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Diversity Assessment of Tree Species in Sitio Dicasalarin, Barangay Zabali, Baler, Aurora, Philippines

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Abstract

This paper provides the diversity assessment of the tree species in Sitio Dicasalarin, Barangay Zabali, Baler, Aurora including the endemism and ecological status. A total of 2239 individuals from 139 morphospecies, 87 genera and 46 families were recorded. A total of 48 Philippine endemic species and 2 Aurora Endemic species were found and at least 29 threatened species were listed either in the IUCN Red List of Threatened Species and Philippine List of Threatened Species. Results of the tree diversity showed that the area is highly diverse being a well-protected and well-managed area.

Keywords

Sitio Dicasalarin, Tree Diversity, Philippine Endemics, Threatened Species, Sierra Madre Mountain Range, Aurora Endemics

1. Introduction

Philippines is one of the most important countries with potential of conserving the diversity of life on Earth [1]. Being one of the megadiverse countries in the world, Philippines holds a wide variety of life forms in both aquatic and terrestrial ecosystems [2]. The country is also one of the hottest biodiversity hotspots with exceptional concentrations of endemic species but is experiencing a continuous and exceptional loss of habitat [3]. The study showed that Philippines is at the 23rd rank in the world and 6th in Southeast Asia in being diverse with 5832 endemic species among the total of 7620 documented species in the country. A number of threatened plant species can be found in the Philippines [4].

Assessing the tree diversity in an area is essential in analyzing forest stand

status considering that trees play vital roles in maintaining natural ecological processes and in providing a source for human consumption [5]. Performing such an assessment can provide necessary information in identifying problems with respect to the trees present in the country and their status. Appropriate measures will only be possible if species present in an area are identified [6].

Sitio Dicasalarin is a part of the Sierra Madre Mountain Range. Studies and researches within the area are lacking especially when it comes to tree diversity [7]. Studies conducted in the past were more focused on the faunal component. This tree diversity assessment provides information necessary for the protection and conservation of the area.

The diversity assessment was conducted from June to July 2017 at Sitio Dicasalarin, Barangay Zabali, Baler, Aurora situated at the Sierra Madre Mountain Range. This study generally aims to assess the diversity of tree species in Sitio Dicasalarin and evaluate the conservation status of each species for better execution of the forest management in the area. Specifically, the study aims to: a) inventory and characterize the tree species in the area and; b) assess the biodiversity status, condition, and distribution of the tree species present through diversity indices and importance values computation, photos, and reports.

2. Review of Related Literature

2.1. World's Biodiversity

Biodiversity considers all types and kinds of organisms existing in the planet including plants, animals and other microorganisms [8]. It has been observed that there is a continuous reduction in the world's biodiversity. Statistics found out a total declination of 40% in the average species abundance, 50% in inland water species, and 30% in the population of marine and terrestrial species [9]. These numbers were brought by the drastic change due to rapid reduction of tropical forests and the increase in human population which both threatened plant and animal species of the world. Despite the decreasing biodiversity level, an evident increase in the number of described species continues to show which means that there is still a large number of species yet to be discovered.

2.2. Status of Philippine Forest

Philippines was one of the many countries largely covered by forest. In the past, the country was covered with about 90 percent or 27 million ha of lush tropical rainforest [10]. It was in 1521 when the Spaniards colonized the Philippines and as the spread of commercial crops begun during their regime, deforestation started. In the year 1900, two years after the Spaniards left, the Americans came while still about 70 percent or 21 million of the country's land is forested until they introduced the first modern logging operations in 1904 and the Philippines became one of the main exporters of Dipterocarp lumbers in the world. Continuous deforestation and cutting of trees happened. The least forest cover that the country has experienced was around 1988 with only 6.5 million ha of fo-

rested lands. It increased by 0.3 million ha by 2010 making the forest cover 23 percent of the land area or 6.8 million ha [11]. According to DENR, the forest cover of the country is about 8.205 million ha in 2015 [12]. The continuous decrease in the forest cover of the Philippines shall be a concern and drive to perform studies for conservation and rehabilitation of forests in the country.

