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DIVERSITY OF GRASSHOPPER ON AGRICULTURAL LAND AND SAVANA IN DOMPU REGENCY, INDONESIA

KEANEKARAGAMAN JENIS BELALANG PADA LAHAN PERTANIAN DAN PADANG SAVANA DI KABUPATEN DOMPU NTB

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ABSTRACT

Grasshopper is one type of insect known as a plant pest that quite affects agricultural production. Grasshoppers also have benefits as natural predators and maintain ecological balance. One area where no research has been carried out on grasshopper diversity is Dompu Regency, West Nusa Tenggara, Indonesia. This research was conducted at 4 locations in Dompu, including corn, ex-corn, intercropping, and Doroncanga agricultural land, by making four transects at each location. Grasshoppers were collected using the insect net, and hand collecting was carried out at 07.00 and 16.00 WITA. The environmental factors that were calculated were air temperature, light intensity, wind speed, and air humidity, while the biotic factors observed were plant vegetation at each location and predators. Data analysis was performed using the Shannon-Wiener diversity index, evenness index, dominance index, and Margalef index. The results of this study indicate that Dompu Regency has the potential for diversity of grasshoppers with moderate criteria where the diversity of grasshoppers is strongly influenced by plant vegetation and human treatment on agricultural land.

Keywords: *Orthoptera, diversity, community, composition*

ABSTRAK

Belalang merupakan salah satu jenis serangga yang dikenal sebagai hama tanaman yang cukup mempengaruhi produksi pertanian. Belalang juga memiliki manfaat sebagai predator alami dan menjaga keseimbangan ekologi. Salah satu daerah yang belum sama sekali dilakukan penelitian terkait dengan diversitas belalang adalah Kabupaten Dompu, Nusa Tenggara Barat. Penelitian ini dilakukan pada 4 lokasi di Dompu diantaranya lahan pertanian Jagung, bekas jagung, tumpang sari dan Savana Doroncanga dengan membuat 4 transek pada setiap lokasi. Belalang dikoleksi menggunakan metode sweeping net dengan menggunakan jaring serangga, dan hand collecting yang dilakukan pada pukul 07.00 dan 16.00 WITA. Faktor lingkungan yang dihitung yakni temperatur udara, intensitas cahaya kecepatan angin, dan kelembaban udara, sementara faktor biotik yang diamati adalah vegetasi tumbuhan pada setiap lokasi dan predator. Analisis data dilakukan dengan menggunakan indeks keragaman Shannon-Wiener, indeks kemerataan Evennes, indeks dominansi, indeks margalef. Untuk mengukur korelasi antara kelimpahan belalang dengan faktor abiotik menggunakan analisis Pearson dan CCA. Hasil penelitian ini menunjukkan bahwa Kabupaten Dompu memiliki potensi keragaman belalang dengan kriteria sedang dimana keragaman belalang sangat dipengaruhi oleh vegetasi tumbuhan dan perlakuan manusia pada lahan pertanian.

Kata kunci: *Orthoptera, diversitas, komunitas, komposisi*

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INTRODUCTION

Indonesia is a mega-biodiversity country and even ranks third with the highest diversity in the world [1]. One group of animals that has a high diversity in Indonesia is the insect group. The number of insects in the world is 10,000,000. There are 150,000 Hymenoptera worldwide and 30,000 in Indonesia, while Orthoptera has as many as 20,000 worldwide, and 2,000 species are found in Indonesia [2].

Most grasshoppers are herbivores and are known as plant pests, so these insects are often the target of insecticide spraying by farmers. Grasshoppers act not only as herbivores but can also act as predators, omnivores, bioindicators, and, most importantly, balance the ecosystem [3]. Currently, the research on grasshoppers is still very limited in various regions in Indonesia. This shows the small number of researchers' interest in conducting research related to grasshoppers, especially the diversity of grasshoppers. Another problem in the study of grasshoppers and their relatives of the Orthoptera order is the low knowledge of diversity, distribution, population, and other basic biological aspects [4].

One of the many areas where grasshopper diversity research has not been conducted is

Dompu Regency, which is located on Sumbawa Island, West Nusa Tenggara Province. Most areas in the Dompu Regency have dry environmental conditions with quite hot air temperatures and hilly topography [5]. Some plants that can live in the Dompu area and become commodities are corn, rice, soybeans, and tobacco. Corn is the most widely planted crop by the majority of farmers in the Dompu Regency [6].

