

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

BIODIVERSITAS

Journal of Biological Diversity

Volume 24 - Number 2 - February 2023



Front cover: Troides helena cerberus f. eumagos (C. & R. Felder 1865)
(PHOTO: SIERRASUNRISE)

Published monthly

PRINTED IN INDONESIA

ISSN: 1412-033X

E-ISSN: 2085-4722



BIODIVERSITAS

Journal of Biological Diversity
Volume 24 – Number 2 – February 2023

ISSN/E-ISSN:

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

EDITORIAL BOARD:

Abdel Fattah N.A. Rabou (Palestine), **Agnieszka B. Najda** (Poland), **Ajar Nath Yadav** (India), **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 Pourbabaie** (Iran), **Joko R. Witono** (Indonesia), **Kartika Dewi** (Indonesia), **Katsuhiko Kondo** (Japan), **Kusumadewi Sri Yulita** (Indonesia), **Livia Wannorp** (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), **Shubhi Avasthi** (India), **Subhash C. Santra** (India), **Sugeng Budiharta** (Indonesia), **Sugiyarto** (Indonesia), **Taufiq Purna Nugraha** (Indonesia), **Wawan Sujarwo** (Indonesia), **Yosep S. Mau** (Indonesia)

EDITOR-IN-CHIEF:

S u t a r n o

EDITORIAL MEMBERS:

English Editors: **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: (i) **Research papers**, (ii) **Reviews**, and (iii) **Short communications**. Original research manuscripts are limited to 8,000 words (including tables and figures) or proportional to articles in this publication number. Review articles are also limited to 8,000 words, while Short communications should be less than 2,500 words, except for pre-study.

Submission: The journal only accepts online submissions through the open journal system (<https://smujo.id/biodiv/about/submissions>) or email 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, and 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 the submitted work has not been published (except as part of a thesis or report, or abstract) and is not being considered for publication elsewhere. When a group writes a manuscript, all authors should read and approve the final version of the submitted manuscript and its revision; and agree on 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 the manuscript, and correcting the revision. All authors must be responsible for the work's quality, accuracy, and ethics.

Ethics Author(s) must be 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 can reproduce articles as long as they are not used for commercial purposes. For the new invention, authors must manage its patent before publication.

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 US 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 align with the journal scope, does not meet the standard quality, is in an inappropriate format, or 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 typographical errors. The corrected proofs should be returned in 7 days to avoid publication delays. The accepted papers will be published online in chronological order at any time but printed at the end of each month.

A charge Authors are charged USD 320 (IDR 4,500,000). Additional charges may be billed for language improvement, USD 75-150 (IDR 1,000,000-2,000,000).

Reprints The sample journal reprint is only available by special request. Additional copies may be purchased when ordering by email and sending back the uncorrected proofs. **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 sizes can be applied in presenting tables and figures (9 pt). Word processing program or additional software can be used; however, it must be PC compatible, use the *Biodiversitas* template, and be 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 the first mention, except where this may generate confusion. name of the author can be eliminated after the first mention. For example, *Rhizopus oryzae* L. UICC 524 can be written hereinafter 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 sequences, it is better to use 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 systems should use equivalent values with the denomination of IS mentioned first. A dot should not follow abbreviations like g, mg, mL, etc. Minus index (m⁻², L⁻¹, h⁻¹) suggested being used, except in things like "per-plant" or "per-plot." **Mathematical equations** can be written down in one column with text;

in that case, they can be written separately. **Numbers** one to ten are written in words, except if it relates to measurement, while values above them are written in number, except in early sentences. The fraction should be expressed in decimal. In the text, it should be used "%" rather than "percent." Avoid expressing ideas with complicated sentences and verbiage/phrasing, and use efficient and effective sentences.

The **article's title should be written in a 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, and address are required. The first page of the manuscript is used for writing the above information.

