

PEER REVIEW

LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU PEER REVIEW
KARYA ILMIAH : JURNAL ILMIAH

Judul Jurnal Ilmiah (Artikel) : Diversity of Wild Bees along Elevational Gradient in an Agricultural Area in Central Java, Indonesia.

Penulis Jurnal Ilmiah *) : 1 Imam Widhiono (*nama pengusul dicetak tebal)
2 **Eming Sudiana**
3 Darsono

Jumlah Penulis : 3

Status Penulis : Penulis Ke-2

Identitas Jurnal Ilmiah :

- a. Nama Jurnal : Psyce : A Journal of Entomologi
- b. Nomor ISSN : -
- c. Edisi/Volume, Nomor : Januari 2017/Volume 2017
- d. Penerbit : Hindawi
- e. DOI artikel : <http://doi.org/10.1155/2017/2968414>
- f. Alamat Web : <https://www.hindawi.com/journals/psyche/2017/2968414/>
- g. Terindeks di : SCOPUS

Kategori Publikasi Jurnal Ilmiah : ☒ Jurnal Ilmiah Internasional /Internasional Bereputasi
(beri v pada kategori yang tepat) ☐ Jurnal Ilmiah Nasional Terakreditasi
☐ Jurnal Nasional/Nasional terindeks di..... *

Hasil Penilaian Peer Review :

Komponen Yang Dinilai	Nilai Maksimal Jurnal Ilmiah				Nilai Akhir Yang Diperoleh
	Internasional/ Internasional bereputasi	Nasional Terakreditasi	Nasional Terindeks *)		
	30				
a Kelengkapan unsur isi artikel (10%)	10 % X 30= 3				2.5
b Ruang lingkup dan kedalaman pembahasan (30%)	30 % X30= 9				8.9
c Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	30 % X30= 9				8.8
d Kelengkapan unsur dan kualitas terbitan/jurnal (30%)	30 % X30= 9				8.9
Total = (100%)	30				29.0
Nilai Pengusul (40 % x Total)/2	6				5.79
Catatan Penilaian artikel oleh Reviewer:					
1. Tentang kelengkapan dan kesesuaian unsur		: Lengkap dan sesuai			
2. Tentang ruang lingkup dan kedalaman pembahasan		: Sangat baik dan cukup mendalam			
3. Kecukupan dan kemutahiran data serta metodologi		: Mutahir			
4. Kelengkapan unsur kualitas penerbit		: Lengkap			
5. Indikasi plagiasi		: Tidak ada			
6. Kesesuaian bidang ilmu		: Sesuai			

Purwokerto,

*) Wajib diisi

Reviewer 1

Dr. Dwi Nugroho Wibowo, M.S.
NIP. 196111251986011001
Jabatan/Gol. : Lektor Kepala/(Gol. IV/c)
Bidang Ilmu : Ekologi
Unit Kerja : Fakultas Biologi Unsoed

Reviewer 2

Drs. Edy Yani, M.S.
NIP. 195811301984031001
Jabatan/Gol. : Lektor Kepala/(Gol. IV/c)
Bidang Ilmu : Ekologi Tumbuhan
Unit Kerja : Fakultas Biologi Unsoed

AS

LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU PEER REVIEW
KARYA ILMIAH : JURNAL ILMIAH

Judul Jurnal Ilmiah (Artikel) : Diversity of Wild Bees along Elevational Gradient in an Agricultural Area in Central Java, Indonesia.

Penulis Jurnal Ilmiah *) : 1 Imam Widhiono (*nama pengusul dicetak tebal)
 2 **Eming Sudiana**
 3 Darsono

Jumlah Penulis : 3

Status Penulis : Penulis Ke-2

Identitas Jurnal Ilmiah :

- a. Nama Jurnal : Psyce : A Journal of Entomologi
- b. Nomor ISSN : -
- c. Edisi/Volume, Nomor : Januari 2017/Volume 2017
- d. Penerbit : Hindawi
- e. DOI artikel : <http://doi.org/10.1155/2017/2968414>
- f. Alamat Web : <https://www.hindawi.com/journals/psyche/2017/2968414/>
- g. Terindeks di : SCOPUS

Kategori Publikasi Jurnal Ilmiah : ☐ Jurnal Ilmiah Internasional /Internasional Bereputasi
 (beri v pada kategori yang tepat) ☐ Jurnal Ilmiah Nasional Terakreditasi
☐ Jurnal Nasional/Nasional terindeks di..... *

Hasil Penilaian Peer Review :

Komponen Yang Dinilai	Nilai Maksimal Jurnal Ilmiah			Nilai Akhir Yang Diperoleh
	Internasional/ Internasional bereputasi	Nasional Terakreditasi	Nasional *)	
	30			
a Kelengkapan unsur isi artikel (10%)	10 % X 30 = 3			2,9
b Ruang lingkup dan kedalaman pembahasan (30%)	30 % X 30 = 9			8,7
c Kecukupan dan kemutakhiran data/informasi dan metodologi (30%)	30 % X 30 = 9			8,7
d Kelengkapan unsur dan kualitas terbitan/jurnal (30%)	30 % X 30 = 9			8,7
Total = (100%)	30			20,1
Nilai Pengusul (40 % x Total)/2	6			5,8

Catatan Penilaian artikel oleh Reviewer:

1. Tentang kelengkapan dan kesesuaian unsur : LENGKAP & SESUAI
2. Tentang ruang lingkup dan kedalaman pembahasan : BANYAK & CUKUP DALAM
3. Kecukupan dan kemutakhiran data serta metodologi : CUKUP MUTAKHIR
4. Kelengkapan unsur kualitas penerbit : LENGKAP
5. Indikasi plagiasi : TIDAK ADA
6. Kesesuaian bidang ilmu : SESUAI

Purwokerto, 10 SEPTEMBER 2020 *) wajib diisi

Reviewer 1



Dr. Dwi Nugroho Wibowo, M.S.
 NIP. 196111251986011001
 Jabatan/Gol. : Lektor Kepala/(Gol. IV/c)
 Bidang Ilmu : Ekologi
 Unit Kerja : Fakultas Biologi Unsoed



Mengetahui :

Dekan :



ref. nat. Imam Widhiono M.Z., M.S.

NIP. 195904201985031002

Unit Kerja :

Fakultas Biologi Unsoed

A5

LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU PEER REVIEW
KARYA ILMIAH : JURNAL ILMIAH

Judul Jurnal Ilmiah (Artikel) : Diversity of Wild Bees along Elevational Gradient in an Agricultural Area in Central Java, Indonesia.

Penulis Jurnal Ilmiah *) : 1 Imam Widhiono (*nama pengusul dicetak tebal)
 2 **Eming Sudiana**
 3 Darsono

Jumlah Penulis : 3

Status Penulis : Penulis Ke-2

Identitas Jurnal Ilmiah :

- a. Nama Jurnal : Psyce : A Journal of Entomologi
- b. Nomor ISSN : -
- c. Edisi/Volume, Nomor : Januari 2017/Volume 2017
- d. Penerbit : Hindawi
- e. DOI artikel : <http://doi.org/10.1155/2017/2968414>
- f. Alamat Web : <https://www.hindawi.com/journals/psyche/2017/2968414/>
- g. Terindeks di : SCOPUS

Kategori Publikasi Jurnal Ilmiah : ☐ Jurnal Ilmiah Internasional /Internasional Bereputasi
 (beri v pada kategori yang tepat) ☐ Jurnal Ilmiah Nasional Terakreditasi
☐ Jurnal Nasional/Nasional terindeks di..... *

Hasil Penilaian Peer Review :

Komponen Yang Dinilai	Nilai Maksimal Jurnal Ilmiah			Nilai Akhir Yang Diperoleh
	Internasional/ Internasional bereputasi	Nasional Terakreditasi	Nasional *)	
	30			
a Kelengkapan unsur isi artikel (10%)	10 % X 30= 3			3
b Ruang lingkup dan kedalaman pembahasan (30%)	30 % X30= 9			9
c Kecukupan dan kemutakhiran data/informasi dan metodologi (30%)	30 % X30= 9			8,9
d Kelengkapan unsur dan kualitas terbitan/jurnal (30%)	30 % X30= 9			9
Total = (100%)	30			29,9
Nilai Pengusul (40 % x Total)/2	6			5,98

Catatan Penilaian artikel oleh Reviewer:

1. Tentang kelengkapan dan kesesuaian unsur : lengkap & sesuai
2. Tentang ruang lingkup dan kedalaman pembahasan : sangat baik
3. Kecukupan dan kemutakhiran data serta metodologi : mutakhir
4. Kelengkapan unsur kualitas penerbit : lengkap
5. Indikasi plagiasi : tidak terduga
6. Kesesuaian bidang ilmu : sesuai

