Presented at the DLSU Research Congress 2017
De La Salle University, Manila, Philippines
June 20 to 22, 2017

Effect of Mowing on Diversity of Fauna in Grassland of De La Salle University, Biñan, Laguna, Philippines

Jaryna O. Limbauan[1,*] and Alberto T. Barrion[2]

[1]Graduate Student in Biology and [2]Visiting Lecturer, De La Salle University
2401 Taft Avenue, Manila 0922, Philippines

**Corresponding author: jaryna_limbauan@dlsu.edu.ph*

Abstract: The diversity of fauna collected from foliage and soil of the mowed and tall grassland in De La Salle University, Biñan, Laguna was analyzed using diversity indices: Shannon index of diversity (H') and evenness (J), and Simpson index of diversity (SID), dominance (D), and equitability (E). Diversity indices values for foliage of mowed grassland are (H'=3.28; J=0.89; D=0.05; SID=0.95; E=0.02), while soil fauna of mowed grassland have diversity indices values of (H'=1.87; J=0.85; D=0.18; SID=0.82; E=0.09). Arthropod diversity in foliage of tall grassland have values of (H'=2.42; J=0.80; D=0.13; SID=0.87; E=0.04), while diversity indices values of soil fauna in tall grassland are (H'=1.69; J=0.73; D=0.13; SID=0.87; E=0.09). The values indicate that fauna in mowed grassland are more diverse compared to the fauna of tall grassland. This suggests that mowing increased the fauna species diversity in the mowed grassland, compared to the stable and undisturbed community of tall grassland.

Key Words: arthropod; diversity; grassland; Shannon index; Simpson index

1. INTRODUCTION

Grasslands are one of the most important ecosystems on Earth, and prevention of grasslands from overgrazing, desertification and other types of overexploitation is a pressing issue. In recent years, grasslands have been dramatically changing due to the changes of global climate and aggravation of human activities; hence, protection and reasonable use of grasslands are attracting more attention worldwide (Liu, 2014). Habitat fragmentation is considered one of the major threats to invertebrate diversity in semi-natural grassland (Braschler, 2009). Fragmentation reduces the area suitable to the organisms and tends to create isolated metapopulations by reducing the exchange of individuals, and thus the gene flow between grassland patches (Hanski, 1998). The effect of fragmentation on population dynamics of invertebrate taxa depends on species' ecological traits, such as movement behavior and habitat specialization, as well as on size and spatial configuration of the fragments (Saunders *et al.,* 1991).

For hundreds of years, these grasslands have been used for pasture and for harvesting hay. Thus, the conservation of the grasslands is a necessary measure to prevent further species extinctions. Among the different management options, mowing without any fertilizer input is a common practice (Knopf, 2006). In this study, the effect of mowing on the abundance and diversity of fauna in mowed and undisturbed grassland are compared.

2. MATERIALS AND METHODS

Study Site. The study was conducted in the grasslands of De La Salle University — Science & Technology Complex (DLSU-STC) 14° 26' 31" North, 121° 4' 22" East, 68 masl, located in Biñan City, Laguna, Philippines (Figure 1).

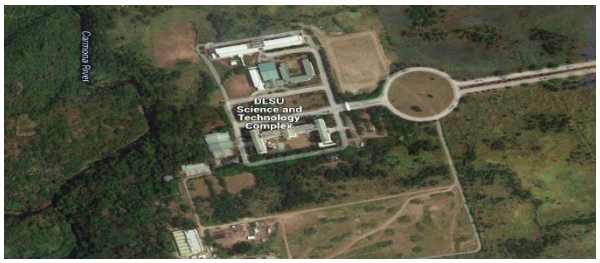

Figure 1. Satellite image of the study site in DLSU-STC, Biñan, Laguna

The two sampling sites include two types of grasslands – disturbed or mowed and undisturbed or tall grassland (Figure 2). Both grasslands' predominant plants are *Napier* grass and *Imperata cylindrica* with presence of few shrubs and trees.

