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Diversity and habitat assessment of mangrove forests in Gonzaga, Cagayan

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Abstract

The stand structure, species composition, vegetation structure, species diversity, and habitat status of mangrove forest in Gonzaga, Cagayan were determined using Belt Transect Method. This baseline data is a basic and prerequisite for the proper conservation and management of mangrove forests. Results revealed that there were 14 true mangrove species belonging to 9 genera and 8 families in the natural mangrove forest of Gonzaga, Cagayan, where *A. rumphiana* is the most important species and the principal species thriving in the areas. The similarity in the species composition between Caroan and San Jose was very high (0.70). The 33.33% of the total mangrove species known in the Philippines and 20% of the total mangrove species known in the world are present in Gonzaga. *A. rumphiana* recorded the largest girth and the tallest mangrove tree. The large tree girths of some mangrove species specifically *A. rumphiana* implied that mangrove forest has the potential to sequester and store a large amount of atmospheric carbon. Very low species diversity of mangroves was observed in the areas. The condition of the mangrove forest in Gonzaga is in fair condition. These findings concluded that the natural and anthropogenic disturbances observed may possess threats and risks to mangroves. It is recommended to have a more serious intervention to rehabilitate degraded mangrove areas and to protect and conserve remaining mangroves; implement local ordinances for the protection, conservation, and management of mangrove forest; and conduct an assessment on the carbon density sequestration of mangrove stands in Gonzaga.

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Introduction

Mangroves are dicotyledonous woody shrubs or trees form unique ecological environments which provide an appropriate habitat for a rich assemblage of species. Thereby, muddy or sandy sediments of the mangroves offers home for different species of epibenthic, infaunal, and meiofaunal invertebrates, reservoirs within the mangroves support communities of phytoplankton, zooplankton, and fish. Additionally, mangroves play a unique role as hatchery and nursery habitat for juveniles of fish whose adults occupy other habitats like coral reefs and seagrass beds (Cañizares and Seronay, 2016). Further, the economic significance of mangroves as efficient blue carbon sink is also becoming popular (Lawrence, 2012) as they store up to 20 billion tons of carbon which is a little more than twice the annual global CO_2 emission and far exceeds the mean carbon stock (C-stock) in tropical upland, temperate, and boreal forests (Donato *et al.*, 2011).

In the Philippines, it has relatively high mangrove diversity and is considered one of the richest in the world with at least 42 species of trees belonging to 18 families out of 70 true mangrove species in the world (Samson & Rollon, 2011). The species composition and structure depend on their physiological tolerances and competitive interactions (Alongi, 2008). The total area of mangroves has decreased by almost half, from 400,000-500,000 ha recorded several decades ago (Brown & Fischer, 1920; Primavera, 2000) to the current estimate of 259,600 ha (Siikamaki *et al.*, 2012). Despite its great importance and high diversity, mangrove forest faces serious problems include mangrove deforestation and major driving force of mangrove forest loss in the country.

The province of Cagayan has approximately 3,967.9 hectares of mangrove areas. These are distributed throughout the municipalities of Abulug, Aparri, Buguey, Calayan, Claveria, Gonzaga, Pamplona, Sanchez-Mira, Santa Ana and Santa Teresita. In particular, the municipality of Gonzaga has mangrove forests sporadically located in seven coastal barangays with swamp and brackish areas, which cover an aggregate area of approximately 69.1 ha. In particular, mangrove forest in Gonzaga, Cagayan is poor with an average of 25% living mangrove forests. Most of the areas manifested severe cutting, heavy erosion and siltation specifically observed in barangays Caroan, and San Jose where the largest tracts of mangrove forest in Gonzaga are located. (Pasion and Tumaliuan, 2015).

With this condition of mangrove forest in the municipality, assessment of the remaining mangrove forest and its habitat are essential for the management and conservation of mangrove resources. However, there is limited baseline information and studies on mangrove forests were conducted in Gonzaga, Cagayan, Philippines.

The study is a preliminary attempt to provide ecological baseline data on the existing mangrove forest, its species composition, vegetation structure, species diversity and habitat. These data are needed by government agencies and non-government agencies for a more serious intervention projects to rehabilitate degraded mangrove areas and to protect, conserve and manage remaining mangroves. The study purposively assessed the diversity and habitat status of mangrove forests in Gonzaga, Cagayan, Philippines.