Purwokerto, 5 -10 -2020 *) wajib diisi

Reviewer 2


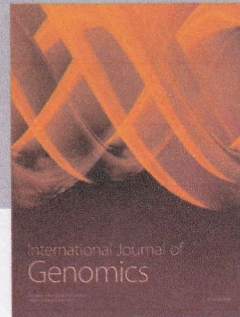
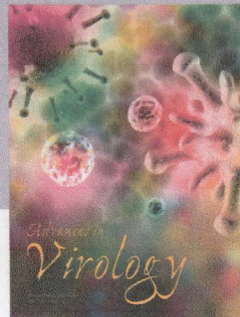
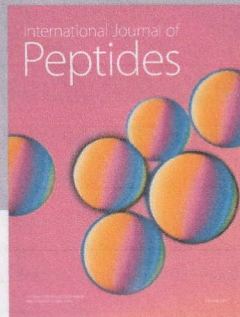
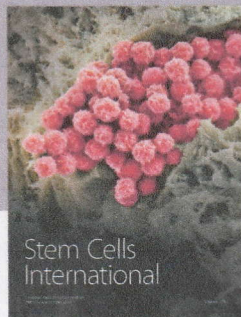
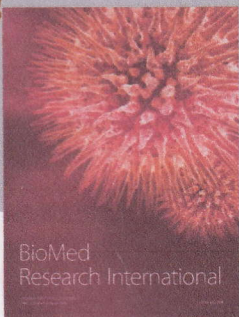
Drs. Edy Yani, M.S.
 NIP. 195811301984031001
 Jabatan/Gol. : Lektor Kepala/(Gol. IV/c)
 Bidang Ilmu : Ekologi Tumbuhan
 Unit Kerja : Fakultas Biologi Unsoed



Mengetahui :

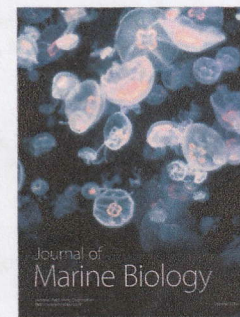
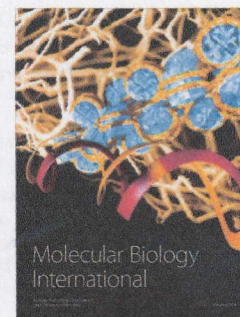
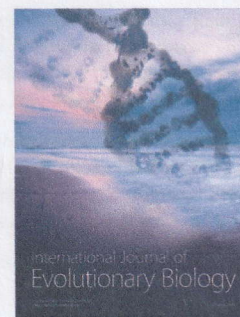
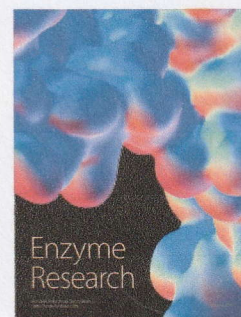
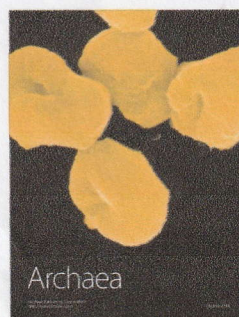
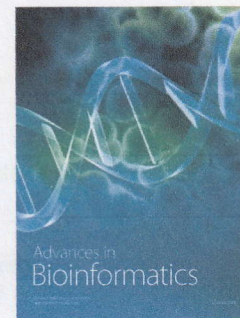
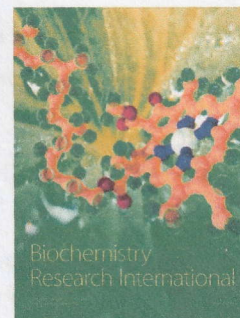
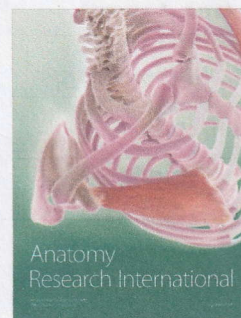
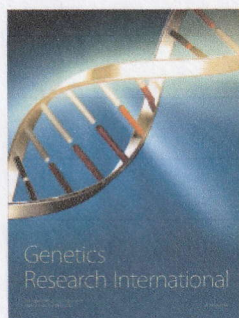
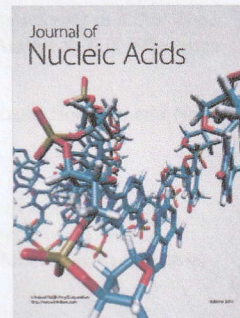
Prof. Dr. Er. Rat. Imam Widhiono M.Z., M.S.
 NIP. 195904201985031002
 Unit Kerja : Fakultas Biologi Unsoed

ARTIKEL



Hindawi

Submit your manuscripts at
<https://www.hindawi.com>



Psyche: A Journal of Entomology

+ Journal Menu

Table of Contents

2017



Psyche: A Journal of Entomology - Volume 2017 - Article ID 3156534 - Research Article

An Insight in the Reproductive Biology of *Therophilus javanus* (Hymenoptera, Braconidae, and Agathidinae), a Potential Biological Control Agent against the Legume Pod Borer (Lepidoptera, Crambidae)

Djibril Aboubakar Souna | Aimé Bokonon-Ganta | ... | Manuele Tamò

28 Sep 2017

PDF



Psyche: A Journal of Entomology - Volume 2017 - Article ID 4520109 - Research Article

The First Workers of the Ant *Camponotus obscuripes* Are a Different Allometric Morph with Relatively Long Antennae to Communicate with Other Larger Colony Members

Saori Watanabe | Mamoru Terayama | ... | Eisuke Hasegawa

22 Jun 2017

PDF






Psyche: A Journal of Entomology - Volume 2017 - Article ID 5468202 - Research Article

Repellent Effect and Insecticidal Activities of *Bridelia ferruginea*, *Blighia sapida*, and *Khaya senegalensis* Leaves Powders and Extracts against *Dinoderus porcellus* in Infested Dried Yam Chips

Laura Yêyinou Loko | Obédadou Alagbe | ... | Manuele Tamò

research is fast-tracked and made available on a preprint server as soon as possible. We will be providing unlimited waivers of publication charges for accepted articles related to COVID-19. [Sign up here](#) as a reviewer to help fast-track new submissions.

+ Journal Menu

U. J. M. Shanika R. Jayasinghe T. H. Saumya E. Silva W. A. Inoka P. Karunaratne		
25 May 2017	PDF	
Psyche: A Journal of Entomology - Volume 2017 - Article ID 3593509 - Research Article		
Sigma Virus (DMelSV) Incidence in Lines of <i>Drosophila melanogaster</i> Selected for Survival following Infection with <i>Bacillus cereus</i>		
Meghan L. Bentz Eve A. Humphrey ... Marta L. Wayne		
13 Mar 2017	PDF	
Psyche: A Journal of Entomology - Volume 2017 - Article ID 2968414 - Research Article		
Diversity of Wild Bees along Elevational Gradient in an Agricultural Area in Central Java, Indonesia		
Imam Widhiono Eming Sudiana Darsono Darsono		
31 Jan 2017	PDF	



Author guidelines



Editorial board



Databases and indexing



Sign up for content alerts

research is fast-tracked and made available on a preprint server as soon as possible. We will be providing unlimited waivers of publication charges for accepted articles related to COVID-19. [Sign up here](#) as a reviewer to help fast-track new submissions.

+ Journal Menu



- > About us
- > Contact us
- > Partnerships
- > Blog

- > Journals
- > Article Processing Charges
- > Print editions

- > Authors
- > Editors
- > Reviewers

- > Hindawi XML Corpus
- > Open Archives Initiative

[Privacy Policy](#) | [Terms of Service](#) | [Cookie Policy](#) | [Copyright](#)

Research Article

Diversity of Wild Bees along Elevational Gradient in an Agricultural Area in Central Java, Indonesia

Imam Widhiono, Eming Sudiana, and Darsono Darsono

Faculty of Biology, Jenderal Soedirman University, Jl. Dr. Soeparno no. 63 Purwokerto, Central Java 53122, Indonesia

Correspondence should be addressed to Imam Widhiono; imamwidhiono@yahoo.com

Received 6 December 2016; Accepted 12 January 2017; Published 31 January 2017

Academic Editor: Jacques Hubert Charles Delabie

Copyright © 2017 Imam Widhiono et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Increases in mean temperature affect the diversity and abundance of wild bees in agricultural ecosystems. Pollinator community composition is expected to change along an elevational gradient due to differences in the daily ambient temperature. This study investigated the diversity and abundance of wild bees in an agricultural area along an elevational gradient in Central Java, Indonesia. Wild bees were collected using a sweep net in 40 green bean (*Phaseolus vulgaris*) cultivation sampling locations at seven different elevations (8, 108, 224, 424, 644, 893, and 1017 m above sea level). Species diversity was determined using the Shannon–Wiener diversity index. We identified 932 individuals from 8 species of wild bee belonging to 3 families. The family Apidae was predominant, with 6 species, while only 1 species was found from each of Megachilidae and Halictidae. Across the study sites, diversity increased with increasing elevation ($(H') = 1.4$, $(D) = 0.25$, and $(E) = 0.78$ at low elevation to $(H') = 2.04$, $D = 0.13$, and $E = 0.96$ at high elevation), and higher numbers of species were found at middle and high elevations. Species richness and abundance increased linearly with increasing elevation, and species diversity was highest at middle elevations.

1. Introduction

Wild bees (order Hymenoptera: Apoidea) represent the most important group of pollinator insects because they play a key role in agriculture, pollinating almost all crop varieties. However, they are increasingly at risk of local and even global extinction due to climate change [1], which can disrupt the overlap of flower production and pollinator flight activity [2]. The major characteristic of climate change is an increase in the mean global temperature. Elevated temperatures are known to influence the foraging activity, body size at maturity, and individual lifespan [3] of wild bees. The physiological impacts of climate warming might not have negative effects on individual insect pollinators; in fact, some could even have positive effects. Increases in mean temperature affect the diversity and abundance of wild bees in agricultural ecosystems.

