E-ISSN 2549-8703 I P-ISSN 2302-7282

BIOTROPIKA *Journal of Tropical Biology*

https://biotropika.ub.ac.id/

Vol. 9 | No. 1 | 2021 | DOI: 10.21776/ub.biotropika.2021.009.01.03

THE ABUNDANCE AND DIVERSITY OF GRASSHOPPER (ORTHOPTERA) IN BATU CITY, EAST JAVA

KELIMPAHAN DAN KEANEKARAGAMAN BELALANG (ORTHOPTERA) DI KOTA BATU, JAWA TIMUR

Mufti Abrori[1)*], Amin Setyo Leksono[2)], Zulfaidah Penata Gama[2)]

Received : December 14th 2020

Accepted : December 24th 2020

Author Affiliation:

[1)] Master Student, Faculty of Mathematics and Natural Sciences, University of Brawijaya

[2)] Biology Departmen, Faculty of Mathematics and Natural Sciences, University of Brawijaya

Correspondence email:

*abrori47@gmail.com

ABSTRACT

Grasshoppers included in the order Orthoptera in the class of insects. Orthoptera orders are divided into two parts, which a large suborder Ensifera and Caelifera. Most grasshopper species have a role as herbivores and a good protein source for other animals. Grasshopper abundance and diversity of ecosystems are more stable in a low disorder and the other way around. The factors that affect grasshoppers which environmental factors such as the structure of the vegetation, atmospheric temperature, and relative humidity. The purpose of this study to analyze the abundance and diversity of grasshoppers in Batu City, East Java. The research location is in Tahura R. Soerjo Cangar, an agricultural area in Sumbergondo Village, Coban Talun, and Junrejo District. Measurement of biotic and abiotic factors was carried out at the grasshoppers living locations, and then the data were analyzed using the Shannon Wiener Diversity index (H'), Importance Value Index (INP), and Biplot analysis. The results were obtained as 754 individual grasshoppers from the Caelifera suborder. While 201 individuals were found in the Ensifera suborder. The results showed that the highest grasshopper abundance was at the Sumbergondo location, which for the Caelifera. While Ensifera on Tahura R. Soerjo Cangar location had the highest grasshopper abundance. The vegetation area influences abundance and diversity of grasshoppers both in the two suborders. The reduction of the grasshopper's natural habitat harms the survival of the grasshopper. Environmental factors and their characteristics can influence the abundance and diversity of insects, including grasshoppers in a habitat.

Keywords*: Batu City, diversity, grasshopper, Orthoptera*

ABSTRAK

Belalang termasuk dalam ordo Orthoptera dalam kelas serangga. Ordo Orthoptera dibagi menjadi dua bagian subordo besar yaitu Ensifera dan Caelifera. Sebagian besar dari spesies belalang memiliki peranan sebagai herbivor dan merupakan sumber protein yang baik bagi hewan lainnya. Kelimpahan dan keanekaragaman belalang lebih stabil pada ekosistem yang sedikit gangguan begitu juga sebaliknya. Faktor yang memengaruhi keragaman belalang antara lain adalah faktor ekologis seperti struktur vegetasi, suhu atmosfer, serta kelembaban relatif. Tujuan dari penelitian ini adalah untuk menganalisis kelimpahan dan keanekaragaman dari belalang di Kota Batu, Jawa Timur. Penelitian ini dilakukan di empat lokasi yaitu, Tahura R. Soerjo Cangar, persawahan Desa Sumbergondo, Coban Talun dan Kecamatan Junrejo. Pengukuran faktor biotik dan abiotik dilakukan pada lokasi tempat hidup belalang, kemudian data dianalisis dengan menggunakan indeks Keanakragaman Shannon Wiener (H'), Indeks Nilai Penting (INP) dan analisis biplot. Hasil dari penelitian diperoleh jumlah belalang sebanyak 754 individu dari subordo Caelifera. Sedangkan pada jenis Ensifera ditemukan sebanyak 201 individu. Hasil penelitian menunjukkan bahwa kelimpahan belalang tertinggi adalah pada lokasi Sumbergondo yakni untuk subordo Caelifera. Sedangkan untuk subordo Ensifera pada lokasi Tahura R. Soerjo Cangar memiliki kelimpahan belalang tertinggi. Area vegetasi memiliki pengaruh terhadap kelimpahan serta keragaman dari belalang baik pada kedua subordo tersebut. Berkurangnya habitat alami belalang berdampak negatif pada keberlangsungan hidup belalang. Faktor lingkungan serta karakteristik lingkungan memberikan pengaruh pada kelimpahan dan keragaman serangga termasuk belalang pada suatu habitat.