Materials and methods

Sampling Site

The municipality of Gonzaga, Cagayan, Philippines lies between 18°16' North latitude and 121°60' East longitude. The study was carried out in the natural mangrove stands of Barangays Caroan, Tapel, and San Jose located in the municipality of Gonzaga, Cagayan (Fig. 1). The area of investigation is 10% of the total mangrove forest area in each barangay. Transect lines and quadrants were used in the assessment of mangroves. Transect lines range from 20-100 meters, depending on the expanse of the mangrove stands, were laid perpendicular to the shoreline and started where the mangrove habitat starts, and ended where the habitat ends. This is adopted from the Participatory Coastal Resource Assessment Training Guide by Deguit *et al.* (2004). Transect lines were established at every 100 m interval. Along the transect line, a series of 10m x 10m quadrant plots were established for the assessment of mangrove trees, and within the 10m x10m quadrat, a small quadrat plot with 2m x 2m was established as a regeneration plot. In more than one transect line, laid with 100 m distance in between. The 10m x10m quadrats plots were laid with 100 m distance in between depending on vegetation characteristics, landscape, and extend of mangrove. This is adopted from the Guidelines on the Assessment of Coastal and Marine Ecosystems by DENR-EMB (2017). Field layout of sampling sites in mangrove forest areas is shown in Fig. 2.

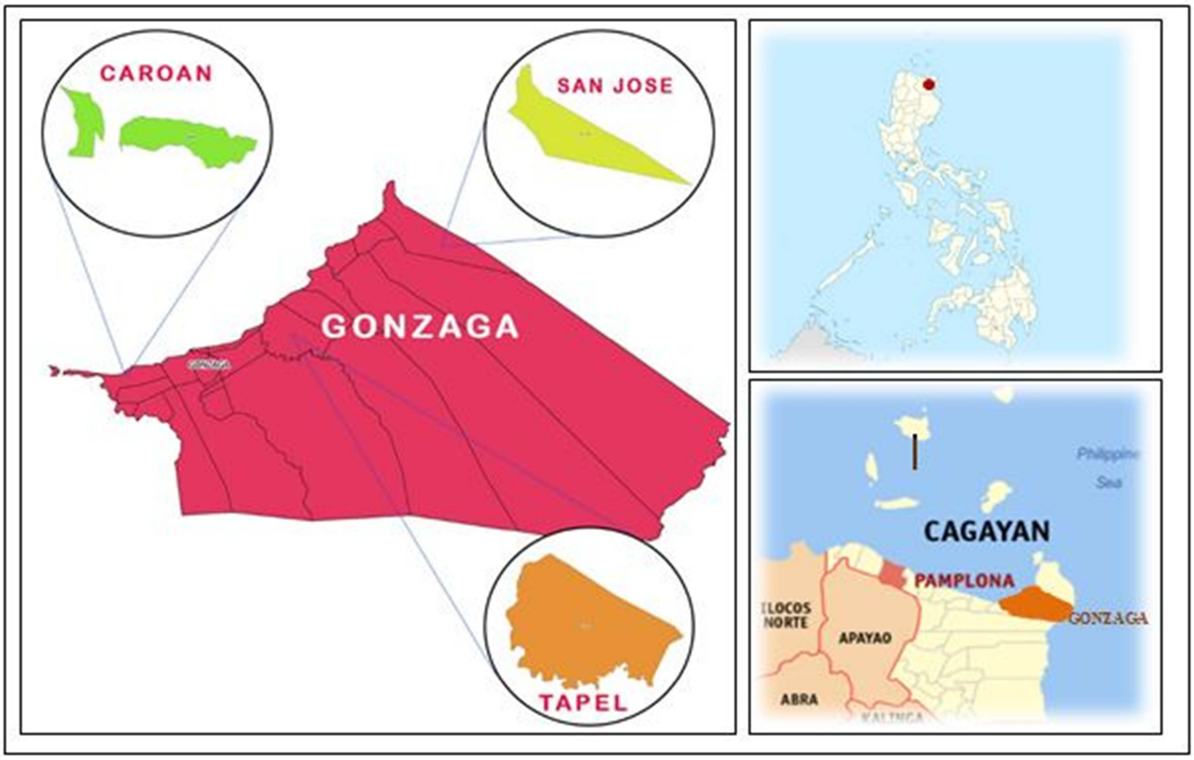

Fig. 1. Location map of sampling sites in Gonzaga, Cagayan, Philippines.