Elevational gradients can be used as model systems for climatic change to analyse the role of environmental filtering effects on animal communities [4]. Comparative studies of

species ecology along elevational gradients can provide clues to the likely response of both species and communities in the study of the effects of increasing temperature on the diversity and abundance of pollinator insects. However, there are significant differences among the characteristics of typical elevational gradients. Pollinator community composition is expected to change along an elevational gradient due to differences in ambient daily temperature. Due to the harsher environmental conditions, the number of pollinator species tends to decrease with increasing elevation [5]. The relative abundance of Hymenoptera has been negatively correlated with increasing elevation [6]. However, some studies have found that Hymenoptera, especially wild bees, are the most abundant floral visitor at high elevations, at least for some plant species [7]. Total pollinator richness [8] and abundance [9] have been found to decrease with increasing elevation, with plants becoming more ecologically specialised at higher elevations [10]. However, to the best of our knowledge, the wild bee diversity and abundance along an elevational gradient in agricultural areas has not previously been studied

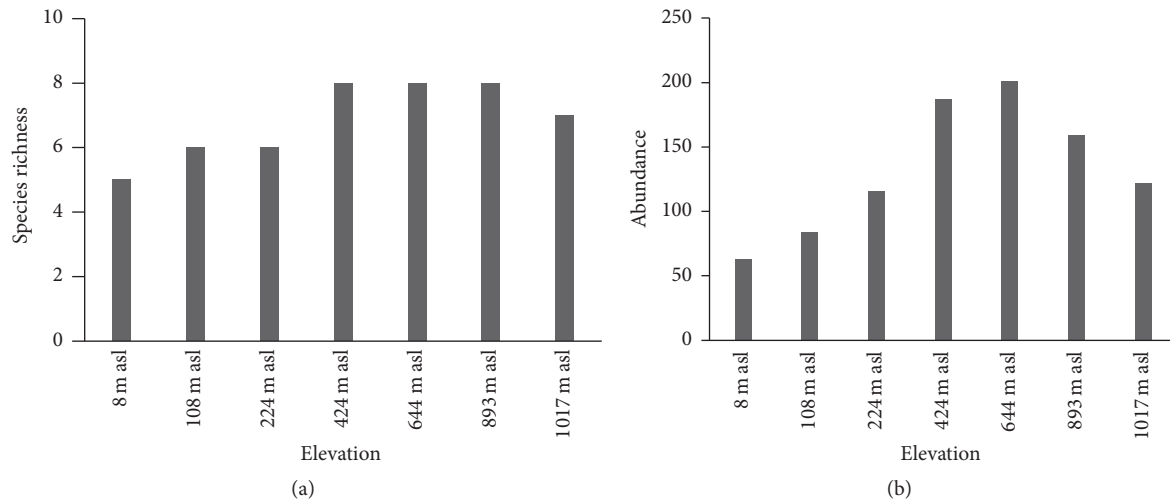


FIGURE 1: Species richness (a) and abundance (b) of wild bees among elevation.

in Java. In this study, we investigated the diversity and abundance of wild bees in an agricultural area along an elevational gradient to test the hypothesis that elevation is a significant factor underlying the species composition and abundance of wild bees.

2. Materials and Methods

2.1. Study Area. The study was conducted in areas of green bean (*Phaseolus vulgaris*) cultivation at seven locations along an elevational gradient: Lomanis, Cilacap Regency (7°41'06 32"N, 109°01'12 24"E, 8 m above sea level (asl)), Gunung Tugel, Purwokerto (7°28'03 92"N, 109°14'06 35"E, 106 m asl), Banteran, Sikapat, and Banyumas Regency (7°20'00 43"N, 109°16'29 49"N, 224, and 442 m asl, resp.), Limpakuwus and Tuwel, Tegal Regency (7°09'46 38"N, 109°09'06 66"E, 664 and 887 m asl), and Serang, Pubalingga Regency (7°14'48 41"E, 109°17'28 91"N, 1077 m asl). In the regions, green bean is a minor vegetable crop that extensive planting is usually very small and located on land planted with other types of vegetables such as long bean, but, as for research purposes, this plant was chosen because it was found at all altitudes.

2.2. Sampling of Bee Diversity and Identification. The seven long bean plantations were sampled twice each month from April to June, 2014. We collected 100 plant individuals at each site, using the standard sweep net procedures described by Brosi et al. [11] (2008) to sample the bees. During each sampling session, 14 members of the field team (two persons per location) aerially netted bees over 30 min periods. Bees both on flowers and in flight were collected individually with the sweep net. Sampling was performed in the morning (07:00–09:00 local time) on fine days. Bee species were identified by the Indonesian Institute of Science, Bogor. Voucher specimens are held at the Entomology Laboratory, Faculty of Biology, Jenderal Soedirman University, Indonesia.

2.3. Statistical Analyses. The species richness and abundance of wild bees recorded in the seven plots were analysed. A general linear model was applied using SPSS ver. 18.0 software. The dependent variables were wild bee species richness and abundance, and the categorical variables were elevation and daily temperature. Raw data from the field were used to reveal species richness, species diversity (Shannon–Weiner index), component of dominance (Simpson dominance index), and relative abundance of different species at each sampling site [12]. Comparisons of species composition according to location were performed using single linkage cluster analysis based on Bray–Curtis similarity. All diversity parameters were analysed using Biodiversity Pro software [13].

3. Results and Discussion

3.1. Species Composition. In total, 932 individual wild bees belonging to 8 species, 5 genera, and 3 families were collected during the study period. Apidae was the most dominant family, with 6 species (*Xylocopa latipes*, *X. confusa*, *X. caerulea*, *Apis cerana*, *A. dorsata*, and *Amegilla cingulata*), and two families (Megachilidae and Halictidae) were represented by one species each. The composition of wild bee species found at the seven elevations varied, with the largest number of species (8) at the middle-to-high elevations (442–1017 m asl), and the lowest species richness at the lowest elevation (8 m asl), with only 3 species. *Xylocopa latipes*, *X. confusa*, *Apis cerana*, and *Megachile relative* were observed at most elevations. *Apis dorsata* and *Xylocopa caerulea* were found only at the middle and high elevations (Figure 1(a)). Species richness differed significantly among elevations (analysis of variance (ANOVA): $F_{6,49} = 5.445$, $p = 0.000223 < 0.05$). Increasing elevation increased wild bee species richness up to 893 m asl ($R^2 = 0.84$) and then decreased species richness above 1017 m asl (Table 1).

TABLE 1: Species composition, abundance, and diversity of wild bees and seven different elevations.

Species	Elevation m above sea level (asl)							Abundance	Relative (%)
	8	108	224	424	644	893	1017		
<i>Xylocopa latipes</i>	18	26	25	27	26	22	16	160	17,16
<i>Xylocopa confusa</i>	15	14	19	44	26	19	23	160	17,16
<i>Xylocopa caerulea</i>	0	0	0	15	29	31	22	97	10,4
<i>Apis cerana</i>	20	23	37	44	38	27	0	189	20,2
<i>Apis dorsata</i>	0	0	0	21	26	16	11	74	7,9
<i>Amegilla cingulata</i>	1	4	11	8	22	13	17	76	8,1
<i>Megachile relativa</i>	9	10	11	16	20	18	19	103	11,05
<i>Lasioglossum malachurum</i>	0	7	13	12	14	13	14	73	7,8
Abundance	63	84	116	187	201	159	122	932	
Relative (%)	6,7	9,01	12,44	20,06	21,56	17,06	13,09		
Mean temperature °C	34,3	32,5	31,2	30,4	29,8	29	28,7		
Shannon_H	1,408	1,622	1,684	1,93	2,045	2,035	1,919		
Simpson.1-D	0,740	0,778	0,7944	0,8361	0,8665	0,8634	0,8498		
Evenness_e^H/S	0,817	0,843	0,897	0,860	0,966	0,956	0,973		

3.2. *Abundance.* In total, 932 individual wild bees belonging to 8 species, 5 genera, and 3 families were recorded. Site 1 supported 4 species with 63 individuals (5.8% of all individuals); Site 2, 5 species and 84 individuals (9.01%); Site 3, 5 species and 116 individuals (12.44%); Site 4, 7 species and 187 individuals (20.06%); Site 5, 8 species and 201 individuals (21.5%); Site 6, 8 species and 169 individuals (17.06%); and Site 7, 7 species and 122 individuals (13.09%) (Figure 1(b)).

Wild bee abundance differed significantly among sites (ANOVA: $F_{6,49} = 3.478$, $p = 0.006 < 0.05$). The most abundant species was *Apis cerana* with 189 individuals (20.2%), followed by *X. confusa* and *X. latipes*, each with 160 individuals (17.16%), *M. relativa* with 103 individuals (11.05%), *X. caerulea* with 97 individuals (10.4%), *A. cingulata* with 76 individuals (8.1%), and *A. dorsata* with 74 individuals (7.9%), and the least abundant was *L. malachurum* with 73 individuals (7.8%). Comparing the wild bee abundance among sampling events at all elevations, the highest abundance was from sampling number 2 with 199 individuals (21.3%), followed by sampling number 1 with 172 individuals (18.4%), sampling number 4 with 157 individuals (16.8%), sampling number 3 with 148 individuals (15.8%), sampling number 5 with 136 individuals (14.5%), and the lowest abundance was from sampling number 6 with 120 individuals (12.8%). However, statistical analysis revealed no significant differences among sampling events (ANOVA: $F_{5,42} = 1.01800$, $p = 0.419 > 0.05$).

Across the study sites, diversity increased with increasing elevation (Shannon–Wiener index (H') = 1.4, dominance (D) = 0.25, and evenness (E) = 0.78 at low elevation to (H') = 2.04, D = 0.13, and E = 0.96 at high elevation), and higher numbers of species were found at middle and high elevations. The distribution of wild bees among the sites was significantly influenced by elevation. The richness, abundance, diversity, and evenness of wild bees at different sites are presented in Table 1.

