

## Species Composition of Mangrove Forests in Aurora, Philippines – A Special Reference to the Presence of *Kandelia Candel* (L.) Druce

Eutiquio L. ROTAQUIO, JR.<sup>1</sup>, Nobukazu NAKAGOSHI<sup>2</sup> and Ronaldo L. ROTAQUIO<sup>3</sup>

<sup>1</sup> Graduate Student, <sup>2</sup> Professor

<sup>1,2</sup> Graduate School for International Development and Cooperation,

Hiroshima University

1-5-1 Kagamiyama, Higashi-Hiroshima, 739-8529, Japan

E-mail: tikz15@yahoo.com

<sup>3</sup> Provincial Environment and Natural Resources Office, Department of Environment and Natural Resources  
Baler 3200, Philippines

### Abstract

This study aimed to conduct a preliminary identification of floral mangrove species, categorizing them as major mangrove species, minor mangrove species, mangrove associates, specialized groups and describing the present conditions and threats in the mangrove areas of Aurora- the only known site of *Kandelia candel* in the Philippines. The results showed that there are thirty (30) major and minor mangrove species; twenty-two (22) mangrove associates and ten (10) specialized groups identified. The three species which have the highest density, frequency, dominance and importance values (IV) are *Avicennia marina*, *Lumnitzera littorea* and *Rhizophora apiculata*, while *Ceriops decandra*, *Pemphis acidula* and *Sonneratia caseolaris* are the species having the lowest importance percentage values respectively. *Kandelia candel*, on the other hand, was placed 18<sup>th</sup> in terms of its rank and/or order among the twenty seven (27) mangrove species subjected for vegetational analysis. Upon comparison with existing data, 56% of the total mangrove species known in the world and almost 77% of the species known in the Philippines alone are present in Aurora. Major problems observed include conversion of mangrove areas into private fishponds for tilapia (*Oreochromis niloticus niloticus*) and milkfish (*Chanos chanos*) culture, conversion to residential and beach development, charcoal production and mud siltation due to the continuing logging operations in the upper parts of the Sierra Madre mountain in the province.

**Keywords:** *Kandelia candel*, Aurora Philippines, major mangroves, minor mangroves, mangrove associates, specialized groups, threats, density, frequency, dominance, importance value (IV).

### 1. Introduction

Aurora has a total of 430 hectares of mangroves (AIADP, 1996). Ninety percent of the mangrove forest is located in the northern municipalities of Casiguran and Dilasag, while the remaining 10% is scattered in small

patches, particularly in Baler, the capital town of the province and where the main population of *Kandelia candel* is also located. *Kandelia candel* is one of the major mangrove species belonging to the Rhizophoraceae family. It is distributed in south and east Asia, from the Ganges Delta and Myanmar, as far as northern Borneo and Sumatra, to the south China and southern Japan (Tomlinson, 1986). In Japan, *Kandelia candel* forms the northern limit of mangrove vegetation beyond the isothermal lines of 10°C (Nakagoshi & Nehira, 1986).

However, there is a gap of its distribution around the Philippines, of which this country is also located and/or within among Southeast Asian countries where *Kandelia candel* is reported to exist. The study of Hou (1958) as cited by Chiang, et al., (2001) stated that there were no natural populations distributed in the Philippines. However, local records in the Philippines (AIADP, 1996) shows that in 1996, an isolated distribution of *Kandelia candel* was discovered by Mette Lochye Wilkie, a mangrove consultant of the Aurora Integrated Area Development (AIADP), (an EU-funded environmental project in Aurora during that time). She found out the presence of *Kandelia candel* along the river banks of Baler and in Cozo, Casiguran mangroves both within the Aurora Province. Orejas (1999) as cited by Yao (2000a) stated that no other sighting of this species has been reported in other suitable mangrove areas in the Philippines since it was first sighted in Baler, Aurora.

The discovery of *Kandelia candel* in Aurora, Philippines provides an opportunity and venue for the researchers to look on the mangrove diversity particularly on the species composition thriving in the mangroves of Aurora. Mangrove vegetation defines the landscape and participates directly or indirectly in the ecological processes that take place in this ecosystem (Lugo & Snedaker, 1974). Therefore, knowledge and information of the exact species plant composition of mangroves in any country or place is a basic and important pre-requisite in understanding all the aspects of structure and function of mangroves, as well as their biogeographical affinities and their conservation and management (Jayatissa, et. al., 2002). To have a better understanding of the occurrence of a certain species, basic ecological information of the area is needed.

This study aimed to identify the species composition of mangrove forests in Aurora and categorize them as major mangrove species, minor mangrove species, mangrove associates and specialized groups. The results of the study are also expected to give information on the density, frequency, dominancy and diversity of mangrove species in Aurora, as well as the rank order of each major and minor species in terms of importance value (IV) and how this could be related and/or compared to the population of *Kandelia candel*.

## **2. Materials and methods**

### **2.1. Study site**

Aurora is located in the north-eastern part of Luzon Island in the Philippines. It is one of the coastal provinces in the Philippines facing the Pacific Ocean on the east and bordered by the Sierra Madre mountain ranges on the south, west and up north. Until February 2006, using narrow, gravel and sand road was the only common way to get to Aurora and so very few researchers have tried to conduct studies there especially in mangrove forests. The limited availability of mangrove literature in the province is clear evidence of this fact. Aurora has 320 kilometers of sandy, rocky and muddy coastline. The rocky and sandy portions are exposed to strong waves and are unsuitable for mangroves. However, in the northern part of the province, particularly in the towns of Casiguran and Dilasag, the coastline has large portion of sandy to muddy substrate and is suitable for mangroves to thrive.

### **2.2. *Kandelia candel***

It is known to be a viviparous mangrove tree species. Viviparous means the ability of the propagules or seeds to germinate while still attached to or within the mother or parent tree. This species was first discovered in

Malabar, India, and was named “Tsjerou-kandel” by Van Rheede in 1686. Carolus Linnaeus, the father of taxonomy named it *Rhizophora candel* as its hypocotyl resembles a candle (as the Latin word “candel” suggests). Until recently, it had the name *Kandelia candel* and was recognized as the monotypic of the genus (Yip and Lai, 2005).

The leaf arrangement is opposite, and leaves are oblong-elliptic with rounded apex and a hint of marginal curling. The flowers have five thin, finely divided, short-lived, white petals and as many as sepals which are notably reflexed and persistent as a calyx “cap” on the fruit. The flowers are organized in cymose clusters of three to five flowers in leaf axils. Each of the flowers has a somewhat “fluffy” look due to the numerous stamen filaments and finely divided hair-like petals. The fruit is typical Rhizophoracean dropper, but with persistent calyx “cap” and long (ca. 40cm in the Thai ecotype) slender and smooth hypocotyls. The bark is orange –brown with splashes of grey in color, smooth in texture on the middle and upper trunk and somewhat flaky below (Aksornkoae, et. al., 1992).