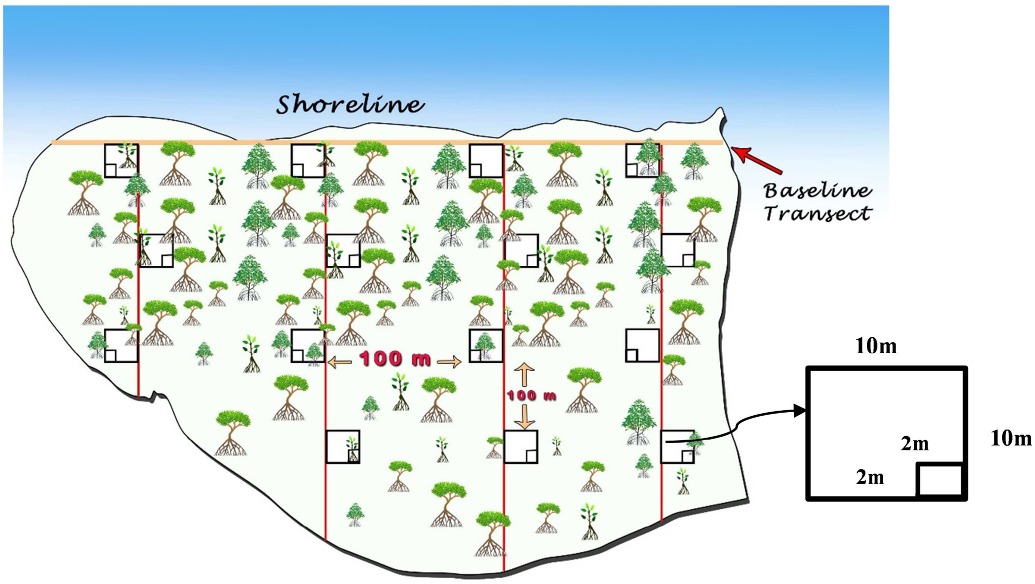

Fig. 2. Illustration of belt transect method used for the assessment of mangroves.

Research Design

The qualitative and quantitative research method was used in the study to obtain accurate information on the mangrove assessment. The qualitative data collected include mangrove species and observations such as natural and anthropogenic factors that may affect mangroves. Quantitative data were gathered by determining the number of mangroves inside the quadrant plot, the diameter at breast height, the basal area, the height of the trees, the diameter of the crown, and the number of regeneration of mangrove.

Data Collection

Mangroves per species within the 10m x 10m quadrant plot were identified and counted, the diameter at breast height (dbh) incm, the height of the trees, and the diameter of the crown were measured. In the 2m x 2m quadrat plot, the regeneration of mangrove seedling and saplings per species was identified and counted. The mangrove species were identified in situ and classify taxonomically using the Field Guide to Philippine Mangroves by Primavera and Dianala (2009). Photos of roots, barks, stems, leaves, flowers, and fruits of each mangrove species were captured for validation and identification purposes. Flowering and fruiting of individual trees and other tree disturbances were observed. Other observations in the vicinity of the mangrove area were also recorded.

Data Analysis

Index of similarities in the species composition of the three barangays or communities was determined using the Jaccard coefficient formula or the similarity index, where:

SJ = 2c/(a + b)

where: SJ = Jaccard similarity coefficient;

c = number of species common to (shared by) communities;

a = number of species unique to the first community; and

b = number of species unique to the second community.

Vegetation analysis was analyzed using the following parameters: population density, frequency, dominance, relative density, relative frequency, relative dominance, and the importance value. The latter provides a better index than density alone regarding the importance or function of a species in its habitat and gives rank or order for a particular species within the forest community. This also indicates the ecological importance of each mangrove species in each barangay or community (Rotaquio Jr, *et al.*, 2007). This is obtained by adding the percentages of relative frequency (RF), relative density (RD), and relative dominance (RDom). These are calculated using the formulas adopted in the study of Abino *et al.* (2014), where:

$$RF = \frac{\text{Number of occurrence of the species}}{\text{Number of occurrence of all the species}} \times 100$$

$$RDom = \frac{\text{Total basal area of the species}}{\text{Total basal area of all the species}} \times 100$$

$$RD = \frac{\text{Number of individual of the species}}{\text{Number of individual of all the species}} \times 100$$

The diversity index value indicates a quantitative description of mangrove habitat in terms of species richness and distribution. Diversity index was computed using Shannon-Weiner Index formula, where:

$H' = - \sum Pi \ln pi$

where: H' = diversity index;

s = number of species;

Pi = proportion of individuals to the 1^{th} species expressed as a portion of the total cover; and

ln = log base n

The diversity values were classified based on a scale used by Gevaña & Pampolina (2009) and is presented in Table 1.

Table 1. Categories of diversity values.