2.2. Status of Philippine Floral Species

Philippines as one of the megadiversity countries and biodiversity hotspots has a significant story to tell when it comes to its floral and faunal composition and status [13]. The country's biodiversity together with its forest areas continues to decrease. Only through the efforts of different studies and research groups can the concern on the matter be addressed.

The number of threatened floral species in the country increased from the 2007 record of 526 to 984 in the year 2017 [14]. It can be said that there is really continuous declination due to certain factors including the anthropogenic and natural factors. It dictates the need to perform activities related to the conservation and rehabilitation of the Philippine forests.

3. Materials and Methods

3.1. Materials

In the conduct of the study, different materials were used starting from site establishment until the preservation of the voucher specimens. Meter tapes, nylon rope, pegs, and bolo were used in establishing the quadrats and transect belts. For the collection of voucher specimens and listing of species and its measurements, pencil, meter tape, datasheets, clipboard, specimen tags, bolo, pruning shears, polyethylene bags, and sacks were used. Transect belts and quadrats were located using a GPS device in obtaining the coordinates and elevation. Lastly, in the preservation of the voucher specimens, herbarium bags, denatured alcohol, pruning shear, newspapers, sacks and packing tape were used.

3.2. Establishment of Quadrats and Transects

Three 2-km transects following the existing trails were established in three different locations (**Figure 1**). A 20 × 20-meter quadrat was established at every 250-meter interval along each transect at the left and right of the existing trail (**Figure 2**). Hence, a total of 27 quadrats were established.

3.3. Survey and Specimen Collection, Preservation, and Identification

Trees with diameter at breast height (DBH) of at least 5 cm inside the quadrats were identified and recorded. The total height (TH) and merchantable height (MH) were also measured. Voucher specimens of each species were collected photographed and placed inside the herbarium bags for identification and verification purposes. Identification of voucher specimens was performed through

Figure 1. Location map of the transect and quadrat established in Sitio Dicasalarin.

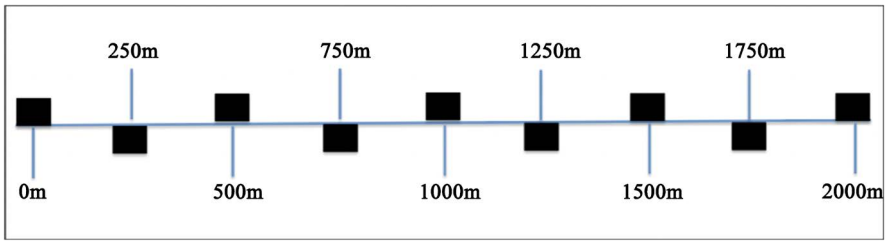

Figure 2. Form of 20 × 20 m quadrat establishment per transect.

different taxonomic references such as Co's Digital Flora of the Philippines, Lexicon of Philippine Trees by Rojo, and Philippine Vascular Plants Checklist by Leonard Co. Also, digital photo database of fresh plants [15] and herbarium specimens of Pastor L. Malabrigo, Jr. were used in comparison with our pressed specimens and its photos for identification and verification.

3.4. Data Analysis

Diversity indices (*i.e.* Shannon, Simpson evenness) were also computed using the Paleontological Statistics Software Package for Education and Data Analysis (PAST v.3.14) [16]. Shannon Index measures the diversity using species richness and distribution. Simpson Evenness measures diversity in terms of evenness in the distribution of species and individuals per quadrat [17]. Diversity indices were interpreted using the scheme of Fernando Biodiversity Scale [18] (**Table 1**). Endemism, conservation status, and distribution record of each species were assessed and verified. For the conservation status, worldwide category was based on the International Union for Conservation of Nature Redlist [19]. While for the Philippine scheme, the local list of threatened species under DAO 2017-11 was used [12]. Importance values were also computed using the data collected

Table 1. Fernando biodiversity scale.