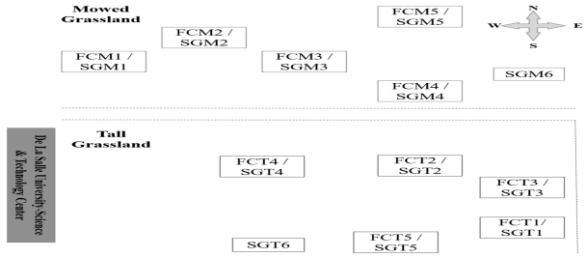

Figure 2. Schematic diagram of sampling sites of mowed and undisturbed (tall) grassland in DLSU-STC in Biñan, Laguna on June 11, 2016. FCM (foliage/ canopy of mowed); FCT (foliage/canopy of tall); SGM (soil/ground of mowed); SGT (soil/ground of tall).

Sampling method. Five randomly selected 6m x 6m subplots were measured for sampling in the foliage of both mowed and undisturbed grassland, while six randomly selected 6m x 6m subplots were measured for sampling in the soil or grounds of both mowed and undisturbed grassland. Fifteen double stroke sweeps using the standard folding sweep net was taken in collecting arthropods inside the five plots of foliage or canopy. Soil or ground fauna samples were handpicked from litter and soil horizon (0-5cm deep) inside 6m x 6m plots. This was done in six replicates. Sweep net and soil samples were emptied in 21.59 cm x 27.94 cm ziplock plastic bag with 70% ethanol and appropriate labels (location [FCT vs FCM; SGT vs SGM]), and replication [R1, R2… R5] (Barrion *et al*, 2016).

Sorting and identification of samples. The alcohol preserved samples in ziplock bags were all taken to the laboratory in DLSU-STC for sorting and counting. All samples from mowed and undisturbed grassland were examined at low magnification (4x) under dissecting microscope (Brownstone Asia-Tech, Inc.) and identified using available keys and guide for the identification of different taxa based on the descriptions in CSIRO (1979).

Diversity Analysis. Species diversity in grassland and secondary forest were measured using Shannon's Index of diversity (H'),

$$H = -\sum_{i=1}^{s} p_i \ln p_i$$

where: p is the proportion (n/N) of individuals of one species (n) found divided by the total number of individuals (N), ln in the natural log, Σ is the sum of the calculations, and S is the number of species, and Simpson's Index of Dominance (D),

$$D = \sum_{i=1}^{s} p_i^2$$

where: p is the proportion (n/N) of individuals of one species (n) found divided by the total number of individuals (N), Σ is the sum of the calculations, and S is the number of species (Yuan *et al.,* 2013).

Also, Shannon's Index of Evenness (J) was determined using the formula H'/lnS, where ln in the natural log and S is the total number of species in the community. Simpson's Index of Diversity (SID) [1-D] and Simpson's Index of Equitability (E) [SID/S] were also measured. Sorensen's Index of Similarity (SI) [2 (Number of shared species in A & B environments) / (A+B) x 100] was used to determine the commonly shared taxa between the mowed and tall grassland. A = total species in mowed grassland (G) and B = total species in tall grassland, and results were expressed in percentage (%) (Barrion *et al*, 2016). Lastly, population density (PD) (Number of individuals per area] and relative density (RD)

[(Number of individuals / Total number of individual species) x 100] were measured. Since the identification was limited to families, the number of families was substituted in the formulae instead of number of species.

3. RESULTS AND DISCUSSION

The arthropods collected from foliage of the mowed and tall grassland in DLSU-STC, Biñan, Laguna constituted of 226 fauna representing 45 families under 10 orders. Of the total catch, 137 (60.6%) fauna comprising 40 families were from mowed grassland and 89 (39.4%) fauna comprising 21 families came from the tall or undisturbed grassland (Figure 3).

The fauna collected from the soil of mowed and tall grassland constituted 64 individuals representing 16 families under 11 orders. Of the total catch, 33(51.6%) individuals comprising 9 families were from mowed grassland and 31(48.4%) individuals comprising 10 families came from the tall grassland (Figure 3).

