca. 53 km to Bogalay town, Ayeyarwady division
Population/Household	ca.680/ca.110
Ethnic group	Bamar
Public facility	One primary school, one store and two stalls (no monastery)
Subsistence*	Rice cultivation: 23% (land size: avg. 2 ha/household) Home garden: 18% (land size: avg. 1ha/household) Fish, shrimp and crab catching: 14% Nipa plantation: 5% (land size: avg. 6 ha/household) Others: 53% (Small business, permanent or casual labors)
Land ownership	Over 50 households are landless
Home garden products	Coconut, betel nut. betel leaf etc.
Live stock	Duck, chicken, pig, cattle, water buffalo, etc.

*%: Household bassis

Table 2 Functional categories of plant resource utilization.

Functional category	Utilization
Fuel	firewood, charcoal
Construction	structure and floor material of buildings
Craft	tool, furniture, non-structure material of buildings, fencing material
Tying	string, cord, cordage, fishnet
Roof & Wall	thatch, partition and walling
Edible	foodstuff, beverage, spice, cooking oil
Medical & Poison	remedial, preventative drug, poison, rejectant, medical care, detergent, tannin, psychoactive drug and taste material
Others	decoration, cosmetic, ceremonial and magic, entertainment, game, dye, food-curing, fertilizer, etc.

names and, ways of gathering, processing and applying plants were recorded, and the parts of the plants used and intended use of each of them were specified. At the same time, the quality and preference of each resource were confirmed. The core interviewees were fourteen village elders who had lived in this village for more than thirty years, and their families. The elders were all well-experienced in using forest products, for they had been working for a long time in the surrounding forests.

Phillips and Gentry (1993) was used as a reference for categorizing the intended uses into functional categories of fuels, construction, crafts, tying, roofs & walls, edible, medical & poison and others (Table 2). Almost all trees and shrubs could be used as fuel, but in this paper, only the plants with good quality, which were usually or frequently used, were regarded as fuel resources. Other necessary information, such as mangrove status and plant types, was added to complete the inventory list with field data. Using Tomlinson (1986) as a reference, the mangrove status of each useful plant was classified into three groups: "mangrove plants," which are characteristically found in tidal swamps; "mangrove associates," which are typically found in back mangroves or along riversides etc.; and "non-mangrove plants," which are considered a component of terrestrial plant communities. Based on Maung Maung Than (2006), plants were categorized into five types: trees, shrubs, palms, herbs and climber/creepers. Finally, we discussed the resource value of plants in the local context by pointing out distinguishing examples of utilization in this mangrove region.

4. Results and Discussion

Out of 82 plants of forest flora, 54 species in 24 families were useful for local subsistence (Table 3). They consisted of 19 mangrove plants, 20 mangrove associates and 15 non-mangrove plants, thus this can be interpreted as the local people deftly enjoying not only mangrove plants but the plant resource diversity resulting from the species richness of the AYWD mangrove forests. Because many of the useful plants had multiple functions, the cumulative number of plant resource stood at 119 species. The plant resources consisted of 28 species for medical & poison, 22 species for crafts, 19 edible species, 14 species for construction, ten species for tying, seven species for fuel and one species for roofs & walls. This shows that the AYWD mangrove forests are a universal resource supply system, which provides resources in all functional categories meeting the local needs, and that the forests are not performing in the capacity of specialized purposes for the people.

4.1 Fuel

Thin axes of richly branching shrubs such as *Brownlowia tersa* and *Hibiscus tiliaceus* were gathered (Fig. 3a). *Cynometra ramiflora* is a tree species but it has many branches and its axes were harvested in the same manner as those shrubs. Thinner branches with a diameter of less than five centimeters were used from four tree species, including *Heritiera fomes*, *Pongamia pinnata* and others, which have a main trunk and branches. Only a

Table 3 Inventory of plant resources in the mangrove forest.

