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The Diversity and Abundance of Grasshopper Communities based on Differences Altitude in Malang Indonesia

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Abstract: ***The diversity of insects in general is influenced by the type of vegetation, climate, latitude, and altitude above sea level. One of the insects that can be easily found is grasshoppers. Areas with upland areas usually have lower locust diversity and abundance when compared to lowland areas. This research was conducted in 5 locations that were used as locust sampling sites in Malang district including SumberPujung sub-district (234-346), Bantur district (46-321) masl, Lawang sub-district (426-446) masl, Pujon sub-district (1184-1246) masl and Poncokususmo sub-district (1228-1482 masl). Each location was made 5 stations by making a transect line at each station with 3 replications. Grasshopper samples were collected using line transect and hand collecting methods with direct sampling using insect nets which were carried out at 09.00 WIB and 16.00 WIB. The abiotic factors observed included temperature, light intensity, wind speed and humidity, while the biotic factors observed in this study were plant vegetation at each station, and the presence of predators. Data were analyzed using species abundance analysis, Shannon Wiener index, evenness index, importance value index, dominance index and Jaccard similarity index to evaluate the proportion of the same species between sites and Biplot analysis to determine the Pearson correlation of each species to abiotic factors. The results showed that the abundance of grasshoppers at each location greatly influenced the elevation gradient. Meanwhile, the diversity of grasshoppers at each location shows moderate diversity. The correlation of grasshoppers with abiotic factors shows that the presence of grasshoppers is strongly influenced by wind speed and light intensity.***

Keywords: Diversity, Abundance, Grasshopper, Orthopthera, Malang.

1. Introduction

The country of Indonesia has abundant and quite high diversity of biological resources, or is often referred to as a country with megabiodiversity, this is because Indonesia has a stable climate and geographically Indonesia is an archipelago with a tropical climate, making it possible for a wide variety of flora and fauna to live and reproduce, one of the endemic fauna from Indonesia which has an abundant diversity, namely insects. The diversity of insects in general is influenced by the type of vegetation, climate, latitude, and altitude above sea level. Insects are part of biodiversity that must be preserved from extinction and decline in its variety. One of the insects that we can easily find is grasshoppers. Differences in the structure and composition of an ecosystem cause differences in the character of the ecosystem which affect the diversity and abundance of biota that live in it. The abundance of grasshoppers is largely determined by their reproductive activities which are supported by a suitable environment and adequate food sources. The abundance and reproductive activities of grasshoppers in the tropics are strongly influenced by seasons, because the season affects the availability of food sources and the ability to live for grasshoppers which directly affect abundance. Areas with upland areas usually have lower locust diversity and abundance when compared to lowland areas (Wong &Wolda, 1998).According to Bhargava (1996), grasshopper diversity is influenced by ecological factors including rainfall patterns, atmospheric temperature, relative humidity, soil type, protection from external enemies and vegetation structure. Baldi (1997) states that vegetation greatly affects the composition and presence of grasshopper species in an ecosystem. Fielding and Bruseven (1995) stated that vegetation greatly affects the composition and presence of grasshopper species in an ecosystem. The higher the diversity of vegetation in a habitat, the higher the source of food for grasshoppers in a habitat, so that its existence will be abundant. Morris (2000) states that "the vegetation structure is an important parameter to determine the diversity of grasshoppers in a habitat on a large scale". So a research was conducted on the diversity and abundance of grasshoppers with different heights in Malang Regency.

2. Methods

This research was conducted in SumberPucung (234-346), Bantur (46-321) masl, Lawang (426-446) masl, Pujon (1184-1246) masl and Poncokususmo (1228-1482 masl) (Figure 1), Malang Regency. Sampling was conducted in January until March 2020 (Research was conducted during the Rainy season) Morning 07.00-11.00 WIB. The sampling method was carried out using the Line Transect Methods technique combined using insect nets and hand collecting. The selection of sample points is adjusted to land conditions and is endeavored to represent the entire stretch. This research was conducted by constructing a 200m2 main transect, then making 5 sampling points (plots) along the main transect line, measuring 2x10 m2 in length. The morphological characteristics of the grasshoppers obtained were immediately observed and recorded on the label. Furthermore, grasshoppers were put into specimen bottles

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containing 70% alcohol to be identified in the Laboratory for identification of grasshopper specimens to the genus level by comparing the morphological characteristics of the specimens with Kalshoven (1981) and the insect identification key book Borror et al., (1981), Willemse (1930, 1965, 2001), Lilis (1991) Rentz (1991), Johnson (2008), and Tan (2012; 2017) and BugGuide.net. The results of the data will be identified and analyzed using the Species Diversity Index, Dominance Index, Importance Value Index (INP), Evenness Index, jaccard Similarity Index to calculate the similarity / similarity of species composition between locations and the Biplot Principal Component Analysis to determine the correlation between grasshoppers and abiotic factors.