### 2.3. Sampling sites

There were fifteen (15) sampling sites (Figure 1). These are the mangrove areas of Baler, Tinib, Esteves, Calabgan, Dibet, Masagana, Casapsapan, Cozo, Lual, Marikit, Mutiong, Dalugan, Dibacong, Ditinagian, Dipalatpat & Dikasew. These sites were selected based on the following criteria: 1) availability of the mangrove forests; 2) accessibility, peace and order situation; 3) tenurial status or ownership, meaning that the area has not been subjected to other land classifications and is owned by the state.

### 2.4. Line transect, plot sampling and basal diameter measurement of mangrove trees

For each site, transect lines ranging from 50-250 meters were laid out from the water shoreline during low tide going towards the land. Along the transect lines, three 10x10 meter plots sampling for mangrove trees (mangrove trees with basal stem diameter of 4 cm and higher with more than 1 meter in height) were set-up randomly, particularly in areas characterized by abrupt changes in vegetation. A uniform number of three plots per site were laid out. Using the tree caliper, the diameter of the trees were measured and recorded on the basal area of a tree. If the stem forks below the point of measurement, basal stem diameter was made on each branch and was considered as a separate stem. When the stem forks at the point of measurement or slightly above, the basal stem diameter measurement was made below the swelling caused by the fork. If the stem has prop roots, the measurement was made 20 centimeters above the root collar. If the stem has swellings, branches or abnormalities at the point of measurement, it was measured either slightly above or slightly below the irregularity.

### 2.5 Categorization of the mangrove species

Identified plants were further categorized into major mangrove species, minor mangrove species, mangrove associates and specialized groups, based on the criteria given by Tomlinson (1986).

### 2.6. Vegetational analysis

The data gathered were analyzed using the vegetational analysis formula of density, relative density, frequency, relative frequency, dominance, relative dominance and the importance value (IV). An importance value is the sum of relative density, relative frequency and relative dominance of a species in a community or forest. It provides a better index than density alone regarding the importance or function of a species in its habitat. It also gives rank or order for a particular species within the forest community (Odum, & Barrett, 2005; Kent & Coker, 1992; Krebs, 1985; Mueller-Dombois & Ellenberg, 1974). Actual observation of the present condition and activities of the

people within the sampling sites were also made. On the spot verbal, non-structured interviews were also conducted with those people met during the field survey. Data gathering lasted for about one year, from January, 2005 to January, 2006. One year duration of the study was intentionally made to secure the availability of morphological parts particularly flowers and fruits which are necessary in the appropriate identification of mangrove species.

Vegetation analysis was decided to limit on the category of “major mangroves and minor mangroves only”. The species which have been categorized as “mangrove associates” and specialized groups were excluded from the analysis for the following reason; 1) the species under the category of “mangrove associates” and “specialized groups” are not the real mangrove species. Most of them were naturally and accidentally dispersed from beach forest and upland areas and not true inhabitant of mangal forest; 2) These species also did not meet or satisfy the criteria as the real mangrove tree specified by Tomlinson (1986); 3) there is now a general trend among new researchers when making a report, they usually included mangrove associates or beach species that occur occasionally within the mangal, where in fact are not real mangrove tree. This might misled future researchers and other interested groups about the real mangrove tree species and may lead to incorrect conclusion.

Also included in the limitation of vegetational analysis were the species of *Nypa fruticans*, *Acrostichum aureum* and *Acrostichum speciosum*. Although these three species were categorized as major and minor mangrove species, they are palm and ground ferns and therefore did not allow the same scientific approach as used in the study of the vegetation ecology of woody plants (e.g. measurement of basal diameter).

Total enumeration or listing of mangrove associates and specialized groups sighted during the survey was also recorded as part of the observation.

**2.6.1. Formula/Equations Used:** (Based on the definitions on the books by *Odum, & Barrett, 2005; Cox, 1996; Kent & Coker, 1992; Krebs, 1985; Mueller-Dumbois & Ellenberg, 1974*)

1. Population Density = 
$$\frac{\text{Number of individuals}}{\text{Total area sampled}}$$
2. Relative Population Density = 
$$\frac{\text{Density for a species}_{(100)}}{\text{Total density for all species}}$$
3. Frequency = 
$$\frac{\text{Number of plots in which a species occurs}}{\text{Total number of plots sampled}}$$
4. Relative Frequency = 
$$\frac{\text{Frequency value for a species}_{(100)}}{\text{Total of frequency value for all species}}$$
5. Dominance = 
$$\frac{\text{Total of basal area of each tree of a species from all plots}}{\text{Total area of all the measured plots}}$$
6. Relative Dominance = 
$$\frac{\text{Dominance for a species}_{(100)}}{\text{Total dominance for all species}}$$
7. Importance Value (IV) = Relative Density + Relative Frequency + Relative Dominance

