BIODIVERSITAS
Volume 18, Number 3, July 2017
Pages: 1218-1225

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d180346

Diversity of plant species in paddy ecosystem in West Sumatra, Indonesia

ENIE TAURUSLINA AMARULLAH[1,2,♥], TRIZELIA[3], YAHERWANDI[3], HASMIANDY HAMID[3]
[1]Food and Horticulture Plant Protection Office of West Sumatra. Complex Agriculture Office, Jl. Raya Padang-Indarung Km.8, Bandar Buat, Padang 25231, West Sumatra, Indonesia. Tel. +62-751-72701, Fax. +62-751-72702, ♥email: etauruslina@yahoo.com
[2] Universitas Andalas, Campus Limau Manih, Padang 24063, West Sumatra, Indonesia
[3]Departement of Plant Protection, Faculty of Agriculture, Universitas Andalas. Campus Limau Manih, Padang 24063, West Sumatra, Indonesia

Manuscript received: 21 September 2016. Revision accepted: 25 July 2017.

Abstract. *Tauruslina EA, Trizelia, Yaherwandi, Hamid H. 2017. Diversity of plant species in paddy ecosystem in West Sumatra. Biodiversitas 18: 1218-1225.* Community is a group of living things which have adjusted and inhabited a natural habitat. Characteristics of the community in an environment are its diversity. The diversity of the plants is a plant species that occupy an ecosystem. The research was aimed at determining species diversity, the dominance of plant species and summed dominance ratio (SDR) in paddy ecosystem. The plant samples were taken from the location of endemic areas of brown plant hopper in Tanjung Mutiara Subdistrict, Agam District West Sumatra. Sampling was done by using two methods, (i) survey methods with direct data collection; (ii) squares method, observation of sample plots in the field. The level of diversity of plant species was analyzed using diversity index of Shannon-Wiener (H'). Plant species dominance was analyzed using dominance index (C). The results showed that index value of Shannon-Wienner ranged 1.00 – 1.73, which indicated that the category of diversity level of plants was medium. Dominance index ranged 0.03 - 0.08 which meant there were a dominant species among the plants in the study areas. The highest SDR in the ecosystem type III were *Cyperus rotundus* (40.87%) and *Borreria laevis* (37.43%), in the type I was *C. rotundus* (34.90%) and in type II was *Portulaca oleracea* (20.08%). The dominant plant species found in the type I were *C. rotundus*, *Eleusine indica*, *Borreria laevis*, in type II were *P. oleracea*, *C. rotundus*, *Amaranthus spinosus* and in type III were *C. rotundus*, *B. laevis,* and *A. spinosus.*

Keywords: Paddy ecosystem, diversity, species dominance

INTRODUCTION

Some species of living are occupying a natural habitat in which each individual could find its need in the environment. A group living together in a natural habitat and has adjusted to an environment is called community. The characteristic of a community in an environment is diversity. The more diverse the biotic components, the higher the diversity and vice versa (Mardiyanti et al. 2013).

Biological diversity covers plants and animals which diverse in an area. Indonesia is one of the fourth highest plant diversity in the world covering about 38.000 plant species (Nugoroho 2015). Plant diversity is the species diversity of the plants occupying an ecosystem. An ecosystem can be maintained through interactions among the species that form it and the interaction between the species and environment (Saleh et al. 2016). Indonesian richness of germplasm in 2010 is noted 27.500 species of flowering plants, 10% of world flowering plants (Pratiwi 2012). According to Yaherwandi (2009), the agricultural landscape consists of paddy ecosystem and weeds. Diversity of paddy agroecosystem does not only affect the diversity of natural enemies in plantation but also its abundance and effectiveness. In an agroecosystem, the role of weeds cannot be ignored because their flowers can provide alternative feed and as the refuge for insects. Most insect predators and parasitoids get benefit from weeds.