Relative Values	Shannon Index	Evenness Index
Very high	3.5 and above	0.75 - 100
High	3.0 - 3.49	0.5 - 0.74
Moderate	2.5 - 2.99	0.25 - 0.49
Low	2.0 - 2.49	0.15 - 0.24
Very low	1.9 and below	0.05 - 0.14

during the collection: individual count per species, frequency of plot occurrence, and dominance (using DBH) [20]. Below are the formulas for IV computation.

- Dominance equals to (0.7854) × Diameter^2
- Relative dominance equals to (dominance of a species/sum of the dominance of all species) × 100
- Frequency equals to (total number of quadrats in which species occurred/total number of quadrats studied)
- Relative frequency equals to (frequency of a species/sum of frequency of all species) × 100
- Density equals to (Total number of individuals of species/ Total number of individuals of all species)
- Relative density equals to (density of a species/sum of density of all species) × 100
- IV equals to Relative dominance + Relative frequency + Relative density

4. Results and Discussion

4.1. Tree Species

A total of 139 morpho-species were recorded along the tree transects with a total of 2239 individuals from 87 genera and 46 families. Number of tree individuals per quadrat varies from 38 to 132. Diameter of trees ranges from 5 cm to 130 centimeters. Only four individuals of trees exceeded 100 cm-diameter which belong to only one species, Dangula (*X. philippinensis*), belonging to the family of myrtles or Myrtaceae. Majority of the species was measured to have DBH of less than 50 cm indicating that the forest is secondary growth.

The importance values (IVs) of the species were computed as the sum of the relative dominance, relative density, and relative frequency. Based on the computed IVs, the five most important species in terms of dominance, frequency, and density are Dangula (*T. ahernianum*) (35.29), Bagoadlau (*X. philippinensis*) (31.49), Yakal malibato (*S. malibato*) (16.60), Bitanghol (*C. blancoi*) (15.51), and Malabetis (*M. oblongifolia*) (11.01) (**Table 2**). These species belong to five different families. All these species except Bitanghol and Dangula are threatened both in the IUCN Redlist and the Philippine Redlist of Forest Plants. Dangula was found to be the most important species in the area which according to studies is still abundant in tropical areas particularly in Asia [21].

4.2. Diversity Indices

The computed diversity indices of Sitio Dicasalarin falls on the category of a very highly diverse area (Shannon diversity = 4.096, Evenness = 0.9735) (Table 3). Transect 3 has the highest diversity with Shannon diversity of 3.856 and Simpson's Evenness value of 0.967 which are both very high values. There were only minimal disturbances (e.g. fallen trees) observed in the site which has potentially no to low effect on the diversity as the diversity index values showed. Studies showed that disturbing activities such as excessive and improper logging can lessen the richness of species in an ecosystem [22].

In terms of diversity per quadrat, 14 fell under the classification of having high diversity: 5 from Transect 1, 4 from Transect 2, and 5 from Transect 3 (Table 4). Quadrat 8 in Transect 1 has the highest diversity (Shannon = 3.367, Simpson = 0.9554). The remaining quadrats fell in the category of having moderate diversity. Considering the small dimensions of the quadrats, it is assuring to know that there is still a relatively high diversity since studies showed that Shannon Index values typically ranges from 1.5 to 3.5, while areas with Shannon values of 4 are very rare [23].

4.3. Noteworthy Species

As part of the tree diversity assessment, there is a need to look for noteworthy species such as the endemic tree species in the country and those species which

Table 2. Top ten trees with highest Importance Value (IV).

Species	Count	Rden	RF	Rdom	IV
Teijsmanniodendron ahernianum	168	7.50	3.21	24.57	35.29
Xanthostemon philippinensis	129	5.76	1.74	23.99	31.49
Shorea malibato	93	4.15	2.81	9.64	16.60
Calophyllum blancoi	117	5.23	2.81	7.48	15.51
Madhuca oblongifolia	62	2.77	2.81	5.43	11.01
Memecylon sympliciforme	81	3.62	2.01	2.16	7.79
Discocalyx psychotrioides	69	3.08	2.14	2.03	7.25
Timonius arboreus	73	3.26	2.54	1.31	7.11
Meiogyne mindorensis	72	3.22	2.27	1.53	7.02
Palaquium ovatum	44	1.97	1.74	2.70	6.40

Table 3. Diversity indices values per transect.

