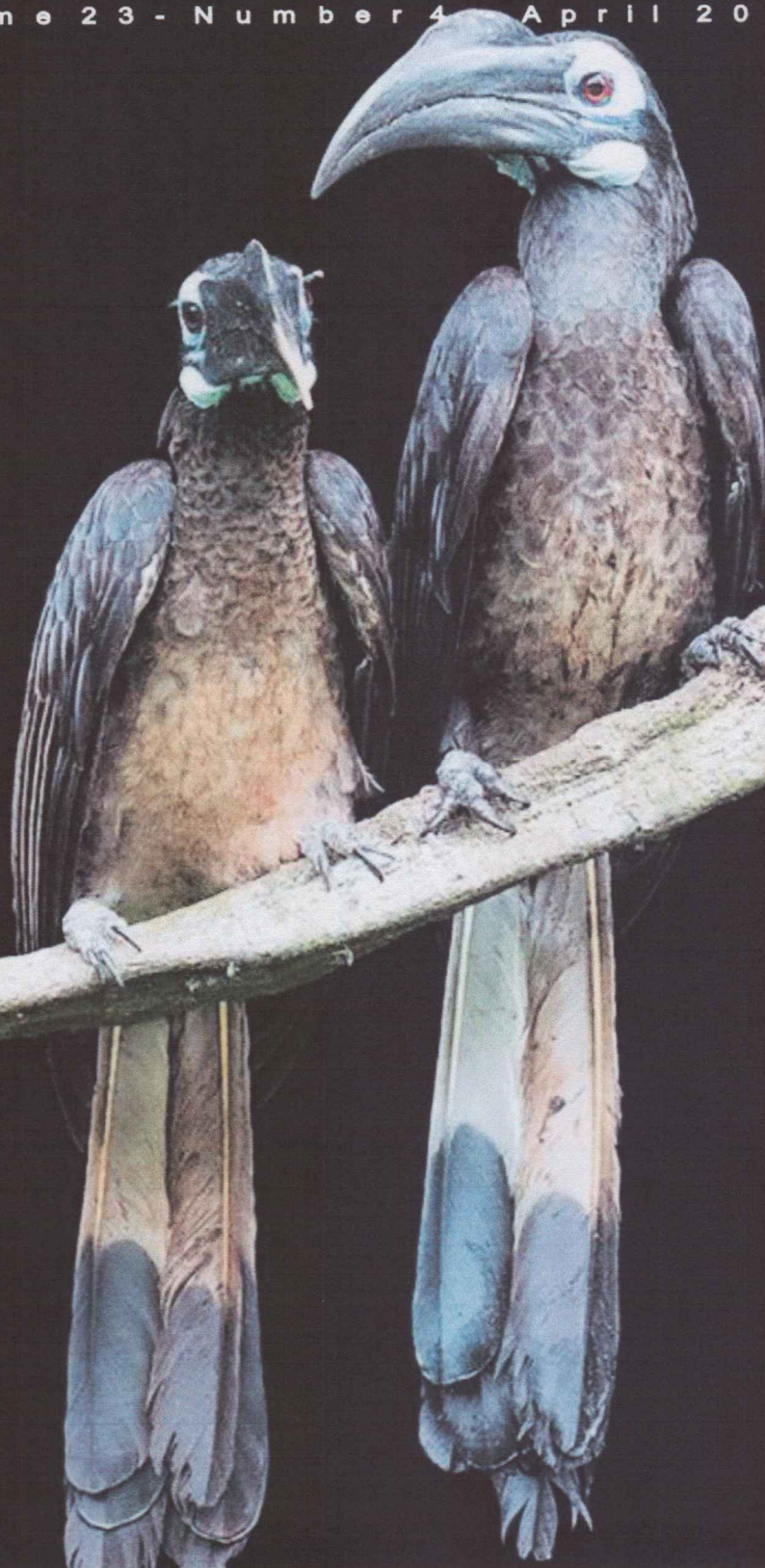


ISSN: 1412-033X
E-ISSN: 2085-4722

BIODIVERSITAS

Journal of Biological Diversity

Volume 23 - Number 4 April 2022



Front cover: *Anorrhinus galeritus* (Temminck, 1831)
(PHOTO: DAVID COOK)

Published monthly

PRINTED IN INDONESIA

ISSN: 1412-033X

E-ISSN: 2085-4722



9 771412 033870



9 772085 472874

BIODIVERSITAS

Journal of Biological Diversity
Volume 23 - Number 3 - March 2022

ISSN/E-ISSN:

1412-033X (printed edition), 2085-4722 (electronic)

EDITORIAL BOARD:

Abdel Fattah N.A. Rabou (Palestine), **Agnieszka B. Najda** (Poland), **Ajay Kumar Gautam** (India), **Alan J. Lymbery** (Australia), **Annisa** (Indonesia), **Bambang H. Saharjo** (Indonesia), **Daiane H. Nunes** (Brazil), **Darlina Md. Naim** (Malaysia), **Ghulam Hassan Dar** (India), **Hassan Pourbabaee** (Iran), **Joko R. Witono** (Indonesia), **Kartika Dewi** (Indonesia), **Katsuhiko Kondo** (Japan), **Kusumadewi Sri Yulita** (Indonesia), **Livia Wanntorp** (Sweden), **M. Jayakara Bhandary** (India), **Mahdi Reyahi-Khoram** (Iran), **Mahendra K. Rai** (India), **Mahesh K. Adhikari** (Nepal), **Maria Panitsa** (Greece), **Mochamad A. Soendjoto** (Indonesia), **Mohamed M.M. Najim** (Srilanka), **Mohib Shah** (Pakistan), **Nurhasanah** (Indonesia), **Praptiwi** (Indonesia), **Rasool B. Tareen** (Pakistan), **Seyed Aliakbar Hedayati** (Iran), **Seyed Mehdi Talebi** (Iran), **Shahabuddin** (Indonesia), **Shahir Shamsir** (Malaysia), **Shri Kant Tripathi** (India), **Subhash C. Santra** (India), **Sugeng Budiharta** (Indonesia), **Sugiyarto** (Indonesia), **Taufiq Purna Nugraha** (Indonesia), **Yosep S. Mau** (Indonesia)

EDITOR-IN-CHIEF:

Sutarno

EDITORIAL MEMBERS:

English Editors: **Graham Eagleton** (grahameagleton@gmail.com), **Suranto** (surantouns@gmail.com); Technical Editor: **Solichatun** (solichatun_s@yahoo.com), **Artini Pangastuti** (pangastuti_tutut@yahoo.co.id); Distribution & Marketing: **Rita Rakhmawati** (oktia@yahoo.com); Webmaster: **Ari Pitoyo** (aripitoyo@yahoo.com)

MANAGING EDITORS:

Ahmad Dwi Setyawan (unsjournals@gmail.com)

PUBLISHER:

The Society for Indonesian Biodiversity

CO-PUBLISHER:

Department of Biology, Faculty of Mathematics and Natural Sciences, Sebelas Maret University, Surakarta

ADDRESS:

Jl. Ir. Sutami 36A Surakarta 57126. Tel. +62-271-7994097, Tel. & Fax.: +62-271-663375, email: editors@smujo.id

ONLINE:

biodiversitas.mipa.uns.ac.id; smujo.id/biodiv



Society for Indonesia
Biodiversity



Sebelas Maret University
Surakarta

GUIDANCE FOR AUTHORS

Aims and Scope *Biodiversitas*, *Journal of Biological Diversity* or *Biodiversitas* encourages submission of manuscripts dealing with all aspects of biodiversity including plants, animals and microbes at the level of the gene, species, and ecosystem. Ethnobiology papers are also considered.

Article types The journal seeks original full-length: (1) **Research papers**, (2) **Reviews**, and (3) **Short communications**. Original research manuscripts are limited to 8,000 words (including tables and picture), or proportional with articles in this publication number. Review articles are also limited to 8,000 words, while Short communications should be less than 2,000 words, except for pre-study.