Plant species richness has a positive effect on insect species richness. The higher the plant species richness, the higher the species richness of insects [7]. Intercropping habitats in Kampas Meci Village, Manggelewa District, Padang Savana Doroncanga located in Sori Tatanga Village, Pekat District, former maize land habitat in Lune Village and corn monoculture in Jambu Village, Pajo District, are believed to have a high potential for Grasshopper diversity.

The four locations have different environmental conditions, from abiotic factors, biotic factors in the form of vegetation and other insects, and the level of human treatment. These habitats are quite favoured by grasshoppers, but no research has been carried out in each of these areas. So it is considered important to conduct this research. This research aims to identify the diversity of grasshoppers in four habitat locations in Dompu Regency. The results of this study can be used as a database and preliminary research that can be used as supporting data for further research.

METHODS

Study area. This research was conducted in January-April 2021 in Dompu Regency, Indonesia. The agricultural lands include intercropping land, corn monoculture and former corn land, intercropping land in Manggelewa District, and Tambora savanna in Pekat District. This research is divided into four locations (habitats), and each location was divided into four sampling points with a difference of 500 m per location. Observations were made once a week for one month, so four observations were made at each location (Figure 1). Determining the plot of the research location used the purposive sampling method, which mean choosing a plot with high vegetation, many grass found, and the optimal abiotic condition with the standard of grasshopper life.

The study was conducted in four locations, namely corn farming land, former corn located in Pajo District, Tumpang Sari located in Manggelewa District and Padang Savana Doroncanga located in Pekat District (Table 1). These four locations are divided into four stations. Each station had an area of 10x10 m. Observations were carried out four times each at 07.00-11.00 and 16.00-18.00 WITA.

Data collection. Data collection used the sweeping net method, the visual encounter survey by taking pictures using a camera, and the hand-picking method by catching grasshoppers directly. Abiotic measurements include temperature using a thermometer, light intensity using a lux meter, wind velocity using an anemometer, and humidity using a hygrometer. At the same time, biotic data are vegetation and grasshopper predators.

Data analysis. The collected data was calculated using the Shannon-Wiener index to find out the diversity of grasshoppers with the following formula.

$$H' = \sum \frac{ni}{N} x \ln \frac{ni}{N} \quad \text{.....1}$$

Note:
H' : Shannon-Wiener diversity index
ni : Total individual-i
N : Total individual

For measuring the abundance of grasshoppers, the evenness index was used with the following formula.

$$E : \frac{H'}{\ln S} \text{.....2}$$

Note:
E : Evenness index
H': Shannon-Wiener diversity index
S : Total species

While to measure the species dominance in the community, the dominance index was used with the following formula.

$$C = \sum(Pi) \quad \text{.....3}$$

Note:
C : dominance index
Pi : number of Species (ni/N)

The Margalef index was used to calculate the species richness of grasshoppers by using the following formula.

$$K = \log S / \log N \text{.....4}$$

Note:
S : the number of species
N : the total number of individuals in the sample

Habitat characteristics based on physical and biological parameters at each research location were analyzed using Canonical