Kata Kunci*: belalang, keanekaragaman, Kota Batu, Orthoptera*

How to cite:
Abrori M., AS. Leksono, ZP Gama. 2021. The abundance and diversity of grasshopper (Orthoptera) in Batu City, East Java. *Journal of Tropical Biology* 9 (1): 19-26.

INTRODUCTION

Indonesia has about 250,000 species of insects found on earth. Indonesia is located in a tropical region with a stable climate and is geographically an archipelago, so all kinds of flora and fauna can live in Indonesia [1]. Java Island is one of the areas with high population density in Indonesia. Lots of rapid habitat destruction from cities to mountainous areas. The frequent destruction of habitat in Java is the effect of graying and expanding agricultural land [2].

The Orthoptera order is divided into two major suborders, namely Ensifera and Caelifera. The difference between the two Orthoptera suborders is in the femora. Caelifera has rear femora that are longer and thicker than the front femora, while the Ensifera has a thick and long hind femora almost the same as the front femora. Caelifera is a jumping Orthoptera, including a type of short-grained grasshopper. Barbels have a relatively short size, tarsi containing two or fewer segments. Meanwhile, Ensifera is also a jumping Orthoptera, with slightly enlarged femora, although not as large as Caelifera. They include long grubby grasshoppers and chuckles. The antenna is almost always hairlike and has three or four segments [3].

The abundance and diversity of grasshoppers are more stable in an ecosystem with less disturbance and vice versa. The factors that influence the diversity of grasshoppers include ecological factors such as vegetation structure, atmospheric temperature, relative humidity, soil type, rainfall patterns, and protection from external enemies [4, 5, 6]. The existence and composition of grasshoppers are very dependent on the state of vegetation in the grasshopper habitat. The higher diversity of vegetation in a habitat will affect the availability of many food sources for grasshoppers, thus affecting the abundance of grasshoppers. The structure of the vegetation itself is an important parameter used to determine the diversity of grasshoppers in a habitat [7].

Grasshoppers and their relatives are insects that can live in various environments such as on vegetation, plantations, agriculture, and forests. Grasshoppers are included in insects that occupy one of the food chains, so if one of the food chains changes, it will have an impact on animals that are predators of grasshoppers and vice versa [8]. Most grasshoppers are grouped into types of pests so that the abundance and diversity of grasshoppers need to be monitored to increase basic knowledge about abundance, diversity, and population ecology [9].

To monitor the diversity of a population in a specific area. Information from each individual is used, which the abundance, function, and role of the habitat and ecosystem [9][10]. The diversity and abundance of grasshoppers have a role and function in the balance of the ecosystem so that their existence is important and requires intense monitoring in a habitat [11].

This study aims to analyze variations in the abundance and diversity of grasshopper species at Batu City, East Java. The research results are expected to provide benefits for further research on grasshoppers (Orthoptera) and beneficial for compilers of various policies and utilization of biological resources, especially as a method of conservation efforts for the species of grasshoppers (Orthoptera).

METHODS

Data collection from grasshoppers was carried out using the direct observation method (search and direct observation). The individual count of each species found was counted using the census method. The method was carried out by counting the entire individual of each species found throughout the study area [12]. Observation starts at 09.00 - 12.00 WIB and continues at 13.00 - 16.00 WIB. Collection of grasshopper families using hand collection or direct capture. This research was conducted in four locations: Tahura R. Soerjo Cangar, Sumbergondo Village rice fields, Coban Talun, and Junrejo District. At each location, it was divided into two stations, each location consisting of two plots which are approximately ± 100 meters apart. This step was carried out the same at each predetermined location point. Determining the plot at each observation point used the purposive sampling method to determine the location where the grasshoppers live, including fields, grasslands, and shrubs [13, 14].