Submission The journal only accepts online submission, through open journal system (<https://smujo.id/biodiv/about/submissions>) or email to the editors at unsjournals@gmail.com. Submitted manuscripts should be the original works of the author(s). Please ensure that the manuscript is submitted using the *Biodiversitas* template, which can be found at (<https://biodiversitas.mipa.uns.ac.id/D/guidance.htm>). The manuscript must be accompanied by a cover letter containing the article title, the first name and last name of all the authors, a paragraph describing the claimed novelty of the findings versus current knowledge. Please also provide a list of five potential reviewers in your cover letter. Submission of a manuscript implies that the submitted work has not been published before (except as part of a thesis or report, or abstract); and is not being considered for publication elsewhere. When a manuscript written by a group, all authors should read and approve the final version of the submitted manuscript and its revision; and agree the submission of manuscripts for this journal. All authors should have made substantial contributions to the concept and design of the research, acquisition of the data and its analysis; drafting of the manuscript and correcting of the revision. All authors must be responsible for the quality, accuracy, and ethics of the work.

Ethics Author(s) must obedient to the law and/or ethics in treating the object of research and pay attention to the legality of material sources and intellectual property rights.

Copyright If the manuscript is accepted for publication, the author(s) still hold the copyright and retain publishing rights without restrictions. Authors are allowed to reproduce articles as long as they are not used for commercial purposes. For the new invention, authors are suggested to manage its patent before published.

Open access The journal is committed to free-open access that does not charge readers or their institutions for access. Readers are entitled to read, download, copy, distribute, print, search, or link to the full texts of articles, as long as not for commercial purposes. The license type is CC-BY-NC-SA.

Acceptance Only articles written in U.S. English are accepted for publication. Manuscripts will be reviewed by editors and invited reviewers (double blind review) according to their disciplines. Authors will generally be notified of acceptance, rejection, or need for revision within 1 to 2 months of receipt. Manuscripts will be rejected if the content does not in line with the journal scope, does not meet the standard quality, is in an inappropriate format, contains complicated grammar, dishonesty (i.e. plagiarism, duplicate publications, fabrication of data, citations manipulation, etc.), or ignoring correspondence in three months. The primary criteria for publication are scientific quality and biological significance. **Uncorrected proofs** will be sent to the corresponding author by email as .doc or .docx files for checking and correcting of typographical errors. To avoid delay in publication, corrected proofs should be returned in 7 days. The accepted papers will be published online in a chronological order at any time, but printed in January, April, July and October.

A charge Starting on January 1, 2017, publishing costs waiver is granted to foreign (non-Indonesian) authors who first publish the manuscript in this journal, especially for graduate students from developing countries. However, other authors are charged USD 250 (IDR 3,500,000).

Reprints The sample journal reprint is only available by special request. Additional copies may be purchased when ordering by sending back the uncorrected proofs by email. Manuscript preparation Manuscript is typed on A4 (210x297 mm²) paper size, in a single column, single space, 10-point (10 pt) Times New Roman font. The margin text is 3 cm from the top, 2 cm from the bottom, and 1.8 cm from the left and right. Smaller lettering size can be applied in presenting table and figure (9 pt). Word processing program or additional software can be used, however, it must be PC compatible, use the *Biodiversitas* template, and Microsoft Word based (.doc or .rtf; not .docx). **Scientific names** of species (incl. subspecies, variety, etc.) should be written in italics, except in italicized sentences. Scientific names (Genus, species, author), and cultivar or strain should be mentioned completely for the first time mentioning it in the body text, especially for taxonomic manuscripts. The Genus name can be shortened after first mention, except where this may generate confusion. Name of the author can be eliminated after first mentioning. For example, *Rhizopus oryzae* L. UICC 524, hereinafter can be written as *R. oryzae* UICC 524. Using trivial names should be avoided. **Biochemical and chemical nomenclature** should follow the order of the IUPAC - IUB. For DNA sequence, it is better used Courier New font. Standard chemical abbreviations can be applied for common and clear used, for example, completely written butilic hydroxyl toluene (BHT) to be BHT hereinafter. **Metric measurements** should use IS denominations, and other system should use equivalent values with the denomination of IS mentioned first. Abbreviations like g, mg, mL, etc. should not be followed by a dot.

Minus index (m-2, L-1, h-1) suggested to be used, except in things like "per-plant" or "per-plot". **Mathematical equations** can be written down in one column with text, in that case can be written separately. **Numbers** one to ten are written in words, except if it relates to measurement, while values above them written in number, except in early sentence. The fraction should be expressed in decimal. In the text, it should be used "%" rather than "percent". Avoid expressing ideas with complicated sentence and verbiage, and used efficient and effective sentence.

The **Title** of the article should be written in compact, clear, and informative sentence, preferably not more than 20 words. Author name(s) should be completely written. Name and institution address should also be completely written with street name and number (location), postal code, telephone number, facsimile number, and email address. Manuscripts written by a group, author for correspondence along with address is required. First page of the manuscript is used for writing above information.

The **Abstract** should not be more than 200 words. Include between five and eight **Keywords**, using both scientific and local names (if any), research themes, and special methods which used; and sorted from A to Z. All important **abbreviations** must be defined at their first mention. Running title is about five words. The **Introduction** is about 400-600 words, covering the background and aims of the research. **Materials and Methods** should emphasize on the procedures and data analysis. **Results and Discussion** should be written as a series of connecting sentences, however, for manuscript with long discussion should be divided into subtitles. Thorough discussion represents the causal effect mainly explains for why and how the results of the research were taken place, and do not only re-express the mentioned results in the form of sentences. A **Conclusion** should be given at the end of the discussion. **Acknowledgments** are expressed in brief; all sources of institutional, private and corporate financial support for the work must be fully acknowledged, and any potential conflicts of interest must be noted.

Figures and Tables of three pages maximum should be clearly presented. Include a label below each figure, and a label above each table (see example). Colored figures can only be accepted if the information in the manuscript can lose without those images; chart is preferred to use black and white images. Author could consign any picture or photo for the front cover, although it does not print in the manuscript. All images property of others should be mentioned source. There is no **Appendix**, all data or data analysis are incorporated into Results and Discussions. For broad data, supplementary information can be provided on the website.

References In the text give the author names followed by the year of publication and arrange from oldest to newest and from A to Z. In citing an article written by two authors, both of them should be mentioned, however, for three and more authors only the first author is mentioned followed by et al., for example: Saharjo and Nurhayati (2006) or (Boonkerd 2003a, b, c; Sugiyarto 2004; El-Bana and Nijs 2005; Balagadde et al. 2008; Webb et al. 2008). Extent citation as shown with word "cit" should be avoided. Reference to unpublished data and personal communication should not appear in the list but should be cited in the text only (e.g., Rifai MA 2007, pers. com. (personal communication); Setyawan AD 2007, unpublished data). In the reference list, the references should be listed in an alphabetical order. Names of journals should be abbreviated. Always use the standard abbreviation of a journal's name according to the **ISSN List of Title Word Abbreviations** (www.issn.org/2-22661-LTWA-online.php). Please include DOI links for journal papers. The following examples are for guidance.

Journal:

Saharjo BH, Nurhayati AD. 2006. Domination and composition structure change at hemic peat natural regeneration following burning; a case study in Pelalawan, Riau Province. *Biodiversitas* 7: 154-158. DOI: 10.13057/biodiv/d070213

Book:

Rai MK, Carpinella C. 2006. Naturally Occurring Bioactive Compounds. Elsevier, Amsterdam.

Chapter in book:

Webb CO, Cannon CH, Davies SJ. 2008. Ecological organization, biogeography, and the phylogenetic structure of rainforest tree communities. In: Carson W, Schnitzer S (eds) *Tropical Forest Community Ecology*. Wiley-Blackwell, New York.