Analysis of community structure similarity among elevations showed that the three sites categorised as low elevation (8–224 m asl) had high similarity (84.53%), the two middle-elevation sites (424–644 m asl) had 83.50% similarity, and

Bray–Curtis cluster analysis (single link)

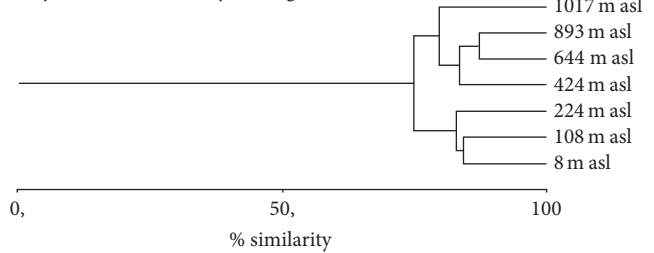


FIGURE 2: Similarity (Bray–Curtis) single linkage of wild bee in seven different elevations.

the two high-elevation sites (893 m–1017 m asl) had 79.7% similarity. However, the highest species similarity (87.2%) was found between Site 5 (644 m asl) and site 6 (893 m asl) (Figure 2).

4. Discussion

The number of wild bee species and the species composition recorded in this study were similar to those reported in previous studies in various regions. Hoiss et al. [14] observed 10 species of wild bees at *Vigna unguiculata* in Ghana belonging to the families Apidae (*Xylocopa*, *Apis*, and *Amegilla*), Megachilidae (*Megachile eurymera*), and Halictidae (*Nomia* sp.). Kwapong et al. [15] reported that the main insects observed on cowpea flowers were bees such as *Apis mellifera*, *Ceratina* sp., *Megachile* sp., *Xylocopa calens*, *Xylocopa imitator*, *Brausepsis* sp., *Lipotriches* sp., *Melecta* sp., and *Amegilla* sp. Kingha et al. [16] reported *Apis mellifera* as the most abundant insect species visiting *P. vulgaris* flowers in Kenya, followed by *Xylocopa calens* and *X. inconstans*. The flowers of long bean attract wild bee pollinators from Apidae, probably because the members of this family have sufficient strength to open the flower to collect pollen and nectar [17]. However, to the best of our knowledge, to date there have been no studies on insect pollinator diversity in green bean cultivation areas

in Indonesia for comparison purposes. In Sukabumi, West Java, in mustard (*Brasica rapus*) at an elevation of approximately 854 m asl, Aouar-Sadli et al. [18] observed insect pollinators from the order Hymenoptera, family Apidae, subfamily Apinae, consisting of the species *Apis cerana*, *Apis dorsata*, and *Trigona* sp., from the subfamily Xylocopinae, the species *Xylocopa caerulea*, *X. confusa*, *X. latipes*, and *Ceratina* sp., from the family Colletidae, subfamily Hylaeinae *Hylaeus* sp., from the family Halictidae, subfamily Nomiinae *Nomia* sp., and from the family Scoliididae *Compsomeris lindenni*. Our study findings indicate that the species composition of insect pollinators on agricultural land is dominated by wild bees.

Elevation strongly influenced the diversity and abundance of wild bee communities. Species richness and abundance increased linearly with increasing elevation, and species diversity was highest at middle elevations. These results are inconsistent with those of Gottlieb et al., [19], who reported that the diversity and abundance of wild bees decreased linearly with increasing elevation from 60 to 2000 m asl. This difference may be due to differences in the geographical region, climate zone, and range of elevational gradient. A commonly reported pattern in species richness along elevational gradients is a unimodal distribution with a mid-elevation peak [20]. In our study, peak species diversity occurred at middle elevations due to the presence of two species (*Apis dorsata* and *Xylocopa caerulea*) that began to appear above 442 m asl. The presence of the giant honey bee (*A. dorsata*) at mid-to-high elevations may be due to habitat suitability rather than elevation effects because these bees require a forested habitat with high trees, whereas blue carpenter bees tend to be abundant in cool environments. Large carpenter bees (genus *Xylocopa*) are wood-nesting generalist pollinators of broad geographical distribution. Their foraging is characterised by a wide range of food plants, long season of activity, tolerance of high temperatures, and activity under low illumination levels [21]. Carpenter bees tolerate high ambient temperatures during foraging, and most species are inactive at low temperatures, and these bees were found in all of our study sites. All of the sites from the lowest to highest elevation had daily temperature ranges appropriate for wild bees. Generally, the genus *Xylocopa* is able to move around well in a daily temperature range of 25–35°C [22]. This heat tolerance suggests efficient heat regulation ability in carpenter bees, possibly controlled by a thermoregulatory centre in the prothorax [23]. In contrast, *Apis cerana* has a tendency to forage in conditions of warm temperatures [24]. The presence of the three species *Megachile relativa*, *Amegilla cingulata*, and *Lasioglossum malachurum* almost evenly at all elevations studied indicates that these species are able to move around in the range of temperatures that occur at these elevations.

5. Conclusion

Eight species of wild bees from four families of the order Hymenoptera were recorded in green bean cultivation areas at seven different elevations in Central Java, Indonesia. Species richness and abundance increased linearly with

increasing elevation, and species diversity was highest at middle elevations.

Disclosure

The English in this document has been checked by at least two professional editors, both native speakers of English. For a certificate, please see: <http://www.textcheck.com/certificate/A8au1l>.

Competing Interests

The authors declare that they have no competing interests.

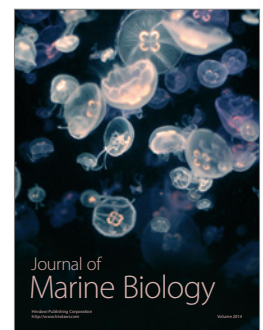
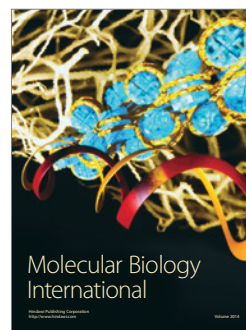
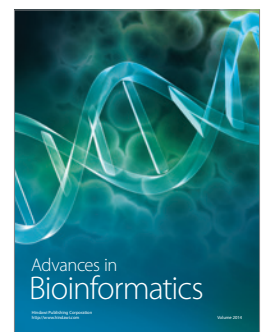
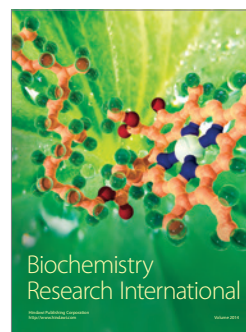
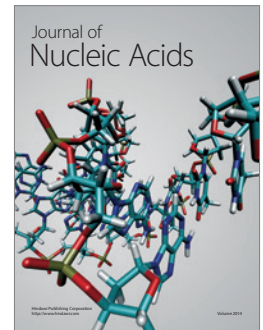
Acknowledgments

The authors are grateful to Yulia Arnitasari, Tutut Kusuma Wahyuni, Ismayanti Pangalanan, Riadiana Sulistyaningrum, and Ganesha Rifky Rinaldi for assistance with data collection and their encouragement of this study from its inception. This study was a part of a larger research programme funded by Jenderal Soedirman University. They also thank the heads of the Institute of Research and Community Services, Jenderal Soedirman University, for their support.

References

- [1] J. C. Biesmeijer, S. P. M. Roberts, M. Reemer et al., "Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands," *Science*, vol. 313, no. 5785, pp. 351–354, 2006.
- [2] M. A. Wall, M. Timmerman-Erskine, and R. S. Boyd, "Conservation impact of climatic variability on pollination of the federally endangered plant, *Clematis socialis* (Ranunculaceae)," *Southeastern Naturalist*, vol. 2, no. 1, pp. 11–24, 2003.
- [3] V. L. Scaven and N. E. Rafferty, "Physiological effects of climate warming on flowering plants and insect pollinators and potential consequences for their interactions," *Current Zoology*, vol. 59, no. 3, pp. 418–426, 2013.
- [4] W. Karunaratne and J. Edirisinghe, "Diversity of bees at different altitudes in the knuckles forest reserve," *Ceylon Journal of Science (Biological Sciences)*, vol. 37, no. 1, pp. 61–72, 2009.
- [5] M. Devoto, D. Medan, and N. H. Montaldo, "Patterns of interaction between plants and pollinators along an environmental gradient," *Oikos*, vol. 109, no. 3, pp. 461–472, 2005.
- [6] I. D. Hodkinson, "Terrestrial insects along elevation gradients: species and community responses to altitude," *Biological Reviews*, vol. 80, no. 3, pp. 489–513, 2005.
- [7] Y. L. Dupont, D. M. Hansen, and J. M. Olesen, "Structure of a plant-flower-visitor network in the high-altitude sub-alpine desert of Tenerife, Canary Islands," *Ecography*, vol. 26, no. 3, pp. 301–310, 2003.
- [8] S. Kimball, "Links between floral morphology and floral visitors along an elevational gradient in a *Penstemon* hybrid zone," *Oikos*, vol. 117, no. 7, pp. 1064–1074, 2008.
- [9] Ø. Totland, "Environment-dependent pollen limitation and selection on floral traits in an alpine species," *Ecology*, vol. 82, no. 8, pp. 2233–2244, 2001.