The **Abstract** should not be more than 200 words. Include between five and eight **Keywords**, using scientific and local names (if any), research themes, and special methods used, and sorted from A to Z. All important **abbreviations** must be defined at their first mention. The 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 the procedures and data analysis. **Results and Discussion** should be written as a series of connecting sentences; however, manuscripts with long discussions should be divided into subtitles. Thorough discussion represents the causal effect that mainly explains why and how the research results occurred and did not only re-express the mentioned results in sentences. A **Conclusion** should be given at the end of the Discussion. Finally, **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 above each table (see example). Colored figures can only be accepted if the manuscript's information can be lost without those images; the chart is preferred to use black and white images. The 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 as sources. Although there is no **Appendix**, all data or data analysis is incorporated into Results and Discussions. For comprehensive/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 should be avoided, as shown with the word "cit." 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 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 the 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 the 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

BIODIVERSITAS

Journal of Biological Diversity
Volume 24 - Number 2 - February 2023

Short Communication: Tabanid and muscoid hematophagous flies as potential vectors of Surra Disease in Yogyakarta, Indonesia NILA QUDSIYATI, RADEN WISNU NURCAHYO, DWI PRIYOWIDODO, SOEDARMANTO INDARJULIANTO	675-680
Moss from Sumbawa District, Indonesia FLORENTINA INDAH WINDADRI	681-689
Characteristics of maleo bird spawning nests (<i>Macrocephalon maleo</i>) in Lake Towuti, South Sulawesi HADIJAH AZIS KARIM, NARDY NOERMAN NAJIB, SRIDA MITRA AYU, FIDEL	690-696
Changes in reef benthic communities in Sumba Timur, East Nusa Tenggara, Indonesia RIZKIE SATRIYA UTAMA, TRI ARYONO HADI, BAMBANG HERMANTO, GIYANTO, AGUS BUDIYANTO	697-707
Abundance and diversity of butterfly in the Lombok Forest Park, Indonesia MOHAMMAD LIWA ILHAMDI, AGIL AL IDRUS, DIDIK SANTOSO, GITO HADIPRAYITNO, MUHAMMAD SYAZALI, ISMAWAN HARIYADI	708-715
Phylogenetic of red snapper (<i>Lutjanidae</i>) in Yapen Island Waters, Papua, Indonesia RIDWAN SALA, ARADEA BUJANA KUSUMA, BAYU PRANATA,	716-723
Sex-linked Single Nucleotide Polymorphism (SNP) identification and molecular marker development of <i>Salacca</i> (<i>Salacca zalacca</i> (Gaertn.) Voss) RIRY PRIHATINI, DINY DINARTI, AGUS SUTANTO, SUDARSONO,	724-732
Analysis of phytochemical constituents and antioxidant activity from the fractions of <i>Luvunga sarmentosa</i> root extract using LCMS/MS SYARPIN, SILVANI PERMATASARI, DWI ARI PUJANTO	733-740
Determination of Begomovirus on chili plants (<i>Capsicum</i> sp.) in Buton and Muna Islands, Southeast Sulawesi, Indonesia CATUR JOKO WIDODO, MUHAMMAD TAUFIK, ANDI KHAERUNI, RAHAYU MALLARANGENG	741-751
Molecular identification of thermophilic bacteria with antimicrobial activity isolated from hot springs in North Sumatra, Indonesia CHRISMIS NOVALINDA GINTING, FINNA PISKA, HARMILENI, EDY FACHRIAL	752-758
Short Communication: Characteristics of the endangered Javan banteng (<i>Bos javanicus</i>) spermatozoa VINCENTIA TRISNA YOELINDA, RADEN IIS ARIFIANITINI, DEDY DURYADI SOLIHIN, MUHAMMAD AGIL, DEDI RAHMAT SETIADI, YOHANA TRI HASTUTI, JANSEN MANANSANG, DONDIN SAJUTHI	759-766
Ethnobotany of medicinal plants in the Dayak Linoh Tribe in Sintang District, Indonesia HENDRIKUS JULUNG, MARKUS IYUS SUPIANDI, BENEDIKTUS EGE, SITI ZUBAIDAH, SUSRIYATI MAHANAL	767-775
Fishing methods and fishing season of the tropical lobster fisheries of southern Java, Indonesia ARIEF SETYANTO, SUMARNO, DGR. WIADNYA, C. PRAYOGO, Z. KUSUMA, R.J. WEST, M. TSAMENYI	776-783
Flowering and fruiting phenology of <i>Anaxagorea luzonensis</i> A. Gray (Annonaceae) DEWI AYU LESTARI, LINDA WIGE NINGRUM, F. MAFTUKHAKH HILMYA NADA, NARESVARA NIRCELA PRADIPTA, DIAN RAKHMAWATI HARSONO4	784-792