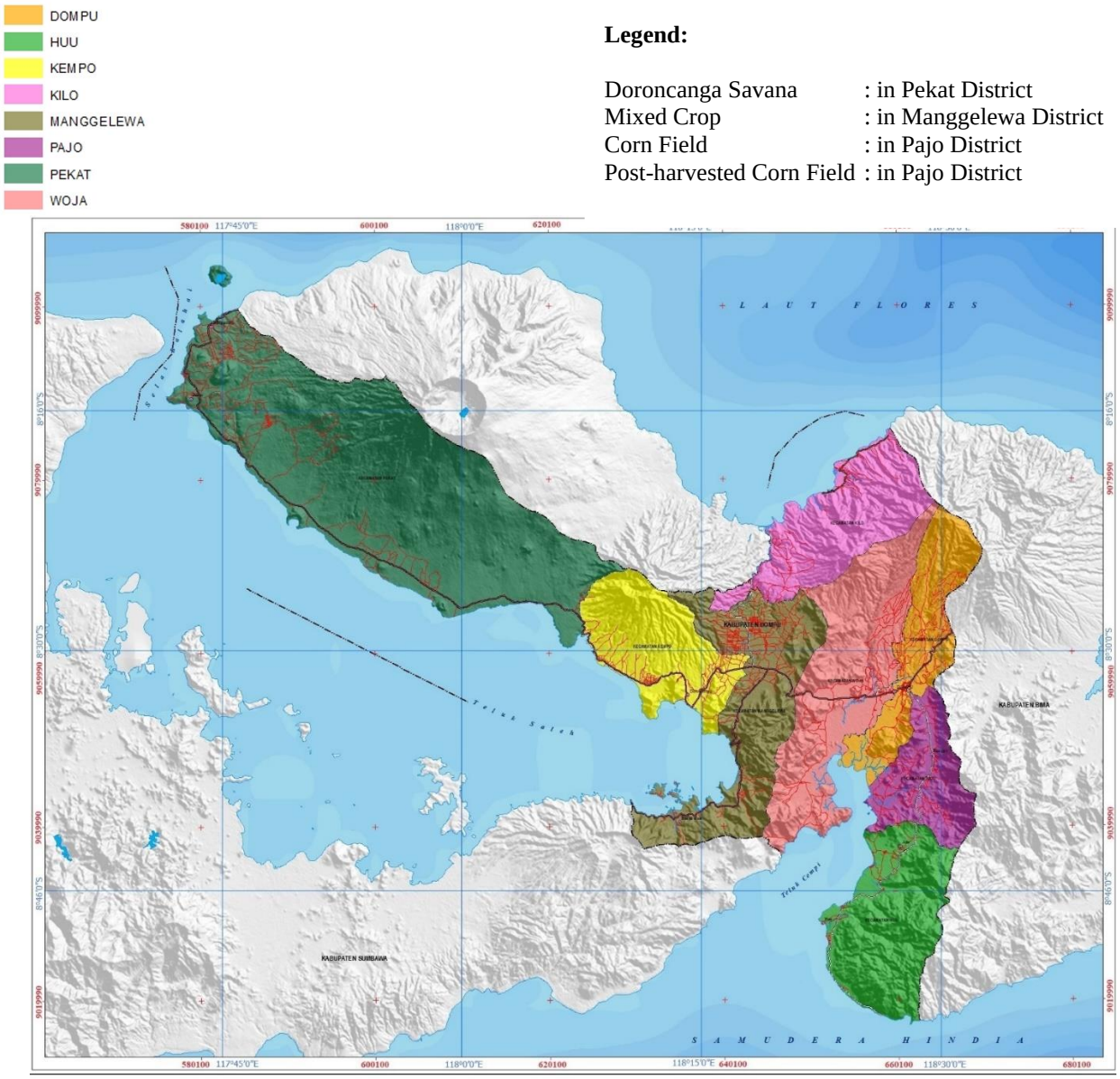


Figure 1. Study sites in Dompu Regency, Indonesia

Table 1. Description of research locations

Description	Doroncanga Savana (DC)	Mixed Crops (MC)	Corn Field (CF)	Post-harvested Corn Field (PC)
Vegetation	Elephant grass, bidara	Chilli, ginger, papaya, tomato, and eggplant	Corn plants	Cogon grass, weeds, and herbs
Land use	Land use for cattle and horse grazing	Mixed crop farming	Corn plant monoculture	Post-harvested land
Pesticide application	No application	Twice a day, morning and afternoon	Pesticide spraying is done once during planting to harvest	No application

Table 2. Average abiotic factors of the four research sites

Abiotic Factors	Doroncanga Savannah (DS)	Mixed Crops (MC)	Corn Field (CF)	Post-harvested Corn Field (PC)
Air temperature (°C)	30.5 ±0.39	29.3±0.19	29.2 ±0.30	28.3 ±0.19
Humidity (%)	77.6 ±2.05	79.5 ±0.77	90.4 ±0.38	87 ±2.60
Light intensity (lux)	593.5 ±3.89	460.3 ±3.31	455.1 ±17.49	440.8 ±9.08
Wind velocity (m/s)	20.3 ±1.44	10.2 ±0.22	15 ±2.50	19.5 ±1.21

Correspondence Analysis (CCA) to displayed in a triplot ordination using the Paleontological Statistics (PAST) software.

RESULTS AND DISCUSSION

Observation result. The identification results showed that as many as 27 grasshoppers were found from five families, including Acrididae, Pyrgomorphidae, Tettigoniidae, Tetrigidae, and Mantidae. Post-harvested corn fields had the highest species richness (22 species), while the Doroncanga Savanna had the lowest (13 species). Based on the role of grasshopper species, it was found that the herbivorous group dominated. Herbivores or plant-eaters are mostly from the Acrididae, Pyrgomorphidae, and Tetrigidae families. However, Tetrigidae is not a pest because it only eats rotting leaves (scavenger), while the Acrididae and Pyrgomorphidae groups are known as herbivores (Table 3).