- [10] J. M. Olesen and P. Jordano, "Geographic patterns in plant-pollinator mutualistic networks," *Ecology*, vol. 83, no. 9, pp. 2416–2424, 2002.
- [11] B. J. Brosi, G. C. Daily, T. M. Shih, F. Oviedo, and G. Durán, "The effects of forest fragmentation on bee communities in tropical countryside," *Journal of Applied Ecology*, vol. 45, no. 3, pp. 773–783, 2008.
- [12] A. E. Magurran, *Ecological Diversity and Its Measurement*, Chapman and Hall, London, UK, 1st edition, 1988.
- [13] N. McAleece, P. J. D. Lamshead, and G. L. J. Paterson, *Biodiversity Pro*, The Natural History Museum, London, UK, 1997.
- [14] B. Hoiss, J. Krauss, S. G. Potts, S. Roberts, and I. Steffan-Dewenter, "Altitude acts as an environmental filter on phylogenetic composition, traits and diversity in bee communities," *Proceedings of the Royal Society B: Biological Sciences*, vol. 279, no. 1746, pp. 4447–4456, 2012.
- [15] P. K. Kwapong, P. O. A. Danquah, and A. T. Asare, "Insect floral visitors of cowpea (*Vigna unguiculata* L.)," *Annals of Biological Research*, vol. 4, no. 4, pp. 12–18, 2013.
- [16] B. M. T. Kingha, F. N. T. Fohouo, A. Ngakou, and D. Brückner, "Foraging and pollination activities of *Xylocopa olivacea* (Hymenoptera, Apidae) on *Phaseolus vulgaris* (Fabaceae) flowers at Dang (Ngaoundere-Cameroon)," *Journal of Agricultural Extension and Rural Development*, vol. 4, no. 6, pp. 330–339, 2012.
- [17] T. Atmowidi, D. Buchori, S. Manuwoto, B. Suryobroto, and P. Hidayat, "Diversity of pollinator insects in relation to seed set of mustard (*Brassica rapus* L.: Cruciferae)," *HAYATI Journal of Biosciences*, vol. 14, no. 4, pp. 155–161, 2007.
- [18] M. Aouar-Sadli, K. Louadi, and S. E. Doumandji, "Pollination of the broad bean (*Vicia faba* L.var. major)(Fabaceae) by wild bees and honey bees (Hymenoptera: Apoidea) and its impact on the seed production in the Tizi-Ouzou area (Algeria)," *African Journal of Agricultural Research*, vol. 3, no. 4, pp. 266–272, 2008.
- [19] D. Gottlieb, T. Keasar, A. Shmida, and U. Motro, "Possible foraging benefits of bimodal daily activity in *Proxycopa olivieri* (Lepeletier) (Hymenoptera: Anthophoridae)," *Environmental Entomology*, vol. 34, no. 2, pp. 417–424, 2005.
- [20] S. Volynchik, M. Plotkin, N. Y. Ermakov, D. J. Bergman, and J. S. Ishay, "Presence of a thermoregulatory hot spot in the prothorax of the large carpenter bee and the bumble bee," *Microscopy Research and Technique*, vol. 69, no. 11, pp. 903–912, 2006.
- [21] T. Keasar, "Large carpenter bees as agricultural pollinators," *Psyche*, vol. 2010, Article ID 927463, 7 pages, 2010.
- [22] T. Keasar, A. Sadeh, M. Shilo, and Y. Ziv, "Social organization and pollination efficiency in the carpenter bee *Xylocopa pubescens* (Hymenoptera: Apidae: Anthophorinae)," *Entomologia Generalis*, vol. 29, no. 2–4, pp. 225–236, 2007.
- [23] K. Tan, S. Yang, Z.-W. Wang, S. E. Radloff, and B. P. Oldroyd, "Differences in foraging and broodnest temperature in the honey bees *Apis cerana* and *A. mellifera*," *Apidologie*, vol. 43, no. 6, pp. 618–623, 2012.
- [24] D. Goulson, "Effects of introduced bees on native ecosystems," *Annual Review of Ecology, Evolution, and Systematics*, vol. 34, no. 1, pp. 1–26, 2003.



TURNITIN

Diversity of Wild Bees along Elevational Gradient in an Agricultural Area in Central Java, Indonesia

by Eming Sudiana

Submission date: 23-Aug-2020 11:24PM (UTC+0700)

Submission ID: 1372914817

File name: PSYCHE_VOL_2017_ARTIKEL.pdf (1.18M)

Word count: 3760

Character count: 20355

Research Article

Diversity of Wild Bees along Elevational Gradient in an Agricultural Area in Central Java, Indonesia

Imam Widhiono, Eming Sudiana, and Darsono Darsono

Faculty of Biology, Jenderal Soedirman University, Jl. Dr. Soeparno no. 63 Purwokerto, Central Java 53122, Indonesia

Correspondence should be addressed to Imam Widhiono; imamwidhiono@yahoo.com

Received 6 December 2016; Accepted 12 January 2017; Published 31 January 2017

Academic Editor: Jacques Hubert Charles Delabie

Copyright © 2017 Imam Widhiono et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Increases in mean temperature affect the diversity and abundance of wild bees in agricultural ecosystems. Pollinator community composition is expected to change along an elevational gradient due to differences in the daily ambient temperature. This study investigated the diversity and abundance of wild bees in an agricultural area along an elevational gradient in Central Java, Indonesia. Wild bees were collected using a sweep net in 40 green bean (*Phaseolus vulgaris*) cultivation sampling locations at seven different elevations (8, 108, 224, 424, 644, 893, and 1017 m above sea level). Species diversity was determined using the Shannon–Wiener diversity index. We identified 932 individuals from 8 species of wild bee belonging to 3 families. The family Apidae was predominant, with 6 species, while only 1 species was found from each of Megachilidae and Halictidae. Across the study sites, diversity increased with increasing elevation ($H' = 1.4$, $D = 0.25$, and $E = 0.78$ at low elevation to $H' = 2.04$, $D = 0.13$, and $E = 0.96$ at high elevation), and higher numbers of species were found at middle and high elevations. Species richness and abundance increased linearly with increasing elevation, and species diversity was highest at middle elevations.

1. Introduction

Wild bees (order Hymenoptera: Apoidea) represent the most important group of pollinator insects because they play a key role in agriculture, pollinating almost all crop varieties. However, they are increasingly at risk of local and even global extinction to climate change [1], which can disrupt the overlap of flower production and pollinator flight activity [2]. The major characteristic of climate change is an increase in the mean global temperature. Elevated temperatures are known to influence the foraging activity, body size at maturity, and individual lifespan [3] of wild bees. The physiological impacts of climate warming might not have negative effects on individual insect pollinators; in fact, some could even have positive effects. Increases in mean temperature affect the diversity and abundance of wild bees in agricultural ecosystems.

Elevational gradients can be used as model systems for climatic change to analyse the role of environmental filtering effects on animal communities [4]. Comparative studies of

species ecology along elevational gradients can provide clues to the likely response of both species and communities in the study of the effects of increasing temperature on the diversity and abundance of pollinator insects. However, there are significant differences among the characteristics of typical elevational gradients. Pollinator community composition is expected to change along an elevational gradient due to differences in ambient daily temperature. Due to the harsher environmental conditions, the number of pollinator species tends to decrease with increasing elevation [5]. The relative abundance of Hymenoptera has been negatively correlated with increasing elevation [6]. However, some studies have found that Hymenoptera, especially wild bees, are the most abundant floral visitor at high elevations, at least for some plant species [7]. Total pollinator richness [8] and abundance [9] have been found to decrease with increasing elevation, with plants becoming more ecologically specialised at higher elevations [10]. However, to the best of our knowledge, the wild bee diversity and abundance along an elevational gradient in agricultural areas has not previously been studied

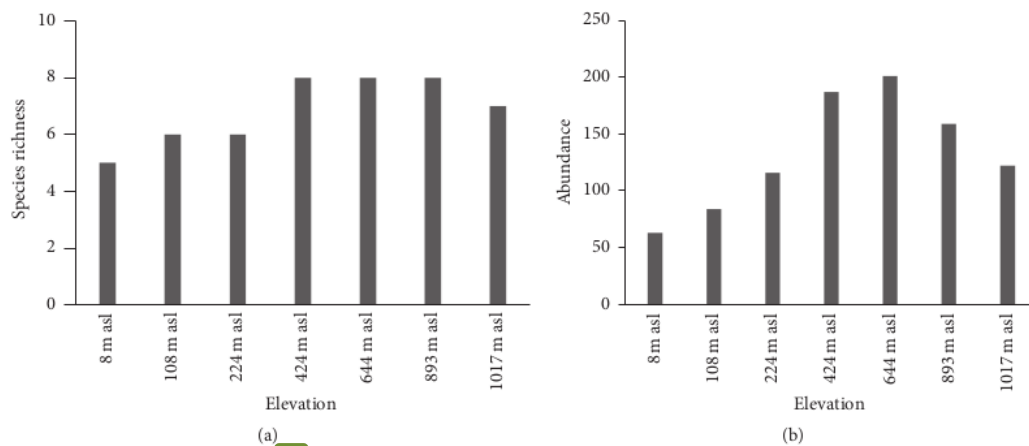


FIGURE 1: Species richness (a) and abundance (b) of wild bees among elevation.

in Java. In this study, we investigated the diversity and abundance of wild bees in an agricultural area along an elevational gradient to test the hypothesis that elevation is a significant factor underlying the species composition and abundance of wild bees.