The influence of inoculum types on the chemical characteristics and β-glucan content of tempe Gembus	793-798
SAMSUL RIZAL, MARIA ERNA KUSTYAWATI, MURHADI, MUHAMAMAD AMIN	
Forest structures and carbon stocks of community forests with different forest management in Maha Sarakham Province, Thailand	799-809
WANNACHAI WANNASINGHA, BHUVADOL GOMONTEAN, YANNAWUT UTTARUK	
Diversity of aquatic plants in the Rote Dead Sea area, East Nusa Tenggara, Indonesia, based on <i>rbcL</i> marker	810-818
DESY WULANSARI LONTHOR, MIFTAHUDIN, KAYAT, ATRIYON JULZARIKA, LUKI SUBEHI, ELISA ISWANDONO, ALFRED O. M DIMA7, AAN DIANTO, FAJAR SETIAWAN, MEDIA FITRI ISMA NUGRAHA8,	
Agronomic performance and selection of green super rice doubled haploid lines from anther culture	819-826
SITI NURHIDAYAH, BAMBANG SAPTA PURWOKO, ISWARI SARASWATI DEWI, WILLY BAYUARDI SUWARNO, ISKANDAR LUBIS	
Mapping coral cover using Sentinel-2A in Karimunjawa, Indonesia	827-836
ERIDHANI DHARMA SATYA, AGUS SABDONO, DIAH PERMATA WIJAYANTI, MUHAMMAD HELMI, RIKHA WIDIARATIH	
State of human tiger conflict around Gunung Leuser National Park in Langkat Landscape, North Sumatra, Indonesia	837-846
PINDI PATANA, HADI S. ALIKODRA, HERMAN MAWENGGANG, R. HAMDANI HARAHAP4	
Short Communication: Biological control of <i>Meloidogyne javanica</i> by <i>Pasteuria penetrans</i> and <i>Trichoderma harzianum</i> on tomato plants	847-851
HAMOOD M. SALEH, AHMED FAWZI SHAFEEQ, MAHER A. KHAIRI	
Seasonal litter production patterns in three tropical forests in Sulawesi, Indonesia: Implications for managing secondary forests	852-860
PUTU SUPADMA PUTRA, AMRAN ACHMAD, TOSHIHIRO YAMADA, PUTU OKA NGAKAN	
Spatial distribution of <i>Vespa affinis</i> based on land use and population density in Bojonegoro District, East Java Province, Indonesia	861-868
LAILY AGUSTINA RAHMAWATI, DEWI HIDAYATI, DIAN SAPTARINI, MRABAWANI INSAN RENDRA, BELLA LUTFIANI AL ZAKINA	
Determinants of symptom variation of <i>Pepper yellow leaf curl Indonesia virus</i> in bell pepper and its spread by <i>Bemisia tabaci</i>	869-877
DEWA GEDE WIRYANGGA SELANGGA, LISTIHANI LISTIHANI, I GEDE RAI MAYA TEMAJA, GUSTI NGURAH ALIT SUSANTA WIRYA, I PUTU SUDIARTA, KETUT AYU YULIADHI	
Low-density polyethylene sheet biodegradation by <i>Tenebrio molitor</i> and <i>Zophobas morio</i> larvae and metagenome studies on their gut bacteria	878-886
BERNADETTA OCTAVIA, ANNA RAKHMAWATI, SUHARTINI, LUTHFIA DWI RACHMANI, TITAN DWIKAMA PUTRA	
The effects of flowering trap crops on diversity and longevity of pollinator insect visitation on chili plants	887-893
TIEN AMINATUN, BUDIWATI, YUNITA FERA RAHMAWATI, DEVITA NURIKA ARI WIDIYANTI, LUFİ ATHIFAH FAHDAH	
Morphological characteristic of dengue vectors <i>Aedes aegypti</i> and <i>Ae. albopictus</i> (Family: Culicidae) using advanced light and scanning electron microscope	894-900
SUPRIYONO, SUSI SOVIANA, MUHAMMAD FALIKHUL MUSYAFFA, DIMAS NOVIATO, UPIK KESUMAWATI HADI	
<i>Serratia marcescens</i> strain NPKC3_2_21 as endophytic phosphate solubilizing bacteria and entomopathogen: promising combination approach as rice biofertilizer and biopesticide	901-909
G. SUTIO, A. NUR AFIFAH, R. MAHARANI, M. BASRI	