Family[*1]	Scientific name	Mgrv. status[*2]	Local name	Plant type[*3]	Fuel	Const-ruction
Acanthaceae	*Acanthus ebracteatus* Vahl	+	Kha-yar	S		
〃	*Acanthus ilicifolius* L.	+	Kha-yar	S		
〃	*Avicennia alba* Blume	++	Thame-kyettet	T		G
〃	*Avicennia marina* (Forssk.) Vierh.	++	Thame-phyu	T		G
〃	*Avicennia officinalis* L.	++	Thame-gyi	T		G
Apocynaceae	*Cerbera odollam* Gaertn.	+	Za-lut	T		
〃	*Finlaysonia obovata* Wall.		Byauk-nwe	C		
〃	*Sarcolobus carinatus* Wall.		Swut-kha-mon-nwe	C		
〃	*Sarcolobus globosus* Wall.		Kyee-ka-lain	C		
Arecaceae	*Nypa fruticans* Wurmb	++	Dani	P		
〃	*Phoenix paludosa* Roxb.	+	Thinbaung	P		
Asteraceae	*Pluchea indica* (L.) Less.		Kha-yu	H		
Bignoniaceae	*Dolichandrone spathacea* (L.f.) Seem.	+	Ye-thakyut	T	g	
Blechnaceae	*Stenochlaena palustris* (Burm.f.) Bedd.		Damin-nwe	C		
Calophyllaceae	*Calophyllum inophyllum* L.	+	Pon-nyet	T		
Combretaceae	*Terminalia catappa* L.	+	Banda	T	g	G
Euphorbiaceae	*Excoecaria agallocha* L.	++	Tha-yaw	T		
〃	*Shirakiopsis indica* (Willd.) Esser		Bonlon	T		
Fabaceae	*Caesalpinia bonduc* (L.) Roxb.	+	Kyee-kalain	C		
〃	*Caesalpinia crista* L.	+	Alo-lay	C		
〃	*Cynometra ramiflora* L.	+	Myin-ga	T	G	
〃	*Dalbergia pinnata* (Lour.) Prain		Yemagi-nwe	C		
〃	*Dalbergia spinosa* Roxb.		Byeik-suu	S		
〃	*Derris scandens* (Roxb.) Benth.		Mi-chaung-nw	C		
〃	*Derris trifoliata* Lour.	+	Nwe-net	C		
〃	*Intsia bijuga* (Colebr.) Kuntze	+	Saka-lun	T		G
〃	*Pongamia pinnata* (L.) Pierre	+	Thinwin-pyu	T	G	
Flagellariaceae	*Flagellaria indica* L.		Myauk-kyein	C		
Lamiaceae	*Clerodendrum inerme* (L.) Gaertn.		Taw-kyaung-pan	S		
〃	*Premna serratifolia* L.		Taw-taung-tangyi	S		
Lythraceae	*Sonneratia apetala* Buch.-Ham.	++	Kant-balar	T		
〃	*Sonneratia caseolaris* (L.) Engl.	++	Lamu	T		G
〃	*Sonneratia griffithii* Kurz	++	Laba	T		G
Malvaceae	*Brownlowia tersa* (L.) Kosterm.	+	Ye-tha-man	S	G	
〃	*Heritiera fomes* Buch.-Ham.	++	Kanazo	T	G	G
〃	*Hibiscus tiliaceus* L.	+	Thaman-shaw	S	G	
Meliaceae	*Aglaia cucullata* (Roxb.) Pellegr.	+	Pant-tha-ka	T		
〃	*Xylocarpus granatum* J. Koenig	++	Pin-le-ohn	T	g	G
〃	*Xylocarpus moluccensis* (Lam.) M. Roem.	++	Kya-na	T	g	
Moraceae	*Ficus benjamina* L.		Nyaung-lun	T	g	
Olacaceae	*Olax psittacorum* (Lam.) Vahl		Lelu	S		
Pandanaceae	*Pandanus foetidus* Roxb.	+	Tha-bot	S		
Primulaceae	*Aegiceras corniculatum* (L.) Blanco	++	Ye-kaya	T	G	
〃	*Ardisia elliptica* Thunb.	+	Kyetma-ok	S		
Pteridaceae	*Acrostichum aureum* L.	++	Nget-gyi-taung	H		
Rhizophoraceae	*Bruguiera gymnorhiza* (L.) Lam.	++	Byu-u-talone	T	g	G
〃	*Bruguiera sexangula* (Lour.) Poir.	++	Byu-shwe-wa	T	g	G
〃	*Ceriops decandra* (Griff.) W.Theob.	++	Madama	T	G,F	
〃	*Kandelia candel* (L.) Druce	++	Byu-baing-daunt	T	g	G
〃	*Rhizophora apiculata* Blume	++	Byu-kyi-dauk-apo	T	g	G
〃	*Rhizophora mucronata* Lam.	++	Byu-kyi-dauk-ama	T	g	G
Rutaceae	*Merope angulata* (Willd.) Swingle	+	Taw-shauk	S		
Sapindaceae	*Allophylus cobbe* (L.) Raeusch.	+	Mo-hman/Say-thon-gwa	S		
Vitaceae	*Cayratia trifolia* (L.) Domin		Yinnaung-nwe	C		
			Total no.of species	55	7	14
			T	27	5	14
			S	12	2	0
			P	3	0	0
			H	2	0	0
			C	11	0	0