Abstract:

Assaeed AM. 2007. Seed production and dispersal of *Rhazya stricta*. 50th annual symposium of the International Association for Vegetation Science, Swansea, UK, 23-27 July 2007.

Proceeding:

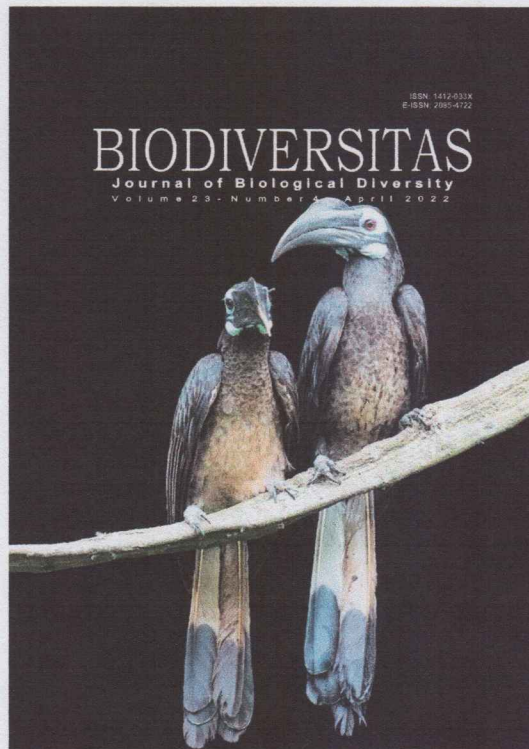
Alikodra HS. 2000. Biodiversity for development of local autonomous government. In: Setyawan AD, Sutarno (eds) *Toward Mount Lawu National Park; Proceeding of National Seminary and Workshop on Biodiversity Conservation to Protect and Save Germplasm in Java Island*. Universitas Sebelas Maret, Surakarta, 17-20 July 2000. [Indonesian]

Thesis, Dissertation:

Sugiyarto. 2004. Soil Macro-invertebrates Diversity and Inter-Cropping Plants Productivity in Agroforestry System based on Sengon. [Dissertation]. Universitas Brawijaya, Malang. [Indonesian]

Information from internet: Balagadde FK, Song H, Ozaki J, Collins CH, Barnet M, Arnold FH, Quake SR, You L. 2008. A synthetic *Escherichia coli* predator-prey ecosystem. *Mol Syst Biol* 4:187. www.molecularsystembiology.com

Home (<https://smujo.id/biodiv/index>) / Archives (<https://smujo.id/biodiv/issue/archive>) / Vol. 23 No. 4 (2022)



(<https://smujo.id/biodiv/issue/view/338>)

Vol. 23 No. 4 (2022)

Full Issue

Front Cover (<https://smujo.id/biodiv/issue/view/338/195>)

Articles

DNA barcoding of freshwater fish in Siberut Island, Mentawai Archipelago, Indonesia (<https://smujo.id/biodiv/article/view/10499>)

DEWI IMELDA ROESMA, DJONG HON TJONG, MUHAMMAD NAZRI JANRA, DYTA RABBANI AIDIL

PDF (<https://smujo.id/biodiv/article/view/10499/5682>)

Role of siamang (*Symphalangus syndactylus*) as seed dispersal agent in a Sumatran lowland tropical forest (<https://smujo.id/biodiv/article/view/10680>)

MUHAMMAD FARHAN ADYN, MARSYA CHRISTYANTI SIBARANI, LAJI UTOYO, RIKHA ARYANIE SURYA, AGUNG SEDAYU

PDF (<https://smujo.id/biodiv/article/view/10680/5686>)

Analysis of heavy metals (Pb and Cd) in seagrasses *Thalassia hemprichii* and *Enhalus acoroides* from Pulau Sembilan, South Sulawesi Province, Indonesia (<https://smujo.id/biodiv/article/view/10626>)

DWI ROSALINA, KATARINA HESTY ROMBE, KHAIRUL JAMIL, AGUS SURACHMAT

PDF (<https://smujo.id/biodiv/article/view/10626/5691>)

Documentation of the traditional Gayo food in Lokop Village, East Aceh, Indonesia (<https://smujo.id/biodiv/article/view/10135>)

RAMAIDANI, ZIDNI ILMAN NAVIA

PDF (<https://smujo.id/biodiv/article/view/10135/5685>)

Phylogeography of *Aplocheilus panchax* in Indonesia, with special focus on the Bangka Island population (<https://smujo.id/biodiv/article/view/10618>)

DIAH MUSTIKASARI, AGUS NURYANTO, SUHESTRI SURYANINGSIH

PDF (<https://smujo.id/biodiv/article/view/10618/5692>)

The rambutan (*Nephelium lappaceum* L.) chromosomes (<https://smujo.id/biodiv/article/view/10444>)

IMANOVTA ICHTI SANTOSO PUTRI, ENDANG YUNIASTUTI, PARJANTO

PDF (<https://smujo.id/biodiv/article/view/10444/5689>)

The use of statistical models in identifying skipjack tuna habitat characteristics during the Southeast Monsoon in the Bone Gulf, Indonesia (<https://smujo.id/biodiv/article/view/10023>)

SAFRUDDIN HASYIM, RACHMAT HIDAYAT, ST. AISJAH FARHUM, MUKTI ZAINUDDIN

PDF (<https://smujo.id/biodiv/article/view/10023/5693>)

The potency of selected ethnomedicinal plants from East Kalimantan, Indonesia as antidiabetic agents and free-radical scavengers (<https://smujo.id/biodiv/article/view/10615>)

RICO RAMADHAN, PREECHA PHUWAPRAIRISAN, RUDIANTO AMIRTA, MUHAMMAD FADIL BAGAS DARMAWAN, KAUTSAR UL-HAQ, IRAWAN WIJAYA KUSUMA, HERY SUWITO, NURLITA ABDULGANI, AHMAD MUKHDOR, SAPARWADI

Some population characteristics and viability of captive Asian elephant (*Elephas maximus*) in Thailand

(<https://smujo.id/biodiv/article/view/10340>)

MANANYA PLA-ARD, RONGLARP SUKMASUANG, SUWIMOL UTHAIRASMEE

PDF (<https://smujo.id/biodiv/article/view/10340/5551>)

Effects of production system on the gut microbiota diversity and IgA distribution of Kampong chickens, Indonesia

(<https://smujo.id/biodiv/article/view/9399>)

R. SUSANTI, WULAN CHRISTIJANTI

PDF (<https://smujo.id/biodiv/article/view/9399/5546>)

Diversity and composition of butterflies in three habitats around Rayow Waterfall, Minahasa District, North Sulawesi, Indonesia

(<https://smujo.id/biodiv/article/view/9806>)

RONI KONERI, MEIS J. NANGOY, PIENCE VERALYN MAABUAT, SAROYO, WAKHID

PDF (<https://smujo.id/biodiv/article/view/9806/5554>)

Short Communication: Impact of introduction of managed honey bee colony on wild bee diversity and abundance in an agroecosystem in Indonesia

(<https://smujo.id/biodiv/article/view/10255>)

IMAM WIDHIONO, EMING SUDIANA, SUHESTRI SURYANINGSIH

PDF (<https://smujo.id/biodiv/article/view/10255/5547>)

Ecosystem services research trends in Indonesia: a bibliometric analysis

(<https://smujo.id/biodiv/article/view/8604>)

NAJMI FIRDAUS, SUPRIATNA, JATNA SUPRIATNA

PDF (<https://smujo.id/biodiv/article/view/8604/5549>)

Bioprospecting of bacterial symbionts of sponge *Spongia officinalis* from Savu Sea, Indonesia for antibacterial potential against multidrug-resistant bacteria

(<https://smujo.id/biodiv/article/view/10350>)