Species frequency. The grasshopper species that had the highest frequency at all research sites was *Trilophidia annulata*. This species showed a very abundant distribution at all research sites, followed by *Conocephalus fuscus*, which was found to have a fairly high frequency in the two locations, namely corn monoculture and former corn farming land (Table 4).

The intensity of the presence of grasshopper species at the four locations was dominated by species such as *T. annulata*, recorded as one species with a fairly high level of presence or emergence compared to other species. This species was even found to be very abundant in all four locations at once, with an abundant number of individuals. Likewise, species from the genus *Phlaeoba* also have a fairly high frequency at all four locations. Insects have the largest number of all species on earth. These insects have various roles, and their presence is everywhere [8]. This is due to the diverse vegetation factors and the adaptability of Acrididae to the environment, which is quite high [9].

Conocephalus fuscus was found abundantly in two fields, namely Corn Field and Post-harvested Corn Field. These species are known as predators and herbivores because they can eat plants and other small animals. The genus *Conocephalus* also has a fairly high level of adaptation, so it is referred to as a cosmopolitan genus or spread everywhere [10].

Tettigidea lateralis was an abundant species in the Doroncanga Savanna and Mixed Crop fields, intercropping apart from having horticultural plants. This location also had fairly high humidity due to watering plants carried out by farmers. This made the soil moist and overgrown with moss and lichen. This location was quite favoured by the Tetrigidae group [11].

Grasshoppers community quality. Based on the dominance index value, the highest dominance was found in the Doroncanga Savanna, with an index value of 0.12, followed by Mixed Crop, Corn Field, and Post-harvested Corn Field, with dominance index values of 0.08, 0.08, and 0.07, respectively. It means Doroncanga Savanna had one or two species that dominated found or had a lower distribution of grasshoppers. The evenness index showed that the highest abundance of grasshoppers was found in the Mixed Crop land with an index value is 0.75, followed by Corn field with an index value 0.74, Post-harvested Corn field with an index value 0.65 and the lowest Abundance of Grasshoppers was found in the Doroncanga Savanna with an index value 0.62 (Figure 2). It means that grasshoppers species at Mixed Crop land had equal distribution. There were no dominant species found.

Table 3. Species found in the study site

Family	Species	Sampling sites				Total	Role
		MC	DS	CF	PC		
Acrididae	*Locusta migratoria*	28	0	21	18	67	Herbivore
	Trilophidia annulata	103	113	100	117	433	Herbivore
	Phlaeoba fumosa	60	64	60	78	262	Herbivore
	Phlaeoba infumata	62	66	50	67	245	Herbivore
	Phlaeoba sp.	0	0	0	8	8	Herbivore
	Oxya japonica	15	0	20	17	52	Herbivore
	Oxya hyla	30	0	25	43	98	Herbivore
	Valanga nigricornis	0	12	0	0	12	Herbivore
	Zacompsa pedestris	35	0	47	30	112	Herbivore
	Eritettix sp.	9	97	53	58	217	Herbivore
	Acrotylus sp.	0	0	0	8	8	Herbivore
	Acrida cinerea	0	0	30	23	53	Herbivore
Pyrgomorphidae	*Atractomorpha crenulata*	42	0	72	50	164	Herbivore
	Achurum sp.	0	0	27	21	48	Herbivore
Tettigoniidae	*Pseudorhynchus lessonii*	0	0	39	24	63	Herbivore
	Orchelimum gladiator	35	42	70	100	247	Omnivore
	Conocephalus fuscus	25	34	100	135	294	Omnivore