Santosa and Sulistyo (2007) stated that paddy ecosystem theoretically is an unstable ecosystem. The stability of paddy ecosystem is not only determined by the diversity of community structure but also by the characteristics of its components, interaction among ecosystem components and species diversity. Paddy ecosystem tends to have limited diversity because human want to have certain plants only which live in the ecosystem, while unwanted plants are removed. Therefore, plant diversity in paddy ecosystem tends to be limited depends on management done by farmers. Before paddy is planted, in the ecosystem there are certainly various species of plants grow. Interaction and species diversity are very important to study to determine the diversity of plant species in natural habitat (Mardiyanti et al. 2013). Information on plant diversity in paddy ecosystem is very crucial as an early step to study about the ecosystem stability. This study was aimed at studying the plant species diversity, dominant plant species and Summed Dominance Ratio (SDR) in paddy ecosystem.

MATERIALS AND METHODS

Study sites

Research was conducted in paddy ecosystems endemic to brown planthopper in Jorong Cacang Tinggi, Nagari Tiku Utara, Tanjung Mutiara Subdistrict, Agam District, West Sumatra, Indonesia at altitude 1-2 meter above sea level (Figure 1). The research was conducted from July-December 2015.

Methods

This was quantitative research using survey method. Sampled locations were needed to determine paddy ecosystem stability. Stability of paddy ecosystem was determined based on the level of plant species diversity.

Sample locations and collections

The locations chosen were those in which the intensity of brown planthopper was increasing. The locations were grouped into three categories, type I (paddy ecosystems located on the edge of rice field), type II (ecosystem located in the middle of rice field) and type III (ecosystem bordered with irrigation system). Samples were collected directly using a quadratic method from sampled plots arranged randomly. There were ten sampled plots, and in each plot there were ten subplots. So, there were 100 total sampled sub plots. The size of a subplot was 1×1 m^2 because the living plants species were mainly herbs. It referred to Gunawan et al. (2010) that the use of quadrate with the size 10×10 m^2 was for tree level, 4×4 m^2 for undergrowth woody vegetations up to 3 m height and 1×1 m^2 for undergrowth vegetations or herbs.

Data analysis

Vegetation analysis

Data collected were analyzed to determine important value index (IVI). The important value was obtained from the sum of relative density, relative frequency and relative dominance (Kainde et al. 2011).

The measure of IVI was taken to determine plant species dominance in a community. A high IVI shows a high dominance (Saharjo and Cornelio 2011; Saputra and Labibah 2011). The value of *summed dominance ratio* (SDR) is based on plant IVI.

Plant species diversity

Shannon-Wiener Index was used to determine the diversity of plant species (H’) (Prasetyo 2007).

Table 1. Standard value for diversity index (Fitriana 2006)

Reference value	Description
H’ < 1,0	Diversity is low, poor, very low productivity, high stress, unstable ecosystem
1,0 < H’ < 3,322	Diversity is medium, enough productivity, enough ecosystem balance, medium ecological stress
H’ > 3,322	Diversity is high, steady ecosystem stability, high productivity, resist ecological stress

