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Population Structure of Wanga(*Pigafetta elata*) and the Community of the Higher Plants in the District South Sangalla', Tana Toraja Regency

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Abstract : The aim of this study was to determine the structure, regeneration and population distribution patterns of Wanga (*Pigafetta elata*) and the community of the higher plants in the District South Sangalla', TanaToraja regency, Indonesia located in three villages namely RaruSibunuan, Tokesan, and Kaero. Importance Value Index (IVI) was obtained based on the density, frequency and dominance taken based on transects method. On each transect made 10 plots with a size of 10m x 10m. In each village created 3 transect each with a size of 100m x 10m. The data of vegetation were collected on plots by counting the number of individuals (density) of each species of trees, determine the presence of species (frequency) in the plot, and determine basal area by measuring the diameter of the trunk (dominance). *P. elata*has the highest IVI in Kaero village, followed by Tokesan and the lowest INP in Raru Sibunuan village. Regeneration of *P. elata* in three villages in South Sangalla' were in danger of extinction where only one seedling found at the location of study, and the density percentage of *P. elata* was very low at less than 10%. Population distribution patterns of *P. elata* and community of a high level of plants in the District South Sangalla' tend to clumped, where many species were found in the lowest interval class (1-5).
Keywords: Population structure, Wanga (*Pigafetta elata*), South Sangalla', TanaToraja, plant community.

Introduction

Sulawesi is one island in Indonesia with the uniqueness of endemic plants and animals. Biogeography of Sulawesi is including in Wallacea region. Wallacea region consisting of the island of Sulawesi, a half of Maluku, Banda islands, and Nusa Tenggara Barat islands, covering a total area of about 346 782 km^2. The area is very unique because it is a melting pot of plants, animals, and the others living from Asia and Australia, and is an area of transition ecology (ecoton) between the two continents[1,2,3].

Sulawesi has a high level of endemism of palm (72 %), where 68 % of species and 58% of the genus of palm that grows in this bioregion is the original from Sulawesi[3,4]. Among the types of palm, there are two are endemic to Central Sulawesi, i.e. *Gronophyllum sarasinorum* and *Pinanga longirachilla*. Other palm species endemic to Sulawesi was a Wanga/banga (*Pigafetta elata* Becc.)[5,6,7].

Based on the research results[8], the literature and observation showed that *P. elata* in South Sulawesi distrubuted in Enrekang (Latimojong mountainous region), North Luwu, North Toraja Regency, and TanaToraja. *P. elata* widely used by Torajanese as known very thick with the customs and culture inhabiting North Toraja Regency, and TanaToraja. One is a custom home building "AlangSura" (granary), which is maintained very well. Alang Sura likely "tongkonan" shaped but smaller and only consisted of one room on the top to store the grain[9]. The rod of *P. elata* used to be the materials a custom home[10]. The rod of *P. elata* used as pole buildings in TanaToraja granary because the stem is strong, long lasting, and difficult to climb by a rat[11,12]. The reasons causing this species were considered very important for the existence of society in Tana Toraja[13].

P. elata is needed by the local community, while its presence in nature was diminish, thus triggering the price of rods P. elata more expensive. The reduction of the population of *P. elata* in nature caused by the high usage by local communities, and the breeding process a little complicated.*P. elata* is a plant with pollinated processes helped by wind or insects, so if the population in the wild rarely doubted the successful of pollination.

Based on the background above, it is necessary to conduct a study to determine the population structure, regeneration, and the populations distribution pattern of *P. elata* and community of the higher plants in the District South Sangalla', Tana Toraja, South Sulawesi, Indonesia. It is important to do as a form of protection against *P. elata* as a plant endemic to Sulawesi, and as an effort to support cultural preservation of Torajanese.

Methods

This research was a descriptive research conducted by a survey on May and October 2015. The research located in the district Southern Sangalla', Tana Toraja Regency, i.e RaruSibunuan, Tokesan, and Kaero village. Determination of the three villages based on the presence of *P. elata* at those locations. The tools used include: GPS (global positioning system), altimeter, compass, clinometer, soil tester, raffia straps, and others.