MUHAMMAD EVY PRASTIYANTO, APRILIA INDRA KARTIKA, SRI DARMAWATI, OCKY KARNA RADJASA

PDF (<https://smujo.id/biodiv/article/view/10350/5545>)

Antibacterial activity of bacteria isolated from earthworm (*Pheretima* sp.) gut against *Salmonella typhi* and *Staphylococcus aureus*: in vitro

Taxonomy and ethnobotany of *Acmella* (Asteraceae) in Thailand (<https://smujo.id/biodiv/article/view/10779>)

PRATEEP PANYADEE, ANGKHANA INTA

PDF (<https://smujo.id/biodiv/article/view/10779/5680>)

Kaempferia sipraiana (Zingiberaceae), a new species from Thailand and a new record of *Kaempferia pseudoparviflora* for Myanmar (<https://smujo.id/biodiv/article/view/10728>)

THAWATPHONG BOONMA, SURAPON SAENSOUK, PIYAPORN SAENSOUK

PDF (<https://smujo.id/biodiv/article/view/10728/5679>)

Information

For Readers (<https://smujo.id/biodiv/information/readers>)

For Authors (<https://smujo.id/biodiv/information/authors>)

For Librarians (<https://smujo.id/biodiv/information/librarians>)

Journals List

Biodiversitas Journal of Biological Diversity (<https://smujo.id/biodiv>)

Nusantara Bioscience (<https://smujo.id/nb>)

Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia (<https://smujo.id/psnmbi>)

Asian Journal of Agriculture (<https://smujo.id/aja>)

Asian Journal of Ethnobiology (<https://smujo.id/aje>)

Asian Journal of Forestry (<https://smujo.id/ajf>)

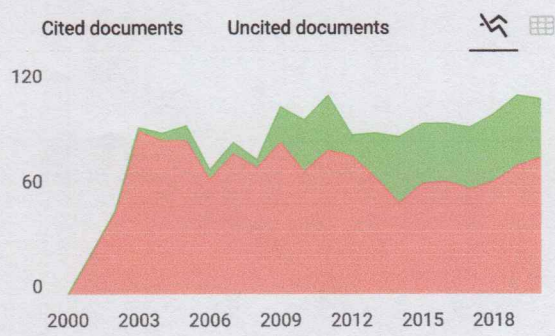
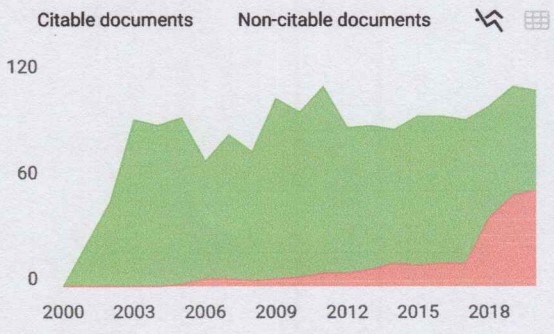
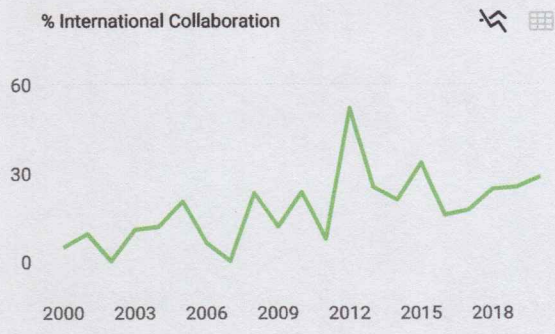
Asian Journal of Natural Product Biochemistry (<https://smujo.id/jnpb>)

Asian Journal of Tropical Biotechnology (<https://smujo.id/bbs>)

International Journal of Bonorowo Wetlands (<https://smujo.id/bw>)

Cell Biology and Development (<https://smujo.id/cbd>)

Biodiversity



Biodiversity

Q2 Ecology

best quartile

SJR 2020 0.44

powered by scimagojr.com

← Show this widget in your own website

Just copy the code below and paste within your html code:

```
<a href="https://www.scimagojr.com" style="display: inline-block; border: 1px solid #ccc; padding: 2px 5px;">

```

SCImago Graphica

Explore, visually communicate and make sense of data with our new free tool.



Get it

Metrics based on Scopus® data as of April 2021

ghada el- Sayed el-Badan 12 months ago

I want to ask about fees in publishing a paper?

reply

Melanie Ortiz 12 months ago

Dear Ghada,
 thank you for contacting us.
 Unfortunately, we cannot help you with your request, we suggest you visit the journal's homepage or contact the journal's editorial staff , so they could inform you more deeply.
 Best Regards, SCImago Team

SCImago Team

Ankit Shrestha 2 years ago

Short Communication:

Impact of introduction of managed honey bee colony on wild bee diversity and abundance in an agroecosystem in Indonesia

IMAM WIDHIONO*, EMING SUDIANA, SUHESTRI SURYANINGSIH

Faculty of Biology, Universitas Jenderal Soedirman, Jl. Dr. Soeparno 63, Purwokerto Utara, Banyumas 53122, Central Java, Indonesia.

Tel.: +62-281-638794, Fax.: +62-281-631700, *email: imam.widhiono@unsoed.ac.id

Manuscript received: 4 January 2022. Revision accepted: 28 January 2022.

Abstract. Widhiono I, Sudiana E, Suryaningsih S. 2022. Short Communication: Impact of introduction of managed honey bee colony on wild bee diversity and abundance in an agroecosystem in Indonesia. *Biodiversitas* 23: 1099-1104. Wild bees are natural pollinators of crops in agroecosystems, but managed honeybee colonies may diminish their diversity and abundance. We aimed to determine the impact of introducing managed honeybee (*Apis cerana* and *A. mellifera*) colonies on the diversity and abundance of wild bees in an agroecosystem in Indonesia. We introduced managed honeybee colonies into the plots containing four crops (tomato, green bean, chili, and green mustard). Sampling was conducted from March to July 2020 on the eastern slopes of Mount Slamet, Indonesia, at an elevation of 1241 m asl. Wild bee diversity was not affected by the introduction of managed honeybee colonies, but their abundance decreased at the end of the flowering period due to resource limitations. The most abundant wild bee species were *Amegilla cyrtandrae* and *A. burneensis*, and some wild bee species tended to be more abundant on certain crop species. We recommend that managed colonies be introduced during the early and mid-stages of crop flowering to reduce potential adverse effects on wild bee populations.

Keywords: *Amegilla burneensis*, *Amegilla cyrtandrae*, crops, Mount Slamet, phenology

INTRODUCTION

Hymenoptera is one of the four largest orders of insects (Budiaman et al. 2017). Wild bees (Hymenoptera: Apiformes). are important components of the agroecosystems because they are primary crop pollinators. The diversity and abundance of wild bee species are highly dependent on environmental conditions (Schindler et al. 2013; Cavigliasso et al. 2020; Odanaka and Rehan 2020). Wild bee species richness varies among locations and crop species. Widhiono et al. (2016) documented 9-11 species belonging to the families Apidae, Halictidae, and Megachilidae on Mount Slamet and in the surrounding area in Indonesia. Koneri et al. (2021) documented ten species belonging to Apidae, four belonging to Halictidae, and one belonging to Megachilidae in Bogani Nani Wartabone National Park, North Sulawesi, Indonesia. This suggests that wild bees remain relatively diverse in agricultural lands in Indonesia. However, given that wild bee species are highly sensitive to environmental change, their diversity and abundance should be monitored over time (Schindler et al. 2013).