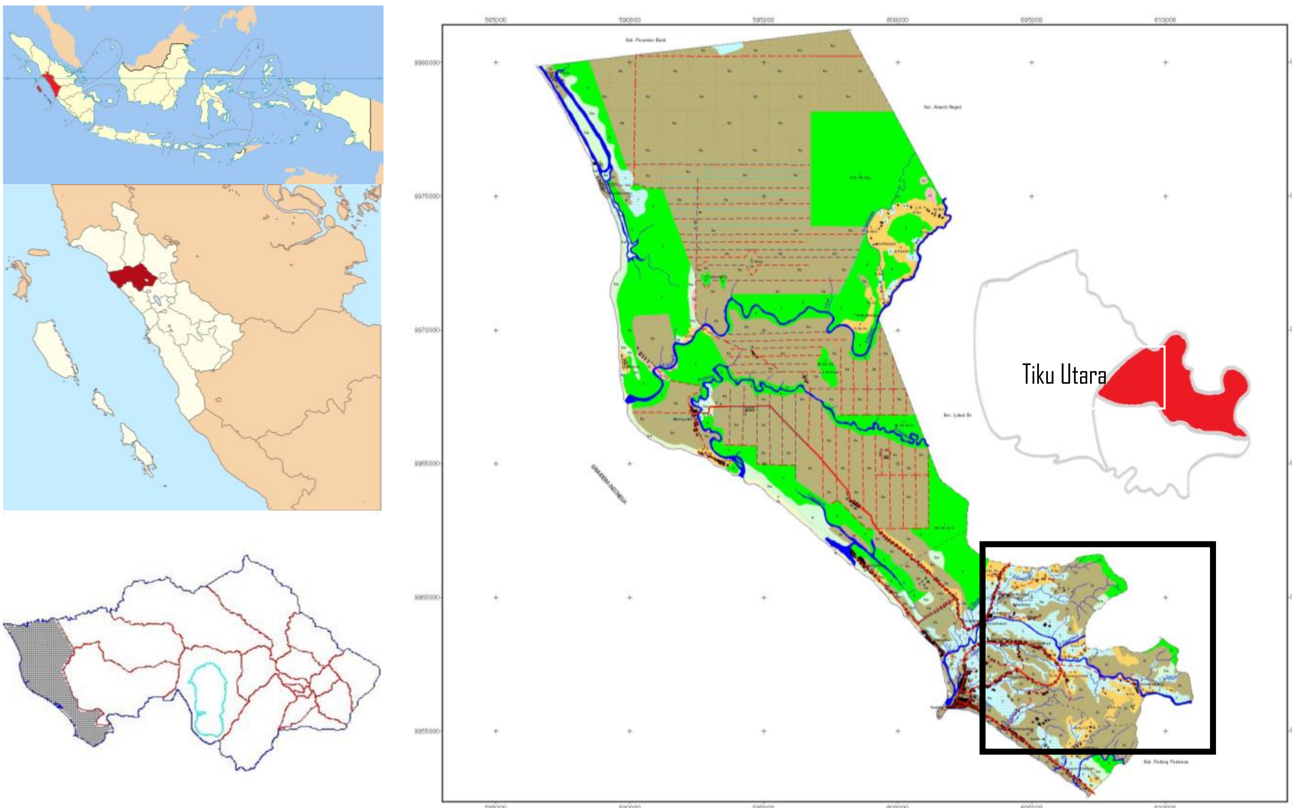

Figure 1. Research location in Nagari Tiku Utara, Tanjung Mutiara Subdistrict, Agam District, West Sumatra, Indonesia

Dominance index

Dominance index (D) was used to determine species richness and balance on total individuals for each species in an ecosystem. If dominance is concentrated to one species, the dominance index value increases. If some species dominate together, dominance index value is low. To determine plant species dominance the following Simpson Index (Kainde et al. 2011).

Dominance index ranged 0 – 1. D = 0, means there is no species dominates others or community structure is stable. D = 1, means there is a species dominates others or community structure is unstable because of ecological stress (Kainde et al. 2011).

RESULTS AND DISCUSSIONS

Ecosystem condition at research locations

Three different conditions of paddy location were used in this study i.e. type I (paddy ecosystems located on the edge of rice field), type II (ecosystem located in the middle of rice field) and type III (ecosystem bordered with irrigation system). The condition of the location affects the changes and plant developmental process known as succession.

At the time the paddy plants were one month old, plant diversity was limited on herbs. Mostly plants found were weeds. According to Wardah et al. (2012), flowering weeds or undergrowth plants were plant community that constructs underground stratification near soil surface (Figure 2).

Simpson dominance index (C) and Shannon-Wiener diversity index (H')

Total plant species found from all lands endemic to brown plant hoppers were 12 species belonged to eight families. Eight species of plants were found in type I, three species in type II and 11 species in type III land (Table 2). Generally, the plant species found in three types of lands belonged to family Passifloraceae, Amaranthaceae, and Cyperaceae.

It was found that there was different plant species dominance in three types of paddy ecosystems. The highest species richness was found in type II ecosystem (11 species) followed with type I (eight species) and type III (three species). The highest dominance index (C) and diversity index (H') were found in type II paddy ecosystem. Hypothetical data on plant species diversity in different types of ecosystems were presented in Table 3. Important value index (IVI) and summed dominance ratio (SDR) of plants IVI were an index that shows the importance of role or effect of plant species on vegetation in one location. IVI was used in interpreting composition of one plant community (Maridi et al. 2015). SDR was determined based on the composition of plant species. Vegetation in ecosystems showed variation in plant species among three different ecosystems. The highest IVI and SDR of plant species were found in type III ecosystem. The results of vegetation analysis in various ecosystems were presented in Table 4.