In each plot area, a minimum of 30 grasshoppers was found to be sampled within one hour. Population data collection was repeated four times with different periods of the day in each study area. This step was carried out the same at each predetermined location point. The specimens were sorted, dried, and then pinned before species-level identification. Grasshopper specimens were identified based on [15], OSF (Orthoptera Species File) online and supported with other studies such as [16-23].

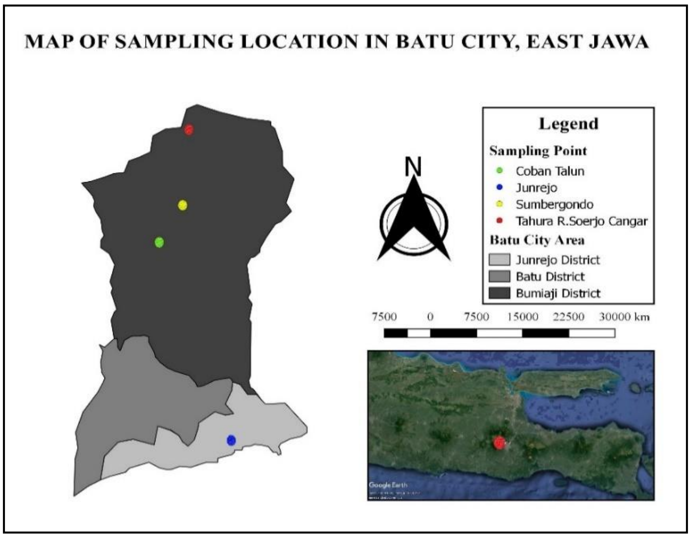

Figure 1. Research sampling location

Environmental factors observed were air temperature, humidity, light intensity, wind speed, and location altitude. The abiotic effect on the Orthoptera diversity factor was analyzed with a biplot analysis using the PAST 4.03 software. Observations of the community structure and diversity of grasshoppers used Shannon diversity and important values index. Species diversity (H') was analyzed using the Shannon-Wiener diversity index, with the following formula [24]:

$$H' = -\sum \frac{(ni)}{N} \times \ln \frac{(ni)}{N}$$

Description:
H' : Shannon-Wiener diversity index
ni : The number of individuals of all types
N : The total number of individuals of all types

Determining the Importance Value Index (IVI) using the following formula equation [25]:

$$IVI = RD + RF$$

Description:
RD : Relative Density
RF : Relative Frequency

RESULTS AND DISCUSSION

Diversity of Orthoptera. Observation of grasshopper diversity, including suborders Caelifera and Ensifera, was carried out at four locations at various heights and different ecosystems. Types of suborder Caelifera the total number of ecosystems found was 754 individuals divided into 11 species from two families, seven subfamilies. Meanwhile, 201 individuals were found in the type of Ensifera, which were divided into four species from two families and two subfamilies (Tabel 1).

In this study, the highest diversity of Caelifera was observed at Junrejo. The results showed that the number of Caelifera found was 194 individuals from eight species with an index H' value of 1.68 (Figure 2) which is included in the medium category. The dominant species was *Phlaeoba fumosa* with 65 individuals, followed by *Acrida* sp. 45 individuals in all replications. *P. fumosa* was the largest and most widespread tribe of Acridinae and was commonly found [26][27]. The genus *Phlaeoba* experienced a population peak in July and August because, in those months, the relative humidity of the soil affected the increase in plant growth [28]. The population of grasshoppers (Orthoptera) was closely related to plants because it became the food source of Orthoptera [29].

The lowest diversity of Caelifera was found at Sumbergondo. The number of Caelifera found was 232 out of three species with a total H' index value of 1.06. It was included in the less category with a fairly stable community structure condition. The dominant species at this location was *Atractmorpha crenulata* with 118 individuals, while the smallest number was *Oxya japonica* with nine individuals in all replications in one location. *Atractmorpha* species had a chewer-mouth type so that this species was grouped into types of pests of crops such as corn plants. *A. crenulata* could adapt to a less beneficial environment to itself, thus making it able to survive in that environment. *A. crenulata* was able to carry out polymorphism, namely the ability to change its body color from green to brown when the environmental temperature was getting higher [30].