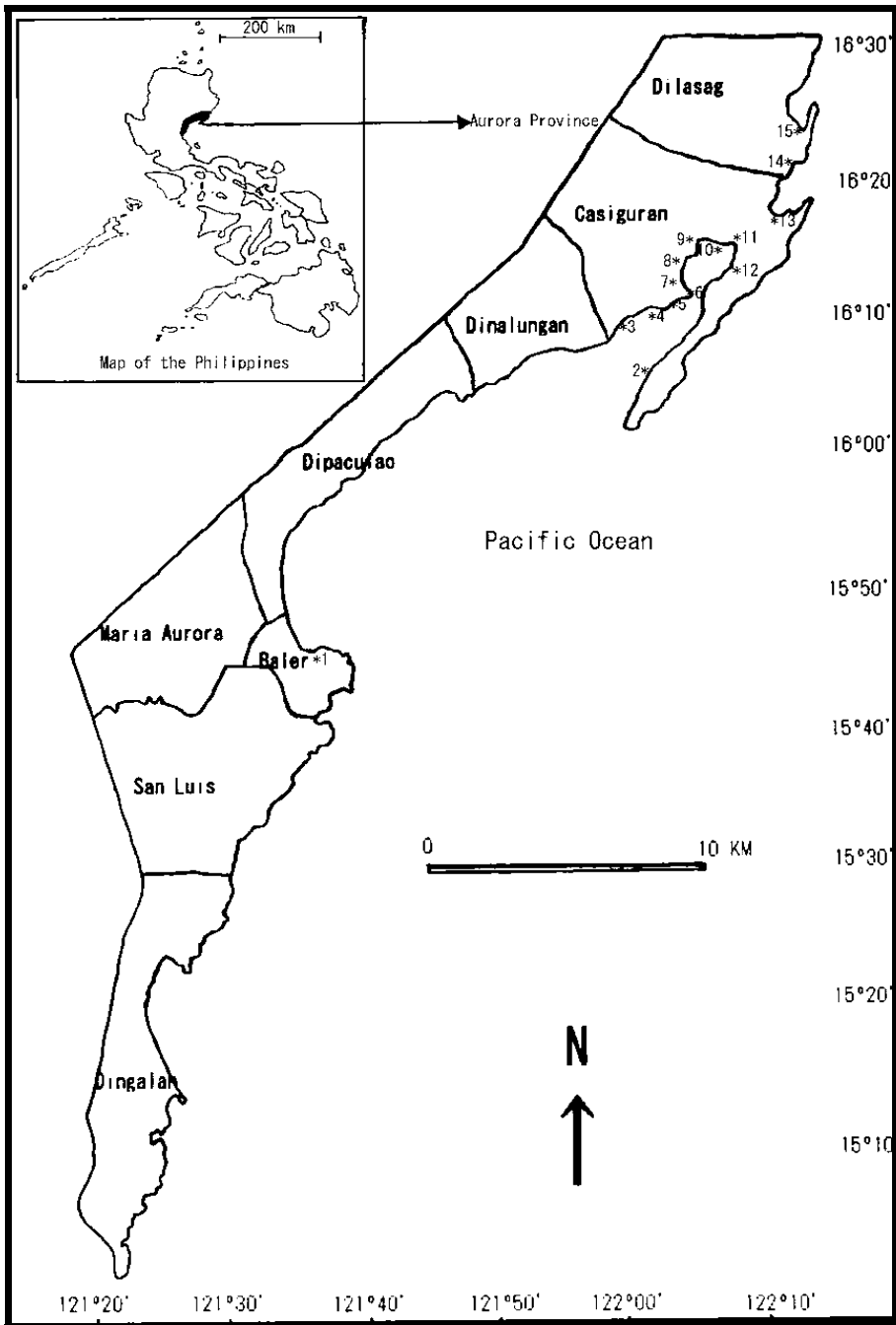


Figure 1. Maps showing the 15 sampling sites.

### 3. Results and Discussions

#### 3.1. Field observations

##### Study Site 01 (Baler).

A large part of this site is basically rocky and coralline, located east of Baler port. Dead corals lessen the impact of strong waves and favor the occurrence of *Rhizophora stylosa*, *Avicennia marina* and *Sonneratia alba* as the major components. Species of *Bruguiera sexangula*, on the other hand, dominates the muddy mid-portion where a small creek flows out into the Pacific Ocean. In the landward part of the mid-portion, an old-growth stand of *Lumnitzera littorea* attaining more than fifty (50) centimeters in diameter was found.

However, along the shallow river banks of Baler, changes in the vegetation pattern were observed. *Nypa fruticans* occurs as the fringe species along the boat or banca pathways with some patches of *Sonneratia alba*, *Bruguiera gymnorrhiza*, and the recently discovered *Kandelia candel*. The leaves of *Nypa fruticans* are important raw materials for thatch production (for cottage roofing and siding). Local residents of Aurora have considered this species as one of the sources of their livelihood. Household wastes, conversion to residential areas and establishment of small fishpond and fish cages are some of the threats observed in the area.

##### Study Site 02 (Sitio Dalugan, San Ildefonso, Casiguran).

This is a coastal coralline mangrove located near Dalugan banca port. Mangrove plants occur on the foreshore extending up to the high tide level following the small creek coming from the upper reaches of Dalugan mountain. Old growth of *Sonneratia alba* are very distinctive in front of the mangrove area. During typhoons, the fishermen use the ground floor of the mangrove forest as a shelter for their banca or boats. *Nypa fruticans* is growing in the back or landward most part upon which the Aeta, the indigenous people, depend for thatch production as their source of livelihood. Unsustainable harvesting of the *Nypa fruticans* shingles has resulted in low production.

##### Study Site 03 (Ditinagian, Casiguran).

Mangrove plants occur on both sides of the Ditinagian creek, which is regularly inundated by the saline water during high tide. Debris of dried leaves, branches and other sediments are quite thick on the transition zone of saline and fresh water. Close canopy of different mangrove species such, as *Avicennia marina*, *Bruguiera sexangula*, *Sonneratia alba* and *Rhizophora mucronata*, are the common species on the seaward zone. The huge trees of *Avicennia lanata* dominates the landward most sides. The area is a good source of milkfish (*Chanos chanos*) or milkfish fry for those who are engaging in milkfish production. In fact, it is now locally recognized as an identified source of fry.

##### Study Site 04 (Calabgan, Casiguran).

This area is a riverine small mangrove following the flow of Calabgan river going out to the Casiguran Bay. The area is exposed to strong winds coming from the ocean which favor the occurrence of *Bruguiera gymnorrhiza*, *Xylocarpus granatum* and *Bruguiera sexangula*. The substrate is muddy, gradually turning sandy towards the shore. Beach species such as *Pongamia pinnata*, *Callophyllum inophyllum* and *Barringtonia asiatica* are the common mangrove associates in the area. Electric fishing and fish poisoning are some of the common problems observed.

##### Study Site 05 (Esteves, Casiguran).

This site has muddy to sandy mudflat facing the Casiguran Bay and is located on the southeastern side of the Casiguran National High School. Mangrove plants are scattered on the edge of the Gaingihan river, extending to the foreshore of Casiguran Bay. A little portion of the mangrove area has been converted to artificial fishponds which are owned and being utilized for the laboratory activities of high school students in the said school. The principal vegetation are *Avicennia marina* and *Sonneratia alba*. There are also squatters who are continuously expanding their residential houses in the mangrove areas. Firewood, pole and shell gathering are the common activities of the residents in the area.

#### **Study Site 06 (Sitio Mutiong, Brgy. Esteves, Casiguran).**

Mangrove plants occur along the lower reaches of the Mutiong River and are somewhat pristine in nature. Thick debris of dried leaves and branches were accumulated in the mouth of the river flowing down to the Casiguran Bay. The *Ceriops tagal* community occupies the inner mangrove portion. Other principal vegetation include *Rhizophora stylosa*, *Bruguiera gymnorrhiza*, *Lumnitzera littorea*, *Sonneratia alba*, *Avicennia marina*, *Bruguiera parviflora* and *Nypa fruticans*. Mangrove conversion to small fishpond and resort development are among the threats seen in the area.