Figure 3 shows that in ecosystem type I the highest IVI was found on *Cyperus rotundus* (69.80) followed by *Eleusine indica* (33.05) and *Borreria laevis* (28.20).

Figure 2. One of sampled locations of vegetation observed

Figure 4 shows the highest IVI of plant species constructing type II paddy ecosystem was species *Portulaca oleracea* (40.16) followed by *Cyperus rotundus* (38.07) and *Amaranthus spinosus* (30.01). Figure 5 shows the highest IVI on plant species constructing type III paddy ecosystem was species *Cyperus rotundus* (81.75) followed by *Borreria laevis* (74.86) and *Amaranthus spinosus* (43.38).

Species dominance

Observation in the field indicated that dominant species found in each type of ecosystem were different. The dominant species found in type I ecosystem were *Cyperus rotundus*, *Eleusine indica*, *Borreria laevis*, in type II ecosystem were *Portulaca oleracea*, *C. rotundus*, *Amaranthus spinosus*, and in type III ecosystem were *C. rotundus*, *B. laevis*, *A. spinosus* (Figure 6).

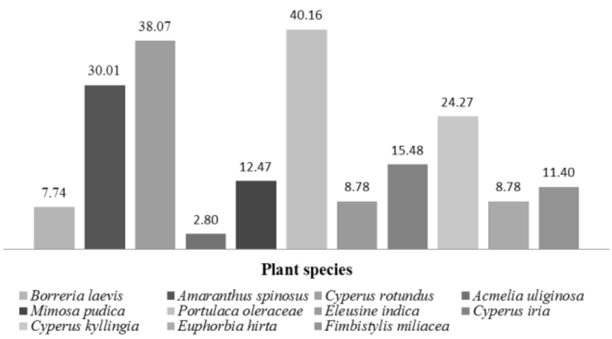

Figure 4. Important value index (IVI) of plant species in type II paddy ecosystem

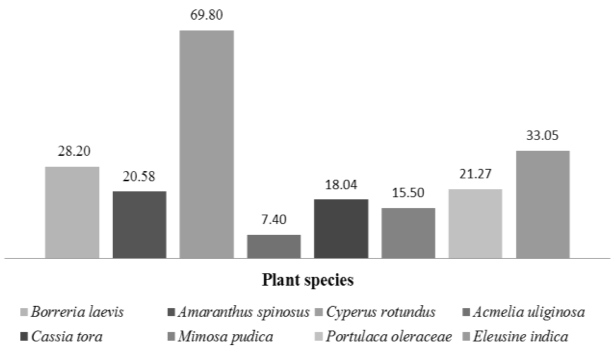

Figure 3. Important value index (IVI) of plant species in type I paddy ecosystem

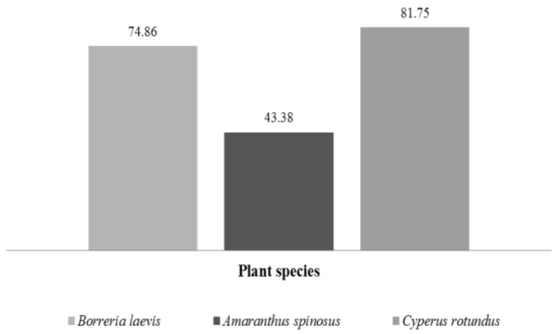

Figure 5. Important value index (IVI) of plant species constructing type III paddy ecosystem