This study uses a transect methods with plots. There was three transects size of 100m x 10m on each village. On each transect, there were 10 plots size of 10m x 10m, so that the total number of plots in the three villages as many as 90 plots. Transects in each village was positioned by purposive and determined by the presence of *P. elata*.

Vegetation data obtained through observation carried out in each plot observations: (1) each species found in the plot are calculated the number of individuals; (2) observing the presence or absence of each species in the plot; and (3) determine the basal area by measuring the diameter of the trunk at chest height. Measurement results can be calculated quantities such as the density, frequency, dominance, relative density (RD), relative frequency (RF), relative dominance (RD), and the Importance Value Index (IVI) were calculated and analyzed following the Mueller-Dumbois & Ellenberg formula[14].

Environmental factors measured were (1) altitude; 2) the height of the litter; 3) pH of the soil; 4) the percentage of canopy cover; 5) soil temperature; 6) soil moisture; 7) air pressure; and 8) slope elevation. Besides other environmental factors were collected geographic coordinates point and rainfall data. Geographic coordinates of the point used to determine the position of the observation location on a map, and data on average monthly rainfall in the district Sangalla 'Tana Toraja, South Sulawesi province during the last 5 years (obtained from the Meteorology and Geophysics Maros, Indonesia).

The relative importance of the species in the study area was determined by using the Importance Value Index (IVI) of the species that make up the tree vegetation. Density, frequency, and dominance calculated by the formula[15].IVI (species diversity and evenness) of each species calculated by using the formulas[16] and species richness[17].

Interval class of density distribution was done by the Sturge formula: 1 + 3.3 log (n). Where, *n* was the number of individual species[18]. Interval class for frequency distribution was determined by assigning 5 grade distribution, with the number of plots were 30 plots in each area of observation.

Results and Discussion

A. Results

The number of species found at the research location as many as 23 species consisted of 17 familia, and identified as many as 22 species (one species has not been identified, namely "Solo Wood"). Families with the highest number of species were Arecaceae and Moraceae that each has three species. Arecaceae was the most families that found and which belong to *P. elata*. There were 47.61 % of the species that can be consumed by local community (Table 1).

Table 1. Species and Familias List of Higher Plants at South Sangalla' District

No	Species	Indonesian or Local name	Familia
1	*Areca catechu* L.	Pinang	Arecaceae
2	*Arenga pinnata*(Wurmb) Merr.	Aren	Arecaceae
3	*Pigafetta elata*(Blume) H. Wendl.	Wanga	Arecaceae
4	*Mangifera indica* L.	Mangga	Anacardiaceae
5	*Leucaena leuchocepala*(Lamk.) de Wit	Lamtoro	Caesalpiniaceae
6	*Casuarina sp.*	Cemara	Casuarinaceae
7	*Garsinia mangostana*L.	Manggis	Clusiaceae
8	*Cyathea contaminans*(Hook) Copel	PakuTiang	Cyatheaceae
9	*Artocarpus heterophyllus*Lam.	Nangka	Euphorbiaceae
10	*Gliricidia maculata*(H. B. K) Steud.	Gamal	Fabaceae
11	*Tectona grandis* L.f..	KayuJati	Verbenaceae
12	*Duriozibethinus*Murr.	Durian	Bombacaceae
13	*Theobroma cacao* L.	Cokelat	Sterculiaceae
14	*Lansium domesticum*Corr.	Langsat	Meliaceae
15	*Toonas urenii*(Blume) Merr.	Suren	Meliaceae
16	*Ficus benjamina*L.	Beringin	Moraceae
17	*Ficus septica*Burm. F.	Awar-Awar	Moraceae
18	*Ficus sp.*	Karet	Moraceae
19	*Psidium guajava*L.	JambuBiji	Myrtaceae
20	*Pinu smerkusii*Jungh. & de Vriese	Pinus	Pinaceae
21	*Coffea arabica*L.	Kopi	Rubiaceae
22	*Citrus maxima L.*	Jerukbesar	Rutaceae
23	-	Kayu Solo	-

1. Population Structure of*P. elata* and dan Community of The Higher Plant

The population structure of *P. elata* and the community of the higher plant on three research locations, RaruSibunuan, Tokesan, and Kaero village are shown in Table 2, Table 3 and Table 4.