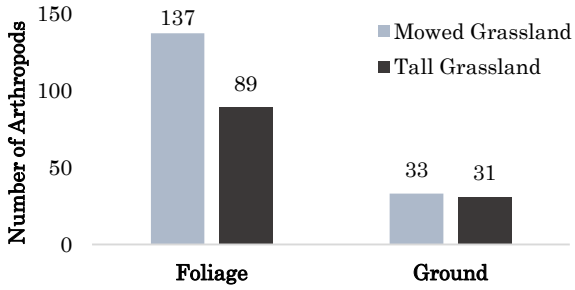

Figure 3. Total fauna collected in foliage and soil of mowed and tall grassland of DLSU-STC in Biñan, Laguna

Foliage arthropods

The computed value for Sorensen's Index of Similarity (SI) of foliage arthropods is 52% (16 families), which indicates that there is high fauna commonly shared between the mowed and undisturbed grassland. Of the 16 families present in both habitats, the top five most dominant families are represented by Formicidae (25 individuals) > Tettigoniidae (24 individuals) > Noctuidae (23 individuals) >Acrididae (14 individuals) > Coccinellidae (11 individuals) (Figure 4). The arthropod family with highest population and relative density of foliage in mowed grassland is Noctuidae (PD =1.33ind./m^2; RD=14.6%), while Tettigoniidae (PD =1.47ind./m^2; RD=24.7%) has the highest population and relative density in undisturbed or tall grassland. This is in line with findings of Andersson *et al.,* (2013) who pointed out that density responses varied considerably among different insect groups.

Soil Fauna

The computed value for Sorensen's Index of Similarity (SI) of soil fauna is 31.58% (3 families), which indicated that there is low fauna commonly shared in the soil between the two grasslands. The top four most dominant families in soil were represented by Lumbricidae (15 individuals) >Formicidae and Trigoniulidae (8 individuals) >Scarabaeidae (7 individuals) (Figure 5). In mowed grassland, Lumbricidae (PD =0.60ind./m^2; RD=27.3%) has the highest population and relative density, while Trigoniulidae (PD =0.533ind./m^2; RD=25.8%) has the highest population and relative density in tall grassland.

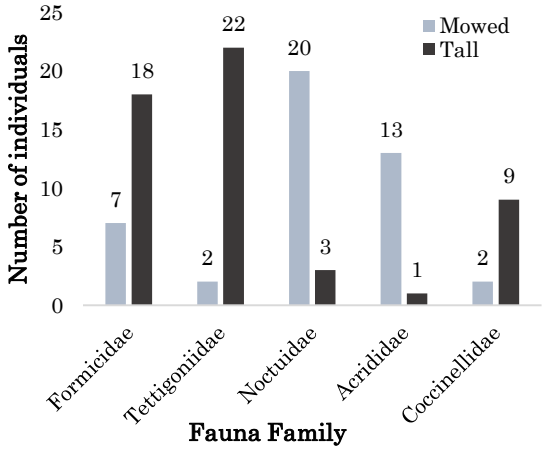

Figure 4. Five most dominant fauna families collected in foliage of mowed and tall grassland of DLSU-STC in Biñan, Laguna

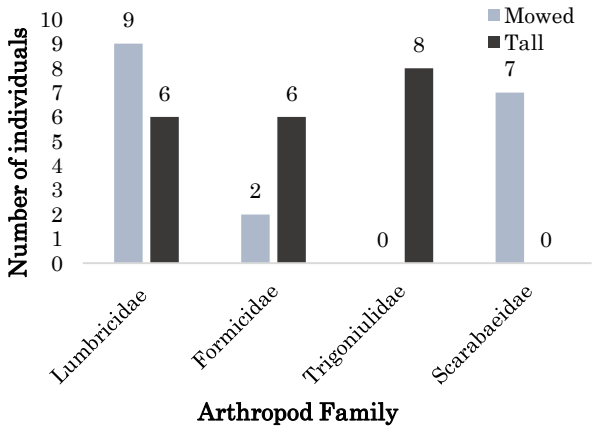

Figure 5. Four most dominant fauna families collected in soil of mowed and tall grassland of DLSU-STC in Biñan, Laguna

Feeding Guilds

Terrestrial arthropods from the foliage of mowed and tall grassland were classified into four functional guilds based on feeding habits of each family (Figure 6). Accordingly, the four arthropod feeding guilds identified were phytophage, predator, parasitoid, and dual feeding guild (parasitoid/predator). For both grasslands, the majority of the total arthropods collected in the foliage were phytophage (72%, 163 individuals) and Tettigoniidae was the dominant phytophagous group with 28 individuals. The predatory guild (24.3%) comprised of 55 individuals, of which Formicidae was the dominant predatory group with 25 individuals. The other two feeding guilds were those with dual feeding habits as parasitoid (2.21%, 5 individuals) and dual feeding guild as parasitoid and/or predator (1.33%, 3 individuals).