2. Materials and Methods

2.1. Study Area. The study was conducted in areas of green bean (*Phaseolus vulgaris*) cultivation at seven locations along an elevational gradient: Lomanis, Cilacap Regency (7°41'06 32"N, 109°01'12 24"E, 8 m above sea level (asl)), Gunung Tugel, Purwokerto (7°28'03 92"N, 109°14'06 35"E, 106 m asl), Banteran, Sikapat, and Banyumas Regency (7°20'00 43"N, 109°16'29 49"N, 224, and 442 m asl, resp.), Limpakuwus and Tuwel, Tegal Regency (7°09'46 38"N, 109°09'06 66"E, 664 and 887 m asl), and Serang, Pubalingga Regency (7°14'48 41"E, 109°17'28 91"N, 1077 m asl). In the regions, green bean is a minor vegetable crop that extensive planting is usually very small and located on land planted with other types of vegetables such as long bean, but, as for research purposes, this plant was chosen because it was found at all altitudes.

2.2. Sampling of Bee Diversity and Identification. The seven long bean plantations were sampled twice each month from April to June, 2014. We collected 100 plant individuals at each site, using the standard sweep net procedures described by Brosi et al. [11] (2008) to sample the bees. During each sampling session, 14 members of the field team (two persons per location) aerially netted bees over 30 min periods. Bees both on flowers and in flight were collected individually with the sweep net. Sampling was performed in the morning (07:00–09:00 local time) on fine days. Bee species were identified by the Indonesian Institute of Science, Bogor. Voucher specimens are held at the Entomology Laboratory, Faculty of Biology, Jenderal Soedirman University, Indonesia.

2.3. Statistical Analyses. The species richness and abundance of wild bees recorded in the seven plots were analysed. A general linear model was applied using SPSS ver. 18.0 software. The dependent variables were wild bee species richness and abundance, and the categorical variables were elevation and daily temperature. Raw data from the field were used to reveal species richness, species diversity (Shannon–Weiner index), component of dominance (Simpson dominance index), and relative abundance of different species at each sampling site [12]. Comparisons of species composition according to location were performed using single linkage cluster analysis based on Bray–Curtis similarity. All diversity parameters were analysed using Biodiversity Pro software [13].

3. Results and Discussion

3.1. Species Composition. In total, 932 individual wild bees belonging to 8 species, 5 genera, and 3 families were collected during the study period. Apidae was the most dominant family, with 6 species (*Xylocopa latipes*, *X. confusa*, *X. caerulea*, *Apis cerana*, *A. dorsata*, and *Amegilla cingulata*), and two families (Megachilidae and Halictidae) were represented by one species each. The composition of wild bee species found at the seven elevations varied, with the largest number of species (8) at the middle-to-high elevations (442–1017 m asl), and the lowest species richness at the lowest elevation (8 m asl), with only 3 species. *Xylocopa latipes*, *X. confusa*, *Apis cerana*, and *Megachile relative* were observed at most elevations. *Apis dorsata* and *Xylocopa caerulea* were found only at the middle and high elevations (Figure 1(a)). Species richness differed significantly among elevations (analysis of variance (ANOVA): $F_{6,49} = 5.445$, $p = 0.000223 < 0.05$). Increasing elevation increased wild bee species richness up to 893 m asl ($R^2 = 0.84$) and then decreased species richness above 1017 m asl (Table 1).

TABLE 1: Species composition, abundance, and diversity of wild bees and seven different elevations.

Species	Elevation m above sea level (asl)							Abundance	Relative (%)
	8	108	224	424	644	893	1017		
<i>Xylocopa latipes</i>	18	26	25	27	26	22	16	160	17,16
<i>Xylocopa confusa</i>	15	14	19	44	26	19	23	160	17,16
<i>Xylocopa caerulea</i>	0	0	0	15	29	31	22	97	10,4
<i>Apis cerana</i>	20	23	37	44	38	27	0	189	20,2
<i>Apis dorsata</i>	0	0	0	21	26	16	11	74	7,9
<i>Amegilla cingulata</i>	1	4	11	8	22	13	17	76	8,1
<i>Megachile relativa</i>	9	10	11	16	20	18	19	103	11,05
<i>Lasioglossum malachurum</i>	0	7	13	12	14	13	14	73	7,8
Abundance	63	84	116	187	201	159	122	932	
Relative (%)	6,7	9,01	12,44	20,06	21,56	17,06	13,09		
33 in temperature °C	34,3	32,5	31,2	30,4	29,8	29	28,7		
Shannon-H	1,408	1,622	1,684	1,93	2,045	2,035	1,919		
Simpson 1-D	0,740	0,778	0,7944	0,8361	0,8665	0,8634	0,8498		
Evenness e^H/S	0,817	0,843	0,897	0,860	0,966	0,956	0,973		

3.2. Abundance. In total, 932 individual wild bees belonging to 8 species, 5 genera, and 3 families were recorded. Site 1 supported 4 species with 63 individuals (5.8% of all individuals); Site 2, 5 species and 84 individuals (9.01%); Site 3, 5 species and 116 individuals (12.44%); Site 4, 7 species and 187 individuals (20.06%); Site 5, 8 species and 201 individuals (21.5%); Site 6, 8 species and 169 individuals (17.06%); and Site 7, 7 species and 122 individuals (13.09%) (Figure 1(b)).

Wild bee abundance differed significantly among sites (ANOVA: $F_{6,49} = 3.478, p = 0.006 < 0.05$). The most abundant species was *Apis cerana* with 189 individuals (20.2%), followed by *X. confusa* and *X. latipes*, each with 160 individuals (17.16%), *M. relativa* with 103 individuals (11.05%), *X. caerulea* with 97 individuals (10.4%), *A. cingulata* with 76 individuals (8.1%), and *A. dorsata* with 74 individuals (7.9%), and the least abundant was *L. malachurum* with 73 individuals (7.8%). Comparing the wild bee abundance among sampling events at all elevations, the highest abundance was from sampling number 2 with 199 individuals (21.3%), followed by sampling number 1 with 172 individuals (18.4%), sampling number 4 with 157 individuals (16.8%), sampling number 3 with 148 individuals (15.8%), sampling number 5 with 136 individuals (14.5%), and the lowest abundance was from sampling number 6 with 120 individuals (12.8%). However, statistical analysis revealed no significant differences among sampling events (ANOVA: $F_{5,42} = 1.01800, p = 0.419 > 0.05$).

Across the study sites, diversity increased with increasing elevation (Shannon–Wiener index (H') = 1.4, dominance (D) = 0.25, and evenness (E) = 0.78 at low elevation to (H') = 2.04, D = 0.13, and E = 0.96 at high elevation), and higher numbers of species were found at middle and high elevations. The distribution of wild bees among the sites was significantly influenced by elevation. The richness, abundance, diversity, and evenness of wild bees at different sites are presented in Table 1.

Analysis of community structure similarity among elevations showed that the three sites categorised as low elevation (8–224 m asl) had high similarity (84.53%), the two middle-elevation sites (424–644 m asl) had 83.50% similarity, and

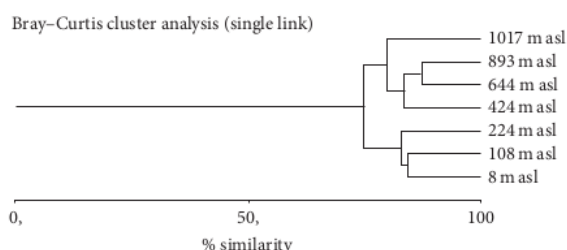


FIGURE 2: Similarity (Bray–Curtis) single linkage of wild bee in seven different elevations.

the two high-elevation sites (893 m–1017 m asl) had 79.7% similarity. However, the highest species similarity (87.2%) was found between Site 5 (644 m asl) and site 6 (893 m asl) (Figure 2).

4. Discussion

39 The number of wild bee species and the species composition recorded in this study were similar to those reported in previous studies in various regions. Hoiss et al. [14] observed 10 species of wild bees at *Vigna unguiculata* in Ghana belonging to the families Apidae (*Xylocopa*, *Apis*, and *Amegilla*), Megachilidae (*Megachile eurymera*), and 12 Ctenidae (*Nomia* sp.). Kwapong et al. [15] reported that the main insects observed on cowpea flowers were bees such as *Apis mellifera*, *Ceratina* sp., *Megachile* sp., *Xylocopa calens*, *Xylocopa imitator*, *Brausepsis* sp., *Lipotriches* sp., *Melecta* sp., and *Amegilla* sp. Kingha et al. [16] reported *Apis mellifera* as the most abundant insect species visiting *P. vulgaris* flowers in Kenya, followed by *Xylocopa calens* and *X. inconstans*. The flowers of long bean attract wild bee pollinators from Apidae, probably because the members of this family have sufficient strength to open the flower to collect pollen and nectar [17]. However, to the best of our knowledge, to date there have been no studies on insect pollinator diversity in green bean cultivation areas

in Indonesia for comparison purposes. In Sukabumi, West Java, in mustard (*Brasica rapus*) at an elevation of approximately 854 masl, Aouar-Sadli et al. [18] observed insect pollinators from the order Hymenoptera, family Apidae, subfamily Apinae, consisting of the species *Apis cerana*, *Apis dorsata*, and *Trigona* sp., from the subfamily Xylocopinae, the species *Xylocopa caerulea*, *X. confusa*, *X. latipes*, and *Ceratina* sp., from the family Colletidae, subfamily Hylaeinae *Hylaeus* sp., from the family Halictidae, subfamily Nominae *Nomia* sp., and from the family Scoliididae *Compsomeris lindennii*. Our study findings indicate that the species composition of insect pollinators on agricultural land is dominated by wild bees.