Table 2. Populations Structure of *P. elata* and Community of the Higher Plant at Raru Sibunuan Village

No.	Species	Absolut Density	Absolut Frequency	Absolut Dominance	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	IVI
1	*Arengapinnata*(Wurmb) Merr.	0,068	61,013	0,021	38,202	48,637	30,435	117,274
2	Kayu Solo	0,012	12,568	0,009	6,742	10,018	13,043	29,803
3	*Theobroma cacao* L.	0,026	3,210	0,007	14,607	2,558	10,145	27,310
4	*Ficusbenjamina*L.	0,001	31,428	0,001	0,562	25,053	1,449	27,065
5	*Toonasurenii*(Blume) Merr.	0,011	2,878	0,007	6,180	2,294	10,145	18,619
6	*Pigafettaelata*(Mart.) H. Wendl.	0,01	7,261	0,003	5,618	5,788	4,348	15,754
7	*Gmelinaarborea*Roxb.	0,01	2,961	0,005	5,618	2,361	7,246	15,225
8	*Leucaenaleuchocepala*(Lamk.) de Wit	0,015	0,305	0,003	8,427	0,243	4,348	13,018
9	*Coffeaarabica*L.	0,012	0,276	0,004	6,742	0,220	5,797	12,758
10	*Casuarina sp.*	0,005	0,576	0,002	2,810	0,459	2,899	6,167
11	*Artocarpusheterophyllus* Lam.	0,002	1,139	0,002	1,124	0,908	2,899	4,930
12	*Psidiumguajava*L.	0,002	0,090	0,002	1,124	0,071	2,899	4,094
13	*Mangiferaindica*	0,002	0,814	0,001	1,124	0,648	1,449	3,221
14	*Duriozibethinus*Murr.	0,001	0,634	0,001	0,562	0,505	1,449	2,516
15	*Citrus maxima L.*	0,001	0,296	0,001	0,562	0,236	1,449	2,247
Total		0,178	125,447	0,069	100	100	100	300

Table 3. Populations Structure of P. elata and Community of the Higher Plant at Tokesan Village

No.	Species	Absolut Density	Absolut Frequency	Absolut Dominance	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	IVI
1	*Arengapinnata*(Wurmb) Merr.	0,023	28,378	0,012	9,127	26,531	9,231	44,888
2	*Casuarina sp.*	0,034	10,997	0,016	13,492	10,281	12,308	36,081
3	*Theobroma cacao* L.	0,039	4,889	0,017	15,476	4,571	13,077	33,124
4	Kayu Solo	0,014	17,721	0,011	5,556	16,568	8,462	30,585
5	*Pigafettaelata*(Mart.) H. Wendl.	0,016	16,016	0,008	6,349	14,973	6,154	27,476
6	*Leucaenaleuchocepala*(Lamk.) de Wit	0,048	1,108	0,007	19,048	1,036	5,385	25,468
7	*Toonasurenii*(Blume) Merr.	0,016	7,583	0,012	6,349	7,090	9,231	22,670
8	*Gmelinaarborea*Roxb.	0,014	7,537	0,011	5,556	7,047	8,462	21,064
9	*Areca catechu* L.	0,012	4,695	0,009	4,762	4,390	6,923	16,075
10	*Coffeaarabica*L.	0,011	0,326	0,006	4,365	0,305	4,615	9,286
11	*Garsiniamangostana*L.	0,008	0,683	0,006	3,175	0,639	4,615	8,429
12	*Lansiumdomesticum*Corr.	0,005	2,329	0,003	1,984	2,178	2,308	6,470
13	*Duriozibethinus*Murr.	0,004	0,819	0,004	1,587	0,766	3,077	5,430
14	*Ficus sp.*	0,003	1,461	0,003	1,190	1,366	2,308	4,864
15	*Ficussepticа*Burm. F.	0,003	1,415	0,003	1,190	1,323	2,308	4,821
16	*Artocarpusheterophyllus*Lam.	0,002	1,004	0,002	0,794	0,938	1,538	3,270
Total		0,252	106,964	0,13	100	100	100	300

Table 4. Populations Structure of P. elata and Community of the Higher Plant at Kaero Village