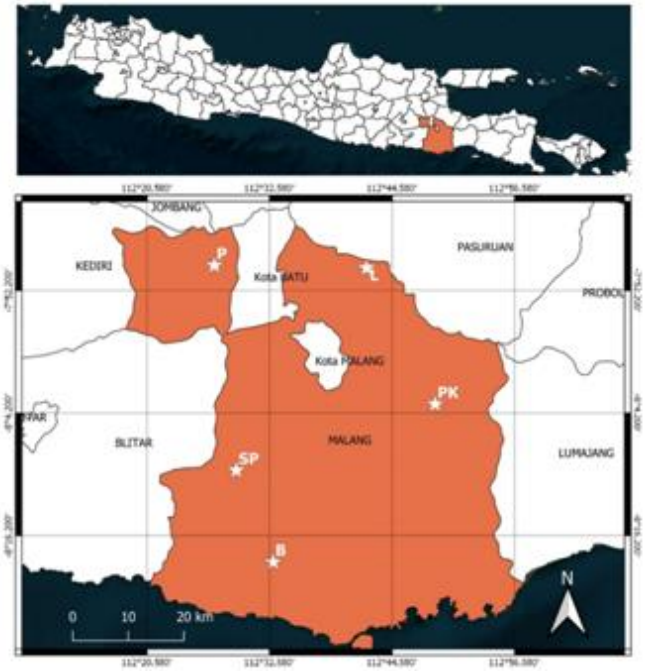

Figure 1: Location of five study sites in Malang District, East Java, Indonesia. **B**.Bantur; **SP**.Sumberpucung;**L**.Lawang;**P**. Pujon; **PK**.Poncokusumo.

3. Result

3.1 Abiotic factors at each location

Table 1: Differences in abiotic factors in each location

No	FaktorAbiotik	PK	LW	PJ	SP	BT
1	Temprature	24,5 ± 0.156	25,5 ± 0,224	24 ± 0,083	27± 0,035*	25 ± 0,181
2	Humidity	24 ± 0.132	25,5± 0.325	23,5± 0.115	28± 0.048*	26± 0.292
3	Light intensity	358,5± 0.155	592,5± 0.246	426± 0.142	650,5± 0.0363*	648± 0.382
4	Wind velocity	1,57± 0.143	3,20± 0.021*	1,15± 0.166	2,42± 0.236	2,36± 0.153

Note: The ± value is represented based on the Std Mean Error. * Sign indicates a significant difference with value p<0.05.

Measurement of abiotic factors is carried out by measuring temperature, humidity, light intensity and wind speed. Based on the results of the calculation of the abiotic factor, it is known that the temperature at SumberPucung location (27 ℃) has a significant difference because the p value is <0.05. This happens because the source of the Pucung is a lowland area that is rarely found in plant vegetation. Meanwhile, for humidity measurement, it is known that the source of the Sumberpucung (28 ℃) has a significant difference with other locations. This is indicated by value p<0.05. In this case, many of the inhabitants of the Sumberpucung are farmers, so that most of the closed ecosystems are used by residents to be opened into agricultural land. The results of the light intensity measurement show that the source of the pale (605.5 lux) has a higher light intensity than other locations. This is influenced by the fact that in addition to the source of the paleo being lowlands, the location also lacks tree groves around it so that there is more light and the pattern of rainfall in lowland areas is arguably lower than in other locations. The results of wind speed measurement show that the Lawang location (3.20 m / s) has a significant difference marked with a p value <0.05. Wind speed in this case greatly affects temperature, humidity, and the distribution of grasshoppers.