Table 1. List of species at all locations

No	Species	Sampling Plot				Total
		TC	SG	CT	JR	
1	*Phlaeoba fumosa*	54	83	82	65	284
2	*Atractmorpha crenulata*	14	118	46	32	210
3	*Ducetia* sp.	98			39	137
4	*Oxya japonica*	9	9	57	10	85
5	*Miramella alpina*	56				56
6	*Conocephalus maculatus*			50		50
7	*Acrida* sp.				45	45
8	*Xenocatantops humilis*				28	28
9	*Paratettix curtipennis*	4	22			26
10	*Gastrimargus* sp.				8	8
11	*Conocephalus cognatus*		5		2	7
12	*Conocephalus melannus*		3	4		7
13	*Formosatettix* sp.	5		1		6
14	*Apalacris varicornis*				5	5
15	*Epistaurus aberrans*				1	1

Note: TC = Tahura R. Soerjo Cangar; SG = Sumbergondo; CT = Coban Talun; JR =Junrejo

In Indonesia, *Oxya* sp. was one of the pests in rice reported to cause significant losses [18]. *Oxya* sp. was a type of pest that knows no season, became a pest in both the rainy and dry seasons. In addition to attacking rice plants, *Oxya* sp. also consumed various crops such as sugarcane, potatoes, vegetables, fruits, tobacco, water plants, and weeds [19]. Besides being found in cultivated plants, this type of *O. japonica* was also found in the weeds *Monochoria vaginalis*, *Brachiria* sp., *Cyperus rotundus*, *Alternanthera sessilis*, *Digitaria sanguinalis*, *Cynodon dactylon*, *Phyllanthus niruri* [31, 32].

The highest diversity value of Ensifera was found at the Sumbergondo, where eight individuals from two species were found with an index value of 0.66 (Figure 2). It was included in the category of low diversity level, with the distribution of community structure types being quite stable. The species found in were *C. cognatus* five individuals and *Conocephalus melannus* three individuals in all replicates in one location. Conocephalinae was the second-largest subfamily of Tettigoniidae, and *Conocephalus* was a genus with a cosmopolitan distribution [33]. Grasshoppers usually appeared in early April and were often associated with cultivated plants and grasses [34].

The lowest diversity of Ensifera was found in Coban Talun where 54 individuals from two species were observed with an H' index value of 0.26, which was included in the category of very low diversity levels. The most species found was *C. maculatus* with 50 individuals. *C. maculatus* was one of the Conochepaline species which was abundant and capable of inhabiting all grassy habitats. *C. maculatus* was a small hygrophilic insect, often associated with swampy habitats that had high grass. This result was consistent with the observation location at Coban Talun in an area close to the river [35].

Important value index of Orthoptera in the various ecosystems. The results of the important value index of the Caelifera suborder showed that three species were dominant in all of the 11 species found in all research locations. The dominant species were *P. fumosa, A. crenulata, O. japonica* with IVI values of 47.92%, 38.11%, and 21.53%, respectively, Table 2. *P. fumosa, A. crenulata, O. japonica* were three species found in all study sites and had a high average number. The predominant were from two different subfamilies, namely Acridinae and Oxyinae. *P. fumosa* and *A. crenulata* from the subfamily Acridinae were two species with high index values in almost every location because these two types had good adaptability to the environment. *P. fumosa* species were Acrididae commonly found in various ecosystems and experience a population peak in July and August [27, 28]. *A. crenulata* was a species with an excellent ability to adapt to an unfavorable environment [30]. Whereas *O. japonica* was included in the subfamily Oxyinae, which was more likely to be found in locations around rice fields because this species tend to prefer agricultural habitat and was one of the pests of rice plants. *Oxya* was a secondary pest of rice plants in Indonesia, primarily found in agro-ecosystem areas that support rice farming adjacent to taro plants, which *Oxya* used as a host for laying eggs [36].