#### **Study Site 07 (Dibet, Casiguran).**

Mangrove plants are found on both edges of the Dibet River connecting to the muddy to sandy Casiguran Bay. Small patches of mangrove appear in the foreshore dominated by *Avicennia marina*, *Sonneratia alba* in the middle part, and *Xylocarpus granatum* in the landward most areas. *Osbornia octodonta* is also present but it appears only in very small numbers. Migratory and shorebirds are very common. Local residents collect shells, mud crabs and shrimps for local consumption. Pneumatophores of mangrove plants are very distinct in controlling soil erosion. There is only minimal exploitation of resources. Strong waves result in the death of seedlings and so, less chance of regeneration is expected. Private resorts are also visible in the area particularly near and along the national road, however, the area is still owned by the government.

#### **Study Site 08 (Dibacong, Casiguran).**

This is a coastal mangrove near the log pond area of a logging company (Industries Development Corporation or IDC), with extensive muddy, sandy and rocky substrate. Fringing mangroves can be found at the back of the Dibacong Elementary School. The muddy mangrove emerges during low tide of about one kilometer from the lowest level of saline water to the landward most part of the mangrove area. *Avicennia marina*, and *Sonneratia alba* are the two common species in the foreshore and *Aegiceras corniculatum*, *Avicennia officinalis* and *Lumnitzera littorea*, the common species in the landward most sides. Since this site is near the log pond of logging company, accumulated debris such as bark, slabs, saw dust and other logging remains are the common threats and obstacles to the survival of mangrove seedlings.

#### **Study Site 09 (Tinib, Casiguran).**

This area is generally an estuarine mangrove where small deep mudflat occurs on both sides of the Disugon river. Associated pockets of mangrove species and plant associates are distributed from the mouth of the river extending northward to the upper reaches of the river. The river flows out to Casiguran Bay where muddy to sandy flats can be found that favor the occurrence of principal vegetation of *Avicennia marina*, *Avicennia lanata* and *Sonneratia alba*. Since this area is near along the national road, some parts have already been converted into residential areas. The majority of the residents are fisherfolk. A tilapia fishpond was found in the upper eastern

part of the Disugon river where some trees of mangroves have been cut to pave the way for the establishment of the said fishpond. The small fishpond is being managed and owned by private individuals, who live nearby. The area is usually disturbed by the fish, shrimps, wild monitor lizard, wild birds, mud crabs and shell collectors and gatherers. Some of the threats being observed include continuous expansion of the residential and small fishpond areas, pole collection, charcoal making and household waste disposal. Also, the collection of bark of mangrove species, particularly the *Xylocarpus granatum*, for coloring fish nets is another threat to the mangrove trees because too much collection of bark has resulted in the death of some trees in the area. So far, no conservation measures have been made in the area.

#### **Study Site 10 (Marikit, Casiguran).**

The area is a shallow coastal mangrove with large sandy to muddy substrate. It favors the regenerating *Avicennia marina* with numerous seedlings. The middle part has deep mud and silt where *Sonneratia alba*, *Rhizophora apiculata* and *Bruguiera gymnoorhiza* are common. Among all other mangrove sites in Aurora, this area is mainly dominated by the species of *Scyphiphora hydrophyllacea*.

#### **Study Site 11 (Lual, Casiguran).**

This is a small island mangrove located on the northwest of Cozo mangrove and southwest of Brgy. Lual port and where the monitoring booth of the Casiguran Mangrove Rehabilitation and Multi-Purpose Cooperative, a non-governmental organization is located. It is an organization working for the protection and conservation of mangrove forests in Casiguran, Aurora, headed by Mr. Jose M. Bosyong Bitong. *Avicennia lanata*, *Avicennia marina*, *Ceriops tagal*, and *Bruguiera parviflora* dominate the place. Species of *Acanthus ebracteatus* and thick saplings of *Bruguiera parviflora* have been observed in the middle portion. The presence of soil mounds, created by mud crabs is very common. It is also important to note that the species of *Scyphiphora hydrophyllaceae*, locally known as "nilad"- the name of the mangrove species from which the name of the capital city of the Philippines was derived, is present here.

#### **Study Site 12 (Cozo, Casiguran).**

This mangrove forest is located near the foot of Cozo mountain, east of Marikit mangrove and southeast of Brgy. Lual port. Legal and illegal logging is rampant in the Cozo mountain, which has resulted in severe soil erosion that flows down to the mangrove area. As a result, siltation and death of *Rhizophora*, *Bruguiera* and *Avicennia* species have been observed. The damaged area is now slightly elevated because of the accumulated eroded soil. This has resulted in the inability of the saline water to penetrate in the mangrove area during high tide. Continuous death of the mangrove is still taking place.

It is in this site that the species of *Kandelia candel* has been recorded. However, it appears only in a small pocket about 200 meters from the open saline water along the muddy small tributary of a creek, together with *Avicennia marina*, *Sonneratia alba*, *Bruguiera parviflora*, *Nypa fruticans*, and *Rhizophora apiculata*. A vine-like creeping plant that belongs to the family of Asclepiadeceae known as *Finlaysonia maritima* was also identified. So far, it is only in this sampling site that this species has been recorded and not in the other sampling sites. Also the third species of *Acanthus*, the *Acanthus volubilis* is found creeping with *Avicennia marina* species approximately three (3) meters in height. The leaves are unarmed and wider above the center with delicate sprawling stems. The principal vegetation are *Avicennia marina* in the foreshore or seaward most part, followed by *Rhizophora apiculata*, *Bruguiera parviflora*, and *Bruguiera gymnorhiza*.

The area is a good source of mud crabs, shells, and shrimps. Wild ducks and pigeons and other shorebirds are



common found feeding on the muddy substrate of the mangrove forest.

### **Study Site 13 (Sitio Casapsapan, Cozo, Casiguran).**

This mangrove area is not popularly known because of its proximity from the national road compared with other mangrove areas in Aurora. It is a pristine riverine mangrove located on the western side of Casapsapan Bay following both edges of the Casapsapan River. The Casapsapan River flows from its upper reaches (Casapsapan Mountain) and moves easterly going down to Casapsapan Bay. Local residents call it the “hidden mangroves of Aurora” because it is not exposed along the foreshore area of Casapsapan Bay. An hour walk is needed to reach the middle part where tall, close-canopy and largest prop roots (up to 5 meters high) can be found. The huge prop roots of *Rhizophora apiculata* make the area apparently looks undisturbed. Besides, the large crown of the mature mangrove species makes the underneath storey dim and so sunlight can hardly pass through the substrate, suppressing saplings and seedlings. It is also very interesting to note that within the mangrove forest, there are a number of springs with potable water flowing out to the river. This means that the area is a potential source of drinking water. Shrimps and mud crabs can only be trapped opportunistically by hand. Ornamental plants like *Asplenium nidus* and different varieties of orchids hang on in taller mangrove trees. Commercial logging in the upper part (Casapsapan Mountain) which causes soil erosion, is one of the threats to the survival of mangroves. Along the tributaries, *Rhizophora apiculata* forms a distinctive species in front of the riverine zone, behind are *Bruguiera gymnorrhiza*, *Heritiera littoralis* and *Ceriops tagal*. *Avicennia lanata* occurs as very occasional large trees. *Sonneratia alba* is present on the corner of the land where the saline water and tributaries of rivers join. At some points, the boundary between mangrove and beach forest is marked by distinctive zones of *Instia bijuga*. Some private developers are converting some parts of the beach into a resort because of its white sand and panoramic attraction. The beach near the mangrove area is one of the greatest tourist attractions, serving as a picnic site. This sometimes results in the accumulation of waste from visitors.