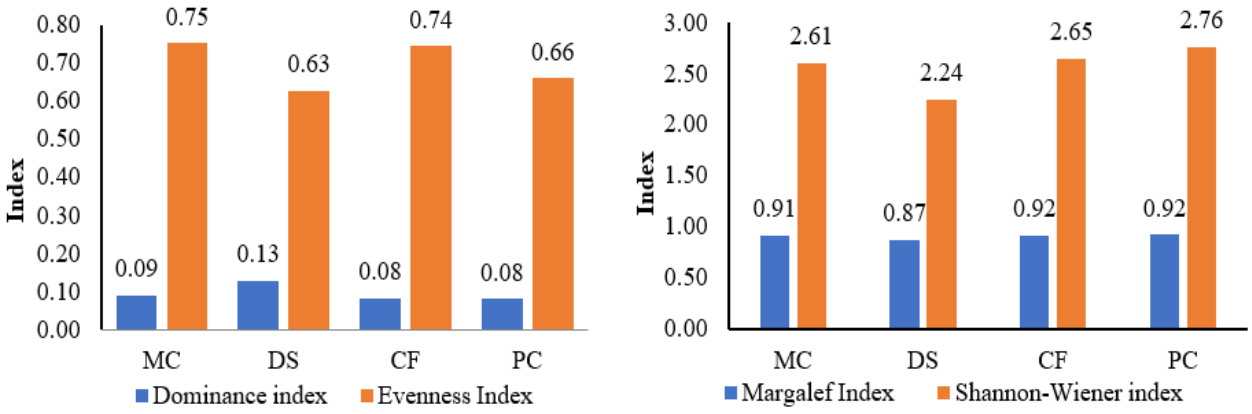
Family	Species	Sampling sites				Total	Role
		MC	DS	CF	PC		
	Tettigonia viridissima	0	0	0	51	51	Predator
	Mecopoda elongata	0	0	0	10	10	Herbivore
	Mecopoda sp.	0	0	0	1	1	Herbivore
Tetrigidae	*Tettigidea lateralis*	81	64	10	7	162	Detritus-Bryophagy
	Tetrix brunerrii	0	0	0	34	34	Detritus-Bryophagy
	Tetrix ceperoi	25	30	15	16	86	Detritus-Bryophagy
	Nomotettix cristatus	34	4	0	0	38	Detritus-Bryophagy
	Neotettix femoratus	15	6	0	0	21	Detritus-Bryophagy
Mantidae	*Hierodula formosana*	4	6	0	0	10	Predator
	Hierodula sp.	0	4	2	1	7	Predator
Total						2803	

Note: MC: Mixed Crops; DS: Doroncanga Savanna; CF: Corn Field; PC: Post-harvested Corn Field

Table 4. Grasshopper frequency at each research location

Species	MC		DS		CF		PC	
	F	RF (%)	F	RF %	F	RF (%)	F	RF (%)
Locusta migratoria	7.00	4.56	0	0	5.25	2.80	4.50	1.95
Trilophidia annulata	**25.75**	**16.80**	**2830**	**20.51**	**25.00**	**13.4**	**29.25**	**12.7**
Phlaeoba fumosa	15.00	9.77	16.00	11.62	15.00	8.01	19.50	8.45
Phlaeoba infumata	15.50	10.10	16.50	11.98	12.50	6.68	16.75	7.26
Phlaeoba sp.	0	0	0	0	0	0	2.00	0.87
Oxya japonica	3.75	2.44	0	0	5.00	2.67	4.25	1.84
Oxya hyla	7.50	4.89	0	0	6.25	3.34	10.75	4.66
Valanga nigricornis	0	0	3.00	2.17	0	0	0	0
Zacompsa pedestris	8.75	5.70	0	0	11.75	6.28	7.50	3.25
Eritettix	2.25	1.47	24.30	17.60	13.25	7.08	14.5	6.28
Acrotylus sp.	0	0	0	0	0	0	2.00	0.87
Acrida cinerea	0	0	0	0	7.50	4.01	5.75	2.49
Atractomorpha crenulata	10.50	6.84	0	0	18.00	9.61	12.5	5.42
Achurum sp.	0	0	0	0	6.75	3.60	5.25	2.28
Pseudorhynchus lessonii	0	0	0	0	9.75	5.21	6.00	2.60
Orchelimum gladiator	8.75	5.70	10.50	7.62	17.5	9.35	25.00	10.80
Conocephalus fuscus	6.25	4.07	8.50	6.17	**25**	**13.4**	**33.75**	**14.6**
Tettigonia viridissima	0	0	0	0	0	0	12.75	5.53
Mecopoda elongata	0	0	0	0	0	0	2.50	1.08
Tettigidea lateralis	20.25	13.20	16	11.62	2.50	1.34	1.75	0.76
Tetrix brunnerii	0	0	0	0	0	0	8.50	3.68
Tetrix ceperoi	6.25	4.07	7.50	5.44	3.75	2.00	4.00	1.73
Nomotettix cristatus	8.50	5.54	1	0.72	0	0	0	0
Neotettix femoratus	3.75	2.44	1.50	1.08	0	0	0	0
Hierodula formosana	1.00	0.65	1.50	1.08	0	0	0	0
Hierodula sp.	0	0	1.00	0.72	0.50	0.27	0.25	0.11