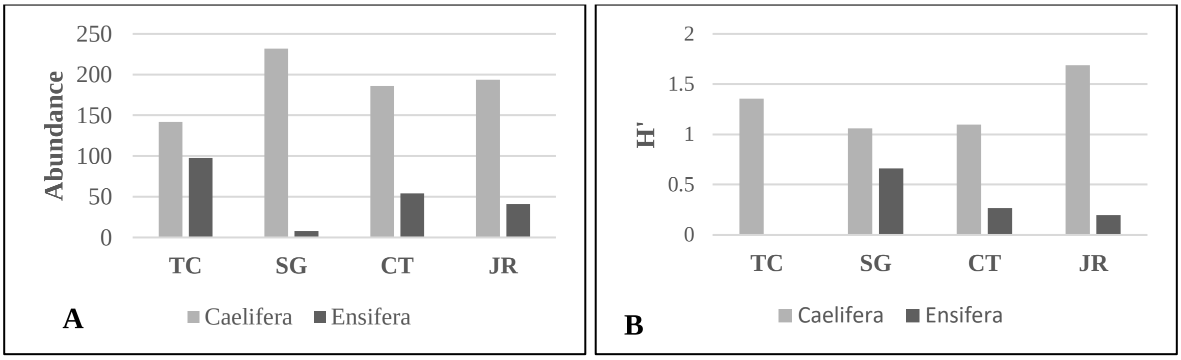

Figure 2. The abundance and diversity variation of grasshopper (Orthoptera) among all study sites [A] Number of individuals, [B] Shannon-Wiener diversity index. Note: TC = Tahura R. Soerjo Cangar; SG = Sumbergondo; CT = Coban Talun; JR = Junrejo

Table 2. Important value index suborder Caelifera

No	Species	Sub Family	IVI (%)
1	*Phlaeoba fumosa*	Acridinae	47,92
2	*Atractmorpha crenulata*	Acridinae	38,11
3	*Oxya Japonica*	Oxyinae	21,53
4	*Miramella alpina*	Melanoplinae	17,68
5	*Acrida* sp.	Acridinae	16,22
6	*Xenocatantops humilis*	Catantopinae	13,97
7	*Paratettix curtipennis*	Tetriginae	13,70
8	*Gastrimargus* sp.	Oedipodinae	11,32
9	*Formosatettix* sp.	Tetriginae	8,49
10	*Apalacris varicornis*	Catantopinae	8,36
11	*Epistaurus aberrans*	Coptacridinae	2,7

Table 3. Important value index suborder Ensifera

No	Species	Sub Family	IVI (%)
1	*Ducetia* sp.	Phaneropterinae	96,73
2	*Conocephalus maculatus*	Conocephalinae	53,45
3	*Conocephalus cognatus*	Conocephalinae	24,91
4	*Conocephalus melaennus*	Conocephalinae	24,91

The important value index (IVI) of the Ensifera suborder showed that two species were dominant in all study locations of the four species found. The dominating species were *Ducetia* sp. with an index value of 96.73% and *Conocephalus maculatus* with an index value of 53.45% (Table 3). *Ducetia* sp. was a species that had a wide area coverage, while *C. maculatus* was mostly in swampy habitats and had high lush grass. This species was widely distributed in China, Pakistan, Japan, Philippines, Malaysia, Indonesia, Burma, Thailand, Nepal, Bengal, India, Sri Lanka, New Guinea, Australia, Ethiopia, Madagascar, and Africa [35, 37].

The IVI value was a quantitative parameter used to see the level of dominance and role of species in a community, to determine the percentage and magnitude of the influence of a species on the community [14][38]. This result proved that the species *Ducetia* sp. and *C. maculatus* were the dominant species and had an essential role in the community structure in these locations.

Effect of abiotic factors on the diversity Orthoptera. Measurement of the microhabitat variable, namely the abiotic factor in all research locations, was carried out to see the effect or relationship of these variables on grasshopper diversity. Some of the abiotic factors observed were air temperature, humidity, light intensity, wind speed, and altitude. The biplot analysis used was principal component analysis (PCA). New variables were formed through a linear combination of the initial variables by reducing or summarizing these variables so that the number of variables formed explained most of the variance in data to facilitate interpretation. PCA analysis was carried out to see the relationship between environmental conditions, in the form of biotic and abiotic factors, with grasshopper diversity. There were five biotic and abiotic factors, namely, air temperature, humidity, light intensity, wind speed, and altitude.

Based on the PCA results, it could be seen that in quadrant I, there was air temperature, light intensity, wind speed, and diversity of Ensifera, which have a very strong correlation (Figure 3). In quadrant II, there was a factor of altitude, and then in quadrant IV, there was a humidity factor—diversity of suborder Caelifera species, which have a strong correlation.