No.	Species	Absolut Density	Absolut Frequency	Absolut Dominance	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	IVI
1	*Theobroma cacao* L.	0,1	13,194	0,023	31,746	18,042	25,000	74,788
2	*Pigafettaelata*(Mart.) H. Wendl.	0,025	25,344	0,015	7,937	34,656	16,304	58,897
3	*Coffeaarabica*L.	0,068	1,555	0,014	21,587	2,126	15,217	38,930
4	*Arengapinnata*(Wurmb) Merr.	0,012	15,720	0,005	3,810	21,496	5,435	30,740
5	*Leucaenaleuchocephala*(Lamk.) de Wit	0,054	1,307	0,010	17,143	1,787	10,870	29,800
6	*Gliricidia maculate*	0,022	3,571	0,006	6,984	4,883	6,522	18,389
7	*Gmelinaarborea*Roxb.	0,01	3,602	0,006	3,175	4,925	6,522	14,622
8	*Casuarina sp.*	0,01	2,260	0,004	3,175	3,090	4,348	10,613
9	*Mangiferaindica*L.	0,005	1,976	0,003	1,587	2,702	3,261	7,550
10	*Artocarpusheterophyllus*Lam.	0,003	0,960	0,002	0,952	1,312	2,174	4,438
11	*Duriozibethinus*Murr.	0,002	1,127	0,001	0,635	1,541	1,087	3,263
12	*Citrus maxima L.*	0,002	1,087	0,001	0,635	1,487	1,087	3,209
13	*Pinusmerkusii*Jungh. & de Vriese	0,001	1,270	0,001	0,317	1,736	1,087	3,141
14	*Cyatheacontaminans*(Hook)	0,001	0,158	0,001	0,317	0,217	1,087	1,621
Total		0,315	73,131	0,092	100	100	100	300

2. Population Regeneration of P. elata and the Community of Higher Plant

The population regeneration of P. elata and the surrounding communities of higher plants can be determined based on the grade distribution of stem diameter (Figure 1 and Figure 2). Based on the distribution classes of diameter, the increasing number of P. elata caused by the increasing the stem diameter. Interval classes of frequency of *P. elata* in the three villages shown that only a few species of *P. elata* found in small diameter (4-9 species), while many species of *P. elata* with the large diameter (40-45) were found. This led to the regeneration of P. elata in the observation location is very vulnerable to extinction because it found only one seed (Figure 1). The diameter class distribution of the higher plants community has decreased, this indicates that the regeneration in higher plants quite well because most are at the level of saplings (Figure 2).