Table 2. Plant species found in paddy ecosystem in different types of ecosystem

Family	Plant species in three types of ecosystem		
	Type I	Type II	Type III
Passifloraceae	*Borreria laevis* (Lamk.) Giseb	*Borreria laevis* (Lamk.) Giseb	*Borreria laevis* (Lamk.) Giseb
Amaranthaceae	*Amaranthus spinousus* L.	*Amaranthus spinousus* L.	*Amaranthus spinousus* L.
Cyperaceae	*Cyperus rotundus* L.	*Cyperus rotundus* L.	*Cyperus rotundus* L.
Cyperaceae	-	*Cyperus iria* L.	-
Cyperaceae	-	*Cyperus kyllingia* Endl.	-
Cyperaceae	-	*Fimbistylis miliacea* Linn. (Vahl)	-
Asteraceae	*Acmelia uliginosa*	*Acmelia uliginosa*	-
Fabaceae	*Cassia tora* L.	-	-
Fabaceae	*Mimosa pudica*	*Mimosa pudica*	-
Portulaceae	*Portulaca oleracea* L.	*Portulaca oleracea* L.	-
Poaceae	*Eleusine indica* (L.) Garth	*Eleusine indica* (L.) Garth	-
Euphorbiacea	-	*Euphorbia hirta* Linn	-

Tabel 3. Hypothetical data on plant species diversity in different types of ecosystem

Plant species	Types of ecosystem								
	I			II			III		
	n_i	p_i	p_i^2	n_i	p_i	p_i^2	n_i	p_i	p_i^2
Borreria laevis	480	0.14	0.020	24	0.02	0.001	200	0.46	0.210
Amaranthus spinousus	200	0.06	0.001	176	0.32	0.100	64	0.15	0.020
Cyperus rotundus	1648	0.47	0.220	488	0.32	0.100	168	0.11	0.010
Acmelia uliginosa	128	0.04	0.001	24	0.01	0.001	-	-	-
Cassia tora	112	0.03	0.001	-	-	-	-	-	-
Mimosa pudica	152	0.04	0.001	2	-	-	-	-	-
Portulaca oleracea	464	0.13	0.020	520	0.34	0.120	-	-	-
Eleusine indica	760	0.22	0.040	40	0.03	0.001	-	-	-
Cyperus iria	-	-	-	48	0.03	0.001	-	-	-
Cyperus kyllingia	-	-	-	88	0.06	0.010	-	-	-
Euphorbia hirta	-	-	-	40	0.03	0.001	-	-	-
Fimbistylis miliacea	-	-	-	80	0.05	0.001	-	-	-
Number of individual (N)	3464			1530			432		
Number of species	8			11			3		
Shannon-Wiener index (H’)	1.67			1.73			1.00		
Dominance index (D)	0.03			0.03			0.08		

Tabel 4. Results of vegetation analysis in various paddy ecosystems

Plant species	Types of ecosystem	D	RD (%)	F	RF (%)	IVI (%)	SDR (%)
Borreria laevis	I	464	13.39	0.2	14.81	28.20	14.10
	II	24	1.57	0.1	6.17	7.74	3.87
	III	200	46.29	0.2	28.57	74.86	37.43
Amaranthus spinosus	I	200	5.77	0.2	14.81	20.58	10.29
	II	176	11.50	0.3	18.51	30.01	15.00
	III	64	14.81	0.2	28.57	43.38	21.69
Cyperus rotundus	I	1648	47.58	0.3	22.22	69.80	34.90
	II	488	31.90	0.1	6.17	38.07	19.03
	III	168	38.89	0.3	42.86	81.75	40.87
Acmelia uliginosa	I	128	3.70	0.05	3.70	7.40	3.70
	II	24	1.57	0.02	1.23	2.80	1.40
	III	-	-	-	-	-	-
Cassia tora	I	112	3.23	0.2	14.81	18.04	9.02
	II	-	-	-	-	-	-
	III	-	-	-	-	-	-
Mimosa pudica	I	152	4.39	0.15	11.11	15.50	7.75
	II	2	0.13	0.2	12.34	12.47	6.23
	III	-	-	-	-	-	-
Portulaca oleracea	I	480	13.86	0.1	7.41	21.27	10.63
	II	520	33.99	0.1	6.17	40.16	20.08
	III	-	-	-	-	-	-
Eleusine indica	I	760	21.94	0.15	11.11	33.05	16.52
	II	40	2.61	0.1	6.17	8.78	4.39
	III	-	-	-	-	-	-
Cyperus iria	I	-	-	-	-	-	-
	II	48	3.14	0.2	12.34	15.48	7.74
	III	-	-	-	-	-	-
Cyperus kyllingia	I	-	-	-	-	-	-
	II	88	5.75	0.3	18.52	24.27	12.13
	III	-	-	-	-	-	-
Euphorbia hirta	I	-	-	-	-	-	-
	II	40	2.61	0.1	6.17	8.78	4.39
	III	-	-	-	-	-	-
Fimbistylis miliacea	I	-	-	-	-	-	-
	II	80	5.23	0.1	6.17	11.40	5.70
	III	-	-	-	-	-	-