Elevation strongly influenced the diversity and abundance of wild bee communities. Species richness and abundance increased linearly with increasing elevation, and species diversity was highest at middle elevations. These results are inconsistent with those of Gottlieb et al., [19], who reported that the diversity and abundance of wild bees decreased linearly with increasing elevation from 60 to 2000 masl. This difference may be due to differences in the geographical region, climate zone, and range of elevational gradient. A commonly reported pattern in species richness along elevational gradients is a unimodal distribution with a mid-elevation peak [20]. In our study, peak species diversity occurred at middle elevations due to the presence of two species (*Apis dorsata* and *Xylocopa caerulea*) that began to appear above 442 masl. The presence of the giant honey bee (*A. dorsata*) at mid-to-high elevations may be due to habitat suitability rather than elevation effects because these bees require a forested habitat with high trees, whereas blue carpenter bees tend to be abundant in cool environments. Large center bees (genus *Xylocopa*) are wood-nesting generalist pollinators of broad geographical distribution. Their foraging is characterised by a wide range of food plants, long season of activity, tolerance of high temperatures, and activity under low illumination levels [21]. Carpenter bees tolerate high ambient temperatures during foraging, and most species are inactive at low temperatures, and these bees were found in all of our study sites. All of the sites from the lowest to highest elevation had daily temperature ranges appropriate for wild bees. Generally, the genus *Xylocopa* is able to move around well in a daily temperature range of 25–35°C [22]. This heat tolerance suggests efficient heat regulation ability in carpenter bees, possibly controlled by a thermoregulatory centre in the prothorax [23]. In contrast, *Apis cerana* has a tendency to forage in conditions of warm temperatures [24]. The presence of the three species *Megachile relativa*, *Amegilla cingulata*, and *Lasioglossum malachurum* almost evenly at all elevations studied indicates that these species are able to move around in the range of temperatures that occur at these elevations.

5. Conclusion

Eight species of wild bees from four families of the order Hymenoptera were recorded in green bean cultivation areas at seven different elevations in Central Java, Indonesia. Species richness and abundance increased linearly with

increasing elevation, and species diversity was highest at middle elevations.

6 Disclosure

The English in this document has been checked by at least two professional editors, both native speakers of English. For a certificate, please see: <http://www.textcheck.com/certificate/A8au1l>.

Competing Interests

The authors declare that they have no competing interests.

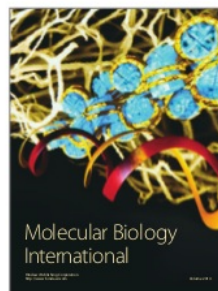
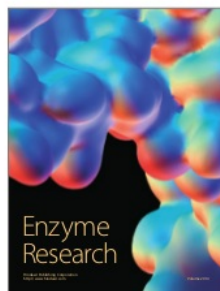
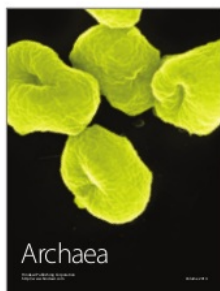
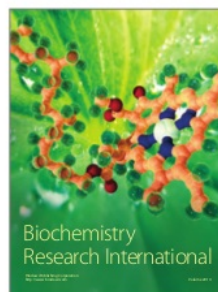
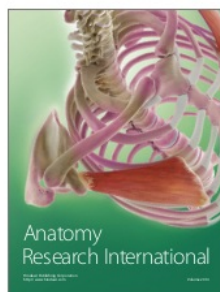
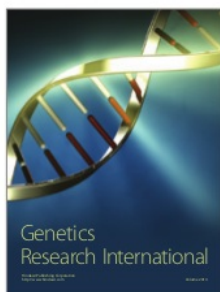
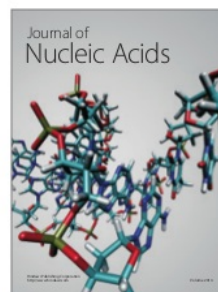
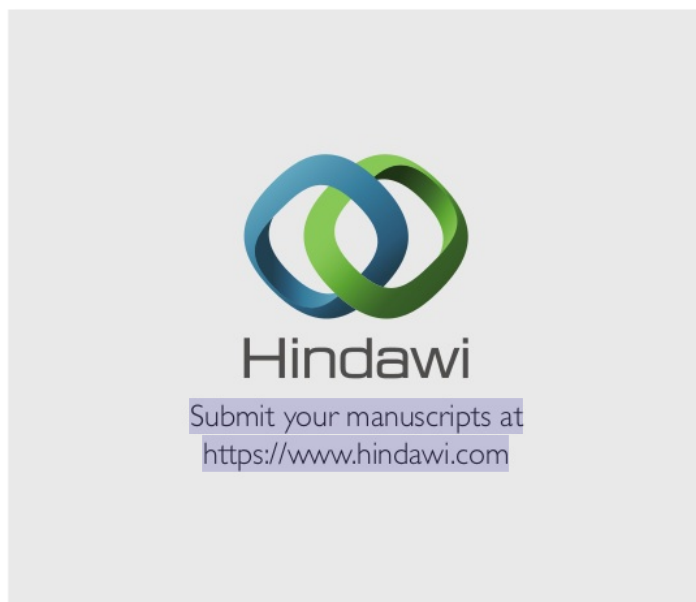
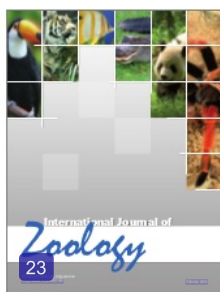
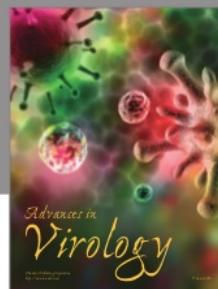
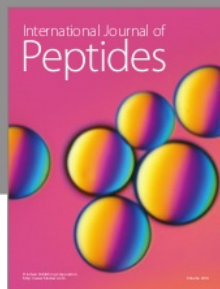
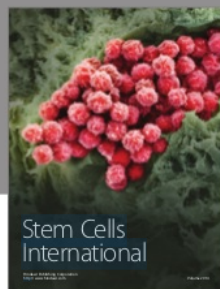
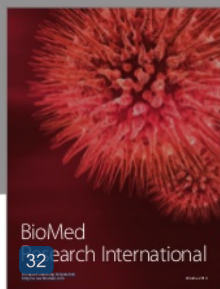
Acknowledgments

The authors are grateful to Yulia Armitasari, Tutut Kusuma Wahyuni, Ismayanti Pangalanan, Riadiana Sulistyanningrum, and Ganesha Rifky Rinaldi for assistance with data collection and their encouragement of this study from its inception. This study was a part of a larger research programme funded by Jenderal Soedirman University. They also thank the heads of the Institute of Research and Community Services, Jenderal Soedirman University, for their support.

7 References

- [1] J. C. Biesmeijer, S. P. M. Roberts, M. Reemer et al., "Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands," *Science*, vol. 313, no. 5785, pp. 351–354, 2006.
- [2] M. A. Wall, M. Timmerman-Erskine, and R. S. Boyd, "Conservation impact of climatic variability on pollination of the federally endangered plant, *Clematis socialis* (Ranunculaceae)," *Southern Naturalist*, vol. 2, no. 1, pp. 11–24, 2003.
- [3] V. L. Scaven and N. E. Rafferty, "Physiological effects of climate warming on flowering plants and insect pollinators and potential consequences for their interactions," *Current Zoology*, vol. 59, no. 3, pp. 418–426, 2013.
- [4] W. Karunaratne and J. Edirisinghe, "Diversity of bees at different altitudes in the knuckles forest reserve," *Ceylon Journal of Science (Biological Sciences)*, vol. 37, no. 1, pp. 61–72, 2009.
- [5] M. Devoto, D. Medan, and N. H. Montaldo, "Patterns of interaction between plants and pollinators along an environmental gradient," *Oikos*, vol. 99, no. 3, pp. 461–472, 2005.
- [6] I. D. Hodkinson, "Terrestrial insects along elevation gradients: species and community responses to altitude," *Biological Reviews*, vol. 80, no. 3, pp. 489–513, 2005.
- [7] Y. L. Dupont, D. M. Hansen, and J. M. Olesen, "Structure of a plant-flower-visitor network in the high-altitude sub-alpine desert of Tenerife, Canary Islands," *Ecography*, vol. 26, no. 3, pp. 301–310, 2003.
- [8] S. Kimball, "Links between floral morphology and floral visitors along an elevational gradient in a *Penstemon* hybrid zone," *Oikos*, vol. 117, no. 7, pp. 1064–1074, 2008.
- [9] O. Totland, "Environment-dependent pollen limitation and selection on floral traits in an alpine species," *Ecology*, vol. 82, no. 8, pp. 2233–2244, 2001.