[*1] Family and Scientific name: based on The Plant List (2010) and Tropicos.org. as references.
[*2] Mangrove status: Tomlinson (1986) used as a reference. Double crosses (++) indicate mangrove plants and single crosses (+), mangrove-associated plants.
[*3] Plant type: based on Maung Maung Than (2006). T: Tree, S: Shrub, H: Herb, C: Climber/Creeper, P: Palm.
[*4] Functional category: the abbreviation in the column shows the part of each plant used. A: whole plant, B: seeds, nuts or fruits, C: leaves, D: sap, E: bark, F: roots, tubers bulbs or rhizome, G: pith, shoots or stems, H: flowers.
A small letter 'g' indicates that pith, shoots or stems are a secondary resource for fuel and used reluctantly only when other fuels are absent.

Functional category[*4]						
Craft	Tying	Roof & Wall	Edible	Medical & Poison	Others	
				C,F,G		
				C,F,G	B(fishing bait)	
G(container, fishing gear, boat)						
G(container, fishing gear, boat)						
G(container, fishing gear, boat)			B		B(fishing bait), C(fodder), G(seafood smoking)	
G(sandal)				B		
				C		
			B			
			B			
	C	C	B,C	B,C		
G(pole)			B,G	B	H(hair accessory, ornamental)	
				C		
G(handle)			B,H	C,F,G,H		
	G		C			
				B	B(toy), H(religious offering)	
C(lap, false ogive), G(plate & pile material)			B	C	A(shade tree)	
G(container, minor construction)				C,G		
				B		
			B,C	B		
	G		C			
			B,C		G(seafood smoking)	
	G					
			C			
	G			C	H(hair accessory, religious offering)	
	E,G				H(hair accessory, religious offering)	
G(furniture, sandal)						
	G			F,H	B(toy), H(hair accessory, religious offering)	
				C		
G(utencil)				G	G(cosmetic)	
G(altar frame/furniture), F(float, bottle-plug)			B,C		B(fishing bait), C(fodder)	
G(plate material, container), F(float, bottle-plug)			B,C		B(fishing bait), C(fodder)	
G(plate material, container, furniture), F(bottle-plug)					B(toy)	
	E					
G(boat, fishing gear, handle, etc.), F(rudder, wash boad)				C,G		
	E			G		
G(padlle brace of boat)				B,C		
G(furniture, plate material)				B		
G(furniture, plate material)				B		
G(container)					C(fodder)	
				G		
C(mat)						
G(utencil, etc.)			B		B(toy), H(hair accessory)	
			C		H(hair accessory)	
			C	F,G		
					B(toy), C(fodder)	
					B(toy), C(fodder)	
G(pole, agricultural material)				G		
G(pole)						
				B,C,G		Accum. no. of species
			B	C		
	G		B,C	F		
22	10	1	19	28	18	119
19	0	0	7	11	11	67
2	2	0	3	8	3	20
1	1	1	2	2	1	8
0	0	0	1	2	0	3
0	7	0	6	5	3	21

certain portion of the axes or branches from one individual tree or shrub were harvested, but the trunks and other branches were left behind, so that the plant body could regenerate by sprouting; and accordingly, the people could harvest fuel resources sustainably. The thinner trunks were harvested form *Ceriops decandra*. They were used first as support poles for betel (*Piper betle*) cultivation (Fig. 3b), one of the important crops in the region; and then the old poles were subsequently used as fuel wood. This kind of cascading use of natural resources is efficient and sound for natural environment (JIE, 2008). Even though degradation of the mangrove forest occurred, it was observed that the people normally used mangrove wood, as compared with other fuel resources such as terrestrial trees.