Relative values	H' Values
Very high	> 3.5000
High	3.0000 – 3.4999
Moderate	2.5000 – 2.9999
Low	2.0000 – 2.4999
Very low	< 1.9999

The status of the mangrove habitat was analyzed using the parameters: percent crown cover, regeneration per m^2, and average height. The computed data were used to determine the condition of the mangrove which is classified into four categories: excellent, good, fair, and poor condition. Table 2 shows the criteria used to assess the condition of mangrove in terms of percent crown cover, number of regeneration per m^2, average tree height and disturbances with their corresponding condition.

This is adopted from the Participatory Coastal Resource Assessment Training Guide by Deguit *et al.* (2004).

Table 2. Criteria in determining the condition of mangrove area.

Condition	Criteria
Excellent	76% and above in% crown cover 1 regeneration per m^2 Above 5m in average tree height Undisturbed to negligible disturbance
Good	51-75% crown cover <1 – 0.76 regeneration per m^2 Between 3m–5m average height of trees Slight disturbance and few cuttings
Fair	26-50% crown cover 0.50-0.75 regeneration per m^2 Between 2m - 3m average height of trees Moderate disturbance and noticeable cuttings
Poor	0-25% crown cover <0.50 regeneration per m^2 Less than 2m in average height of trees Heavy disturbance/cuttings/pollution, rampant conversion to other uses, nearly destroyed

Results and discussion

Species composition and stand structure of mangrove forest in Gonzaga, Cagayan

The mangrove forest of Barangays Caroan, San Jose, and Tapel in Gonzaga, Cagayan was assessed, wherein natural mangrove stands are abundant. Species composition and stand structure such as diameter breast height, height, and canopy of mangroves were recorded.

In Barangay Caroan, a total of 514 mangrove samples were recorded, representing 10 true mangrove species, belonging to 7 genera and 7 families (Table 3).

The species of mangrove found are *Acanthus ilicifolius, Acanthus volubilis, Acrostichum aureum, Aegiceras corniculatum, Aegicera floridum, Avicennia marina, Avicennia rumphiana, Ceriops decandra, Excoecaria agallocha and Nypa fruticans.*

These are true mangrove species because they are exclusively restricted to tropical intertidal habitats and do not extend into terrestrial plant community and are morphologically, physiologically, and reproductively adapted to the saline, waterlogged and anaerobic conditions as defined by Polidoro *et al.* (2010). The depth breast height (DBH) of the mangrove trees is ranged from 0.48cm to 57.32cm while the height of the trees is varied from 1.0m to 9.50m. *A. rumphiana* has the largest girth and the largest tree among the mangroves, while *A. speciosum* has the smallest girth and smallest height.

Table 3. Species composition and stand structure of mangrove forest in Barangay Caroan.

Family	Species	No. of trees	DBH (cm)			Height (m)			Canopy (m)		
			Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Acanthaceae	*Acanthus ilicifolius*	54	0.48	0.48	0.48	1.50	3.0	1.89	0.30	0.80	0.55
	Acanthus volubilis	71	0.48	0.48	0.48	1.50	3.0	1.73	0.20	0.80	0.50
Pteridaceae	*Acrostichum speciosum*	6	0.48	0.48	0.48	1.0	1.70	1.12	0.30	1.50	0.50
Myrsinaceae	*Aegiceras corniculatum*	68	1.91	3.03	2.49	1.40	2.0	1.34	0.50	1.20	0.68
	Aegicera floridum	2	2.74	2.99	2.87	1.30	2.30	1.80	1.10	1.20	1.15
Avicenniaceae	*Avicennia marina*	89	2.80	12.36	4.99	1.0	4.80	1.70	0.50	4.50	1.70
	Avicennia rumphiana	68	1.34	57.32	9.44	1.10	9.50	3.88	0.30	10.0	2.69
Rhizophoraceae	*Ceriops decandra*	81	1.91	3.03	2.41	1.20	2.90	1.38	0.50	1.0	0.72
Euphorbiaceae	*Excoecaria agallocha*	73	1.72	16.18	4.95	1.20	6.10	3.64	0.20	4.50	1.45
Arecaceae	*Nypa fruticans*	2	3.12	3.18	3.15	2.50	3.0	2.75	1.40	1.80	1.60

In Barangay San Jose, a total of 225 mangrovesamples were recorded, representing 12 true mangrove species, belonging to 9 genera and 8 families (Table 4). The species of mangrove recorded are *Acanthus ilicifolius, Acanthus volubilis, Acrostichum aureum, Aegicera floridum, Avicennia marina, Avicennia rumphiana, Bruguiera cylindrica, Bruguiera sexangula, Ceriops tagal, Excoecaria agallocha, Heritiera littoralis and Nypa fruticans.* The DBH of mangroves varies between 0.45cm and 192.87cm, whereas the height of the trees varies between 0.50 m to 11.60 m.