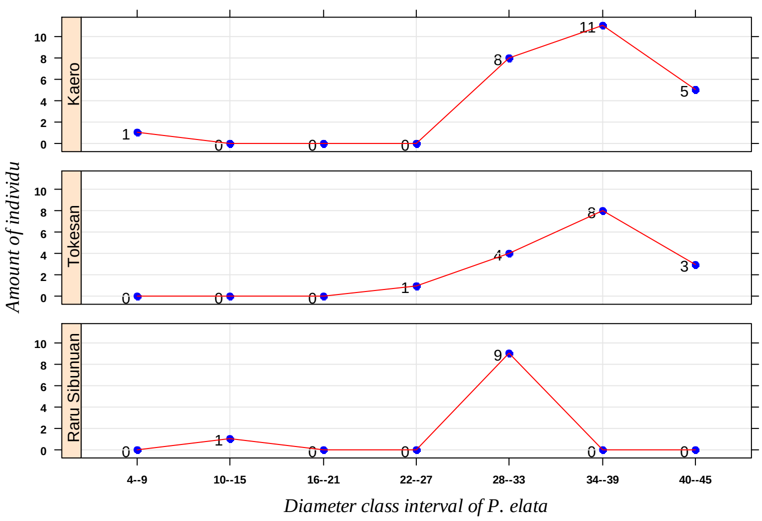

Figure 1. Class Distribution of Stem Diameter of *P. elata* Population

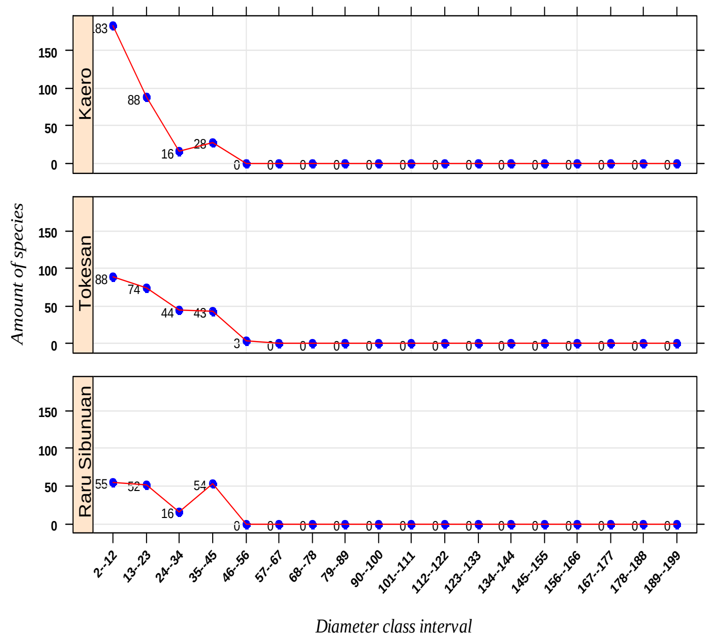

Figure 2. Class Distribution of Stem Diameter of Higher plant Community

3. Distribution Pattern of *P. elata* Population and The Higher Plant Community

The pattern of population distribution of *P. elata* and the higher plants communities can be determined based on the distribution of the frequency interval classes (Figure 3). The result of observation showed that many species were at the lowest interval class compared to other interval class, it was indicated that most of the species were spread with clumped pattern.

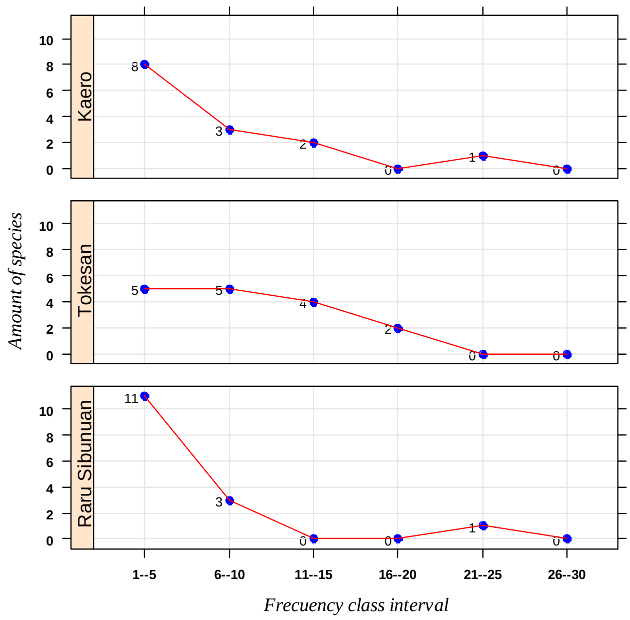

Figure 3. Interval Class Distribution of Species Frequency on each Location

4. Species Diversity Index and Environmental Factors on the Higher Plants Comunities

Figure 4 shows that the RaruSibunuan village has the highest score on the index of species richness, the index of species diversity Wienner Shannon was the lowest compared to the other two villages. Tokesan village has an index value of species diversity and species evenness index was the highest compared to Kaero and RaruSibunuan village. Kaero village has the lowest value of species richness index and index of species evenness of the other two villages.