Characterization, and screening of urease activity of ureolytic bacteria from landfills soil in Banda Aceh, Indonesia	910-915
LENNI FITRI, TEUKU BUDI AULIA, AMIR FAUZI, GALIH AHMAD KAMIL	
Amplicon metabarcoding analysis of bio-extract and its potential on plant growth promotion	916-922
THANAKORN SAENGSANGA, WASSANA PHANURAK	
Predicting the current potential geographical distribution of <i>Baccaurea (B. lanceolata and B. motleyana)</i> in South Kalimantan, Indonesia	930-939
GUNAWAN, KHOERUL ANWAR, ABDUL GAFUR, RAUDATUL HILALIYAH, AZMIL AQILATUL WARO, NUR HIKMAH, SAKINAH, MUHAMMAD ERWANSYAH, DIAN SUSILAWATI, RATNA DWI LESTARI, DINDA TRIANA	
Phenotypic detection strategies of multidrug-resistant <i>Staphylococcus aureus</i> isolated from cat nasal swab in Madiun city, Indonesia	940-946
SAUMI KIREY MILLANNIA, ASWIN RAFIF KHAIRULLAH, MUSTOFA HELMI EFFENDI, SUZANITA UTAMA, SHENDY CANADYA KURNIAWAN, DANIAH ASHRI AFNANI, OTTO SAHAT MARTUA SILAEN, SAFIRA RAMADHANI, SANCAKA CHASYER RAMANDINIANTO, YUSAC KRISTANTO KHODA WARUWU, AGUS WIDODO9, GIOVANNI DWI SYAHNI PUTRA, MUHAMMAD THORIQ IHZA FARIZQI, KATTY HENDRIANA PRISCILIA RIWU	
Ethnobotany of wild and semi-wild edible plants of the Madurese Tribe in Sampang and Pamekasan Districts, Indonesia	947-957
THOBIB HASAN AL YAMINI, NINA RATNA DJUITA, TATIK CHIKMAWATI, YOHANES PURWANTO	
Inhibitor α-glucosidase activity of <i>Pediococcus acidilactici</i> DNH16 isolated from Dali ni Horbo, a traditional food from North Sumatra, Indonesia	958-965
EDY FACHRIAL, SARI ANGGRAINI, HARMILENI, SARYONO, TITANIA T. NUGROHO4	
Morphometric characterization and zoometric indices of female Bali cattle reared in Lombok Tengah District, West Nusa Tenggara, Indonesia	966-974
ADI TIYA WARMAN, GALIH TRIE FADHILAH, ALEK IBRAHIM, BAYU ANDRI ATMOKO, ENDANG BALIARTI, PANJONO,	
Short Communication: Notes on a new distribution record of the Critically Endangered Sunda Pangolin (<i>Manis javanica</i>) in Sabah, Malaysian Borneo	975-981
JEPHTE SOMPUD, NURHIDAYAH SAHAR, CARMEN ADROS, EVELYN RICHARD, CYNTHIA BOON SOMPUD	
Population survey and red list assessment of <i>Kandelia candel (L.) Druce</i>, a critically endangered mangrove species in the Philippines	982-989
Pastor L. Malabrigo Jr., Gerald T. Eduarte, Damasa M. Macandog, LERMA SJ. MALDIA, NELSON M. PAMPOLINA, RACHEL C. SOTTO, INOCENCIO E. BUOT JR.	
Visualization of paddy in Panel 65 of the Karmawibhangga section of Borobudur Temple	990-1003
ARYO ANGGOROJATI, RAHMANU WIDAYAT, SETYO BUDI	
Short Communication: Avian sanctuary within the city: the case of Timaco Hill, Cotabato City, Bangsamoro Autonomous Region in Muslim Mindanao (BARMM), Mindanao Island, Philippines	1004-1009
PETER JAN D. DE VERA, JOHN PAUL C. CATIPAY, MARIAN DARA T. TAGOON, ELSA MAY DELIMA-BARON, BENITO ANTHONY PINGGOY5	
Abundance and diversity of plant parasitic nematodes associated with vegetable cultivation on various types of organic fertilizers	1010-1016
SIWI INDARTI, TARYONO, CHANDRA WAHYU PURNOMO, AYU SUCI WULANDARI, RINA MAHARANI	