A. rumphiana has the largest girth and the tallest among the mangroves while *A. volubilis* has the smallest girth and the shortest mangrove.

Table 4. Species composition and stand structure of mangrove forest in Barangay San Jose.

Family	Species	No. of trees	DBH (cm)			Height (m)			Canopy (m)		
			Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Acanthaceae	*Acanthus ilicifolius*	50	0.38	0.60	0.48	0.50	2.0	1.48	0.50	1.0	0.64
	Acanthus volubilis	22	0.45	0.48	0.47	0.50	2.0	1.20	0.50	0.80	0.65
Pteridaceae	*Acrostichum speciosum*	5	0.48	0.48	0.48	1.30	2.0	1.62	0.50	0.50	0.50
Myrsinaceae	*Aegiceras floridum*	5	2.55	2.86	2.65	1.68	3.0	2.38	0.59	1.59	1.06
Avicenniaceae	*Avicennia marina*	3	10.98	19.11	14.46	3.0	6.95	4.75	1.26	7.20	4.29
	Avicennia rumphiana	78	1.31	192.87	17.91	1.36	11.60	6.09	0.50	13.0	4.57
Rhizophoraceae	*Bruguiera cylindrica*	1	1.27	1.27	1.27	3.40	3.40	3.40	2.80	2.80	2.80
	Bruguiera sexangula	22	1.31	36.92	6.47	1.20	6.30	2.97	0.70	3.65	2.02
	Ceriops tagal	1	2.26	2.26	2.26	3.50	3.50	3.50	1.00	1.00	1.00
Euphorbiaceae	*Excoecaria agallocha*	4	6.75	18.78	12.75	2.90	6.30	4.70	1.65	3.95	2.95
Sterculiaceae	*Heritiera littoralis*	12	1.75	12.58	5.98	1.70	5.80	3.88	0.50	5.50	2.52
Arecaceae	*Nypa fruticans*	22	7.50	12.0	9.84	2.0	3.0	2.49	0.50	3.0	1.32

In Barangay Tapel, a total of 76 sample mangrove trees were recorded, representing 3 true mangrove species, belonging to 3 genera and 3 families (Table 5). The species of mangrove found are *Bruguiera sexangular, Heritiera littoralis, and Nypa fruticans.* The DBH of the mangrove trees is ranged from 1.11cm to 35.19cm, while the height of the trees is ranged from 0.3m to 6.25m. *H. littoralis* has the largest girth and the tallest tree among the mangroves, while *N. fruticans* has the smallest girth and smallest height.

Table 5. Species composition and stand structure of mangrove forest in Barangay Tapel.

Family	Species	No. of trees	DBH (cm)			Height (m)			Canopy (m)		
			Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Rhizophoraceae	*Bruguiera sexangula*	47	1.11	35.19	4.48	1.0	6.25	2.24	0.20	7.0	1.39
Sterculiaceae	*Heritiera littoralis*	26	2.01	11.15	5.21	0.30	5.50	2.79	0.20	3.0	1.38
Arecaceae	*Nypa fruticans*	3	2.23	6.35	3.84	1.30	2.75	1.92	1.50	1.50	1.50

In general, *A. rumphiana* recorded the largest girth and the tallest tree among the mangrove stands assessed in the three barangays. This species is found in Barangay San Jose. *A. rumphiana* was also the biggest mangrove observed in the assessment conducted by Middeljans (2014). This result agrees with the statement of Giesen *et al.* (2007) that *A. rumphiana* is the largest *Avicennia* species, growing up to 30 meters in height with a girth of 3 meters. In terms of species composition, Barangay San Jose has the highest number of mangrove species recorded which composed of 12 species followed by Barangay Caroan with 10 species and Barangay Tapel with 3 species. Overall, a total of 14 true mangrove species namely *A. ilicifolius, A. volubilis, A. aureum, A. corniculatum, A. floridum, A. marina, A. rumphiana, B. cylindrica, B. sexangula, C. decandra, C. tagal, E. agallocha, H. littoralis,* and *N. fruticans*, belonging to 9 genera and 8 families were found in Gonzaga, Cagayan. This result implies that mangrove species are growing in a specific area. These baseline data together with the findings of Pacris *et al.* (2020) on the biophysical and chemical characteristics of mangrove waters in the same municipality can serve as a guide in the sustainable rehabilitation of degraded mangrove areas.

According to Samson and Rollon (2011), 42 mangrove species known to occur throughout the Philippines, and 70 true mangrove species in the world.