The PCA results showed that in quadrant I, there were air temperature, light intensity, wind speed, and diversity of suborder Ensifera negatively correlated with TC and CT locations. In quadrant II, the SG location negatively correlated with air temperature, Caelifera diversity, and JR location. In quadrant III, the locations of CT and TC were in the same quadrant and close together, which means that they were similar and negatively correlated with air temperature, light intensity, wind speed, and diversity of ensemble suborders. In quadrant IV, a JR location was characterized by high humidity and diversity of suborders of Caelifera but had a negative correlation with elevation factors and SG location. Arthropods' body temperature was affected by environmental temperature to provide a range of tolerance to arthropods in habitats. The range of temperature tolerance could make arthropods death at a temperature that could not be tolerated. Thus, the distribution of species would be limited by temperatures experienced in the geographical area of different [39].

The diversity of grasshopper was affected by several ecological factors such as rainfall patterns, atmospheric temperature, relative humidity, type of soil, protection from external enemies, and vegetation structure [6]. The intensity of light could affect the biological clock of insects, including grasshoppers. The light had a considerable effect on the ability of insects to survive and reproduce. In the short term, light affected behavioral responses at certain times in a 24-hour cycle, whereas it affected physiological responses that keep organisms in tune with environmental conditions in the long term. The situation related to habitat composition had a role in grasshoppers variation. Temperature and humidity were among the factors that influence it [49, 40].

Grasshopper communities were not always associated with grassland habitats but also supported by herbaceous shrubs. The existence of this plant group supported the diversity of grasshoppers because it was associated with providing a source of food. Shrub and tree cover appeared to be an important factor in establishing locust habitat, providing shelter, oviposition, and a source of food for some grasshopper species [40].

CONCLUSION

The diversity of grasshoppers in several ecosystems in Batu City resulted in the Caelifera suborder with the highest diversity at the Junrejo location. Whereas in the suborder Ensifera the highest diversity was at the Sumbergondo location. The availability of sufficient vegetation areas for grasshoppers affects the diversity of the two suborders because of the vegetation as a food source provider and as a habitat for locusts to live. Abiotic factors (temperature, humidity, light intensity, wind speed) had an important influence on grasshopper activity and reproduction. Environmental factors influence the abundance and diversity of insects, including grasshoppers. Grasshopper response of any kind to the environment characteristics affected the existence of the habitat.

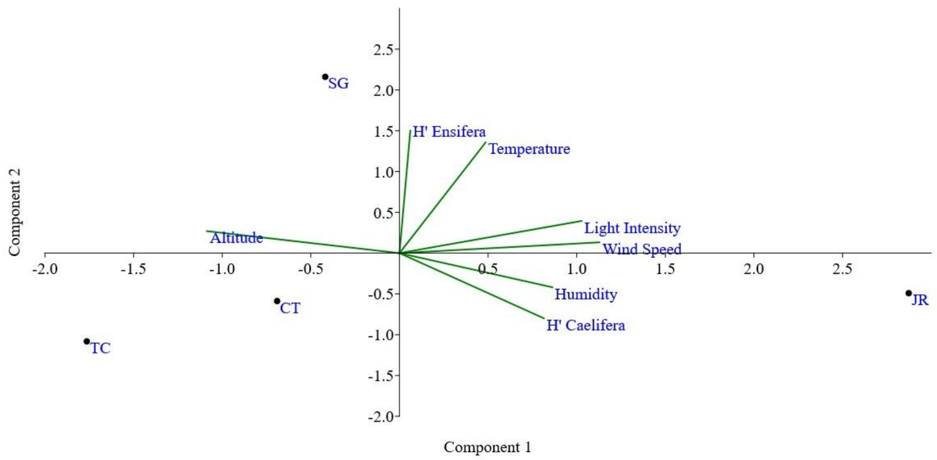

Figure 3. PCA analysis of the relationship between biotic and abiotic factor with grasshopper (Orthoptera) diversity

ACKNOWLEDGEMENT

The author is grateful to all those who helped and supported this series of research.