Stakeholder and social networks analysis of conservation partnership in Bantimurung Bulusaraung National Park, South Sulawesi, Indonesia	1017-1024
ADRAYANTI SABAR, RISMA ILLA MAULANY, YUSRAN, ANDY KURNIAWAN, RIO AKBAR RAHMATULLAH, MUH. ARIEF SYAM, MUHAMMAD AKBAR SYAWAL, ARDIAN HALIS, MUHAMMAD TEGAR RAFIADI	
The effect of different honey concentrations on the ultrastructure profile of spermatozoa in Dewa Mahseer (<i>Neolissochilus soro</i>)	1025-1031
A. ABINAWANTO, SUCI LESTARI, ANOM BOWOLAKSONO, ASTARI DWIRANTI, RETNO LESTARI, RUDHY GUSTIANO, ANANG HARI KRISTANTO4	
The heterosis, heterobeltiosis, and the yielding ability of hybrids of three parental crossings of soybean (<i>Glycine max</i>)	1032-1038
DIANA SOFIA HANAFIAH, LUTHFI AZIZ MAHMUD SIREGAR, KHAIRUNNISA LUBIS, HARYATI, FADILLAH RAHMADANA	
Nutritional values of <i>Avicennia marina</i> leaves and its application as fodder for Kacang goat (<i>Capra aegagrus</i>)	1039-1048
MOHAMMAD BASYUNI, MUHAMMAD RISKY RIZALDI, RIZKA AMELIA, YUNTHA BIMANTARA, NURDIN SULISTIYONO, BEJO SLAMET, SHOFIYAH SABILAH AL MUSTANIROH	
Application of remote sensing and GIS for mapping changes in land area and mangrove density in the Kuri Caddi Mangrove tourism, South Sulawesi Province, Indonesia	1049-1056
DWI ROSALINA, HAWATI, KATARINA HESTY ROMBE, AGUS SURACHMAT, AWALUDDIN, MUCHTAR AMILUDDIN, ANI LEILANI, ASRIYANTI	
Recorded and predicted butterflies in the Padang Bindu Karst, South Sumatra, Indonesia	1057-1082
AGMAL QODRI, ENCILIA, YULIZAH, DEDEN GIRMANSYAH, SUNARDI, WAHYUDI SANTOSO, MEGAWATI, RINA RACHMATIYAH, FATIMAH, DARMAWAN, SARINO, DJUNIJANTI PEGGIE	
Diversity of dinoflagellate cysts isolated from estuarine sediments of the Bengawan Solo and Brantas rivers, Indonesia	1083-1091
SAPTO ANDRIYONO, NITA RUKMINASARI, ANDI ALIAH HIDAYANI, INDRA JUNAIDI ZAKARIA, MD. JOB Aidul Alam, HYUN-WOO KIM	
Phylogeny and taxonomic status evaluation of Dark-sided Narrow-mouthed Frog, <i>Microhyla heymonsi</i>, (Anura: Microhylidae) from Sumatra, Indonesia	1092-1103
RURY EPRILURAHMAN, VESTIDHIA Y. ATMAJA, MISBAHUL MUNIR, ROSICHON UBaidillah, Tuty Arisuryanti, ERIC N. SMITH, AMIR HAMIDY	
Inventory of terrestrial vertebrate wildlife species in a private-owned forest patch in Tagum City, Mindanao, Philippines	1104-1116
LIEF ERIKSON D. GAMALO, SHIELA MAE E. CABRERA, NOEL CARL L. DE LOS REYES, ALEYLA E. DE CADIZ, JOSELITO B. CHAVEZ JR., AARON FROILAN M. RAGANAS, MA. NIÑA REGINA M. QUIBOD	
Next Generation Sequencing (NGS) for Cyanobacterial study in Agung and Sunter Barat Lakes, North Jakarta, Indonesia	1117-1124
DIAN HENDRAYANTI, NINING BETAWATI PRIHANTINI, FITRIA NINGSIH, FADHLURAHMAN MAULANA	
Diversity and distribution pattern of bioactive compound potential seaweed in Menganti Beach, Central Java, Indonesia	1125-1135
DWI SUNU WIDYARTINI, HEXA APRILIANA HIDAYAH, ACHMAD ILALQISNY INSAN	
Antagonist and plant growth promoting potential of indigenous bacteria isolated from oil palm empty fruit bunches	1136-1142
DERMIYATI, RADIX SUHARJO, MARELI TELAUMBANUA, RULLY YOSITA, ANGGI WINANDA SARI, ANIS PUJI ANDAYANI	