Comparing the data gathered in the study with the total number of mangrove species found in the Philippines, 33.33% of the total mangrove species known to occur in the Philippines are present in the mangrove forest of Gonzaga, Cagayan. Also, using the data stated by Samson and Rollon (2011), 20% of the total mangrove species known to occur in the world are found in the mangrove forest of Gonzaga, Cagayan. The higher number of mangrove species is recorded in some provinces of the Philippines. These are mangrove areas along the Abatan River in Lincod, Maribojoc, Bohol with 31 species (Middeljans, 2014), Aurora with 30 species (Rotaquio Jr. *et al.*, 2007), Bugtong Bato-Naisud basin along the Ibajay River, Aklan Province with 28 true mangrove species (Primavera *et al.*, 2010), Jawili, Tangalan River, Aklan Province with 25 species (Primavera *et al.*, 2010), Pagbilao Bay in Quezon Province with 25 species (Janssen and Padilla, 1999), Olango Island with 23 species (Magsalay *et al.*, 1989) and the Makato River in Aklan Province with 22 species (Primavera *et al.*, 2010).

Index of similarities in the species composition of the three barangays in Gonzaga, Cagayan

Table 6 shows the index of similarities in the species composition of the three barangays in Gonzaga, Cagayan. The similarity in mangrove species between Barangays Caroan and San Jose was very high (0.70). There are 8 common mangrove species found in both barangays namely *A. ilicifolius, A. volubilis, A. aureum, A. floridum, A. marina, A. rumphiana, E. agallocha,* and *N. fruticans*. The high similarity between the two barangays is evident since most of the species present in Barangay Caroan is occurred in Barangay San Jose.

Table 6. Index of similarities in species composition in the three barangays.

Barangay	No. of species	No. of common species	Similarity index of species
Caroan	10	8 [a]	0.70 [a]
San Jose	13	3 [b]	0.38 [b]
Tapel	3	1 [c]	0.15 [c]

[a] Common species in Barangays Caroan and San Jose
[b] Common species in Barangays San Jose and Tapel
[c] Common species in Barangays Tapel and Caroan

On the other hand, similarities in the species composition between Barangays San Jose and Tapel and between Barangays Tapel and Caroan were very low, 0.38 and 0.15, respectively. The common mangrove species found in barangays San Jose and Tapel are *B. sexangula, H. littoralis,* and *N. fruticans* while common mangrove species in barangays Tapel and Caroan is *N. fruticans*.

Importance value and species diversity of mangrove forest in Gonzaga, Cagayan

The importance value of a mangrove species is based on the total contribution that a species made to the community in relation to the number of plants within the quadrats (relative abundance), its influence on the other species through its competition, shading, or aggressiveness (relative dominance), and its contribution to the community by means of distribution (relative frequency) in a study plot (Faridah-Hanum *et al.*, 2012). On the other hand, diversity index is used to determine species diversity.

Comparing the abundance of mangrove species in Barangay Caroan, *A. marina* was the most abundant species with 89 stands recorded, representing 17.32% of the total density. It was followed by *C. decandra* with 81 stands recorded, representing 15.76% of the total density. On the other hand, *A. floridum* and *N. fruticans* were least dense with only 2 stands recorded, representing 0.39% of the total density. *A. rumphiana* had the highest species distribution occurred in 26.67% of the quadrant plots, followed by *A. marina* with a frequency of 20%.

In terms of the importance value, *A. rumphiana* dominated among the mangrove species recorded with an importance value index (IVI) of 81.19%, as shown in Table 7. It was followed by *A. marina* with 58.29% IVI and *E. agallocha* with 41.27% IVI. The abundant species, *A. marina* ranked only second in importance value due to its lower species distribution (relative frequency) and smaller relative basal area (relative dominance) than *A. rumphiana*. On the other hand, *A. floridum* obtained the least important value of 3.99%. Meanwhile, the calculated diversity index (H') value of mangrove forest in the barangay is 0.87 which is considered very low based on the diversity scale that H' of less than 1.999 is very low (Gevaña & Pampolina, 2009). This result can be attributed to the dominance of some mangrove species such as *A. marina, C. decandra, E. agallocha, A. volubilis, A. rumphiana* and *A. corniculatum* over other species in terms of density and relative density.

Table 7. Analysis of importance value and diversity index value of mangrove forest in Barangay Caroan, Gonzaga, Cagayan.