Diversity Indices	Transect 1	Transect 2	Transect 3	DICASALARIN
Taxa/Species	88	79	85	139
Individuals	699	934	606	2239
Simpson Evenness	0.963	0.957	0.967	0.9735
Shannon	3.791	3.567	3.856	4.096

Table 4. Quadrats with high diversity.

Transect	Quadrat	Taxa	Individuals	Simpson	Shannon
1	8	37	71	0.9554	3.367
2	1	40	125	0.9516	3.323
3	5	35	81	0.9447	3.234
3	9	33	81	0.9505	3.23
1	7	35	82	0.9453	3.227
1	5	32	85	0.95	3.212
2	7	30	132	0.9525	3.191
3	8	29	71	0.9443	3.103
2	6	29	119	0.9447	3.095
2	5	28	61	0.9417	3.085
1	6	32	87	0.9372	3.084
3	7	29	109	0.9376	3.03
1	9	27	59	0.9377	3.02
3	2	29	80	0.9316	3.019

are critically important in terms of their conservation status. This information is essential to be able to manage an area's conservation and rehabilitation.

4.3.1. Philippine Endemics

Among the 139 recorded species found in the area, 48 (34.53%) were found to be Philippine Endemic (Table 5). Noteworthy among the endemics is the *Cinnamomum nanophyllum* Kosterm, which was, so far, only recorded in Aurora (Mt. Alzapan).

4.3.2. Aurora Endemics

Table 6 shows the species which only have recorded occurrence in the province of Aurora. It includes *Cinnamomum nanophyllum* Kosterm. which was recorded to be found at Mt. Alzapan, and *Syzygium ramosii* (C.B.Rob.) Merr. Recorded in the province of Aurora.

4.3.3. Threatened Species

Philippine forests are homes to different critically important species. In the study, 29 species were found to be threatened as listed in the International Union for Conservation of Nature (IUCN) Redlist of Threatened Species and/or in the DENR Administrative Order (DAO) No. 2017-11 or the Updated National List of Threatened Philippine Plants and their Categories (Table 7).

Based on the IUCN red list the threatened species found in the area include 5 critically endangered (CR) species, 7 endangered (EN) species, and 8 vulnerable (VU) species. In the categorization of the DENR in the DAO No. 2017-11 there are 6 critically endangered (CR), 6 endangered (EN), and 7 vulnerable (VU) species. 5 other threatened species (OTS), and 5 are not in the list. All the critically