3.1 Community Structure and Composition of Grasshoppers based on Altitude differences

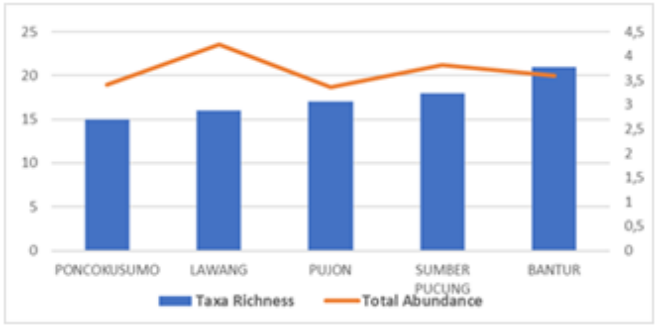

Figure 2: Taxa Richness and Total Abundance

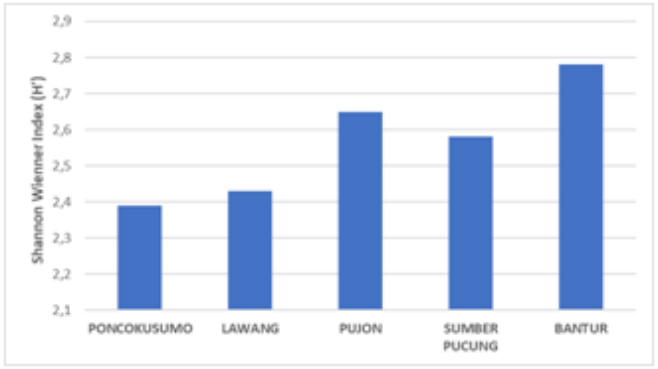

Figure 3: Diversity index Shannon wienner

Based on the research results found 2252 individuals, 11 and 33 Grasshopper species found in all five locations Poncokusumo (427 individuals), Lawang (530 individuals), Pujon (379 individuals), SumberPucung (467 individuals), and Bantur (449 individuals) (Table 2). The abundance and reproductive activities of grasshoppers in the tropics are strongly influenced by seasons, because the season affects the availability of food sources and the ability to live for grasshoppers which directly affect abundance. Areas with plains high species usually have lower locust diversity and abundance when compared to lowland areas (Wong &Wolda, 1998). This is consistent with the results of the research that Bantur, SumberPucung and Lawang are lowland areas with

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Table 2: Types of grasshoppers found and their roles

No	Spesies	PK	LW	PJ	SP	BT	Role
1	Conocephalus cognatus	+	-	+	+	-	Omnivore
2	Atractomorphacrenulata	+	+	+	+	+	Herbivore
3	Euconocephalusvarius	+	+	+	-	-	Omnivore
4	Seduliaspecularia	+	-	+	-	+	Herbivore
5	Phlaeobafumosa	+	+	+	+	+	Herbivore
6	Phlaeobainfumata	+	+	+	+	+	Herbivore
7	Acromantissp	+	-	-	-	-	Predator
8	Phlaeobasp	-	-	-	-	+	Herbivore
9	Apalacrisvaricornis	+	+	-	+	+	Herbivore
10	Trauliaazureipennis	+	-	-	-	+	Herbivore
11	Alloteraturasp	-	+	+	+	-	Omnivore
12	Gesonulamundata	+	+	+	-	-	Herbivore
13	Pseudoxyadiminuta	-	+	-	+	-	Herbivore
14	Hieroudulasp	-	-	+	-	-	Predator
15	Pteronemobiussp	+	-	-	-	-	Herbivore
16	Xenocatantops humilis	-	+	-	+	+	Herbivore
17	Asioplugisthaumasia	+	+	+	+	+	Omnivore
18	Anchialebriareus	+	-	-	-	-	Omnivore
19	Schistocerca sp	-	+	+	+	+	Herbivore
20	Valanganignicornis	-	+	-	-	-	Herbivore
21	Locusta sp	-	-	-	+	+	Herbivore
22	Iris oratoria	-	-	-	+	+	Predator
23	Tenoderaaustralasiae	-	-	-	-	+	Predator
24	Melanoplussp	-	+	+	+	+	Herbivore
25	Oxya japonica	+	+	+	+	+	Herbivore
26	Trilophida annulate	+	+	+	+	+	Herbivore
27	Lucretilissp	-	-	+	-	+	Herbivore
28	Tetrix sp	-	-	-	-	+	Herbivore
29	Nomotettixcristatus	-	-	-	-	+	Herbivore
30	Acromatisgestri	-	-	-	-	+	Predator
31	Phaenopharossp	-	-	-	+	-	Herbivore
32	Conocephalinisp	-	-	-	+	-	Scavanger
33	Acridaconica	-	+	+	+	+	Herbivore

Note: **PK**:Poncokusumo, **LW**:Lawang, **PJ**:Pujon, **SP**:SumberPucung, **BT**:Bantur.