Species	No. of Individual	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	IVI (%)	Diversity Index
A. ilicifolius	54	10.51	13.33	1.22	25.06	
A. volubilis	71	13.81	10.00	1.61	25.42	
A. speciosum	6	1.17	6.67	0.11	7.95	
A. corniculatum	68	13.23	3.33	7.98	24.54	
A. floridum	2	0.39	3.33	0.27	3.99	
A. marina	89	17.32	20.00	20.95	58.27	0.87
A. rumphiana	68	13.23	26.67	41.30	81.19	
C. decandra	81	15.76	3.33	9.19	28.29	
E. agallocha	73	14.20	10.00	17.07	41.27	
N. fruticans	2	0.39	3.33	0.30	4.02	
Total	514	100.00	100.00	100.00	300.00	

In Barangay San Jose, *A. rumphiana* was the most abundant species with 78 stands recorded, representing 34.67% of the total density, followed by *A. ilicifolius* with 50 stands recorded, representing 22.22% of the total density. Meanwhile, *B. cylindrica* and *C. tagal* were least abundant with 1 stand recorded, representing 0.44% of the total density. *A. rumphiana* had the highest species distribution occurred in 23.26% of the quadrant plots, followed by *B. sexangula* and *A. ilicifolius* with a frequency of 13.95%.

Table 8 shows that *A. rumphiana* is found dominating among the mangrove species recorded in Barangay San Jose with 127.54% IVI. *A. rumphiana* is the most important species among mangroves because it has the highest relative density, relative frequency and relative dominance. It was followed by *A. ilicifolius* with 37.33% IVI and *B. sexangula* with 29.90% IVI. While *C. tagal* obtained the least important value of 2.88%.

The calculated diversity index (1.9) of mangrove stands in the barangay is considered very low based on the diversity scale that H' of less than 1.999 is very low (Gevaña & Pampolina, 2009). This is attributed to the dominance of few mangrove species specifically *A. rumphiana*, and *A. ilicifolius*, over other species in terms of density and relative density.

Table 8. Analysis of importance value and diversity index value of mangrove forest in Barangay San Jose, Gonzaga, Cagayan.

Species	No. of Individual	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	IVI (%)	Diversity Index
A. ilicifolius	50	22.22	13.95	1.16	37.33	
A. volubilis	22	9.78	6.98	0.50	17.26	
A. speciosum	5	2.22	4.65	0.12	6.99	
A. floridum	3	2.22	4.65	0.6	7.47	
A. marina	3	1.33	6.98	3.52	11.83	
A. rumphiana	78	34.67	23.26	69.62	127.54	
B. cylindrica	1	0.44	2.33	0.35	3.12	1.90
B. sexangula	22	9.78	13.95	6.17	29.90	
C. tagal	1	0.44	2.33	0.11	2.88	
E. agallocha	4	1.78	2.33	3.94	8.04	
H. littoralis	12	5.33	11.63	3.47	20.43	
N. fruticans	22	9.78	6.98	10.45	27.21	
Total	225	100.00	100.00	100.00	300.00	

It can be seen in Table 9 that *B. sexangula* was the most abundant species with 47 stands recorded, representing 61.84% of the total density. While *N. fruticans* was the least abundant with 3 stands recorded, representing 3.95% of the total density. In terms of species distribution, *B. sexangula* and *H. littoralis* both had the highest species distribution being recorded in 23.26% of the quadrant plots.

It shows in Table 9 that *B. sexangula* dominated among the three mangrove species with 157.86% IVI, followed by *H. littoralis* with 109.94% IVI and *N. fruticans* with 32.20% IVI. On the other hand, *N. fruticans* obtained the least important value of 32.20%.

The calculated H' (0.79) of mangrove stands is considered very low. This is based on the diversity scale used by Gevaña & Pampolina (2009) in which H' of less than 1.999 indicates very low diversity value. This reflects the dominance of few mangrove species specifically *B. sexangula* over other species in terms of density and relative density.

Table 9. Analysis of importance value and diversity index value of mangrove forest in Barangay Tapel, Gonzaga, Cagayan.

Species	No. of individual	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	IVI (%)	Diversity Index
B. sexangula	47	61.84	37.5	58.52	157.86	0.79
H. littoralis	26	34.21	37.5	38.23	109.94	
N. fruticans	3	3.95	25.00	3.25	32.20	
Total	76	100.00	100	100.00	300.00	

Generally, among the 14 true mangrove species subjected for vegetation analysis, *A. rumphiana* is the most important species thriving in Barangays Caroan and San Jose, while *B. sexangula* in Tapel. This means that *A. rumphiana* is the principal species in Barangays Caroan and San Jose, and *B. sexangula* is the principal species in Barangay Tapel. On the other hand, *A. floridum*, *C. tagal*, and *N. fruticans* are the least important species found in Barangays Caroan, San Jose, and Tapel, respectively.