Honeybees and wild bees play important roles as crop pollinators (Evans et al. 2018). However, there is alarming evidence of population decline and diversity loss in wild bees. As a result, managed honeybee colonies are often introduced to ensure sufficient pollination of crops. Colonies of *Apis mellifera* or *Apis cerana* are widely used in agricultural settings. Both species can thrive in highly dense colonies (Evans et al. 2018), are generalist

pollinators (Clos et al. 2020), and are easy to manage (McCune et al. 2020). Honeybee colonies have positive impacts on crop yield but are believed to negatively affect the diversity and abundance of wild bees (Lázaro et al. 2021). Notably, even where managed colonies are introduced, wild bees continue to pollinate crops (Widhiono et al. 2016). Ultimately, wild bee abundance is driven by the availability of pollen and nectar (Roulston and Goodell 2011; McCune et al. 2020), and pollen availability is a critical factor regulating wild bee populations (Roulston and Goodell 2011). In these settings, wild bees must compete with honey bees for limited nectar and protein-rich pollen resources (Russo 2016; Alaux et al. 2019). Mallinger et al. (2017) found that competition between wild bees and honeybees increased with increasing honeybee abundance.

Although many studies have assessed the impact of managed honeybee colonies on wild bees in agricultural settings (Barcala et al. 2019; Kline and Joshi 2020; Angelella et al. 2021; Garibaldi et al. 2021) the results have been somewhat inconsistent. The majority of studies have reported negative effects of colony introduction (Mallinger et al. 2017). For example, Angelella et al. (2021) found that honeybee presence reduced the presence of wild bees on coffee flowers in coffee plantations.

Managed honeybee colonies are not widely used for pollination in Indonesia. However, given the ongoing declines in wild bee species diversity and populations, this practice may soon be necessary, and thus suitable conditions for its application should be assessed. Before

introducing managed colonies in crops, we must understand the potential negative impact on wild bees. Here, we aimed to determine these impacts in an upland agroecosystem.

MATERIALS AND METHODS

Study area

This study was conducted in Serang Village, Purbalingga Regency, Central Java, Indonesia (7°14'41" S, 109°16'49" E), at an elevation of 1240-1300 m (Figure 1). The study area was 2100 m² in size.

Sampling design and methodology

We used colonies of two honeybee species, *A. mellifera* and *A. cerana*, in our study. The colony used came from a seller in Subang, West Java, Indonesia. All colonies used are young colonies were marked with 4 combs in the nest with white combs filled with larvae and pupae. One colony was maintained in 400 m² plots that included a maximum of 360 plant stems, 90 each of *Solanum lycopersicum* (tomatoes), *Phaseolus vulgaris* (green beans), *Capsicum frutescens* (chili), and *Brassica juncea* (green mustard) and located at the center of the plots. These crop species are used in research with the consideration that they are very commonly planted by farmers in the area and produce fruit as a result of pollination. Twelve plots were placed across the study site, spaced 300-400 m apart. The determination of the distance between the plots was based on the results of previous studies conducted at this location (Widhiono et al. 2019 unpublished data). The results of our previous study showed that honeybees *A. cerana* and *A. mellifera* on land conditions rich in food sources (flowers) tended to visit flowers or take food resources closer to the nest than

those farther from the nest. Each plot included a single, centrally placed colony. Four plots contained colonies of *A. cerana*, four contained colonies of *A. mellifera*, and four had no managed bee colony (control).

Four surveyors observed 120 plant stems (n : 30 per crop species) for 30-minute periods. Observations were made between 9 AM and 12 PM. Surveyors were non-experts and were given a photo guide for wild bee identification, all wild bees found in this area were identified and confirmed to LIPI (Indonesian Science Institute) in 2017. All insects visiting the plant stems were either photographed or captured with an insect net. This sampling was repeated over three periods corresponding to phenological phases, the onset of the crop flowering period, the middle, and the end.

Statistical analyses

We assessed wild bee diversity using three indices: Shannon-Wiener (H'), Evenness (E) and Simpson's Dominance Index Indices were calculated using the software PAST 3 as:

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

Where: H' is the Shannon-Wiener diversity index and p_i is the number of individuals of species I , and:

$$E = \frac{H'}{\ln S}$$

Where, E is the Evenness index, H' is the Shannon-Wiener diversity index and S is the total number of wild bee species.



Figure 1. Study area map showing the location of the research site in Central Java, Indonesia

In addition, Simpson's dominance index was used to assess dominance, determined by:

$$D = \sum (pi)^2 = \sum \left(\frac{ni}{N}\right)^2$$

Where, D is Simpson's dominance index, ni is the number of individuals of each species, and N is the total number of individuals. Finally, we used analysis of variance to determine differences in wild bee abundance among treatments, crop species, and flowering period. Pearson Correlation analysis was used to determine relationships between wild bee species richness and abundance with the number of flowers in each plot. These analyses were conducted using SPSS version 21 (IBM Corp., Armonk, NY, USA).

RESULTS AND DISCUSSION

Wild bee species richness

We recorded 1630 individuals of 11 wild bee species belonging to three families. Specifically, we photographed or captured carpenter bees (Apidae: Xylocopa), blue-banded bees, leaf-cutting bees (Megachilidae), and sweat and alkaline bees (Halictidae).

Wild bee species richness in plots with honeybee colonies did not differ significantly from control ($F 7.21 p > 0.05$). In the *A. cerana* treatment, wild bee species richness was highest on tomatoes, followed by chili, green mustard, and green beans (Table 1). In the *A. mellifera* treatment, species richness was highest on tomatoes, followed by green beans, chili, and green mustard (Table 1). Similar species diversity was recorded in the control

plots (Table 1). This lack of difference may be due to low competition for pollen and nectar between honeybees and wild bees or a shift in niche breadth between these two groups (Lázaro et al. 2021). Based on Pearson's correlation analysis showed that there is no correlation between wild bee species richness with the number of flowers ($r: 0.014 p 0.670 > 0.05$). Most wild bees are polylectic and thus can easily shift their foraging in the presence of honeybees (Valido et al. 2019).

However, competition can still occur even where there has been a shift in foraging behavior if food resources are limited, as wild bees may be driven to low-quality food sources that are insufficient for their growth (McCune et al. 2020). Renner et al. (2021) suggested that the presence of managed honeybees does not affect wild bee species diversity. However, Lindström et al. (2016) found that the introduction of *A. mellifera* colonies led to declines in wild bee populations and diversity in green mustard (*Brassica rapa*) fields. Ropars et al. (2019) found that honeybees affected wild bee populations in urban habitats. Research from the United States found an overall decrease in fruit production when *A. mellifera* colonies were introduced to agricultural fields, suggesting suppression of wild bee populations and thus their pollination services (Angelella et al. 2021). These varied results likely reflect the overall availability of floral food resources among study areas, where negative effects on wild bee populations are more likely to occur when resources are limited (Garibaldi et al. 2021). In our study, flower number and mean flower cover were positively correlated with bee species richness and abundance in all treatments and all three flowering periods. This is logical, given that sites with greater flower cover than the surrounding area typically attract greater numbers of bee species and individuals (Kratschmer et al. 2019, 2021).