the highest number of individuals compared to Poncokusumo and Pujon which are highlands with the least number of individuals.Based on the results of research data analysis by calculating the number of taxa and total abundance, it is known that the highest grasshopper abundance is found in Lawang District with values (4,240 individuals / m^3), SumberPucung (3,824 individuals / m^3) and Bantur (3,592 individuals / m^3). while the lowest abundance values were in Pujon (3,368 individuals / m^3) and Poncokusumo (3,416 individuals / m^3) (Figure 2).The abundance value of grasshoppers is found more in the lowlands (Bantur, Lawang and SumberPucung), this can be influenced by rainfall, temperature and humidity. Lowland and highland areas or different altitude factors indirectly affect the reproduction and reproduction of grasshoppers. While the wealth of taxa is known that Bantur has the highest taxa wealth value (21) then SumberPucung (18) taxa, Pujon (17) taxa, Lawang (16) taxa, until the least is Poncokusumo (15) taxa (Figure 2). This can be from the ability to survive each type of grasshopper so that grasshoppers that have the potential to find food and breed are often found in both the highlands and the lowlands.

Based on the results of data analysis, it is known that the value of the Shannon Wiener diversity index in each location is the highest in Bantur (2.78), Pujon (2.65), SumberPucung (2.58), Lawang (2.39) districts.), and the lowest diversity was found in Poncokusumo District (2.43) (Figure 3).

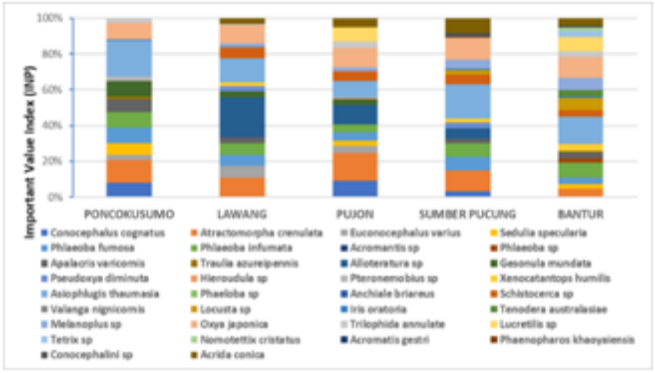

Figure 4: Index of Importance Value of each grasshopper species at each location

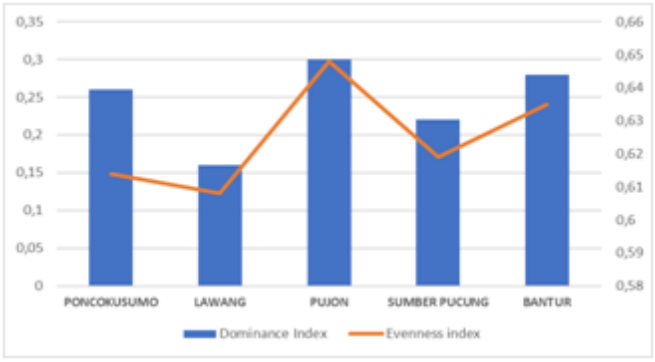

Figure 5: Dominance Index and Species Uniformity in each location

Bantur district has the highest diversity because it has the most high / diverse species compared to Poncokusumo which has fewer species.

Based on the results of the important value index calculation, it is known that there are codominations of the species *Alloteraturasp*, *Asioplugisthaumasia*, *Oxya japonica* and *Actractomorphacrenulata*. Alloteraturasp and Asioplugisthaumasia are 2 types that come from the same famili, namely Tettigoniidae, while *Oxya japonica* is a grasshopper which is a grasshopper from the Phyrogomorphidaefamili (Figure 3).

According to Rahmawati (2012), insects of the Order Orthoptera often become a problem for the community, for example the families of Acrididae and Gryllidae which are pests of cultivated plants and cause harm to humans from the families of Acrididae and Actractomorpha crenulate.