Incidence of <i>Escherichia coli</i> producing Extended-spectrum beta-lactamase in wastewater of dairy farms in East Java, Indonesia	1143-1150
FIDI NUR AINI EKA PUJI DAMEANTI, SHEILA MARTY YANESTRIA, AGUS WIDODO, MUSTOFA HELMI EFFENDI, HANI PLUMERIASTUTI, WIWIEK TYASNINGSIH, RAHAYU SUTRISNO, M. ALI AKRAMSYAH	
Antibacterial activity of sponge-associated bacteria from Torosiaje marine area, Gorontalo, Indonesia	1151-1156
YULIANA RETNOWATI, ABUBAKAR SIDIK KATILI	
Immunomodulatory effects of probiotics isolated from traditional fermented foods and beverages of Sumatra (Indonesia) and synbiotics in mice	1157-1162
NUR INDAH PERMATASARI HARAHAP, ERMAN MUNIR, SALOMO HUTAHAEAN	
Ethnomedicine exploration of medicinal plants in Dayak Bakumpai and Ngaju Tribes, Central Kalimantan, Indonesia	1163-1174
NANIK LESTARININGSIH, MUHAMAD JALIL, AYATUSA'ADAH, RIDHA NIRMALASARI	
Genotypes assessment for developing varieties on multi-canopy rice cultivation system	1175-1185
MIFTAKHUL BAKHRIR ROZAQ KHAMID, AHMAD JUNAEDI, HENI PURNAMAWATI, HAJRIAL ASWIDINNOOR, LILIK BUDI PRASETYO4	
Short Communication: The flowering process of <i>Prunus cerasoides</i> in Bali Botanic Gardens, Indonesia	1186-1191
GEBBY AGNESSYA ESA OKTAVIA, RAJIF IRYADI, TRI WARSENSO, HERY PURNOBASUKI	
Characterization and virulence of two indigenous entomopathogenic fungal isolates from decayed oil palm empty fruit bunches against <i>Spodoptera litura</i> (Lepidoptera: Noctuidae)	1192-1199
ABDUL SAHID, PINTAKA KUSUMANINGTYAS	
Amylase enzyme production with variation of carbon sources and molecular identification of thermophilic fungus <i>Aspergillus</i> sp. LBKURCC304 from Bukik Gadang, West Sumatra, Indonesia	1200-1205
SARYONO, SILVERA DEVI, TITANIA T NUGROHO, WIDYLIA FITRI FADHILA, LORENA LORENITA, FIDA SELFIANA NASUTION, NABELLA SURAYA	
Analysis of land cover change due to mining and its potential economic loss: A case study in the Bukit Soeharto Forest Park, East Kalimantan, Indonesia	1206-1214
SUNARTO, MARLON I. AIPASSA, RUJEHAN, ALI SUHARDIMAN, ROCHADI KRISTININGRUM, YOSEP RUSLIM, WULAN IR SARI	
Exploration of indigenous copper and dye-resistant bacteria isolated from Citarum River, West Java, Indonesia	1215-1223
WAHYU IRAWATI, DWI NINGSIH SUSILOWATI, INDAH SOFIANA, VALENTINE LINDARTO, REINHARD PINONTOAN, TRIWIBOWO YUWONO	
Short communication: Macrofungi assemblage in Rawa Bento Forest, Kerinci Seblat National Park, Indonesia	1224-1230
IRDA SAYUTI , ZULFARINA, ZATRI RAHAYU	
Ecological index and economic potential of mollusks (Gastropods and Bivalves) in Ayah Mangrove Forest, Kebumen District, Indonesia	1231-1241
MINI AMBARWATI KUSUMA DEWI, DEVI MAYANG AURINA, AQRA DANIAL FATURRAHMAN, LAYYINATUSSYIFA A'YUNI FATIKHA, FAYZA RACHMALIA, FADIA AULIANISSA AINAYA, ASIH KINANTHI, CAHYA MAULIDTA ROHMAN, FARIZ PRADHANA ADIL FADZILAH, DESMA ASTY PRAMUDITA, MUHAMMAD FADHIL RAMADHAN, EDWI MAHAJOENO, GILANG DWI NUGROHO, PUGUH SUJARTA, MUH. SULAIMAN DADIONO, CHEE KONG YAP, KHAIRUL ADHA BIN A. RAHIM, AHMAD DWI SETYAWAN	
Butterfly species in Bogani Nani Wartabone National Park, North Sulawesi, Indonesia	1242-1251
RONI KONERI, MEIS JACINTA NANGOY, PIENCE VERALYN MAABUAT, WAKHID	