### **Study Site 14 (Sitio Mahogany, Masagana, Dilasag).**

This is an estuarine mangrove with deep muddy substrate ranging from 0.5 to 1.5 meters. The area is closed to Dilasag town proper. *Chanos chanos* and *Oreochromis niloticus niloticus* fishponds have been established on the northwestern part of the mangrove forest. There are also indications of cutting for *Rhizophora apiculata* and *Lumnitzera littorea* species for charcoal and firewood production. Thick accumulations of mangrove forest litters were also observed. During the survey, local residents said that in the 1970's, crocodiles were commonly sighted in this mangrove site. The dominant species are *Rhizophora apiculata*, *Bruguiera gymnorrhiza* and *Excoecaria agallocha*. It is also important to note that the mature mangrove trees are relatively high around 2 to 15 meters in height. The area provides food for the migratory birds during migration season. Local residents also gather mud crabs, shells, shrimps, and go bird hunting. Ground and hanging orchids are very common which add aesthetic value to the mangrove area. Continuous cutting of mangrove trees for charcoal making, post gathering and small fishpond construction are the major threats in the area.

### **Study Site 15 (Sitio Depalatpat and Dekasew, Diniog, Dilasag).**

This is a coralline sandy to rocky mangrove and facing directly the Pacific Ocean. Strong waves regularly inundate the area. However, due to the presence of dead corals, the high impact of waves are lessened and controlled. This situation favors the presence of locally known “bakawan-bonsai” (*Pemphis acidula*) and *Avicennia marina* on the seaward most part. Other associated species are *Rhizophora stylosa*, *Sonneratia alba*, *Sonneratia caseolaris*, *Lumnitzera littorea* and *Aegiceras corniculatum*.

*Lumnitzera littorea* has a dense zone, but, there are indications of continuous cutting for charcoal production. Visitors and residents collect bonsai species of *Pemphis acidula* for commercial purposes. This serves as one of the major threats to this mangrove plant.

Table 1 shows that there were about thirty (30) major and minor mangrove species; 22 mangrove associates; and 10 specialized groups.

According to Tomlinson (1986) major mangrove species are recognized because they possess all or most of these features: 1) Complete fidelity to the mangrove environment; that is they occur only in mangal and do not extend into terrestrial communities; 2) A major role in the structure of the community and the ability to form pure stands; 3) Morphological specialization that adapts them to their environment; the most obvious are aerial roots, associated with gas exchange, and vivipary of the embryo; 4) Some physiological mechanism for salt exclusion so that they can grow in sea water; they frequently visibly excrete salt; 5) Taxonomic isolation from terrestrial relatives. Major mangroves are separated from their relatives at least at the generic level and often at the subfamily or family level. Minor species are distinguished by their inability to form a conspicuous element of the vegetation. They may occupy peripheral habitats and only rarely form pure communities. Mangrove associates are never inhabitants of strict or major mangrove communities and may occur only in transitional vegetation. They are plants woody or non-woody, herbaceous or sub-woody, grasses, rushes, sedges from nearby and/or adjacent tropical beach community to the mangrove areas which are basically dispersed by water current. Specialized groups on the other hand include climbers, epiphytes, and parasites.

Tomlinson (1986) listed about fifty four (54) species of true mangroves (major and minor) worldwide and sixty (60) species of mangrove associates.

Primavera (2000b) confirmed the presence of thirty nine (39) major and minor mangrove species in the Philippines from other sources stated by Tomlinson (1986); Brown and Fisher (1920); Fernando and Pancho (1980); AIADP (1996); Spalding et. al (1997); Yao (1999); and her personal communication to N. C. Duke of the University of Queensland.

Yao (2000b) in his article published in the Canopy International for March-April 2000 publication, stated that the number of mangrove species in the Philippines varies with different sources and/or authors. He cited that the Asian Development Bank (ADB) (1992) listed eighty five (85) species; Aragonés et. al (1999) thirty nine (39) species; Fernando and Pancho (1980) forty five (45) species; and Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) (1991) seventy one (71) species. Yao (2000b) also further stated that the big difference in number is more related to the associate species, depending on the author's area of coverage. This means that there is no clear categorization of the species they identified, whether the species belongs to major or strict mangroves, minor mangroves, mangrove associates and specialized groups. On the other hand, Zamora (2003) cited about thirty five (35) mangrove vascular plants, of which twenty three (23) have been categorized as major mangrove and twelve (12) minor mangrove species.

Comparing the data gathered in this study with the total number of mangroves cited by Tomlinson (1986) throughout the world, this means that almost 56% of the total major and minor mangrove species known to occur in the world are present in Aurora mangroves. Also, using the data cited by Primavera (2000a), who stated that there are about thirty nine (39) major and minor mangrove species known to occur throughout the Philippines, 77% of these are known to be, sometimes only, in Aurora.

The species composition recorded in the mangrove of Cozo is the most diverse among all the sampling sites. This is because of the additional presence of *Kandelia candel*, *Acanthus volubilis* and *Finlaysonia maritima*. These three species are absent in other sites except for *Kandelia candel*, which is also present in Baler.

*Kandelia candel* trees in Cozo, Casiguran (16° 15.04' N; 12° 207.34' E) appears only in a small pocket about 200 meters from the open saline water along the muddy and small tributary of a creek. It is commonly associated with other mangrove species such as *Avicennia marina*, *Sonneratia alba*, *Bruguiera parviflora*, *Rhizophora apiculata* and even *Nypa fruticans*. The main population of *Kandelia candel* in Baler (15° 44' 936" N; 121° 34' 633" E) mangrove are scattered and can be found along the edges of shallow and muddy river bank of Zabali just behind the back side of the Aurora State College of Technology (ASCOT) Marine Laboratory Building extending up to the river mouth which is also connected and/or joining to the Pacific Ocean. Fruiting trees with a maximum height of seven meters start to produce flowers from the month of May and fruit matures in November. Some of the local residents near the main population have started to convert some portion of the mangrove area into brackish fishpond and is now expanding which pose threat to the *Kandelia candel* and other mangrove species.