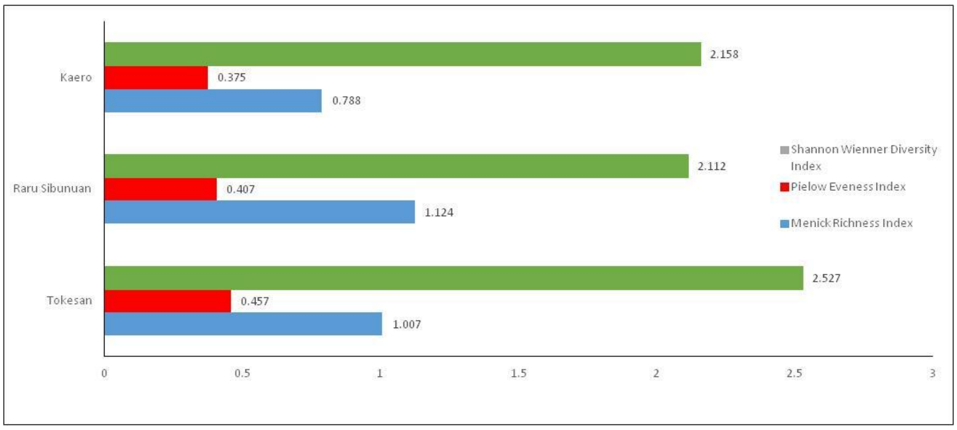

Figure 4.ShanonWienner Diversity Index, Richness Index, and Evenness Index at Research Locatio

Table 5. Descriptive Data Analysis of Environmental Factors at South Sangalla' District

Name of Villages	Descriptive Statistics	Environmental Factors							
		Altitude (m)	Height of Litter (cm)	pH	Canopy Cover (%)	Soil Temperature (^oC)	Soil Moisture	Air Pressure (atm)	Slope Elevation (^{o})
RaruSibunuan	Average	879.4	2.43	5.65	80.2	27	79	1014.8	50
	Minimum Value	870	1.5	5.2	70	27	74	1010	50
	Maximum Value	889	3.7	5.9	90	27	88	1016	50
Tokesan	Average	789.7	2.71	5.48	77.0	28	77.3	928.81	40
	Minimum Value	781	1.4	2.8	65	28	72	928.2	40
	Maximum Value	800	3.7	5.8	90	28	85	929.7	40
Kaero	Average	927.4	2.76	5.50	85.4	27	82.9	1017	70
	Minimum Value	926	1	5.2	50	27	75	1016	70
	Maximum Value	930	5	5.8	95	27	89	1018	70

Discussion

1. Population Structure of *P. elata* and the Higher Plants Communities

a. Density of the Higher Plant Communities

The density of higher plants communities at each observation location in the South Sangalla' district indicates that the families Arecaceae and Moraceae has a number of species was more than other families. Families with more species were found suspected to have adaptability and tolerance better relatively than other families. Families Arecaceae has the most members of the species, and that families have a good adaptation to the environment.

In addition, many rare species was found at the location of observation. According to the hypothesis[19] that predators and pathogens were the causing of the rare species in tropical rainforests. If the seedlings grow close to their parents, the chances for survival were very few because very easily found by predators or attacked by pathogens, so to survive the seedlings should grow away from its parent, thus the opportunities to be found by predators and pathogens was low[20].

b. Community Frequency of the Higher Plants

Teobrema cacao was a species with the highest frequency compared to other species throughout the observation location. *Arenga pinnata* was the second highest frequency. The high frequency (presence) of those species was allegedly due to environmental factors that support the growth of those species. *A. pinnata*weel growth at the area with abundant sunlight and water.These species grow very well in warm areas with full sunlight and water supplies on arable land, and could grow in altitude from 0-1400 m[21].

Species that have the lowest frequency was *Ficus benjamina* and *Pinus merkusii*. Despite the presence of F. Benjamina was minimal, this species has a distinctive character with a large basal area. In addition, this species was included in the families Moraceae that was quite commonly found at the observation locations, which serves as an indicator of groundwater.

c. Dominance of the Higher Plants Communities

Arengapinnata was the species with the highest of dominance value in RaruSibunuan village. In the Tokesan village, the highest of dominance value consecutive *Theobroma cacao*,*Casuarina* sp, and *Arenga pinnata*. In the Kaero village,the species with the highest dominance value was *Theobroma cacao*. The previous study result[22]showed that each species of plant has a minimum, maximum and optimum condition to the environmental factors. Species which dominates means having a wider range limitations when compared with other species to environmental factors, so that the wide tolerance range of environmental factors causing this species would have a wide distribution.

d. Importance Value Index (IVI) of the Higher Plants Communities

Analysis of vegetation showed that *A. pinnata* was the species with the highest IVI in Raru Sibunuan and Tokesan villages, and the fourth highest IVI in Kaero village. IVI could be used to determine the degree of dominance of species in a plant community[23]. The dominant species (most powerful) in a community was a species that has the greatest IVI, so *A. pinnata* was the most dominant species in Raru Sibunuan and Tokesan village.