In soil, four functional guilds were identified (Figure 7). Accordingly, the four feeding guilds identified were phytophage, predator, scavenger, and dual feeding guild (parasitoid/predator). For both grasslands, the majority of the total soil fauna collected were scavengers (51%, 33 individuals), where Lumbricidae was the dominant scavenger group with 15 individuals. The phytophage guild (32.8%) comprised of 21 individuals, where Scarabaeidae was the dominant phytophage group with 7 individuals. The other two feeding guilds were those with predatory group (12.5%, 8 individuals) and dual feeding habits as parasitoid and/or predator (3.13%, 2 individuals). No parasitoid was collected in soil of mowed and tall grassland.

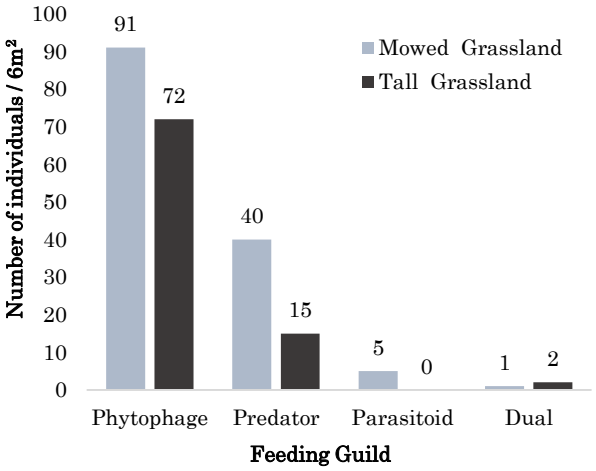

Figure 6. Feeding guilds of the arthropods collected using sweep net method in the foliage of mowed and tall grassland of DLSU-STC in Biñan, Laguna

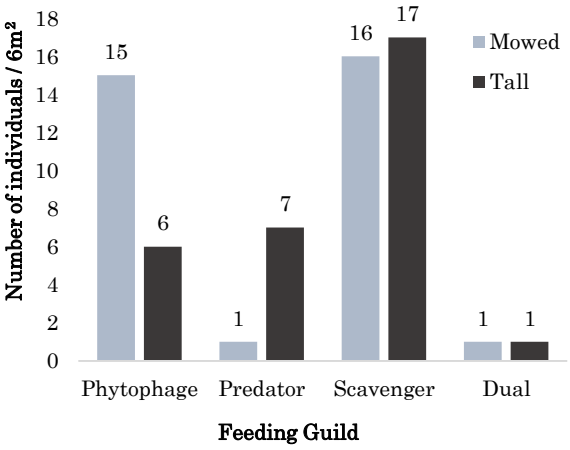

Figure 7. Feeding guilds of the fauna in the soil of mowed and tall grassland of DLSU-STC in Biñan, Laguna

Diversity Analyses

The most commonly used diversity indices are the Shannon Index of Diversity (H') and Simpson Index of Diversity (SID) (Gorelick, 2006). However, richness and evenness are the components of diversity (Omernik, 2003; Ricotta, 2003; Liu *et al.,* 2008). Simpson index is used to assess the dominance, but fails to provide an idea about species richness. Shannon index is expected to determine both diversity characteristics, that is, evenness and richness (Melo, 2008) but does not provide any information on the rare species which, however, are very important in studies of biodiversity. This implies that diversity cannot be estimated just by one index (Purvis and Hector, 2000). To overcome these limitations, both diversity matrices have been utilized in the study (Table 1).