Note: D=density, RD=relative density, F=frequency, RF=relative frequency, IVI=important value index, SDR=summed dominance ratio

Figure 6. Dominant plant species found in type I ecosystem (A) *Cyperus rotundus*, (B) *Eleusine indica*, (C) *Borreria laevis*; type II (D) *P. oleraceae* (E) *C. rotundus*, (F) *Amaranthus spinosus*; type III (G) *C. rotundus*, (H) *B. laevis*, (I) *A. spinosus*

Discussion

Paddy ecosystem has various plant species grow in it. Therefore their interaction and diversity are very important to know in their natural habitat. The existence, abundance, and distribution of one species in an ecosystem are determined by the availability of resources and chemical and physical factors which are tolerable. It is not impossible that we could find a stable paddy ecosystem (Santosa and Sulistyo 2007; Mardiyanti et al. 2013). Plant species diversity indicates a measure that shows variation of plant species in a community. Dominance index is used to determine species richness and the balance of total individuals of each species in an ecosystem (Mardiyanti et al. 2013). Shannon-Wiener Index and Simpson Index do not grade diversity and dominance in the point of land condition. Based on the results of the research, Shannon-Wiener index (H') of plant species constructing the paddy ecosystems ranged 1.00 – 1.73. The value indicated that paddy ecosystem had a plant species diversity where the category was medium. That condition indicated that the ecosystems were balanced enough. The value of $1.0 < H' < 3.322$ means that the diversity is medium, productivity was enough, ecosystem condition was balanced enough ecological stress was medium (Fitriana 2006).

In general, there is a decrease in plant diversity at one period of time because each plant species need different time in completing its life cycle. Early diversity is shown by annual plants. Annual plants only need time one year/season to complete their life cycle. These plants could grow very fast and produce seeds within a short period. Then there was a shift of plant diversity constructing the ecosystem by biennial plants. The plants needed two seasons time in completing their life cycle, in the end, the diversity was shown by perennial plants. The plants were able to grow continuously for more than two seasons from the same root system (Mardiyanti et al. 2013).

Based on the results of data analysis, Simpson dominance index (C) in observation ecosystems ranged from 0.03-0.08. Even though based on IVI, plants growing in each type of ecosystem there was dominance by certain species of plant. However, the dominance did not affect other plants. That case was proven by the result of data analysis of Simpson Index that showed no certain plant species dominance in the ecosystem, either in type I ecosystem, type II or type III. The condition indicated that the community structure was stable. According to Mardiyanti et al. (2013), the more stable the ecosystems the higher the species diversity, either on the general species or the rare species found as a result of adaptation to their environment. The diversity showed stability of a community. According to Karmana (2010), species diversity in a community would be relatively stable although disruption to the community. According to Marsal et al. (2015), in succesion process, plants and animals composition occupying an area also changed. The speed, course (direction) and succession composition are determined by available species and develop fast after disturbance. Some species would come and the most successful that adapt to the environment will dominate the new location.

In this study, even though ecosystems observed were relatively the same i.e. paddy ecosystems. However, the species of plants found were different. The growth of plants in type II ecosystem was faster and diverse compared to type I and type III. In type II ecosystem, the land condition supported plant diversity. According to Herlinda et al. (2008), more diverse vegetation tends to have higher species diversity. This could happen because there had been seeds scattered and distributed in the land. This is supported by Nicholls and Altieri (2013) that weeds are plant community constructing ground stratification.