Mangroves in Barangay San Jose have the highest diversity index value (H'=1.90) among the barangays. This shows a more even distribution of species among the plots. Overall, the species diversity of mangroves in the three barangays of Gonzaga, Cagayan was very low. A similar finding was reported in the natural mangrove forest of Bahile, Puerto Princesa City, Palawan (Abino *et al.*, 2014) and Verde Passage, San Juan, Batangas (Gevaña *et al.*, 2009).

According to several studies, mangroves had very low diversity indices attributed to their unique stand's formation in contrast to other tropical forests ecosystems (Stanley & Lewis, 2009; Kovacs *et al.*, 2011).

Condition of the mangroves in Gonzaga, Cagayan

It is shown in Table 10 that the mangrove stands in Barangay San Jose have 3.63 meters average height, 54.38% crown cover, 0.75 regeneration per m^2. Based on the criteria adopted by Deguit *et al.* (2004), the recorded data showed that the mangroves in this barangay are in good condition. This is due to slight disturbance and few cuttings observed. Also, communities near the area are prohibited to disturb the mangrove trees in the area. On the other hand, mangroves in Barangays Caroan and Tapel are in fair condition. The status of mangroves in Barangay Caroan is evident by some disturbances observed such as the presence of wastes (plastics, tin cans, broken bottles, and other non-biodegradable materials) in some portions of the mangrove areas, noticeable cuttings naturally and anthropogenically, and conversion of some mangrove areas to fishponds. In the nearby municipality of Gonzaga, the same observation was documented by Calicdan *et al.* (2015) in the mangrove forest of Palaui Island, Santa Ana, Cagayan, Philippines. Development into fishponds was also observed in mangrove areas of the municipalities of Buguey, Santa Teresita, Aparri and Santa Ana in Cagayan (Pasion and Tumaliuan, 2015).

This observation agrees with the statement of Lawrence (2012) that vast areas of mangroves in the country have been subjected to natural and human-induced degradations specifically conversion to fish and shrimp ponds. Meanwhile, the fair condition of mangroves in Barangay Tapel is attributed to disturbances specifically on noticeable cuttings and the presence of invasive plants.

Table 10. Analysis of the condition of mangroves in Gonzaga, Cagayan.

Barangay	Data obtained on the assessment			Criteria (adopted by Deguit *et al.* (2004))	Mangrove Condition
	Average Height (m)	Crown cover (%)	Regeneration per m^2		
Caroan	2.00	35.67	0.48	26-50% crown cover 0.50-0.75 regeneration per m^2 2m - 3m average height of trees Moderate disturbance and noticeable cuttings	Fair Condition
San Jose	3.63	54.38	0.76	51-75% crown cover <1 – 0.76 regeneration per m^2 3m – 5m average height of trees Slight disturbance and few cuttings	Good Condition
Tapel	2.40	26.12	0.75	26-50% crown cover 0.50-0.75 regeneration per m^2 2m-3m average height of trees Moderate disturbance and noticeable cuttings	Fair Condition

Table 10 showed low regeneration of mangroves in the three barangays which is varied from 0.48-0.76 regeneration per m^2. In Barangay San Jose, species that were regenerated are *B. sexangula, A. rumphiana,* and *N. fruticans*; while Barangay Caroan is *A. marina, C. decandra* and *A. corniculatum* and in Tapel is *B. sexangula*. Overall, a total of six mangrove species can serve as seed sources for regeneration. These regenerations specifically mangrove seedlings can be collected and conditioned in the nursery for planting purposes.

Conclusion

The study revealed that there were 14 true mangrove species, belonging to 9 genera and 8 families found in the natural mangrove forest of Gonzaga, Cagayan, Philippines. Fifteen mangrove species or 33.33% of the total mangrove species known in the Philippines and 20% of the total mangrove species known in the world is present in Gonzaga, Cagayan. *Avicennia rumphiana* recorded the largest girth and the tallest tree mangrove tree. The large tree girths of some species in mangrove forest implied that can have the potential to sequester and store a large amount of atmospheric carbon. Generally, *A. rumphiana* is the most important species and principal species thriving in the mangrove areas. Overall, very low species diversity was observed in the municipality. The study also revealed that the mangrove forest in the municipality is in fair condition.

Based on the result of the study, it was concluded that the species composition, stand structure, vegetation structure, species diversity and condition of mangrove forest highly depends on the environmental, ecological conditions and anthropogenic disturbances. The study also revealed that the mangrove forest in Gonzaga, Cagayan is being threatened and near of degradation due to various factors such as natural disturbance, population pressure, pollution from household wastes, and fishpond conversion. This ecological baseline data gathered serves as reference for the conservation, management, and sustainable development of mangrove ecosystems.

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