T. cacao was the species with the highest IVI in Kaero village, and this species as the third highest IVI in Raru Sibunuan and Tokesan villages. It was presumably because this species has a high tolerance to environmental conditions of the study. The success of each species to dominate an area was affected by its ability to adapt optimally to all physical environmental factors, chemical factors and biotic factors[24].

2. Regeneration of *P. elata* Population and the Higher PlantsCommunities

Based on the diameter interval class of *P. elata* stem, regenerating unfavorable because only a few seedling of *P. elata* were found at the locations. The higher plants communities had a high regeneration as seen from the large number of seedlings were found.

3. Distribution Patterns of *P. elata* Population and the Higher PlantsCommunities

The results of research showed that almost 50% of the tree species cultivated with very low of the presence value. It indicates that many species have clumped distribution patterns. The plants were rarely found in a uniform distribution pattern in nature, but generally have a clumped pattern[25].

The pattern of spread depended on the physicochemical properties of the environment as well as the privilege of a biological organism itself[26]. An infinite variety of such distribution patterns that occur in nature could be divided into three categories, i.e: 1) regular or uniform, in which individuals are at a certain place in the community. This pattern occurs when there is a tough competition causing competition that encourages sharing the same living space, 2) randomized, individuals are distributed in some places and cluster in other places. This pattern is rare and it happens if environment homogeneously, and 3) groups or clumped, individuals are always in groups and are very rarely seen separately. This pattern is generally found in nature because of the need for the same environmental factors.

4. Shannon-Wienner diversity index, Menhienick Richness Index, and Pieleou Evenness Index of the Higher Plants Communities

Tokesan village has the highest species diversity index value compared Raru Sibunuan and Kaero villages, even based on each values showed no striking difference. It was caused by the number of species and individuals was almost equal, so the index value of species diversity was not much different. High diversity index showed that a community has a high complexity due to the interaction of species that occur in the community is high[23]. The highest species evenness index was also demonstrated at Tokesan village. If some species dominant while other species are not dominant or density was lower, then the value of evennes would be lower[27]. On the fact, the highest of richness index at Raru Sibunuan village, but not much different at Tokesan village. Diversity was a combination of species richness and evenness. Species diversity index could be used as important information about the community[25].

Kaero village has the lowest value from the other two villages regarded to species richness index and species evenness index, and RaruSibunuan village has the lowest value on the species diversity index. The low value of diversity index, richness index, and evenness index of the higher plants communities at the two villages could be caused by the high of ecological pressure. It is similarly with the statement[28] that the low diversity index showed that there was the high ecological pressure, both from the biotic factors (competition among individual plants for each level) or abiotic factors. The high ecological pressures caused not all kinds of plants can survive in an environment.

The low index of species richness and species evenness in Kaero village, might be caused by the location has a high elevation compared to the other two villages. The high elevation caused the water rapidly down the slope[29]. The more rugged of surface, the greater power of water scraped the arable of ground surface, so that the thickness of the soil was reduced. The sloping ground each unit usually has a fewer number of flora than on flat ground. It is caused by water reserves gone since moving down rapidly.

Conclusions

Based on the results of research and discussion, it is conclude that the population structure of Wanga (*P. elata*) in South Sangalla' district varied at the three locations with the highest to lowest IVI sequentially, Kaero, Tokesan, and Raru Sibunuan village. Regeneration of *P. elata* in the South Sangalla' district was in danger of extinction with only one seed was found, and the percentage of *P. elata* density was very low at less than 10%. While the higher plants communities has a good regeneration because it is found in the form of seedlings. The pattern of population distribution of *P. elata* and higher plants communities surrounding in the South Sangalla' district tend to clumped, where many species were found in the lowest interval class (1-5). The structure of the higher plants communities with the highest IVI at three locations was Palm (*Arenga pinnata*) and the lowest IVI was *Cyathea contaminans*.

Suggestion

Expected to observers of plant biodiversity to conduct further research on plants Wanga (*P. elata*) in other areas in TanaToraja, South Sulawesi province that has not been explored.

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