This study provides information regarding the floral composition of Aurora mangroves, the only known Philippine site for *Kandelia candel*. Basic information regarding the vegetation structure of a certain mangrove area is needed to further explain the presence or absence of certain plants or animals in this particular area. This is because there are some species of plants and/or animals that co-exist together. The absence of one species may result to the demise of the other species. Besides, the occurrence of one plant or animal in one ecosystem may answer or indicate a certain ecological phenomenon. For instance, the presence of mangrove fern *Acrostichum aureum* is an indication that the area is regularly disturbed. This term is known as bioindicator. The presence and limited distribution of *Kandelia candel* in Aurora mangrove is one of the unique characteristics when comparing species composition with other mangrove areas in the Philippines. So far, no other sighting and natural population of *Kandelia candel* has been recorded in other mangrove forest throughout the Philippines except in Aurora. This species really lends truth to the diversity of Aurora mangroves and therefore an in depth separate study of the different factors affecting the habitat ecology of this species is needed for proper protection, conservation and management.

**Table 1.** List of identified major, minor, associate and specialized group mangrove species in Aurora, Philippines based on the criteria set by Tomlinson, 1986.

No.	Species	Family	Local name
<b>Major Mangrove Species</b>			
1.	<i>Avicennia lanata</i>	Avicenniaceae	Avicennia
2.	<i>Avicennia marina</i>	Avicenniaceae	Bungalon
3.	<i>Avicennia officinalis</i>	Avicenniaceae	Api-api
4.	<i>Bruguiera cylindrica</i>	Rhizophoraceae	Pototan-lalake
5.	<i>Bruguiera gymnorrhiza</i>	Rhizophoraceae	Busain
6.	<i>Bruguiera parviflora</i>	Rhizophoraceae	Langaral
7.	<i>Bruguiera sexangula</i>	Rhizophoraceae	Pototan
8.	<i>Ceriops decandra</i>	Rhizophoraceae	Ceriops
9.	<i>Ceriops tagal</i>	Rhizophoraceae	Tangal
10.	<i>Kandelia candel</i>	Rhizophoraceae	Bakawan-Baler
11.	<i>Lumnitzera littorea</i>	Combretaceae	Sagasa
12.	<i>Lumnitzera racemosa</i>	Combretaceae	Lumnitzera
13.	<i>Nypa fruticans</i>	Arecaceae	Nipa; Sasa

14.	<i>Rhizophora apiculata</i>	Rhizophoraceae	Bakawan-lalake
15.	<i>Rhizophora mucronata</i>	Rhizophoraceae	Bakawan-babae
16.	<i>Rhizophora stylosa</i>	Rhizophoraceae	Bakawan-bato
17.	<i>Sonneratia alba</i>	Sonneratiaceae	Fire-fly mangrove
18.	<i>Sonneratia caseolaris</i>	Sonneratiaceae	Pedada
<b>Minor Mangrove Species</b>			
19.	<i>Acrostichum aureum</i>	Pteridaceae	Mangrove fern
20.	<i>Acrostichum speciosum</i>	Pteridaceae	Paku-laot
21.	<i>Aegiceras corniculatum</i>	Myrsinaceae	Saging-saging
22.	<i>Aegiceras floridum</i>	Myrsinaceae	Saging-saging
23.	<i>Excoecaria agallocha</i>	Euphorbiaceae	Buta-buta
24.	<i>Heritiera littoralis</i>	Sterculiaceae	Dungon-late
25.	<i>Osbornia octodonta</i>	Myrtaceae	Tualis
26.	<i>Pemphis acidula</i>	Lythraceae	Bakawan-bonsai
27.	<i>Planchonella obovata</i>	Sapotaceae	Planchonella
28.	<i>Scyphiphora hydrophyllacea</i>	Rubiaceae	Nilad
29.	<i>Xylocarpus granatum</i>	Meliaceae	Tabigi
30.	<i>Xylocarpus mollucensis</i>	Meliaceae	Piagau
<b>Mangrove Associates</b>			
31.	<i>Acanthus ebracteatus</i>	Acanthaceae	Diliutiao
32.	<i>Acanthus ilicifolius</i>	Acanthaceae	Tinlui
33.	<i>Acanthus volubilis</i>	Acanthaceae	Acanthus
34.	<i>Barringtonia asiatica</i> *	Lecythydaceae	Botong
35.	<i>Barringtonia racemosa</i>	Barringtoniaceae	Putat
36.	<i>Brownlowia tersa</i>	Tiliaceae	Brownlowia
37.	<i>Calophyllum inophyllum</i> *	Guttiferae	Painted leaf
38.	<i>Cerbera manghas</i> *	Apocynaceae	Cerbera
39.	<i>Cerbera odallam</i> *	Apocynaceae	Cerbera
40.	<i>Clerodendrum inerme</i>	Verbenaceae	Clerodendrum
41.	<i>Crinum asiaticum</i>	Amaryllidaceae	Bacon
42.	<i>Cynometra ramiflora</i>	Caesalpinioideae	Cynometra
43.	<i>Dolichandrone spathacea</i>	Bignoniaceae	Tui
44.	<i>Inocarpus edulis</i>	Papilionoideae	Inocarpus
45.	<i>Instia bijuga</i>	Caesalpinioideae	Ipil
46.	<i>Hibiscus tiliaceus</i>	Malvaceae	Malubago
47.	<i>Morinda citrifolia</i> *	Rubiaceae	Bancudo
48.	<i>Pandanus tectorius</i> *	Panadanaceae	Screw pine
49.	<i>Pongamia pinnata</i> *	Fabaceae	Bani
50.	<i>Scaevola taccada</i> *	Goodeniaceae	Scaevola
51.	<i>Thespesia populnea</i>	Malvaceae	Banago
52.	<i>Terminalia catappa</i> *	Combretaceae	Talisay
<b>Specialized Groups</b>			
53.	<i>Aganope heptaphylla</i>	Papilionoideae	Aganope

54.	<i>Asplenium nidus</i>	Aspleniaceae	Dapdap
55.	<i>Caesalpinia crista</i>	Caesalpinioideae	Calumbibit
56.	<i>Caesalpinia bonduc</i>	Caesalpinioideae	Caesalpinia
57.	<i>Derris trifoliata</i>	Fabaceae	Tuble
58.	<i>Drynaria quercifolia</i>	Polypodiaceae	Pakpak-lawin
59.	<i>Finlaysonia maritima</i>	Asclepiadaceae	Finlaysonia
60.	<i>Flagellaria indica</i>	Flagellariaceae	Mangrove rattan
61.	<i>Ligodium microphyllum</i>	Schizaeaceae	Nitong-dagat
62.	<i>Flagellaria indica</i>	Flagellariaceae	Mangrove rattan

\* These plants are actually beach species but, based on our actual observations, they are commonly associated with the Aurora mangroves.