Type I (Figure 3) shows that dominant species is Cyperus rotundus. In dominant non-crop vegetation found, *Cyperus rotundus* could serve as a shelter for some insects, a place for refugee, as an alternative host and as a feed for adult insects (Azmi et al. 2014). Weeds could stimulate more natural enemies and arthropods to come compared to agricultural lands without weeds (Hasyim 2012). More various vegetation tended to have more various species of fauna (Meidalima 2013). Type II (Figure 4) show species *Portulaca oleraceae* which was dominantly found. According to Van Veen et al. (2008) could function as a trapped plant or alternative host for herbivore insects. Therefore, it could decrease the population of herbivore insects on crops. Type III (Figure 5) show dominant species is *Amaranthus* spp. In the plant, *Amaranthus* spp encountered herbivore insects. The presence of herbivore insects depend on weeds growing around rice plants (Aminatum et al. 2010)

Table 3 and Figure 6 show that dominant weed in all types of paddy ecosystems is *Cyperus rotundus* (Cyperaceae).

Species richness and the balance of total individuals of each plant species in an ecosystem based on species dominance index (Mardiyanti et al. 2013). The dominance of *Cyperus rotundus* which belongs to *Cyperus* sp is caused by the means of its multiplication by seeds. This caused the plant to have a chance to grow and dominate other plants. This is supported by Suryaningsih et al. (2011) that family Cyperaceae highly adapted because it could multiplicate by seeds. According to Mardiyanti et al. (2013), the existence of plant seeds that could survive in and on the soil was potential seed bank. Plant seeds consist of new beans produced by plants that fall down to soil surface and able to survive inside. The seeds stored in soil would grow when the condition support the growth. Dominance could also happen because the seeds left in the soil that could survive in standing water at the time of land cultivation. According to Tanasale (2012), the weeds that could survive were the ones that could multiply vegetatively and generatively. According to Saharjo and Cornelio (2011), a species could dominate a community if the species could allocate more sources compared to other. An important value for weeds is as a source of feed for pollinating insects; therefore, it could enhance diversity (Carvell et al. 2007). Menz et al. (2011) stated that to construct a habitat for pollinating insects, weeds need to be planted.

In conclusion, Shanon-Wiener Index ranged from 1.00 – 1.73 which meant the diversity of plant species in paddy ecosystem in West Sumatra was medium. Dominance index ranged from 0.03 – 0.08 which meant there was species dominating other species. Plant species dominating type I ecosystem was *Cyperus rotundus, Eleusine indica, Portulaca oleraceae*, in type II were *P. oleraceae, C. rotundus, Amaranthus spinosus,* and in type III were *C. rotundus, Borreria laevis, A. spinosus.*

REFERENCES

Azmi SL, Amin SL, Bagyo Y, Endang A. 2014. Diversity of arthropod herbivore red rice visitors in organic farm in Sengguruh Kepanjen Village. Pembangunan dan Alam Lestari 5 (1): 57-64. [Indonesian]

Carvell C, Meek WR, Pywell RF, Goulson D, Nowakowski M. 2007. Comparing the efficacy of agri-environment schemes to enhance bumble bee abundance and diversity on arable field margins. J App Ecol 44: 29-40.

Fitriana YR. 2006. Diversity and macro-zoobenthos abundance in mangrove forest rehabilitated, Ngurah Rai Forest Park, Bali. Biodiversitas 7 (1): 67-72. [Indonesian]

Gunawan H, Prasetyo LB, Mardiastuti A, Kartono AP. 2010. Fragmentation of natural forests dryland in the Province of Central Java. Penelitian Hutan dan Konservasi Alam 7 (1): 75-91. [Indonesian]

Hasyim MA. 2012. The composition of insect potentially as pollinators apple blossoms and interest in the weeds in di around the apple garden, Bumiaji Village, Batu City [Thesis]. Department of Biology, Faculty of Mathematics dan Science, Brawijaya University, Malang. [Indonesian]

Herlinda S, Waluyo, Estuningsih SP, Chandra I. 2008. Comparison of species diversity and abundance of arthropod predators habitat on the land in lowland rice fields with insecticide application and non-application. J Entomol Indon 5 (2): 96-107. [Indonesian]

Kainde RP, Ratag SP, Tasirin JS, Faryanti D. 2011. Analysis of forest protected in Tumpa Mountain. Eugenia 7 (2): 1-11. [Indonesian]

Karmana IW. 2010. Analysis of epifauna diversity with pitfall trap method in Cangar Malang Forest. Gane Swara. 4: 1-5. [Indonesian]

Nicholls CI, Altieri MA. 2013. Plant biodiversity enhances bees and other insect pollinators in agroecosystems. A review. Agron Sustain Dev 33: 257-274.