Research in Malaysia and Thailand pointed out that trees of *Rhizophora* spp., *Bruguiera* spp. and *Avicennia* spp. were valuable for fuel (*e.g.*, Taylor, 1982; Chan & Salleh, 1987), however in the AYWD Delta, the local people preferred *Cy. ramiflora* and *He. fomes instead,* because of their favorable characteristics of long-lasting burning with less bursting. The mangrove vegetation that includes those two species as distinguishing elements is mainly distributed from Myanmar to Bangladesh (Chapman, 1976), so it can be noted that the people in the AYWD Delta have high quality fuel from endemic plant resources.

4.2 Construction

All fourteen species used in construction were tree species and their trunks were used. The bark was stripped from logs of *He. fomes*, *Bruguiera gymnorhiza, Bruguiera sexangula* and *Rhizophora apiculata* with a diameter of more than 10 centimeters, and the logs were utilized as posts (Fig. 3c), and the thinner ones of these four species and *Ce. decandra* as beams for houses, with planks of other trees applied as floors. The strength and density of the wood play a fundamental role in determining the timber quality of a given species (Cotton, 1996). Comparing the wood density as dry weight among those 14 trees, *He. fomes* gives the highest figure of 1.01 g cm^{-3}, then *Ce. decandra* at 0.88-1.07 g cm^{-3} and *Rh. apiculata* at 0.81-0.90 g cm^{-3} or *Bruguiera* spp. at 0.67-0.97 g cm^{-3} follow (Saenger, 2002). Compared to *Dipterocarpus alatus*, the density of which is 0.70-0.95 g cm^{-3} (Nettai Shokubutsu Kenkyukai, 1984), making it one of the best terrestrial tree for construction, it is understood that mangrove timber is of good quality. Because the AYWD Delta is frequently subjected to cyclones, those trees from the mangrove forests must be quite important as plant resources for building strong dwellings. In fact, mangrove trees were applied as building materials in considerable portion of the each house.

4.3 Crafts

The stems of 19 tree species out of 22 resource plants were utilized for various kinds of craft processing for daily living or subsistence work such as tools for fishing or farming; parts for row boats, houses and huts; furniture; utensils; sandals etc. Physical wood properties and the amount of timber required for particular tasks influenced the usages of tree species (Phillips & Gentry, 1993). To cite one case, *He. fomes,* which is highly dominant in the AYWD mangrove forests had the most multiple and typical local usages. It was observed that the lever-like processor for *mohinga* (Burmese noodles) was made of this strong and flexible wood (Fig. 3d).

Noting the parts of a row boat, which was main means of transportation in the area, the wood of *Aglaia cucullata* was used in the mounting portion of the paddles, because of its flexibility and appropriate frangibility. When the paddle was pressed against an obstacle in the narrow creek, the mounting portion broke down first, so that the damage to the boat body itself could be minimized. This suggests that the local people have adapted their utilization of plant resources to their natural and social environment in the mangrove area.

Until recently, the long cone-shaped pneumatophores (respiratory roots) of *Sonneratia* spp. (Fig. 3e) were utilized as bottle-plugs and fishing floats, and the board-like buttress roots of *He. fomes* were utilized as scrubbing boards. The soft, light pneumatophores of *Sonneratia* spp. and broad and hard buttresses of *He. fomes* must be well suited to the demands of those tools and equipment, and at the same time, it is easier to harvest those terrestrial roots than subterranean roots. Thus, it is possible to conclude that the local people had a livelihood culture of wisely applying the specialized forms of plants adapted to the tidal habitat.

4.4 Tying

The flexible stems of seven climbers or creepers (vines) were used directly, and the bark of two shrubs and the midribs of leaflets of *Nypa fruticans* (nipa palm) were processed and applied as tying materials. The general tying materials for farming implements and fishing gear were vines of *Flagellaria indica* and *Stenochlaena palustris* (Fig. 3f), because of their strength and durability. Although industrial products had become popular in the village, those mangrove materials were still applied as string.

Fiber plants are considered second to food plants in terms of their usefulness to humans and their influence on the advancement of civilization (Plotkin, 1988). However, previous research in the AYWD Delta (*e.g.*, Ohn, 1992; JICA, 2005) didn't deal with tying usages. The fact that materials of those two vines were often used in fundamental work in the rural village demonstrates the intimacy between plants from the mangrove forests and the local livelihood.

4.5 Roofs and walls

The walling was made from several kinds of materials including bamboo, nipa thatch and wood. On the other hand, the roofing of all dwellings in the village was nipa thatch (Fig. 3g), except for one or two houses with corrugated iron. The thatch element was made of leaflet bunches of *Ny. fruticans*, which were fixed by thin strips

of bamboo.