- [10] J. M. Olesen and P. Jordano, "Geographic patterns in plant-pollinator mutualistic networks," *Ecology*, vol. 83, no. 9, pp. 2416–2424, 2002.
- [11] B. J. Brosi, G. C. Daily, T. M. Shih, F. Oviedo, and G. Durán, "The effects of forest fragmentation on bee communities in tropical countryside," *Journal of Applied Ecology*, vol. 45, no. 3, pp. 773–782, 2008.
- [12] A. E. Magurran, *Ecological Diversity and Its Measurement*, Chapman and Hall, London, UK, 1st edition, 1988.
- [13] N. McAleece, P. J. D. Lambshead, and G. L. J. Paterson, *Biodiversity Pro*, The Natural History Museum, London, UK, 1997.
- [14] B. Hoiss, J. Krauss, S. G. Potts, S. Roberts, and I. Steffan-Dewenter, "Altitude acts as an environmental filter on phylogenetic composition, traits and diversity in bee communities," *Proceedings of the Royal Society B: Biological Sciences*, vol. 279, no. 1746, pp. 4447–4456, 2012.
- [15] P. K. Kwabong, P. O. A. Danquah, and A. T. Asare, "Insect floral visitors of cowpea (*Vigna unguiculata* L.)," *Annals of Biological Research*, vol. 4, no. 4, pp. 12–18, 2013.
- [16] B. M. T. Kingha, F. N. T. Fohouo, A. Ngakou, and D. Brückner, "Foraging and pollination activities of *Xylocopa olivacea* (Hymenoptera, Apidae) on *Phaseolus vulgaris* (Fabaceae) flowers at Dang (Ngaoundere-Cameroon)," *Journal of Agricultural Extension and Rural Development*, vol. 4, no. 6, pp. 330–339, 2012.
- [17] T. Atmowidi, D. Buchori, S. Manuwoto, B. Suryobroto, and P. Hidayat, "Diversity of pollinator insects in relation to seed set of mustard (*Brassica rapus* L.: Cruciferae)," *HAYATI Journal of Biosciences*, vol. 14, no. 4, pp. 155–161, 2007.
- [18] M. Aouar-Sadli, K. Louadi, and S. E. Doumandji, "Pollination of the broad bean (*Vicia faba* L.var. major)(Fabaceae) by wild bees and honey bees (Hymenoptera: Apoidea) and its impact on the seed production in the Tizi-Ouzou area (Algeria)," *African Journal of Agricultural Research*, vol. 3, no. 4, pp. 266–272, 2008.
- [19] D. Gottlieb, T. Keasar, A. Shmida, and U. Motro, "Possible foraging benefits of bimodal daily activity in *Proxycopa olivieri* (Lepeletier) (Hymenoptera: Anthophoridae)," *Environmental Entomology*, vol. 34, no. 2, pp. 417–424, 2005.
- [20] S. Volynchik, M. Plotkin, N. Y. Ermakov, D. J. Bergman, and J. S. Boy, "Presence of a thermoregulatory hot spot in the prothorax of the large carpenter bee and the bumble bee," *Microscopy Research and Technique*, vol. 69, no. 11, pp. 903–912, 2006.
- [21] T. Keasar, "Large carpenter bees as agricultural pollinators," *Psyche*, vol. 2010, Article ID 927463, 7 pages, 2010.
- [22] T. Keasar, A. Sadeh, M. Shilo, and Y. Ziv, "Social organization and pollination efficiency in the carpenter bee *Xylocopa pubescens* (Hymenoptera: Apidae: Anthophorinae)," *Entomologia Generalis*, vol. 29, no. 2–4, pp. 225–236, 2007.
- [23] K. Tan, S. Yang, Z.-W. Wang, S. E. Radloff, and B. P. Oldroyd, "Differences in foraging and broodnest temperature in the honey bees *Apis cerana* and *A. mellifera*," *Apidologie*, vol. 43, no. 4, pp. 618–623, 2012.
- [24] D. Goulson, "Effects of introduced bees on native ecosystems," *Annual Review of Ecology, Evolution, and Systematics*, vol. 34, no. 1, pp. 1–26, 2003.



Diversity of Wild Bees along Elevational Gradient in an Agricultural Area in Central Java, Indonesia

ORIGINALITY REPORT

24%

SIMILARITY INDEX

18%

INTERNET SOURCES

21%

PUBLICATIONS

12%

STUDENT PAPERS

PRIMARY SOURCES

1

Hellen K. Mandela, Mugatsia H. Tsingalia, Mary Gikungu, Wilbur M. Lwande. " Distance Effects on Diversity and Abundance of the Flower Visitors of in the Kakamega Forest Ecosystem ", International Journal of Biodiversity, 2018

Publication

2%

2

tel.archives-ouvertes.fr

Internet Source

2%

3

Bernhard Hoiss, Jochen Krauss, Simon G. Potts, Stuart Roberts, Ingolf Steffan-Dewenter. "Altitude acts as an environmental filter on phylogenetic composition, traits and diversity in bee communities", Proceedings of the Royal Society B: Biological Sciences, 2012

Publication

1%

4

complete.bioone.org

Internet Source

1%

5

Mezani, Samir, Karima Khelfane-Goucem, and Ferroudja Medjdoub-Bensaad. "Evaluation of

1%

invertebrate diversity on a broad bean crop
(*Vicia faba* L. var. *major*) in Tizi-Ouzou area
(Algeria)", *Zoology and Ecology*, 2016.

Publication

6

Borah Kim, Sang-Hyuk Lee, Yen Kuang Yang,
Jong-Il Park, Young-Chul Chung. "Long-Acting
Injectable Antipsychotics for First-Episode
Schizophrenia: The Pros and Cons",
Schizophrenia Research and Treatment, 2012

Publication

1 %

7

arxiv.org

Internet Source

1 %

8

bioone.org

Internet Source

1 %

9

ia601606.us.archive.org

Internet Source

1 %

10

hal-univ-rennes1.archives-ouvertes.fr

Internet Source

1 %

11

krishikosh.egranth.ac.in

Internet Source

1 %

12

www.oalib.com

Internet Source

1 %

13

Shane Stiles, Jon Lundgren, Charles Fenster,
Henning Nottebrock. " Maximizing Ecosystem
Services Provided to the New Oil Crop Through

1 %

Landscape and Arthropod Diversity ", Cold Spring Harbor Laboratory, 2019

Publication

14	hal.archives-ouvertes.fr Internet Source	1 %
15	Abrol, Dharam P.. "Climate Change and Pollinators", Pollination Biology, 2012. Publication	1 %
16	asiajol.info Internet Source	1 %
17	www.ncbi.nlm.nih.gov Internet Source	1 %
18	Submitted to University of Birmingham Student Paper	<1 %
19	esajournals.onlinelibrary.wiley.com Internet Source	<1 %
20	Ramos-Jiliberto, R.. "Topological change of Andean plant-pollinator networks along an altitudinal gradient", Ecological Complexity, 201003 Publication	<1 %
21	Submitted to National University of Singapore Student Paper	<1 %
22	Andrieu, E.. "The town Crepis and the country Crepis: How does fragmentation affect a plant-	<1 %

23

www.sp-rop.com

Internet Source

<1 %

24

O. Dangles, C. Carpio, A. R. Barragan, J.-L. Zeddam, J.-F. Silvain. "TEMPERATURE AS A KEY DRIVER OF ECOLOGICAL SORTING AMONG INVASIVE PEST SPECIES IN THE TROPICAL ANDES", Ecological Applications, 2008

Publication

<1 %

25

ÖZBEK, Hikmet. "New data on large carpenter-bees of Turkey with considerations about their importance as pollinators", Gazi Entomological Research Society, 2013.

Publication

<1 %

26

Petanidou, Theodora, Athanasios S. Kallimanis, Stefanos P. Sgardelis, Antonios D. Mazaris, John D. Pantis, and Nickolas M. Waser. "Variable flowering phenology and pollinator use in a community suggest future phenological mismatch", Acta Oecologica, 2014.

Publication

<1 %

27

www.mdpi.com

Internet Source

<1 %

28

Internet Source

<1 %

29

m.scirp.org

Internet Source

<1 %

30

pdfs.semanticscholar.org

Internet Source

<1 %

31

Evy Sulistyoningrum, Eka Rachmani, Hanif Baroroh, Lantip Rujito. "Annona muricata Leaves Extract Reduce Proliferative Indexes And Improve Histological Changes In Rat's Breast Cancer", Journal of Applied Pharmaceutical Science, 2017

Publication

<1 %

32

Submitted to Liverpool John Moores University

Student Paper

<1 %

33

ncr-journal.bear-land.org

Internet Source

<1 %

34

Hillary S. Sardiñas, Claire Kremen. "Pollination services from field-scale agricultural diversification may be context-dependent", Agriculture, Ecosystems & Environment, 2015

Publication

<1 %

35

s3-eu-west-1.amazonaws.com

Internet Source

<1 %

36

www.researchsquare.com

<1 %

37

Sydenham, Markus A. K., Stein R. Moe, Diana N. Stanescu-Yadav, Ørjan Totland, and Katrine Eldegard. "The effects of habitat management on the species, phylogenetic and functional diversity of bees are modified by the environmental context", *Ecology and Evolution*, 2016.

Publication

<1 %

38

Achik Dorchin, Amots Dafni, Ido Izhaki, Yuval Sapir, Nicolas J. Vereecken. "Patterns and drivers of wild bee community assembly in a Mediterranean IUCN important plant area", *Biodiversity and Conservation*, 2017

Publication

<1 %

39

Sara Diana Leonhardt, Nicola Gallai, Lucas Alejandro Garibaldi, Michael Kuhlmann, Alexandra-Maria Klein. "Economic gain, stability of pollination and bee diversity decrease from southern to northern Europe", *Basic and Applied Ecology*, 2013

Publication

<1 %

40

Sydenham, Markus A. K., Lise D. Häusler, Stein R. Moe, and Katrine Eldegard. "Inter-assemblage facilitation: the functional diversity of cavity-producing beetles drives the size

<1 %

diversity of cavity-nesting bees", Ecology and Evolution, 2016.

Publication

41

Ashworth, L.. "Pollinator-dependent food production in Mexico", Biological Conservation, 200905

Publication

<1 %

Exclude quotes Off

Exclude matches Off

Exclude bibliography Off