Table 1. Diversity indices of the fauna collected in the mowed and tall grassland of DLSU-STC in Biñan, Laguna on June 11, 2016

Diversity Indices	Mowed		Tall	
	Foliage	Soil	Foliage	Soil
Shannon Index of Diversity (H')	3.28	1.87	2.42	1.69
Shannon Index of Evenness (J)	0.89	0.85	0.80	0.73
Simpson Index of Dominance (D)	0.05	0.18	0.13	0.13
Simpson Index of Diversity (SID)	0.95	0.82	0.87	0.87
Simpson Index of Equitability (E)	0.02	0.09	0.04	0.09

Shannon index was interpreted using the descriptions proposed by Gevaña *et al.,* (2013), e.g. a) low (H'=1.00-2.49), b) moderate (H'=2.50-2.90), and c) high (H'=3.00-4.00). Based on the computed Shannon diversity index value, the fauna were more diverse in foliage in both mowed (H'=3.28) and tall (H'=2.42) grassland than the ground fauna of mowed and tall grassland having values of 1.87 and 1.69 respectively. The computed values indicated that there is low diversity of fauna in the soil of both mowed and tall grassland and foliage of tall grassland. Notably, the foliage of the mowed grassland is highly diverse. This indicates that mowing increased the species diversity in the grassland, unlike in a stable community such as in undisturbed grassland.

Shannon index of evenness (J) showed close values between the foliage (J=0.89) and ground (J=0.85) of mowed grassland and the foliage (J=0.80) and ground (J=0.73) of the tall grassland. The values indicate that abundance of faunal families in both habitats is not equally represented. However, comparing the two ecosystems, the mowed grassland has evenness values that are closer to one, which indicates that fauna families in this ecosystem that are more equally represented than the fauna families in the tall grassland. Results of Shannon Index also shows evident increase in evenness as the organism in the ecosystem become diverse. This concurs with the observation of Shah and Pandit (2013) on the direct relationship of Shannon diversity index with evenness index.

Generally, Simpson index ranges from 0 to 1 (Nagendra, 2002). Mature and stable communities have high diversity value (0.6 to 0.9), while communities under stress conditions, exhibiting low diversity, usually show close to zero value (Dash, 2003). Based on Simpson index of dominance, the two grassland ecosystems are dominated by few number of faunal families with D values near to zero (FCM =0.05; SGM=0.18; FCT/SGT=0.13), which resulted to high diversity index in both foliage (SID=0.95) and ground (SID=0.82) of mowed grassland, as well as foliage and soil of tall grassland (SID=0.87). All values for equitability (E) are close to zero, which indicates that the foliage (E=0.02) and ground (E=0.09) fauna of mowed, as well as foliage (0.04) and ground (0.09) fauna of tall grassland have low uniform evenness or distribution in the ecosystem.

Although similar data were used, the two indices used gave different values for diversity of fauna in grassland ecosystem. According to Nagendra (2002), this is because Shannon index stresses the richness component and rare organisms, while the Simpson index lays greater

emphasis on the evenness component and on the dominant organisms.

Emphasizing richness, the Shannon index suggests that the fauna diversity in foliage and ground of tall grassland (H' 2.42 vs 1.69, respectively) is less diverse than the fauna diversity of foliage and ground of mowed grassland (H'3.28 vs 1.87, respectively). Although the values for Simpson index also indicate that mowed grassland is more diverse than tall grassland, the Simpson index, emphasizing evenness, also suggests that the fauna in both foliage and ground of tall grassland are equally diverse (SID=0.87). Also, Shannon index indicate that ground diversity of both mowed and tall grassland is low, while in Simpson index, it was interpreted as having high diversity. An explanation of this divergence was provided by Peet (1974), who stated that the Shannon diversity index responds most strongly to changes in importance of the rarest species, while the Simpson index responds most strongly to changes in the proportional abundance of the most common species.

4. CONCLUSION

Five faunal feeding guilds were identified in both mowed and tall grassland particularly phytophage, predator, dual (parasitoid/predator), parasitoid, and scavenger. For both grasslands, the majority of the total fauna collected in foliage were phytophages, while in the ground, the dominant guild is the scavenger. Diversity indices values indicate that fauna in mowed grassland are more diverse compared to the fauna of tall grassland. Thus, mowing increased the species diversity in the grassland. Since in mowed grassland, cutting of plant and grazing is common, this disturbance enhances soil composition, which results to increased plant diversity. Increased plant diversity lead to more phytophage and scavenger present in the ecosystem, as revealed by the result of the study. In comparison with the mowed grassland, undisturbed grassland has lower diversity because of its stable and undisturbed ecosystem.