Table 1. Species richness and abundance of wild bee species across three treatments and four crop types

Wild bee species	<i>Apis cerana</i>				<i>Apis mellifera</i>				Control				%	
	TM	GB	CH	GM	TM	GB	CH	GM	TM	GB	CH	GM		
<i>Xylocopa confusa</i>	4	22	0	0	5	31	0	0	6	30	2	0	100	16.3
<i>Xylocopa latipes</i>	4	22	0	0	4	20	0	0	6	25	2	0	83	5
<i>Xylocopa caerulea</i>	4	21	0	0	5	21	1	0	3	26	2	0	83	5
<i>Amegilla cyrtandrae</i>	31	22	13	14	34	26	10	14	46	31	38	41	320	19
<i>Amegilla burneensis</i>	30	23	15	17	30	21	18	17	44	24	35	34	308	18.8
<i>Megachile conjuncta</i>	4	5	14	16	4	0	13	16	15	2	7	48	144	8.8
<i>Megachile fulvifrons</i>	6	0	13	16	6	0	10	16	14	6	11	34	132	8.9
<i>Ceratina cognata</i>	8	0	11	20	8	0	13	20	8	0	15	28	131	8.03
<i>Lasioglossum malachurum</i>	7	0	14	24	7	0	12	24	4	2	9	36	139	8.5
<i>Lasioglossum leucozonium</i>	8	0	10	18	8	0	16	18	8	6	8	65	165	10.04
<i>Nomia quadridentata</i>	2	0	3	4	2	0	4	4	2	0	2	2	25	0.53
Species richness	11	6	8	8	11	5	9	8	11	9	11	8	1630	100
No. individuals	108	115	93	129	113	119	97	129	156	152	131	288		
Dominance_D	0.18	0.185	0.14	0.139	0.184	0.2061	0.1359	0.139	0.1932	0.1653	0.1879	0.152		
Simpson_1-D	0.82	0.815	0.86	0.861	0.816	0.7939	0.8641	0.861	0.8068	0.8347	0.8121	0.848		
Shannon_H	2	1.718	2.02	2.01	2	1.595	2.054	2.01	1.94	1.904	1.934	1.938		
Evenness_e^H/S	0.67	0.929	0.94	0.933	0.672	0.9854	0.8667	0.9331	0.6324	0.7459	0.6291	0.8678		

Note: TM: tomato; GB: green bean; CH: chili; and GM: green mustard. (n: 30/ plots)

Wild bee species richness among crop plants

The relative abundance of wild bees varied among the four crop species and three treatments (Table 2). *Xylocopa caerulea* and *Amegilla cyrtandrae* were dominant on tomatoes. *Xylocopa confusa*, *Xylocopa latipes*, *X. caerulea*, *Amegilla burneensis*, *Ceratina cognata*, and *Nomia quadridentata* were never observed on green bean plants. *Amegilla cyrtandrae* and *A. burneensis* were the dominant species on chili plants. Finally, the most abundant species on green mustard plants was *Lasioglossum leucozonium*, and species of *Xylocopa* were never found on this crop. *C. cognata* was also abundant on green mustard (Table 2).

There was evidence of a pattern between wild bee visitation and crop type. Specifically, species of *Xylocopa* tended to only visit tomatoes and green beans. Carpenter bees are known to visit green bean plants (Widhiono et al. 2016; Mainkete et al. 2019). It is probable that these bees extract pollen from tomato plants by buzzing (Kesar 2010). Buzzing pollination is a pollination process where the release of pollen from the anther requires vibration and sonification mechanisms. The genera of bees that are capable of buzzing include: *Halictus*, *Megachile*, *Bombus* and *Xylocopa* (Tayal and Kariyat 2021).

Wild bee abundance

The introduction of managed honeybee colonies negatively affected the total abundance of wild bees ($F_{7,21}$ $p < 0.05$). Based on Pearson's correlation analysis showed that wild bee abundance correlate with numbers of flowers ($r: 0.57$ $p: 0.047 < 0.05$). In total, 445 wild bee individuals were found in the *A. cerana* plots, 458 in the *A. mellifera* plots, and 727 in the control plots. In terms of relative abundance, *A. cyrtandrae* and *A. burneensis*, two blue-banded bee species, dominated (19% and 18.8%, respectively), whereas *N. quadridentata* was the least abundant species (0.5%). The high relative abundance of the two blue-banded bee species likely reflects their abundance in the study area. Both species are broad

generalists that are widely distributed throughout the tropics (Engel 2007), and both were observed visiting all four crop species. These findings reflect those of (Kumar et al. 2017), who found that blue-banded bees visited *Solanum melongena* (eggplant), *Capsicum frutescens* (Chili), and *Solanum lycopersicum* (tomatoes). Notably, many solanaceous crops are dependent on insect pollinators for sufficient yield (Kumar et al. 2017).

The second most abundant genus in our study was *Xylocopa*, represented by three species, *X. confusa*, *X. latipes*, and *X. caerulea*. Of these, *X. confusa* was the most abundant (relative abundance of 16.7%) and the two remaining species were found at a relative abundance of approximately 5%. All three species were most abundant on green beans. Members of the genus *Xylocopa* are large carpenter bees that typically have broad geographic ranges (Sadeh et al. 2007). They forage on a wide range of food plants, have a long period of seasonal activity, tolerate high temperatures, and show activity under low light levels (Fohouo et al. 2014; Azo'o et al. 2020). These traits make them attractive candidates for agricultural pollination in hot climates, particularly in greenhouses, and of night-blooming crops (Kesar 2010). Carpenter bees are efficient pollinators of tomato (Indraswari et al. 2016), *Vigna unguiculata* (long bean) (Mainkete et al. 2019), *Cajanus cajan* (pigeon pea) (Mireille et al. 2012), and *Cucumis sativus* (cucumber) (Hashifah et al. 2020).

The third most abundant genus was *Lasioglossum*, represented by *L. leucozonium* and *L. malachurum*, with relative abundances of 10.04% and 8.5%, respectively. Both species are common in the study area, likely due to the availability of Asteraceae and Euphorbiaceae plants and the suitability of the soil for nesting (Polidori et al. 2010). Both species were found primarily on chili, green mustard, and tomato plants, similar to other research results (Rodrigo-Gómez et al. 2016). Members of the Halictidae (sweat bees), to which *Lasioglossum* belongs, are efficient pollinators of crops worldwide (Murao et al. 2017).

Table 2. The abundance of 11 wild bee species on four crop species

Wild bee species	TM		GB		CH		GM	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<i>Xylocopa confusa</i>	4.66	1.15	27.66	4.93	0.66	1.15	0	0
<i>Xylocopa latipes</i>	4	1	22.33	2.51	0.66	1.15	0	0
<i>Xylocopa caerulea</i>	37	7.93	22.66	2.88	1	1	0	0
<i>Amegilla cyrtandrae</i>	34.66	8.08	26.33	4.50	20.33	15.37	23	15.58
<i>Amegilla burneensis</i>	7.66	6.35	22.666	1.52	22.66	10.78	22.66	9.81
<i>Megachile conjuncta</i>	8.66	4.61	2.33	2.51	11.33	3.78	26.66	18.47
<i>Megachile fulvifrons</i>	8	0	2	3.46	11.33	1.52	22	10.39
<i>Ceratina cognata</i>	6	1.73	0	0	13	2	22.66	4.61
<i>Lasioglossum malachurum</i>	8	0	0.66	1.15	11.66	2.51	28	6.92
<i>Lasioglossum leucozonium</i>	2	0	2	3.46	11.33	4.16	33.66	27.13
<i>Nomia quadridentata</i>	2	0	0	0	3	1	3.33	1.15

Note: TM: tomato; GB: green bean; CH: chili; GM: green mustard; SD: standard deviation

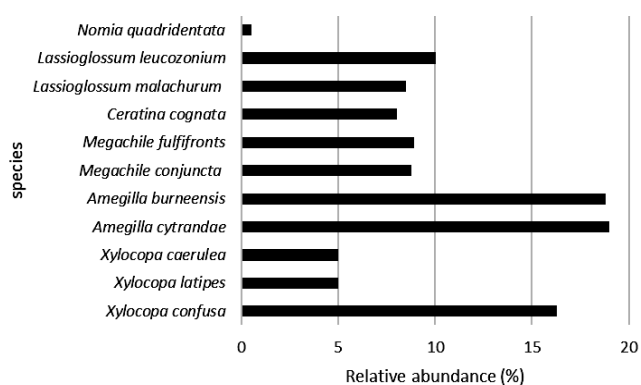


Figure 2. Relative abundance of 11 wild bee species on crop species in Mount Slamet, Central Java, Indonesia

Finally, members of the family Megachilidae (leaf-cutter bees) were abundant in our study area, represented by *Megachile relativa* (8.9%) and *M. centuncularis* (8.8%). Both species were abundant in chili and green mustard plants. This is due to the color and nectar and pollen resources of these crops (Soroka et al. 2000; Kambli et al. 2017). Leaf-cutter bees are pollinators of the Malvaceae (Ali et al. 2019). The high abundance of *Megachile* bees in our study area may also be due to the availability of suitable food resources and nesting sites (Pitts-Singer and Bosch 2010).