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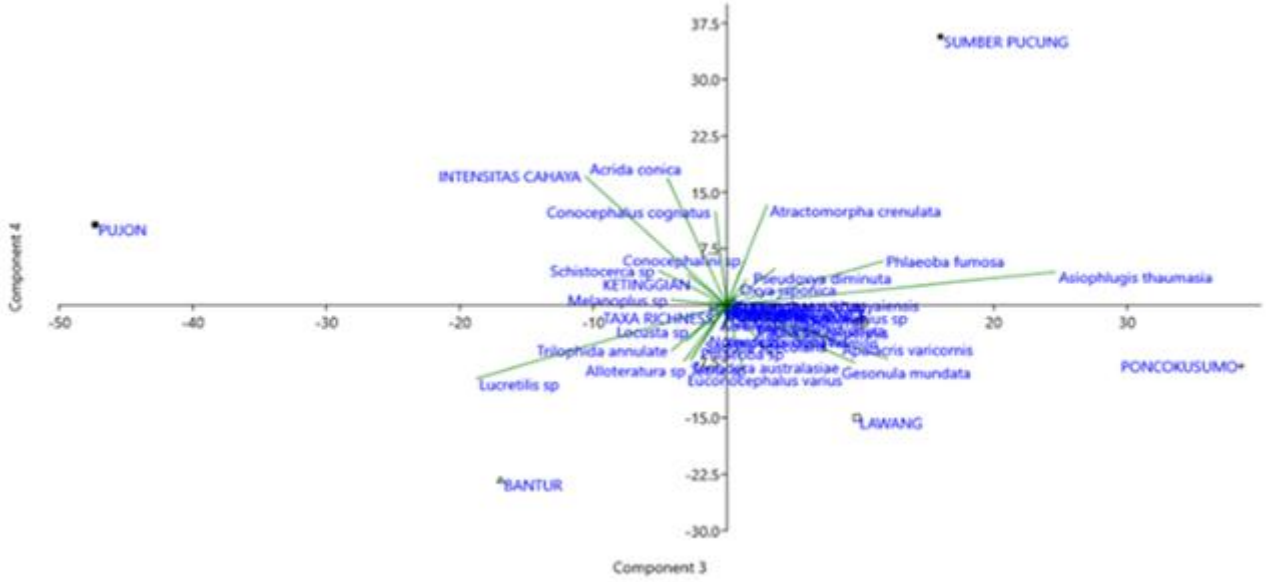

Addition, insects of the Order Orthoptera act as predators like the family Omnivores such as Tettigonidae can be used as natural enemies for plant pests.

Based on the results of the calculation of the dominance index, it is known that the dominance values in Pujon (0.3), Bantur (0.28) and Poncokusumo (0.26) districts have a higher dominance value than SumberPucung (0.22) and Lawang (0.16). (Figure 4). This indicates that Pujon, BanturPoncokusumo and SumberPucung have many species of grasshoppers that dominate and in Lawang District only a few species dominate.The dominance index value is close to one (1) if the community is dominated by certain species or species and if the dominance index is close to zero (0) then no species or species will dominate. The results of the analysis of the Evenness index in each location are Poncokusumo (0.614), Lawang (0.608), Pujon (0.648), SumberPucung (0.619) and Bantur (0.635) (Figure 4). The uniformity value in the five locations has almost the same value in the range of 0.6, this indicates that the five locations have nearly low species uniformity.

3.2 Correlation between abiotic factors and type of grasshoppers

The results of the Biplot analysis, it is known that temperature has a positive correlation with *Oxya japonica, Conochepalinisp, Atractomorphacrenulata, Phlaeobafumosa, Phaenopharoskhaoyaiensis* and *Pseudoxyadiminuta.* This means that the higher the temperature, the higher the existence of these species. *Temperature was negatively correlated with Schistocerca sp, Hierodulasp, Acridaconica*and*Conocephalus cognatus*. This means that the higher the temperature, the lower the presence of these species.Humidity was positively correlated with *Alloteraturasp, Xenocatantops humilis, Locusta sp, Tenoderaaustralasiae, Melanoplussp, Trilophida annulate, Lucretilissp,* and *Nomotettixcristatus*and negatively correlated with the species Schistocerca sp, Acridaconica and Conocephalus cognatus.