Note: numbers in bold indicate the species with the highest frequency



(A) (B)

Figure 2. Biotic indices of the grasshoppers community structure. A. Dominance and abundance index, B. Diversity and richness index

The values of the diversity index and species richness of grasshoppers that have been analyzed get the following results. The diversity index and species richness of grasshoppers had a direct relationship meaning that the higher the diversity value, the higher the value of grasshopper species richness.

The location with the highest diversity and richness index is the Post-harvested Corn Field with a diversity index of 2.76 and a species richness value of 0.92; the second is the Corn Field with a diversity value of 2.64 and a richness of 0.91; the last, Mixed Crop with a diversity value of 2.60 and a richness value of 0.91. Meanwhile, the lowest diversity and species richness values were in the Doroncanga Savanna, with a diversity index of 2.24 and a species richness index of 0.87 (Figure 2).

Several indices that we have analyzed, both diversity indices and abiotic analysis, showed some indications in the four lands or research locations. The location with the highest diversity was Post-Harvested Corn Field, with a value of 2.76, followed by the highest Richness value of 0.92. Post-Harvested Corn Field has the smallest dominance index, which is 0.079. The high level of grasshoppers diversity in Post-Harvested Corn Field is caused by vegetation. Post-Harvested Corn Field has vegetation that is quite favoured by the grasshopper community, namely abundant grass plants, herbaceous plants, and some shrubs.

As a dominant animal, grasshoppers inhabit a wide range of grassland ecosystems, from the prairie to meadows in the world [12, 13]. Plant species richness has a positive effect on insect species richness. The higher of plant species richness, the higher the insect species richness [7].

This location was also not regularly sprayed with pesticides because this land is not used as agricultural land. As a result of not being sprayed with pesticides, Post-Harvested Corn Field is overgrown with wild plants such as grass that grows naturally. In natural ecosystems, there has been population stability between pests and natural enemies so that the presence of insect pests is no longer detrimental [14]. Furthermore, Corn Field has a quite high diversity value of 2.65 and is followed by a species richness value of 0.91. Based on the intensity of pesticide spraying at this location, spraying is carried out only before planting corn which aims to remove weeds that can interfere with the growth of corn. The second spraying is at the time of post-planting when the corn is one week old to remove nuisance plants. This means that corn farmers do not get too much pesticide spraying at the corn location. The vegetation in this location is corn plants that are 2 to 3 weeks old. Young corn leaves are also one of the grasshopper's favourite foods. So that the diversity of grasshopper species becomes quite high, this result is in accordance with the other research, which describes the results of the evenness of locusts in corn plants with moderate values [15]. The insects with the highest abundance in maize farming were grasshoppers, with a composition of 22% [16].

Meanwhile, the Mixed Crop field location was estimated to have a fairly high diversity value. The diversity value was in third place, 2.60, followed by a species richness value of 0.91. To support plant growth and eliminate pests, farmers at Mixed Crop locations sprayed pesticides every time. So this is a factor that the location of Mixed Crop does not become the location with the highest diversity. Based on the intensity of pesticide spraying, this location got pesticide sprays daily from the farmers. Pesticide spraying was carried out in the morning and evening.

The vegetation at this location consists of medicinal plants and vegetables in the form of red ginger combined with papaya, eggplant, and tomato plants combined in one plot. The other field contained two plants, such as chilli and long beans. The vegetation structure is an important parameter in determining the diversity of grasshoppers in a habitat on a large scale [17].

The Doroncanga Savanna had the aridest abiotic character with newly growing grass vegetation. This location often experienced primary succession. The grass would only grow in the rainy season and die or dry up during the dry season. This location was also used for cattle and horse grazing so that the grass that grows would be directly eaten by livestock. The dominant vegetation in the Doroncanga Savanna is only small grass (Cogon grass) and bidara trees. This vegetation is also in accordance with the coastal soil structure.

The comparison of diversity values and criteria for the Shannon-Wiener diversity index value (H') shows that the four locations have moderate diversity. The species diversity and richness at the 4 locations are directly proportional. This means that the higher the value of diversity. The value of species richness will also be higher.