REFERENCES

[1] Riek EF, Peck JK (1984) A new interpretation of dragonfly wing venation based upon early upper carboniferous fossils from Argentina (Insecta: Odonatoidea) and basic character states in Pterygote wing. Can J. Zoology. 62: 1150-1166

[2] Leksono AS, Feriwibisono B, Arifianto T, Pratama AF (2017) The abundance and diversity of Odonata along an altitudinal gradient in East Java, Indonesia. Entomological Research 47 (4): 248-255.

[3] Borror DJ, Triplehorn CA, Johnson NF (1996) Pengenalan pelajaran serangga. Terjemah oleh Soetiyono Partosoedjono. Yogyakarta: Gadjah Mada University Press

[4] Baldi A, Kisbenedek T (1997) Orthopteran assemblages as indicators of grassland naturalness in Hungary. Agr. Ecosys. Environ. 66: 121-129

[5] Saha HK, Sarkar A, Haldar P (2011) Effects of anthropogenic disturbance on the diversity and composition of the Acridid fauna of sites in the dry deciduous forest of West Bengal, India. Journal of Biodiversity and Ecological Science 1 (4): 313-320.

[6] Bhargava RN (1996) Grylloid fauna of Thar desert. In: Faunal diversity in the Thar Desert: Gaps in research. Eds. Ghosh, A.K., Baqri, Q.H. and Prakash, I. Scientific Publ. Jodhpur pp: 410.

[7] Fielding DJ, Bruseven MA (1995) Grasshopper densities on grazed and ungrazed rangeland under drought conditions in Southern Idaho. Great Basin Naturalist 55 (4): 352-358

[8] Falahudin I, Mareta DE, Rahayu IAP (2015) Diversitas serangga Ordo Orthoptera pada lahan gambut di Kecamatan Lalan Kabupaten Musi Banyuasin. Bioilmi 1 (1): 1-7.

[9] Erawati NV, Atmowidi T, Kahono S (2004) Keanekaragaman dan kelimpahan Orthoptera (Insecta) di Gunung Kendeng dan Gunung Botol, Taman Nasional Gunung Halimun, Jawa Barat, Indonesia. Berita Biologi 7(1): 7-15.

[10] Primack RB, Supriatna J, Indrawan M, Kramadibrata P (1988) Biologi konservasi. Yayasan Obor Indonesia. Jakarta.

[11] Gwynne D. T (1988) Courtship feeding and the fitness of female katydids (Orthoptera: Tettigoniidae). Evolution 42(3): 545–555.

[12] Sutherland WJ (2006) Ecological census techniques, Second Edition. Cambridge University Press, UK. 432p

[13] Fachrul MF (2007) Metode sampling bioekologi. Bumi Aksara. Jakarta

[14] Soegianto A (1994). Ekologi Kuantitatif. Surabaya: Usaha Nasional.

[15] Borror DJ, Triplehor N, Johnson NF (1989) An Introduction to the Study of Insect. 6th ed. Saunders College Publishing, New York.

[16] Willemse C (1930) Fauna Sumatrensis (Bijdrage Nr. 62). Preliminary Revision of the Acrididae (Orthoptera). De Nederlandsche Entomiligsche Vereeniding.

[17] Willemse F (1965) Orthoptera, Acridiidae chiefly from Java in the Zoologisches Staats Institut und Zoologisches Museum of Hamburg Entomologiche Mitteilungen aus dem. Zoologisches Staats institut und Zoologisches Museum, Hamburg 3: 53-67.

[18] Willemse L (2001) Fauna Malesiana Guide to The Pest Orthoptera of Indomalayana Region. Backhuys Publisher, Leiden.

[19] Kalshoven LGE (1981) Pests of Crops in Indonesia. Laan PA van der (trans.). PT. Ichtiar Baru van Hoeve, Jakarta.

[20] Rentz DCF (1991) Orthoptera (Grasshoppers, locus, katydids, crickets). In: CSIRO (eds) The Insects of Australia. A Textbook For Students and Research Workers. Volume 2. Melbourne University Press, Carlton.

[21] Johnson DL (2008) Grasshopper Identification and Control Methods to Protect Crops and the Environment. Pulse Canada and Saskatchewan Agriculture and Food, Canada.

[22] Tan MK (2012) Orthoptera in the Bukit Timah and Central Catchment Nature Reserves (Part 1): Suborder Caelifera. Raffles Museum of Biodiversity Research, National University Singapore, Singapore.