It is reported that many kinds of plant material, such as leaves of *Cocos nucifera*, *Borassus flabellifer*, *Livistona* spp. (Hotta, 2002), *Pandanus* spp. (Furukawa, 1994) and stems of *Phragmites* spp. (Hotta, 2002), *Imperata cylindrical* (Kunstadter, 1988), *Calotropis* spp. (Abbiw, 1990) are used as roofing of traditional dwellings in the tropics. In the AYWD Delta, however, no terrestrial plants were applied as roofing, even though they all exemplified species thriving in and around the village.

Ny. fruticans is a mangrove plant that is well-adapted to low-salinity water. The local people were cultivating this palm along the tidal banks of creeks here and there. Leaves of *Ny. fruticans* could be harvested once or twice a year. Leaving only one leaf, people could expect new leaves to come out from the same stump the next season, and they could harvest them sustainably on a long-term basis. In addition, the leaflets are soft for easy work and light for less of a load on the house structure, and they have the proper body structure for draining rain water efficiently. Therefore, it can be said that this mangrove palm is extremely appropriate for local use in roofing in terms of both quantitative and qualitative aspects in the AYWD Delta.

Fig. 3 Utilization of plant resources. (a) Wood of *Brownlowia tersa* for fuel and bark for tying material. (b) Support poles of *Ceriops decandra* for betel cultivation. (c) Trunks of *Heritiera fomes* are suitable for main pillars of houses. (d) Burmese noodle processors are made of *He. fomes* wood. (e) Pneumatophores of *Sonneratia caseolaris*. (f) Stems of *Stenochlaena palustris* are used for tying. (g) Thatch for roofing is made of *Nypa fruticans* leaflets. (h) A village girl enjoying a fruit of *Sonneratia apetala*. (i) An edible fruit of *Sarcolobus carinatus*. (j), (k) & (l) Boiled fruits of *Avicennia officinalis* are mashed and then used in Burmese tealeaf salads. (m) Leaf extracts of *Merope angulata* ease body pain. (n) Dried shrimp processed by smoke of *Av. officinalis* wood. (o) Viviparous seeds of *Bruguiera gymnorhiza* are used as toys for children.

4.6 Edible materials

None of the plant types of the twelve species out of 18 edible plants were trees; and various parts, except subterranean, were utilized. Above all, the seeds, nuts or fruits of twelve species and the leaves of eleven species were edible, and just as a few examples, the fruits of *Sonneratia* spp. were cooked as ingredients of *hinn* (Burmese curry) and also eaten raw as snacks by children (Fig. 3h). The fruits of *Sarcolobus carinatus* (Fig. 3i) and *Sarcolobus globosus* provided snacks for children playing in the mangrove forests, too. The calyx lobe and flesh of *Sonneratia* spp. fruits, the flowers and fruits of *Dolichandrone spathacea* and the seeds of *Avicennia officinalis* (Fig. 3j) were boiled, mashed up and mixed into *laphet-thoke* (Burmese tealeaf salad), which is a national delicacy served with tea (Figs. 3k, 3l). They said that *laphet-thoke* containing mangrove ingredients was only found in the AYWD Delta, and the local people seemed to be proud to serve it to outsiders. It was observed that foodstuffs from mangrove plants were common in the daily life of the village.

Shoots, leaves, subterranean organs, inflorescences and fruits are edible, if they are young, non-poisonous and not awful tasting (Hotta, 2002). Nevertheless, edible plants normally contribute little to the overall diet in many societies (Cotton, 1996). It is inferred that the people try to obtain a rich and varied diet by enjoying edible plants from the mangrove forests. Even if there is little practical value, a bio-resource use, identified as 'minor subsistence,' for changing or enriching daily life has significant meaning (Matsui, 2004). It can be interpreted to mean that snacks and foodstuffs from mangroves constitute minor subsistence contributing to the local cultural identity in the AYWD Delta.