Table 2 shows the results of the vegetation analysis based on the actual observation and data gathered. Of the 27 mangrove tree species subjected for analysis, the *Avicennia marina* turned out to have the highest relative density of 19.71%, relative frequency of 9.79%, relative dominance of 9.57%, and therefore got the highest importance value (IV) of 39.07%. This is followed by the species of *Lumnitzera littorea* having a relative density of 7.66%, relative frequency of 9.26%, relative dominance of 20.63% and with an IV of 37.56%. The species of *Rhizophora apiculata* ranked third with a relative density of 9.49%, relative frequency of 9.26%, relative dominance of 15.62% and with an IV of 34.37%.

On the other hand, the three mangroves species having the lowest ranks were *Ceriops decandra* with a relative density of 0.11%, relative frequency of 0.21%, relative dominance of 0.05% and with an IV of 0.37%. This is followed by the species of *Pemphis acidula* with a relative density of 0.37%, relative frequency of 0.21%, relative dominance of 0.24% and an IV of 0.82%. The species of *Ceriops decandra* revealed to have the lowest relative density of 0.11%, relative frequency of 0.21%, relative dominance of 0.05% and an IV of 0.37%.

According to Tomlinson (1986) *Avicennia marina* species has the broadest distribution, both latitudinally and longitudinally, of the genus (indeed of any mangrove), with a range from east Africa and the Red Sea along tropical and subtropical coasts of the Indian Ocean to the South China Sea, throughout much of Australia into Polynesia as far as Fiji, and south to the North Island of New Zealand.

*Lumnitzera littorea* is better suited to less saline, well-drained sites and is most vigorous on highly organic substrates (Tomlinson, 1986). This situation is true in Aurora mangroves because the dominant and huge trees of this species have been found near the mouth of creeks and small rivers with a thick forest ground litter.

*Rhizophora apiculata* in Aurora mangroves can be found mostly in the interior portion with shallow current of water of which the substrate is basically muddy. Among all other mangrove trees, this species has the most distinct prop or stilt roots which are known to support the main stem, natural adaptation for oxygen absorption and intake of nutrients from the soil.

*Ceriops decandra* more often grows within the tidal zone mixed with other Rhizophoraceae. This species is widely distributed from east Africa and Madagascar throughout tropical Asia and Queensland, to Melanesia (New Caledonia and the Solomon Islands) and through Micronesia north Hongkong.

*Pemphis acidula* is generally coastal shrubs or at most small trees, ranging from east Africa through southeastern Asia to northern Australia, Polynesia, and northward to Hongkong but with an apparent disjunction in east Malaysia (Tomlinson, 1986).

*Sonneratia caseolaris* according to Tomlinson (1986) is a typical constituent of mangrove communities throughout its range, often forming seaward fringe, and it is recognized by its tall canonical pneumatophores

arising from horizontal roots.

The species of *Avicennia marina* in Aurora mangrove occupies the most foreshore area or zone which by nature, is regularly inundated with strong tidal water currents and higher water salinity. This is common in almost all of the sampling sites. Having the highest importance value of this species (39.07%), as compared to other mangrove species in the sampling sites, a generalization can be drawn that the said species has the greatest influence in the mangrove ecosystem of Aurora in terms of water and nutrients uptake, competition and other survival and growth factors. However, these aspects need further and specific separate study in the future to clearly verify its relationship to this species.

The *Lumnitzera littorea* on the other hand, occupies the landward most part with a continuous flow of fresh water from the small creek and rivers. This means that this mangrove species is not salt tolerant as compared with to other species thriving in the seawardward most areas. This is so because in general, the salinity concentrations of sea water tends to reduced in the landward areas because of the outflow of fresh water coming from the rivers and creeks and its tributaries. This species is locally known as one of the best mangrove tree used for charcoal production according to the local residents as it produces good charcoal with long lasting heat effects needed by the bakery owners in cooking bread and other bakery products. This species was recorded only in Sitio Mahogany, Masagana, Dilasag, Aurora.

The third species which has the highest importance value is the *Rhizophora apiculata*. It usually appears at shallow muddy river edges regularly inundated by saline water during high tide and is known best for reforestation if the main objective is to protect soil erosion because this species has stilt and/or prop roots which holds soil more tightly.

*Ceriops decandra*, *Pemphis acidula* and *Sonneratia caseolaris* are the three mangrove species which have the lowest density, lowest frequency, lowest dominancy and revealed also as the species having the lowest importance values respectively. *Ceriops decandra* was recorded only in one site (Ditinagian) and has only two mature trees.

*Pemphis acidula* (bakawan-bonsai) on the other hand, is present only in the coralline mangroves of Sitio Dipalatpat and Dekasew, Diniog, Dilasag, Aurora where serious and unsustainable collection and gathering is still taking place. Local people are collecting bonsai trees of this species and commercially sold to urban beach resort owners as an ornamental plant.

The fruit of *Sonneratia caseolaris* is being used by the local fisherman as a substitute for tomatoe in cooking fish.

*Kandelia candel* has a relative density of 0.73%, relative frequency of 1.05%, relative dominance of 0.24% and an IV of 2.02%. These data made *Kandelia candel* ranked 18<sup>th</sup> in terms of importance value, out of twenty seven (27) species compared. It gives a clear picture that this species has a less influence in the mangroves of Aurora in terms of density, frequency and dominance. It is also noted that, of the 15 sampling sites, only two of them, Baler and Cozo have the presence of *Kandelia candel*.