Effect of environmental temperature and relative humidity towards postural behavior and activity patterns of female <i>Pongo pygmaeus</i> at Bukit Merah Orang Utan Island, Perak, Malaysia	1252-1263
NORAMIRA NOZMI, SABAPATHY DHARMALINGAM, NUR NADIAH MD YUSOF, FARIDA ZURAINA MOHD YUSOF	
Characteristics of vegetation in the <i>gumuk</i> ecosystem in Jember District, East Java, Indonesia	1264-1271
WIWIN MAISYAROH, LUCHMAN HAKIM, SUDARTO, JATI BATORO	
Exploration of phosphate solubilizing bacteria from mangrove soil of Lamongan, East Java, Indonesia	1272-1278
FATIMAH, NUR AULA, SYARIFAH SALSABILA, ZAKIA ASRIFAH RAMLY, SHERINA YULIA ROSE, TINI SURTINGSIH, TRI NURHARIYATI	
Isolation and characterization of endophytic bacteria from some halophytes in saline desert regions of Uzbekistan	1279-1288
BEGALI ALIKULOV, DOSTON GULBOEV, DILNOZA MAXAMMADIEVA, ZARRINA TILLAEVA, SADOKAT OLIMJONOVA, ZAFAR ISMAILOV	
Comparative study on Pb absorption ability of five shade plants species in Industrial Estate and Urban Forests of Bekasi, Indonesia	1289-1295
DAYANA ZULFADILLAH INTAN, RATNA YUNIATI, RETNO LESTARI	
Habitat suitability model for <i>Banteng</i> (<i>Bos javanicus</i> d'Alton, 1823) in Meru Betiri National Park, Indonesia	1296-1302
ARIF MOHAMMAD SIDDIQ, WACHJU SUBCHAN, HAIKAL IDRIS MAULAHILA, NUR KHOLIQ	
The false alarm of experimentally companion plants to the cabbage pests with their ecological effects	1303-1312
AGUNG SIH KURNIANTO, LUHUR SEPTIADI, NANANG TRI HARYADI, WILDAN MUHLISON, IRWANTO SUCIPTO, NILASARI DEWI, AHMAD ILHAM TANZIL, AYU LESTARI, ROSE NOVITA SARI HANDOKO	
α-amylase and α-glucosidase inhibitory effects of four piper species and GC-MS analysis of <i>Piper crocatum</i>	1313-1319
YUSTINA SRI HARTINI, DEWI SETYANINGSIH	
Antimicrobial activity of <i>Kaempferia galanga</i> against plant pathogen on rice	1320-1326
WORO SRI SUHARTI, ETIK WUKIR TINI, DINA ISTIQOMAH	