Maridi, Alanindra S, Putri A. 2015. Analysis of vegetation structure in Ampel Subdistrict, Boyolali District. Bioedukasi 8 (1): 28-42. [Indonesian]

Mardiyanti ED, Karuniawan PW, Medha B. 2013. Dynamics of plant species diversity post-planting rice. Produksi Tanaman 1 (1): 24-35. [Indonesian]

Marsal D, Karuniawan PW, Eko W. 2015. Dynamics of changed weeds in keprasan sugarcane in the land of reynoso system and dry land. Produksi Tanaman 3 (1): 81-90. [Indonesian]

Meidalima D. 2013. Effect of flower weeds to sugarcane and parasitoids existence in dry land sugarcane, Cinta Manis, South Sumatra. Lahan Suboptimal 2 (1): 36-44. [Indonesian]

Menz MHM, Phillips RD, Winfree R. 2011. Reconnecting plants and pollinators: challenges in the restoration of pollination mutualisms. Trends Plant Sci. 16: 4-12.

Nugroho AS, Anis T, Ulfah M. 2015. Analysis of the fruit plant species diversity in Surokonto protection forest, Kendal, Central Java and its potential as a bird conservation area. Pros Sem Nas Masy Biodiv Indon 1: 472-476. [Indonesian]

Pratiwi P. 2012. Analysis of genetic variation *Globba leucantha* Miq. Population in West Sumatra with *Random Amplified Polymorphic DNA* (RAPD) [Dissertation]. Graduate Program Andalas University, Padang. [Indonesian]

Prasetyo B. 2007. Diversity of fruits plant in Jabon Mekar Village, Parung Subdistrict, Bogor. Biodiversitas 8 (1): 44-46. [Indonesian]

Radiyanto I, Mochammad S, Noeng MN. 2010. Diversity of pests and natural enemies in soybean land, Balong Ponorogo Subdistrict. J Entomol. Indon. 7 (2): 116-121. [Indonesian]

Saleh S, Iris M, Thomas CW, Teja T. 2016. Habitat management on multiple spatial scales can enhance bee pollination and crop yield in tropical homegardens. In: Agriculture Ecosystems & Environment. Elsevier, Amsterdam.

Saharjo BH, Cornelio G. 2011. Natural succession post-fire in secondary forest, Fatuquero Village, Railaco Subdistrict, Ermera District, Timor Leste. Silvikultur Tropika 2 (1): 40-45. [Indonesian]

Saputra F, Labibah Q. 2011. Study of pteridophyte diversity and vegetation analysis in Jatikerep Legonlel and Nyamplung, Karimunjawa Island Central Jawa. Biologi Indonesia 7 (2): 207-212.

Santosa SJ, Joko S. 2007. Role of natural enemies in the paddy ecosystem. Inovasi Pertanian 6 (1): 1-10. [Indonesian]

Suryaningsih, Martin J, Ketut D. 2011. Inventory of weeds in corn crop (*Zea mays* L.) in the land Padang Galak Subdistrict, Denpasar Timur, Denpasar City, Bali Province. Simbiosis 1 (1): 1-8. [Indonesian]

Tanasale VL. 2012. Study of weeds community in gandaria (*Bouea macrophylla* Griff.) in immature and generating plant, Urimessing Village, Nusaniwe Subdistrict, Ambon Island. Budidaya Pertanian 8 (1): 7-12. [Indonesian]

Van Veen FJF, Muller CB, Pell JK, Godfray HCJ. 2008. Food web structure of three guilds of natural enemies: predators, parasitoids, and pathogens of aphids. J Animal Ecology 77: 191-200.

Wardah, Labiro E, Sudirman DM, Sustri, Mursidin 2012. Vegetation of key anoa habitats, Pangi Binangga Conservation Area, Central Sulawesi. Penelitian Kehutanan Wallacea 1 (1): 1-12. [Indonesian]

Yaherwandi 2009. Structure of community parasitoids Hymenoptera in various agriculture landscape, West Sumatra. J Entomol Indon 6 (1): 1-14. [Indonesian]