The results obtained that *P. lessonii*, *Achurum* sp., *C. fuscus*, *O. gladiator* and *A. cinerea* had a positive correlation with the abiotic factors of temperature and light intensity, which means that the higher the temperature and light intensity, the higher the abundance or number of these species. However, it negatively correlated with humidity, meaning that these three species like high light intensity and temperatures but not high humidity. Whereas *N. cristatus, N. femoratus, T. lateralis,* and *H. formosana* had a positive correlation

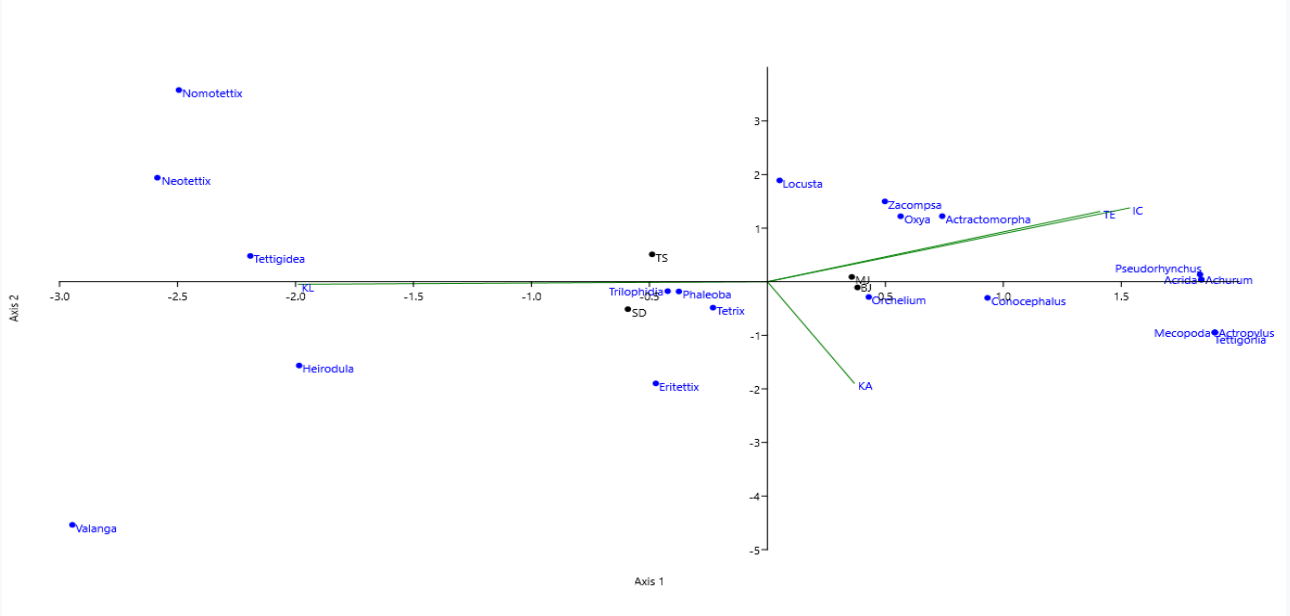


Figure 3. The result of CCA

Table 5. The results of Pearson correlation analysis between abiotic factors and grasshoppers community structure in four research locations

Abiotic Factors		Air Temperature	Humidity	Light Intensity	Wind Velocity
Diversity	Pearson	**.992****	-.743	.761	-.318
	Significance	**.008**	.257	.239	.682
Abundance	Pearson	.234	.482	.166	-.913
	Significance	.766	.518	.834	.087
Dominance	Pearson	**-.998****	.675	-.701	.418
	Significance	**.002**	.325	.299	.582
Richness	Pearson	**.964***	-.624	.808	-.427
	Significance	**.036**	.376	.192	.573

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

with humidity. This mean that these species preferred high humidity or high abundance depending on high humidity.

The species group *T. annulata, P. fumosa, T. ceperoi* had a negative correlation with wind speed, which mean that this group did not like high wind speeds. Meanwhile, the *M. elongata, Acrotylus* sp., and *T. viridissima* species groups positively correlate with the wind speed of the three species depending on the high wind speed.

Pearson correlation analysis showed that air temperature positively correlated with diversity and species richness values. These results concluded that air temperature plays an important role in determining the high level of diversity and species richness of grasshoppers. It mean the high air temperature, the high diversity and richness value of the grasshoppers can be found.