**Table 2.** Vegetational analysis for true or strict (major and minor) mangrove tree species

No.	Species		PD (m <sup>2</sup> )	RPD	F	RF	D	RD	IV	Rank
1.	<i>Avicennia marina</i>	0.054	19.71	0.93	9.79	3.99	9.57	39.07	<b>1</b>	
2.	<i>Lumnitzera littorea</i>		0.021	7.66	0.88	9.26	8.60	20.63	37.56	<b>2</b>
3.	<i>Rhizophora apiculata</i>		0.026	9.49	0.88	9.26	6.51	15.62	34.37	<b>3</b>
4.	<i>Sonneratia alba</i>	0.036	13.14	0.95	10.00	3.56	8.54	31.68	<b>4</b>	
5.	<i>Bruguiera gymnorhiza</i>		0.024	8.76	0.92	9.68	3.29	9.40	27.85	<b>5</b>
6.	<i>Xylocarpus granatum</i>		0.016	5.84	0.88	9.26	4.97	11.92	27.02	<b>6</b>
7.	<i>Bruguiera sexangula</i>		0.014	5.11	0.82	8.63	1.59	3.81	17.56	<b>7</b>
8.	<i>Bruguiera parviflora</i>		0.013	4.75	0.90	9.47	1.13	2.71	16.93	<b>8</b>
9.	<i>Aegiceras corniculatum</i>		0.014	5.11	0.45	4.74	0.45	1.08	10.93	<b>9</b>
10.	<i>Ceriops tagal</i>		0.011	4.02	0.25	2.63	1.52	3.65	10.29	<b>10</b>
11.	<i>Rhizophora stylosa</i>		0.011	4.02	0.20	2.11	1.40	3.36	9.48	<b>11</b>
12.	<i>Rhizophora mucronata</i>		0.004	1.46	0.20	2.11	0.88	2.11	5.68	<b>12</b>
13.	<i>Avicennia lanata</i>	0.004	1.46	0.12	1.26	0.87	2.09	4.81	<b>13</b>	
14.	<i>Excoecaria agallocha</i>		0.006	2.19	0.15	1.58	0.35	0.84	4.61	<b>14</b>
15.	<i>Heritiera littoralis</i>		0.004	1.46	0.15	1.58	0.40	0.96	3.99	<b>15</b>
16.	<i>Bruguiera cylindrica</i>		0.002	0.73	0.22	2.32	0.17	0.41	3.45	<b>16</b>
17.	<i>Avicennia officinalis</i>		0.003	1.10	0.10	1.05	0.28	0.67	2.82	<b>17</b>
18.	<i>Kandelia candel</i>	0.002	0.73	0.10	1.05	0.10	0.24	2.02	<b>18</b>	
19.	<i>Osbornia octodonta</i>		0.002	0.73	0.10	1.05	0.01	0.02	1.81	<b>19</b>
20.	<i>Lumnitzera racemosa</i>		0.001	0.37	0.05	0.53	0.34	0.82	1.71	<b>20</b>
21.	<i>Xylocarpus mollucensis</i>		0.001	0.37	0.05	0.53	0.26	0.62	1.52	<b>21</b>
22.	<i>Scyphiphora hydrophyllacea</i>	0.001	0.37	0.05	0.53	0.12	0.29	1.18	<b>22</b>	
23.	<i>Planchonella obovata</i>		0.001	0.37	0.05	0.53	0.05	0.12	1.01	<b>23</b>
24.	<i>Aegiceras floridum</i>		0.001	0.37	0.05	0.53	0.01	0.02	0.92	<b>24</b>
25.	<i>Sonneratia caseolaris</i>		0.001	0.37	0.02	0.21	0.09	0.22	0.79	<b>25</b>
26.	<i>Pemphis acidula</i>	0.001	0.37	0.02	0.21	0.01	0.24	0.82	<b>26</b>	
27.	<i>Ceriops decandra</i>		0.0003	0.11	0.02	0.21	0.02	0.05	0.37	<b>27</b>
<b>Total</b>			<b>0.274</b>	<b>100</b>	<b>9.51</b>	<b>100</b>	<b>41.69</b>	<b>100</b>	<b>300</b>	

\* PD=Population density; RPD=Relative population density; F=Frequency; RF=Relative frequency; D=Dominance; RD=Relative dominance; IV=Importance value

\**Acrostichum aureum* and *Acrostichum speciosum* were not included in the computation table because these two species are fern in nature and have no trunk to measure. *Nypa fruticans* has also no trunk or bole to measure and was excluded in the analysis.

## 5. Conclusions

Based on the results of this study the following are therefore concluded:

1. That the *Avicennia marina*, *Lumnitzera littorea* and *Rhizophora apiculata* were the three most dense, most frequent, most dominant and therefore have the most highest IV's in the mangrove forest of Aurora. The species of *Avicennia marina* in terms of density and frequency has an advantage to *Lumnitzera littorea* and *Rhizophora apiculata*, however, the species of *Lumnitzera littorea* emerged as the most dominant among all other species. This suggests that these mangrove species are highly adaptable to the ecological conditions in the mangroves of Aurora and therefore suitable for reforestation and other mangrove conservation activities in the area. However, other important factors should also be considered such substrate, salinity, tidal current, availability of propagules, competition, and other factors within the local conditions;
2. That the *Ceriops decandra*, *Pemphis acidula* and *Sonneratia caseolaris* turned out to be the species having lowest density, frequency, dominancy and importance values. This means that these mangrove species in general, have the lowest ability for adaptation in the area and might have a less suitability and survival if used in reforestation and other mangrove management activities;
3. That based on the data gathered, the species having the most dense, most frequent and most dominant is most likely to turned out to be the species having the highest importance percentage value and vice-versa;
4. That the wide distributions of *Avicennia marina* in global scale is also true and can be seen in the local mangroves of Aurora, Philippines;
5. That among the 27 species subjected for vegetational analysis, *Kandelia candel* was placed 18<sup>th</sup> in terms of its rank and/or order. This simply means that this species is just only a small component of Aurora mangrove and therefore proper propagation is needed to maintain its presence and population in this area. The absence of this species in the other mangal areas within the Philippines makes the mangrove of Aurora unique and exceptional and it lends truth to the biodiversity of Aurora mangroves.
6. That the distribution of *Kandelia candel* in the Philippines is commonly observed and limited to shallow, soft and muddy riverine type of mangrove in Aurora. This means that this species can be considered as an interior mangrove and therefore less resistant to strong tidal current and salinity unlike *Avicennia marina* which is normally seen on the seaward most part.
7. That based on observations made, the species of *Avicennia marina*, *Sonneratia alba* and *Rhizophora stylosa* can withstand and survived on the seaward most parts having a coralline, sandy and/or rocky substrates. On the other hand, *Rhizophora apiculata*, *Bruguiera gymnorhiza*, *Kandelia candel*, *Nypa fruticans* preferred the shallow and muddy river bank in the middle zone of mangroves. The species of *Lumnitzera* and *Xylocarpus* have found out growing on the landward most sides.
8. That other possible researchable area, such as geomorphologic factors, climatic factors, physiological adaptation to environmental gradients, biotic and other ecological factors are indeed necessary to investigate, to further explain and fully understand the mangrove forest structure of a certain place.
9. That there were 30 major and minor mangrove species, 22 mangrove associates and 10 specialized groups identified in the study sites. Out of the 54 species of true mangroves (major and minor) known throughout the world (Tomlinson, 1986), 56% of it are growing in the area. And of the 39 major and minor mangrove species known in the Philippines (Primavera, 2000a), 77% of it can be found in the



mangrove forest of Aurora. This data shows that the mangrove species composition in this place is relatively high and therefore needs proper protection, conservation, and management.

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