Flower abundance and wild bee abundance

There was variation in wild bee abundance across the three flowering periods (F 7.21 p < 0.05), with peak abundance during the middle of the flowering period and the lowest abundance during the end of the flowering period (Figure 3). Ultimately, our results indicated that wild bee abundance declined in the presence of managed honeybees and with decreased flower resources. This decline was likely due to insufficient food resources, potentially due to competition between honeybees and wild bees (Clos et al. 2020; Urbanowicz et al. 2020; Kratschmer et al. 2021).

In conclusion, the introduction of managed honeybee colonies affects the abundance, but not diversity, of wild bees in agricultural settings, especially during the end of the flowering period. Thus, we suggest that where crop pollination is augmented with managed colonies, that these colonies are introduced during the onset and middle of the flowering period to reduce pressure on wild bee populations during a period of resource limitation and the end of the flowering period.

ACKNOWLEDGEMENTS

We express our sincere gratitude to the Rector of the University of Jenderal, Soedirman Purwokerto, for funding this research through the *Riset Unggulan Terapan* Scheme (contract no. T/230/UN23.18/PT.01.03/2020). The authors declare that there is no conflict of interest.

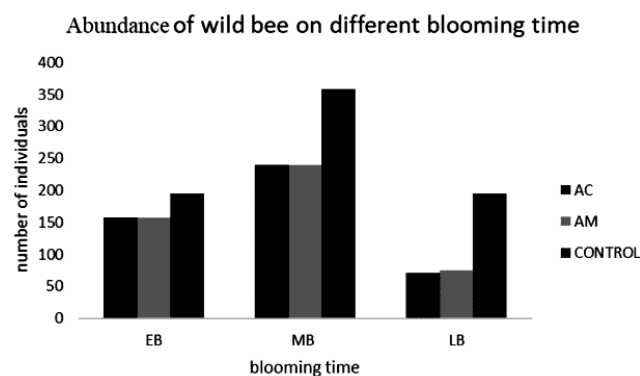


Figure 3. Wild bee abundance during three flowering periods, early blooming (EB), middle blooming (MB), and late blooming (LB), among three treatments. AC: *Apis cerana*, AM: *Apis mellifera*

REFERENCES

- Alaux C, le Conte Y, Decourtye A. 2019. Pitting wild bees against managed honey bees in their native range, a losing strategy for the conservation of honey bee biodiversity. *Front Ecol Evol* 7: 60. DOI: 10.3389/fevo.2019.00060.
- Ali S, Muhammad A, Shareef N, Farooqi MA. 2019. Pollination of *Grewia asiatica* (Malvaceae) by *Megachile cephalotes* (Hymenoptera: Megachilidae): Male vs. female pollination. *Sociobiology* 66 (3), 467-474. DOI: 10.13102/sociobiology.v66i3.434.
- Angelella GM, McCullough C, O'Rourke ME. 2021. Honey bee hives decrease wild bee abundance, species richness, and fruit count on farms regardless of wildflower strips. *Sci Rep* 11 (1): 3202. DOI: 10.1038/s41598-021-81967-1.
- Azo'o EM, Bissou WB, Tchuenguem FFN. 2020. Comparing the foraging behaviour and pollination efficiency of *Apis mellifera* with *Xylocopa olivacea* (Apidae: Hymenoptera) on flowers. *J Appl Hortic* 22 (1): 18-23. DOI: 10.37855/jah.2020.v22i01.04.
- Barcala MCE, Palottini F, Farina WM. 2019. Honey bee and native solitary bee foraging behavior in a crop with dimorphic parental lines. *Plos One* 14 (10): e0223865. DOI: 10.1371/journal.pone.0223865.
- Budiaman A, Haneda NF, Robaikah ID. 2017. Short Communication: Effects of felling intensity on Hymenoptera biodiversity in a natural production forest in East Kalimantan, Indonesia. *Biodiversitas* 18 (3): 990-995. DOI: 10.13057/biodiv/d180317.
- Cavigliasso P, Bello F, Rivadeneira MF, Monzon NO, Gennari GP, Basualdo M. 2020. Pollination efficiency of managed bee species (*Apis mellifera* and *Bombus pauloensis*) in Highbush Blueberry (*Vaccinium corymbosum*) Productivity. *Hortic Res* 28 (1): 57-64. DOI: 10.2478/johr-2020-0003.
- Clos B, du Drummond FA, Loftin CS. 2020. Noncrop habitat use by wild bees (Hymenoptera: Apoidea) in a mixed-use agricultural landscape. *Environ Entomol* 49 (2): 502-515. DOI: 10.1093/EE/NVAA001.
- Engel MS. 2007. A new *Amegilla* of the zonata group from Malaysia and Thailand (Hymenoptera: Apidae). *Trans Kansas Acad Sci* 110 (1): 16-22. DOI: 10.1660/0022-8443(2007)110[16:ANAOTZ]2.0.CO;2.
- Evans E, Smart M, Cariveau D, Spivak M. 2018. Wild, native bees and managed honey bees benefit from similar agricultural land uses. *Agric Ecosyst Environ* 268: 162-170. DOI: 10.1016/j.agee.2018.09.014.
- Fohouo FNT, Pando JB, Tamesse JL. 2014. Pollination efficiency of *Xylocopa olivacea* Hymenoptera: Apidae) on *Cajanus cajan* Fabaceae) flowers at Yaoundé, Cameroon. *Intl J Trop Insect Sci* 34 (2): 138-148. DOI: 10.1017/S1742758414000307.
- Garibaldi LA, Pérez-Méndez N, Cordeiro GD, Hughes A, Orr M, Alves-dos-Santos I, Freitas BM, de Oliveira F, LeBuhn G, Bartomeus I, Aizen MA, Andrade PB, Blochtein B, Boscolo D, Drummond PM, Gaglianone MC, Gemmill-Herren B, Halinski R, Krug C, Viana BF. 2021. Negative impacts of dominance on bee communities: Does the influence of invasive honey bees differ from native bees? *Ecology* 102 (12): e03526. DOI: 10.1002/ecy.3526.
- Hashifah FN, Indraswari SAGM, Hidayat SRC. 2020. Visiting frequency of bees in *Cucumis sativus* (Cucurbitaceae) Plants. *AIP Conf Proc* 2260. DOI: 10.1063/5.0016375.