4.7 Medical uses and poisons

The 28 plants that were used medically or as poisons among the whole included all plant types, and various parts of plants were applied. In addition, processing methods varied as well; for instance, a leaf decoction of *Do. spathacea* was taken for neutralizing a mushroom toxin, and an extraction of *Merope angulata* (Fig. 3m) was put on the affected part of the body for easing pain. Flower buds of *Fl. indica* were anthelmintic and burned ash of *Ny. fruticans* fruits was antiodontalgic. *Ny. fruticans* fruits were also used as a substitute for betel nut (*Areca catechu*), chewed daily as a stimulant. Extracted liquid from pericarps (fruit walls) of *Shirakiopsis indica,* which occurs in *Ny. fruticans* forests and tidal river banks (Giesen *et al*., 2007) was used as an important fish poison.

Plants provide a source of bioactive compounds, which can be used as medicines, poisons or stimulants (Farnsworth, 1990), and knowledge of the collection and processing techniques is essential to ensuring the efficient preparation of a particular chemical (Cotton, 1996). In the AYWD Delta, the number of plant resources for medical and poison uses was a comparative majority within the functional category; and besides, various types and parts of plants were used and ways processing and usage were diverse. Therefore it can be said that the plant resources from mangrove forests are vital for the local population and botanical knowledge and techniques have been cultivated traditionally.

4.8 Others

The 18 species in this category had wide-ranging purposes. For example, shrimp and fish were smoked using the wood of *Av. officinalis* for small-scale business (Fig. 3n). The stick-like viviparous seeds of *Bruguiera* spp. (Fig. 3o) were used as toys to provide amusement to children. Inflorescences of *Derris* spp., *Phoenix paludosa* and *Fl. indica* were of much avail as hair accessories, and offerings to Buddhist altars or spirit shrines. Those examples show that plant resources are a familiar presence and firmly associated with the local subsistence and livelihood culture.

5. Conclusion

The AYWD mangrove forests can be regarded as a universal resource supply system, which provides resources in any functional category meeting the local needs. Different plant species have a range of specific adaptations, with both morphological and chemical characteristics favored by a particular ecological niche (Cotton, 1996). On the other hand, human beings firstly recognize the physical structure and chemical features of plants, then secondly select items depending on the purpose, based on requirements for their lives, and then utilize them by adequate means (Kobayashi, 1994). Every plant in mangrove forests has adapted itself to circumstances influenced by inundation, saline water and climate such as occasional rainstorms, by specializing its form and/or developing appropriate biochemical functions.

From the viewpoint of purpose based on requisites for life in the AYWD Delta, for construction, the people there selected trees from the mangrove forests which were better able to resist the meteorological environment of tropical storms and cyclones. Examples include practical use of *He. fomes* and other tougher mangrove woods instead of terrestrial trees; for roofing, which is important in the continuous heavy rain during the wet season, the inhabitants found an optimum plant resource in *Ny. fruticans*, but not any other potential plant resources; and for crafts, tying, poisons and other uses, they found and used proper materials from plants in the mangrove forests for tools and equipment related to transportation and fundamental work, which conform to the geographical environment of deltaic land.

Speaking from the viewpoint of physical and chemical characteristics of plants in mangrove forests, terrestrial roots of the plants can be easily harvested, and the specialized form of plants can be cleverly utilized in craftwork. The people can also enjoy quality fuel from the unique vegetation along the Bay of Bengal, and prime roofing, too. In addition, they wisely process and apply

each plant with various pharmacologic features from the floristically rich forests. In addition, from the standpoint of vegetation features, they utilize the wide range of plant diversity of the AYWD mangrove forest for medical uses and as poisons or food. Furthermore, it is understood that the local people have ecological knowledge of sustainable practices for harvesting fuel-wood and roof material, and it is recognized that some edible plant resources, such as the seeds of *Av. officinalis* for tealeaf salad are related to local cultural identity.

In summary, it can be said that the Bamar, who originally lived in the central dry plains, have developed new traditional knowledge by adapting to the coastal lowland environment in the Ayeyarwady Delta. Although past research on mangrove resources in the AYWD Delta had focused on the value of wood species, this paper inventoried the diversified plant resources in relation to the functions of the resources, and the types and parts of plants used. As a result it was found that the plant resources in the AYWD mangrove forests are harmonized with the endemic life culture, which is founded based on the deltaic environment, plant features and requisites for the life. The endemic bio-culture revealed by this study has implications as a key for selecting or prioritizing plants or plant communities in mangrove conservation from the local point of view. As the next phase of the study, it must be important to clarify the degree of people's dependence on each mangrove plant resource and to examine the local knowledge of gathering, processing storing it.

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