Table 5. Taxonomic list of Philippine Endemic species in Sitio Dicasalarin

No.	Species	Family	Transect
1	*Actinodaphne dolichophylla* (Merr.) Merr.	Lauraceae	1
2	*Adenanthera intermedia* Merr.	Fabaceaea	3
3	*Artocarpus blancoi* (Elmer) Merr.	Moraceae	2 & 3
4	*Artocarpus rubrovenius* Warb.	Moraceae	3
5	*Brackenridgea fascicularis* (Blanco) Fern.-Vill.	Ochnaceae	1, 2, & 3
6	*Canthium obovatifolium* (Merr.) Merr.	Rubiaceae	1
7	*Canthium subcapitatum* (Merr.) Merr.	Rubiaceae	1 & 3
8	*Chionanthus remotinervius* (Merr.) Kiew	Oleaceae	2
9	*Cinnamomum mercadoi* S.Vidal	Lauraceae	2 & 3
10	*Cinnamomum nanophyllum* Kosterm.	Lauraceae	3
11	*Dillenia luzoniensis* (Vidal) Merr.	Dilleniaceae	1, 2, & 3
12	*Diospyros pilosanthera* Blanco	Ebenaceae	3
13	*Diospyros vera* (Lour.) A.Chev.	Ebenaceae	1, 2, & 3
14	*Discocalyx micrantha* Merr.	Primulaceae	1, 2, & 3
15	*Discocalyx psychotrioides* Elmer	Primulaceae	1, 2, & 3
16	*Ficus balete* Merr.	Moraceae	3
17	*Garcinia rubra* Merr.	Clusiaceae	1, 2, & 3
18	*Greeniopsis discolor* Merr.	Rubiaceae	3
19	*Guioa discolor* Radlk.	Sapindaceae	2
20	*Helicia rigidiflora var robusta*	Proteaceae	1 & 2
21	*Homalium bracteatum* Benth.	Salicaeae	3
22	*Hopea acuminata* Merr.	Dipterocarpaceae	1
23	*Hopea malibato* Foxw.	Dipterocarpaceae	1
24	*Kibatalia elmeri* Woodson	Apocynaceae	3
25	*Lithocarpus apoensis* (Elmer) Rehder	Fagaceae	1, 2, & 3
26	*Litsea leytensis* Merr.	Lauraceae	3
27	*Madhuca lenceolata* (Merr.) Merr.	Sapotaceae	2
28	*Madhuca oblongifolia* (Merr.) Merr.	Sapotaceae	1, 2, & 3
29	*Mangifera altissima* Blanco	Anacardiaceae	1, 2, & 3
30	*Memecylon symplociforme* Merr.	Memecylaceae	1, 2, & 3
31	*Mitrephora multifolia* Elmer ex Weeras. & R.M.K.Saunders Elmer	Annonaceae	1 & 2
32	*Myristica colinridsdalei* W.J.de Wilde	Myristicaceae	1 & 2
33	*Myrsine fastigiata* (Elmer) Pipoly	Primulaceae	1, 2, & 3
34	*Osmoxylon eminens* (W.Bull) Philipson	Araliaceae	1
35	*Palaquium glabrum* Merr.	Sapotaceae	1 & 3
36	*Podocarpus macrocarpus* de Laub.	Podocarpaceae	1 & 2

Continued

37	*Psychotria luzoniensis* (Cham. & Schltdl.) Fern.-Vill.	Rubiaceae	1, 2, & 3
38	*Radermachera coriacea* Merr.	Bignoniaceae	2
39	*Shorea malibato* Foxw.	Dipterocarpaceae	1, 2, & 3
40	*Shorea polysperma* Merr.	Dipterocarpaceae	1 & 2
41	*Sindora supa* Merr.	Fabaceaea	3
42	*Syzygium curranii* (C.B.Rob.) Merr.	Myrtaceae	1
43	*Syzygium ramosii* (C.B.Rob.) Merr.	Myrtaceae	1, 2, & 3
44	*Terminalia darlingii* Merr.	Combretaceae	1, 2, & 3
45	*Trigonostemon longipes (*Merr.) Merr.	Euphorbiaceae	1, 2, & 3
46	*Tristaniopsis micrantha* (Merr.) Peter G.Wilson & J.T.Waterh.	Myrtaceae	1, 2, & 3
47	*Weinmannia luzoniensis* S.Vidal	Cunoniaceae	1 & 2
48	*Xanthostemon philippinensis* Merr.	Myrtaceae	1, 2, & 3

Table 6. Taxonomic list of Aurora Endemic species in Sitio Dicasalarin.

No.	Species	Family	Transect
1	*Cinnamomum nanophyllum* Kosterm.	Lauraceae	3
2	*Syzygium ramosii* (C.B. Rob) Merr.	Myrtaceae	1,2, &3

Table 7. Taxonomic list of threatened species in Dicasalarin.