- Indraswari AGM, Atmowidi T, Kahono S. 2016. Keanekaragaman, aktivitas kunjungan, dan keefektifan lebah penyerbuk pada tanaman tomat (*Solanum lycopersicum* L: Solanaceae). Jurnal Entomologi Indonesia 13 (1): 21-29. DOI: 10.5994/jei.13.1.21.
- Kambli SS, Aiswarya MS, Manoj K, Varma S, Asha G, Rajesh TP, Sinu PA. 2017. Leaf foraging sources of leafcutter bees in a tropical environment: Implications for conservation. *Apidologie* 48 (4): 473-482. DOI: 10.1007/s13592-016-0490-2.
- Keasar T. 2010. Large carpenter bees as agricultural pollinators. *Psyche* 2010: 927463. DOI: 10.1155/2010/927463.
- Kline O, Joshi NK. 2020. Mitigating the effects of habitat loss on solitary bees in agricultural ecosystems. *Agriculture* 10 (4): 115. DOI: 10.3390/agriculture10040115.
- Koneri R, Nangoy MJ, Wakhid. 2021. Richness and diversity of insect pollinators in various habitats around bogani nani wartabone national park, North Sulawesi, Indonesia. *Biodiversitas* 22 (1): 288-297. DOI: 10.13057/biodiv/d220135.
- Kratschmer S, Pachinger B, Gaigher R, Pryke JS, van Schalkwyk J, Samways MJ, Melin A, Kehinde T, Zaller JG, Winter S. 2021. Enhancing flowering plant functional richness improves wild bee diversity in vineyard inter-rows in different floral kingdoms. *Ecol Evol* 11 (12): 7927-7945. DOI: 10.1002/ece3.7623.
- Kratschmer S, Pachinger B, Schwantzer M, Paredes D, Guzmán G, Gómez JA, Entrenas JA, Guernion M, Burel F, Nicolai A, Fertil A, Popescu D, Macavei L, Hoble A, Bunea C, Kriechbaum M, Zaller JG, Winter S. 2019. Response of wild bee diversity, abundance, and functional traits to vineyard inter-row management intensity and landscape diversity across Europe. *Ecol Evol* 9 (7): 4103-4115. DOI: 10.1002/ece3.5039.
- Kumar H, Kaushik RA, Ameta KD, Lal Regar A, Singh K, Kumari P. 2017. Effect of humic acid and nutrients mixture on quality parameter of Tomato (*Lycopersicon esculentum* Mill.) under polyhouse condition. *J Appl Nat Sci* 9 (3): 1369-1372. DOI: 10.31018/jans.v9i3.1369.
- Lázaro A, Müller A, Ebmer AW, Dathe HH, Scheuchl E, Schwarz M, Risch S, Pauly A, Devalez J, Tschoulin T, Gómez-Martínez C, Papas E, Pickering J, Waser NM, Petanidou T. 2021. Impacts of beekeeping on wild bee diversity and pollination networks in the Aegean Archipelago. *Ecography* 44 (9): 1353-1365. DOI: 10.1111/ecog.05553.
- Lindström SAM, Herbertsson L, Rundlöf M, Bommarco R, Smith HG. 2016. Experimental evidence that honeybees depress wild insect densities in a flowering crop. *Proc Royal Soc B* 283 (1843): 20161641. DOI: 10.1098/rspb.2016.1641.
- Mainkete S, Madjimbe G, Mireille B, Tekombo K, Nadine E, Atibita O, Tchuenguem N, Fohouo F-NT. 2019. Foraging and pollination behavior of *Xylocopa olivacea* (Hymenoptera: Apidae) on *Phaseolus vulgaris* (Fabaceae) flowers at Doyaba (Sarh, Tchad). *J Entomol Zool Stud* 7 (1): 645-651. DOI: 10.22271/j.ento.
- Mallinger RE, Gaines-Day HR, Gratton C. 2017. Do managed bees have negative effects on wild bees?: A systematic review of the literature. *Plos One* 12 (12): e0189268. DOI: 10.1371/journal.pone.0189268.
- McCune F, Normandin É, Mazerolle MJ, Fournier V. 2020. Response of wild bee communities to beekeeping, urbanization, and flower availability. *Urban Ecosyst* 23 (1): 39-54. DOI: 10.1007/s11252-019-00909-y.
- Mireille B, Kingha T, Fohouo FNT, Ngakou A, Brückner D. 2012. Foraging and pollination activities of *Xylocopa olivacea* (Hymenoptera, Apidae) on *Phaseolus vulgaris* (Fabaceae) flowers at Dang (Ngaoundere-Cameroon). *J Agric Ext Rural Dev* 4 (6): 330-339. DOI: 10.5897/JAERD11.151.
- Murao R, Tadauchi O, Miyanaga R. 2017. The bee family Halictidae (Hymenoptera, Apoidea) from Central Asia collected by the Kyushu and Shimane Universities Expeditions. *Biodivers Data J* 5 (1): e15050. DOI: 10.3897/BDJ.5.e15050.
- Odanaka KA, Rehan SM. 2020. Wild bee distribution near forested landscapes is dependent on successional state. *For Ecosyst* 7 (1): 26. DOI: 10.1186/s40663-020-00241-4.
- Pitts-Singer TL, Bosch J. 2010. Nest establishment, pollination efficiency, and reproductive success of *Megachile rotundata* Hymenoptera: Megachilidae) in relation to resource availability in field enclosures. *Environ Entomol* 39 (1): 149-158. DOI: 10.1603/EN09077.
- Polidori C, Rubichi A, Barbieri V, Trombino L, Donegana M. 2010. Floral resources and nesting requirements of the ground-nesting social bee, *Lasioglossum malachurum* (hymenoptera: Halictidae), in a Mediterranean semiagricultural landscape. *Psyche* 2010: 851947. DOI: 10.1155/2010/851947.
- Renner SS, Graf MS, Hentschel Z, Krause H, Fleischmann A. 2021. High honeybee abundances reduce wild bee abundances on flowers in the city of Munich. *Oecologia* 195 (3): 825-831. DOI: 10.1007/s00442-021-04862-6.
- Rodrigo-Gómez S, Ornos C, Selfa J, Guara M, Polidori C. 2016. Small sweat bees (Hymenoptera: Halictidae) as potential major pollinators of melon (*Cucumis melo*) in the Mediterranean. *Entomol Sci* 19 (1): 55-66. DOI: 10.1111/ens.12168.
- Ropars L, Dajoz I, Fontaine C, Muratet A, Geslin B. 2019. Wild pollinator activity negatively related to honey bee colony densities in urban context. *Plos One* 14 (9): e0222316. DOI: 10.1371/journal.pone.0222316.
- Roulston TH, Goodell K. 2011. The role of resources and risks in regulating wild bee populations. *Ann Rev Entomol* 56: 293-312. DOI: 10.1146/annurev-ento-120709-144802.
- Russo L. 2016. Positive and negative impacts of non-native bee species around the world. *Insects* 7: 69. DOI: 10.3390/insects7040069.
- Sadeh A, Shmida A, Keasar T. 2007. The carpenter bee *Xylocopa pubescens* as an agricultural pollinator in greenhouses. *Apidologie* 38 (6): 508-517. DOI: 10.1051/apido:2007036.
- Schindler M, Diestelhorst O, Härtel S, Saure C, Schanowski A, Schwenninger HR. 2013. Monitoring agricultural ecosystems by using wild bees as environmental indicators. *BioRisk* 8: 53-71. DOI: 10.3897/biorisk.8.3600.
- Soroka JJ, Goerzen DW, Falk KC, Bett KE, Et Bett KE. 2000. Alfalfa leafcutting bee (Hymenoptera: Megachilidae) pollination of oilseed rape (*Brassica napus* L.) under isolation tents for hybrid seed production. *Can J Plant Sci* 81: 199-204. DOI: 10.4141/P00-081.
- Tayal M, Kariyat R. 2021. Examining the role of buzzing time and acoustics on pollen extraction of *Solanum elaeagnifolium*. *Plants* 10: 2592. DOI: 10.3390/plants10122592.
- Urbanowicz C, Muñiz PA, McArt SH. 2020. Honey bees and wild pollinators differ in their preference for and use of introduced floral resources. *Ecol Evol* 10 (13): 6741-6751. DOI: 10.1002/ece3.6417.
- Valido A, Rodríguez-Rodríguez MC, Jordano P. 2019. Honeybees disrupt the structure and functionality of plant-pollinator networks. *Sci Rep* 9 (1): 4711. DOI: 10.1038/s41598-019-41271-5.
- Widhiono I, Sudiana E, Sucianto ET. 2016. Insect pollinator diversity along a habitat quality gradient on Mount Slamet, Central Java, Indonesia. *Biodiversitas* 17 (2): 746-752. DOI: 10.13057/biodiv/d170250.
- Widhiono I, Darsono, Sudiana E. 2019. Pengaruh jarak sumber pakan terhadap aktivitas pencarian pakan lebah madu. Laporan Hasil Penelitian. [unpublished data]. [Indonesia]