[23] Tan MK (2017) Orthoptera in the Bukit Timah and Central Catchment Nature Reserves (Part 2): Suborder Ensifera. Raffles Museum of Biodiversity Research, National University Singapore, Singapore.

[24] Krebs CJ (1985) Ecology the experimental analisys of distribution and abudance 3rd ed. Harper & Raws Publishers. New York.
[25] Soerianegara I, Indrawan A (1998) Ekologi hutan Indonesia. Institut Pertanian Bogor. Bogor.
[26] Popov GB, Lincoln D, Fishpool C, Rowell HF (2019) A review of the Acridinae s. str. (Orthoptera: Acridoidea: Acrididae) of eastern Africa with taxonomic changes and description of new taxa. Journal of Orthoptera Research 28 (1): 37–105.
[27] Sulistiyowati E (2015) Studi populasi serangga sebagai upaya konservasi biodiversitas Sungai Oyo, di Desa Wisata Bleberan Gunung Kidul. Jurnal Biologi Universitas Andalas (J.Bio.UA.) 4(4): 233-241.
[28] 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
[29] Hsiao TF, Yang JT, Chen MY (2017) Grasshopper mandibles functional morphology adaptation to food plants (Orthoptera: Caelifera) from subtropical forest ecosystem, Central Taiwan. Advances in Entomology 5: 40-53.
[30] Hadi M, Aminah (2012) Keragaman serangga dan perannya di ekosistem sawah. Jurnal Sains dan Matematika 20 (3): 54-57.
[31] Aminatun T, Martono E, Worosuprojo S, Tandjung SD, Memmott J (2011) Pola interaksi serangga herbivor-gulma pada ekosistem sawah surjan organik dan konvensional dalam dua musim tanam. Prosiding Seminar Nasional Penelitian, Pendidikan dan Penerapan MIPA. Fakultas MIPA, Universitas Negeri Yogyakarta. Hal: 1-17.
[32] Kandibane M, Raguraman S, Ganapathy N (2004) Diversity and relative abundance of Orthoptera in an irrigated rice ecosystem in Madurai, India. International Rice Research Notes 29 (1): 33-35.
[33] Farooqi MK, Usmani MK (2018) Review of genus Conocephalus Thunberg, 1815 (Orthoptera: Tettigoniidae: Conocephalinae) with one new species from India. Zootaxa 4461 (3): 381–39.
[34] Mahasneh A, Katbeh-Bader A (2004) A taxonomic study on the long-horned grasshoppers of Jordan (Orthoptera: Tettigoniidae). Landesmuseen Neue Serie 2: 245-264.
[35] Panhwar WA, Sultana R, Wagan MS, Khatari I, Kumar S (2014) Systematic Study on the Various Tribes of Phaneropterinae (Tettigonioidea: Orthoptera) Occurring in Pakistan. Pakistan J. Zool., vol. 46(1), pp. 203-213.
[36] Yuliani D, Napisah K, Maryana N (2016) Status Oxya spp. (Orthoptera: Acrididae), sebagai hama pada pertanaman padi dan talas di daerah Bogor. Prosiding Seminar Nasional Inovasi Teknologi Pertanian Banjarbaru, 20 Juli 2016.
[37] Heller KG, Ingrisch S, Liu CH, Shi FM, Hemp C, Liwa EW, Rentz DCF (2017) Complex songs and cryptic ethospecies: the case of the *Ducetia japonica* group (Orthoptera: Tettigonioidea: Phaneropteridae: Phaneropterinae). Zoological Journal of the Linnean Society 181 (2): 286-307.
[38] Bengan DG (2002) Sinopsis ekosistem dan sumberdaya alam pesisir dan lautan serta prinsip pengelolaannya. Pusat Kajian Sumberdaya Pesisir dan Laut. IPB Bogor
[39] Leksono AS (2017) Ekologi Arthropoda. UB Press. Malang.
[40] Leksono AS, Yanuwiadi B, Afandhi A, Farhan M, Zairina A (2020) The abundance and diversity of grasshopper communities in relation to elevation and land use in Malang, Indonesia. Biodiversitas 21 (12): 5614-5620.