No.	Species	Family	IUCN Redlist	DAO 2017-11	Transects
1	*Adenanthera intermedia* Merr.	Fabaceaea	VU	OTS	3
2	*Anisoptera thurifera* ssp *thurifera*	Dipterocarpaceae	VU	-	1 & 2
3	*Bhesa robusta* (Roxb.) Ding Hou	Celastraceae	LC	-	3
4	*Cinnamomum mercadoi* S.Vidal	Lauraceae	VU	OTS	2 & 3
5	*Dillenia luzoniensis* (Vidal) Merr.	Dilleniaceae	-	VU	1, 2, & 3
6	*Diospyros discolor* Willd.	Ebenaceae	-	VU	3
7	*Diospyros pilosanthera* Blanco	Ebenaceae	EN	-	3
8	*Diospyros pyrrhocarpa* Miq.	Ebenaceae	-	VU	2
9	*Diospyros vera* (Lour.) A.Chev.	Ebenaceae	EN	VU	1, 2, & 3
10	*Greeniopsis discolor* Merr.	Rubiaceae	-	CR	3
11	*Guioa discolor* Radlk.	Sapindaceae	EN	VU	2
12	*Hopea acuminata* Merr.	Dipterocarpaceae	CR	EN	1
13	*Hopea malibato* Foxw.	Dipterocarpaceae	CR	CR	1
14	*Kibatalia elmeri* Woodson	Apocynaceae	VU	OTS	3
15	*Lithocarpus apoensis* (Elmer) Rehder	Fagaceae	-	VU	1, 2, & 3
16	*Litsea leytensis* Merr.	Lauraceae	VU	EN	3

Continued

17	*Madhuca lenceolata* (Merr.) Merr.	Sapotaceae	EN	-	2
18	*Madhuca oblongifolia* (Merr.) Merr.	Sapotaceae	VU	EN	1, 2, & 3
19	*Mangifera altissima* Blanco	Anacardiaceae	VU	-	1, 2, & 3
20	*Myristica colinridsdalei* W.J.de Wilde	Myristicaceae	VU	CR	1 & 2
21	*Myristica philippinensis* Gand.	Myristicaceae	-	OTS	3
22	*Nageia wallichiana* (C.Presl) Kuntze	Podocarpaceae	-	OTS	1
23	*Podocarpus macrocarpus* de Laub.	Podocarpaceae	EN	EN	1 & 2
24	*Radermachera coriacea* Merr.	Bignoniaceae	-	VU	2
25	*Shorea malibato* Foxw.	Dipterocarpaceae	CR	CR	1, 2, & 3
26	*Shorea polysperma* Merr.	Dipterocarpaceae	CR	CR	1 & 2
27	*Sindora supa* Merr.	Fabaceaea	EN	EN	3
28	*Terminalia darlingii* Merr.	Combretaceae	EN	EN	1, 2, & 3
29	*Xanthostemon philippinensis* Merr.	Myrtaceae	CR	CR	1, 2, & 3

endangered species (IUCN and DAO classification) in the area are present in Transect 1. Thus, the conservation is mostly needed in this transect having all the species with the highest category of threatened species in the area.

5. Conclusion and Recommendations

Based on the results of the tree diversity study conducted, it is safe to say that Sitio Dicasalarin is a very highly diverse area. The study site is home to at least 139 species and 46 families. It obtained a very high Shannon Index value of 4.195 which indicates a very high diversity. The most abundant, most frequent and most important species found in the area was *Teijsmanniodendron ahernianum* (Merr.) Bakh. with 168 individuals and occurred in 24 out of 27 quadrats. Hence, it emerged as the most important species in the area having an importance value of 35.29 or 11.76% of the total value of all species.

The area can be considered very important for having so many noteworthy species. There were 48 Philippine endemic species wherein 2 of those were only found to have occurred in the province of Aurora. Lastly, there were 29 species found to be threatened as listed in IUCN and DAO 2017-11.

The study yielded important and vital results that can be useful in the field of science. However, there were certain limitations of the study that can be addressed in the future research undertakings. Firstly, the survey was only conducted in 1.08 ha divided into three transects with nine 20 by 20 m quadrat each in the forests of Sitio Dicasalarin of the Sierra Madre Mountain Range. It would be better to conduct studies in other parts of the mountain range to better assess its diversity. Some of the species were not fully identified to species level due to the absence of reproductive parts. Thus, species endemism and conservation status of the unidentified specimens remained unknown together with its identity. The collection of reproductive parts of the species must be performed in the

field in order to perform more accurate and convenient identification.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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