Light intensity was positively correlated with *Apalacrisvaricornis, Asiophlugisthaumasia, Euconocephalusvarius, Seduliaspecularia, Phlaeobainfumata, Trauliaazureipennis, Gesonulamundata,* and*Pteronemobiussp* and negatively correlated with *Schistocerca sp, Hierodulasp, Acephaluscognica and Conocephaluscognica*. Wind speed is positively correlated with *Asiophlugisthaumasia, Euconocephalusvarius, Seduliaspecularia, Phlaeobainfumata, Trauliaazureipennis*and*Gesonulamundata* and negatively correlated with *Alloteraturasp, Xenocatantops humilis, Locusta sp, Tenoderaaustralasiae,* and *Melanoplus sp*. The correlation of grasshopper diversity with wind speed shows a negative correlation, meaning that it is inversely proportional, the higher the wind speed, the lower the grasshopper diversity, and vice versa for the positive correlation. The presence of insects is strongly influenced by abiotic factors which include temperature, humidity, sunlight and wind (Sun et al., 2014). According to Solimanet al., (2017), every study regarding the number of species of living things cannot be separated from abiotic factors as a determining factor for the optimal environment for these living things. Environmental factors that play a role in the presence and number of insect species include temperature, rainfall, light and humidity. Altitude was positively correlated with the species *Melanoplussp, Conocephalinisp, Conocephalus cognatus, Schistocerca sp*and *Acridaconica* and negatively correlated with the species *Locusta sp, Trilophidaannulata, Lucretilissp, Euconocephalusvarius* and *Alloteratura sp*. Based on literature by Hoiss et al. (2012) which states that the number of insect species decreases with increasing latitude or altitude caused by environmental influences. In addition, higher ground can slow insect reproduction so that the number of generations and the number of insect populations tends to be less (Duyck et al., 2010).

4. Discussion

This study showed grasshopper abundance varied between study sites. This variation is influenced by environmental factors, including altitude, temperature and humidity. The

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results of the study by knowing the role of grasshoppers in their habitat found 5 grasshoppers as Omnivores, 22 grasshoppers as Herbivores, 1 grasshopper as Scavanger and 5 grasshoppers as Predators. The high number of herbivore insects in each location indicates that this type of grasshopper eats plants and also crops belonging to farmers such as rice, corn, sugar cane and others. According to Branson et al., (2006), grasshoppers are the dominant native herbivores in grassland ecosystems worldwide, with economically destructive locust outbreaks occurring frequently in western North America. It is known that the abundance value of grasshoppers is found more in the lowlands (Bantur, Lawang and SumberPucung), this can be influenced by rainfall, temperature and humidity. Lowland and highland areas or different altitude factors indirectly affect the reproduction and reproduction of grasshoppers. This is consistent with the literature by Bhargava (1996), where grasshoppers are influenced by ecological factors including rainfall patterns, atmospheric temperature, relative humidity, soil type, protection from external enemies and vegetation structure. This is also supported by the results of research by Hoiss et al. (2012) which states that the number of insect species decreases with increasing latitude or altitude caused by environmental influences. In addition, higher ground can slow insect reproduction so that the number of generations and the number of insect populations tends to be less (Duyck et al. 2010). The results of this study are supported by previous studies which state that the species diversity and abundance of grasshoppers is highest in the mediumlands and lower in the high and lowlands (Sirin et al. 2010). Differences in altitude, crop composition, rugged nature, urbanization and livestock grazing, and latitude also contribute to variation (Sirin et al. 2010). Based on the diversity index value of Poncokusumo, Lawang, Pujon, SumberPujon and Bantur Districts, all of them are categorized into moderate diversity due to the value of 1 <H '<3. Bantur has diversity close to the value of 3 which means high, this can happen because there is a stable ecosystem without many species dominating. This is reinforced by the literature of Sugianto (1994) which states that high species diversity indicates that a community has high complexity, because in that community there is also high species interaction. So in a community that has high species diversity, species interactions will occur which involve energy transfer (food webs), predation, competition, and division of niches which are theoretically more complex. Many factors can influence the diversity of grasshopper species, including resource availability, habitat structure, escape space, and predators (Joern 2004; Joern 2005). Five environmental factors, including number of flower heads, disturbance intensity, altitude, humidity, and cover of shrubs and trees in the wider plot area, significantly influenced the distribution patterns of grasshopper communities, explaining 32% of the overall variance. Endemic grasshoppers are strongly associated with flower count and humidity, while negatively associated with disturbance intensity and shrub and tree cover. Humidity has a regulatory effect on grasshopper hatcheries and their seasonal life cycle (Kati et al. 2006).

The abundance and diversity of grasshoppers varies according to altitude and environmental factors, namely temperature, humidity, light intensity and wind speed. The composition of grasshoppers in the lowlands is higher than in the highlands. The abundance of grasshoppers is strongly influenced by the altitude gradient, while the diversity is not too different because the diversity values in all locations are almost the same. The correlation between grasshoppers and abiotic factors is very influential in determining the type of grasshopper and its habitat type.

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