Air temperature has a negative correlation with dominance index values. This means that the dominance value does not depend on the increase in air temperature. The low the air temperature, the high the dominance value. Other abiotic factors such as air humidity, light intensity, and wind speed, do not correlate with the grashoppers community structure. Several species of grasshoppers prefer warmer environmental conditions [19].

CONCLUSION

The result showed that the highest grasshopper diversity was found in Post-harvested Corn fields, whole lowest in Doroncanga savanna. Location diversity is affected by vegetation and pesticide spraying. This study recommends the farmer take care of the land even at the postharvest time.

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REFERENCES

[1] Primack RB, Sher A, Sher AA (2016) Introduction to conservation biology. Sinauer Associates, Incorporated, Publishers. p. 476.

[2] BAPPENAS (2016) Indonesian Biodiversity Strategy and Action Plan (IBSAP) 2015-2020. The National Development Planning Agency (BAPPENAS), Jakarta.

[3] Cigliano MM, Braun H, Eades DC, Otte D (2017) Orthoptera species file online. Version 5 (5.0). http://orthoptera.speciesfile.org

[4] Erawati NV, Kahono S (2010) Keanekaragaman dan kelimpahan belalang dan kerabatnya (Orthoptera) pada dua ekosistem pegunungan di Taman Nasional Gunung Halimun-Salak. Jurnal Entomologi Indonesia 7(2): 100-100.

[5] Leksono AS, Yanuwiadi B, Khotimah A, Zairina A (2022) Grasshopper diversity in several agricultural areas and savannas in Dompu, Sumbawa Island, Indonesia. Biodiversitas Journal of Biological Diversity 23(1): 75-80.

[6] Dompu Statistic Central Beaureau (2014) Padi sawah dan padi ladang (Hektar), https://dompukab.bps.go.id/indicator/53/65/1/padi-sawah-dan-padi-ladang.html.

[7] Haddad NM, Crutsinger GM, Gross K, Haarstad J, Knops JM, Tilman D (2009) Plant species loss decreases arthropod diversity and shifts trophic structure. Ecology Letters, 12(10), 1029-1039.

[8] Suheriyanto D (2008) Ekologi serangga. UIN-Maliki Press, Malang.

[9] Meena S, Kumari V, Singh N (2020) Effect of temperature and relative humidity on the growth and development of Acridid grasshopper, *Chrotogonus trachypterus* Blanchard. Indian Journal of Agricultural Research 2020(54): 471-476.

[10] Kuřavová K, Šipoš J, Wahab RA, Kahar RS, Kočárek P (2017) Feeding patterns in tropical groundhoppers (Tetrigidae): a case of phylogenetic dietary conservatism in a basal group of Caelifera. Zoological Journal of the Linnean Society 179(2).

[11] Sharma N (2012) Population fluctuation of grasshopper fauna in a field near Kakdwip, Sunderbans, West Bengal. Zoological Survey of India 3 (Part 3): 27-30.

[12] Laws AN, Prather CM, Branson DH, Pennings SC (2018) Effects of grasshoppers on prairies: Herbivore composition matters more than richness in three grassland ecosystems. Journal of Animal Ecology 87(6): 1727-1737.

[13] Zhu H, Qu Y, Zhang D, Li J, Wen M, Wang D, Ren B (2017) Impacts of grazing intensity and increased precipitation on a grasshopper assemblage (Orthoptera: Acrididae) in a meadow steppe. Ecological Entomology 42(4): 458-468.

[14] Pradhana R (2014) Keanekaragaman serangga dan laba-laba pada pertanaman padi organik dan konvensional. Ph.D. Thesis. Universitas Brawijaya.

[15] Prakoso B (2017) Biodiversitas belalang (Acrididae: ordo Orthoptera) pada agroekosistem (*Zea mays* L.) dan ekosistem hutan tanaman di Kebun Raya Baturaden, Banyumas. Biosfera 34(2): 80-88.

[16] Azwir A, Jalaluddin J, Rubiah R, Listiana L (2019) Identifikasi keanekaragaman jenis serangga pada tanaman jagung (*Zea mays* L.) di Gampong Sukamulia Kecamatan Lembah Seulawah Kabupaten Aceh Besar. In Prosiding Seminar Nasional USM 2(1): 358-365.

[17] Loaiza V, Jonas JL, Joern A (2011) Grasshoppers (Orthoptera: Acrididae) select vegetation patches in local-scale responses to foliar nitrogen but not phosphorus in native grassland. Insect Science 18(5): 533-540.