5. REFERENCES

Andersson P., Lofstedt, C., and Hamback. P.A., (2013). Insect density-plant density relationships: a modified view of insect responses to resource concentrations. *Oecologia.* 173:1333-1344.

Barrion, A.T., Zhu, P., Zheng, X., Chen, G., Mei, Z., and Lu, Z. (2016). Diversity and Functional Guild Composition of Rice Leaffolder [*Cnaphalocrocis medinalis* (Guenee), Lepidoptera:Pyralidae] Natural enemies in Irrigated Super Hybrid Rice and Non-rice Habitats in China. *Asia Life Sciences.* 25(2):547-563.

Braschler, B. (2009). Effects of small-scale grassland fragmentation and frequent mowing on population density and species diversity of orthopterans: a long-term study. *Ecological Entomology* 34. 321-329.

Commonwealth Scientific and Industrial Research Organization (CSIRO). (1979). The Insects of Australia: A Textbook for Students and Research Workers. Australia: Melbourne Press.

Dash, M.C. (2003). Fundamental of Ecology. 2nd Edition Tata McGraw Hill Publishing Company Limited, New Delhi.

Gevaña, D.T., Pollisco, J.P.T., Pampolina, N.M., Kim, D. and Im, S. (2013). Plant Diversity and Aboveground Carbon Stock along Altitudinal Gradients in Quezon Mountain Range in Southern Mindanao, Philippines. *Journal of Environmental Science and Management. 16*(1): 20-28.

Gorelick, R. (2006). Combining richness and abundance into a single diversity index using matrix analogues of Shannon's and Simpson's indices. *Ecography. 29*:525-530.

Hanski, I. (1998). Metapopulation dynamics. *Nature*. 396. 41-49.

Knopf, E. (2006). Effectiveness of the Swiss agri-environment scheme in promoting biodiversity. *Journal of Applied Ecology*. *43*: 333-342.

Liu, G. (2014). A review on the book, Grasslands: Types, Biodiversity and Impacts. *Selforganizology. 1*(3-4): 211-215

Liu, Z.F., Liu, G.H., Fu, B.J. and Zheng, X.X. (2008). Relationship between plant and species diversity and soil microbial functional diversity along a longitudinal gradient intemperate grasslands of Hulunbeir, Inner Mongolia, China. *Ecol. Res. 23*:511-518.

Melo, A.S. (2008). What we win "confounding" species richness and evenness in a diversity index? *Biota Neotropica*. 8:012-027.

Nagendra, H. (2002). Opposite Trends in Response for the Shannon and Simpson Indices of Landscape Diversity. *Applied Geography. 22*:175-186.

Omernik, J.M. (2003). The misuse of hydrologic unit maps for extrapolation, reporting, and ecosystem management. *Journal of American Water Resources Association. 39*(3):563-573.

Peet, R. K. (1974). The measurement of species diversity. *Annual Review of Ecology and Systematics, 5*: 285–307.

Purvis, A. and Hector, A. (2000). Getting the measure of biodiversity. *Nature. 405*:212-219.

Ricotta, C. (2003). On parametric evenness measures. *Journal of Theoretical Biology, 22*:189-197.

Saunders, D.A., Robbs, R.J., and Margules, C.R. (1991). Biological consequences of ecosystem fragmentation: a review. *Conservation Biology 5*:18-32.

Shah, J.A. and Pandit, A.K. (2013). Application of Diversity Indices to Crustacean Community of Wular Lake, Kashmir Himalaya. *International Journal of Biodiversity and Conservation. 5*(6): 311-316.

Yuan, F., Zhang, J., An, K., Shen, K., and Zhang, R. (2013). Arthropod Biodiversity and Community Structure in Dongxiang Wild Rice (*Oryza rufipogon* Griff.) Fields. *J. Agric. Urban Entomology. 29*:55-67.