Incidence of *Escherichia coli* producing Extended-spectrum beta-lactamase in wastewater of dairy farms in East Java, Indonesia

FIDI NUR AINI EKA PUJI DAMEANTI^{1,2}, SHEILA MARTY YANESTRIA¹, AGUS WIDODO¹, MUSTOFA HELMI EFFENDI^{3,*}, HANI PLUMERIASTUTI³, WIWIEK TYASNINGSIH³, RAHAYU SUTRISNO², M. ALI AKRAMSYAH⁴

¹Doctoral Student of Veterinary Science, Faculty of Veterinary Medicine, Universitas Airlangga. Jl. Mulyorejo, Kampus C, Surabaya 60115, East Java, Indonesia

²Laboratory of Veterinary Microbiology and Immunology, Faculty of Veterinary Medicine, Universitas Brawijaya. Jl. Veteran, Malang 65145, East Java, Indonesia

³Faculty of Veterinary Medicine, Universitas Airlangga. Jl. Mulyorejo, Kampus C, Surabaya 60115, East Java, Indonesia. Tel./fax.: +62-31-5993016, *email: mhelmiEFFENDI@gmail.com

⁴Veterinary Professional Program, Faculty of Veterinary Medicine, Universitas Brawijaya. Jl. Veteran, Malang 65145, East Java, Indonesia

Manuscript received: 16 December 2022. Revision accepted: 13 February 2023.

Abstract. Dameanti FNAP, Yanestria SM, Widodo A, Effendi MH, Plumeriastuti H, Tyasningsih W, Sutrisno R, Akramsyah MA. 2023. Incidence of *Escherichia coli* producing Extended-spectrum beta-lactamase (ESBL) in wastewater of dairy farms in East Java, Indonesia. *Biodiversitas* 24: 1143-1150. Poor wastewater treatment on dairy farms can potentially become environmental contaminants (hazardous chemicals, organic matter, and pathogenic bacteria). Bacteria from dairy cattle that have been resistant can be found in wastewater. It can migrate around the farm and cause resistance to environmental microbiota. Over the years, cases of antimicrobial resistance (AMR) in *Escherichia coli* bacteria are increasing due to the uncontrolled use of antibiotics in dairy farms. The present study aimed to identify the potential occurrence of dairy farm wastewater as a reservoir for Extended-Spectrum Beta-Lactamase (ESBL)-producing *E. coli* in East Java. The number of research samples used was 342 and came from 6 cities/districts with the highest dairy cattle population in East Java (Pasuruan District, Malang District, Tulungagung District, Blitar District, Batu City, and Kediri District). The results showed that 69.30% (237/342) of dairy farm wastewater samples were positive for *E. coli*. The incidence of *Escherichia coli* AMR was 99.17% (235/237). The resistance conditions to each class of antibiotics were 76.4% ampicillin, 66.2% cefotaxime, 37.6% tetracycline, 15.6% ciprofloxacin, 96.2% streptomycin, 16.5% sulfamethoxazole-trimethoprim, and 84.0% chloramphenicol. The incidence of *E. coli* MDR was 84.25% (198/235), with the highest incidence (44.44%; 88/198) found in the four groups of antibiotics. The incidence of ESBL-producing *E. coli* from samples of dairy farm wastewater in East Java through DDST confirmation was 22.80% (78/342), with the highest incidence (20.51%; 16/78) in Pasuruan District and Batu City. In conclusion, dairy farm wastewater could be a reservoir for ESBL-producing *E. coli* which has the potential to impact human health in East Java Province.

Keywords: AMR-MDR, dairy farm, ESBL, *Escherichia coli*, human health, wastewater

INTRODUCTION

Dairy cattle in Indonesia use antibiotics as cattle need antibiotics during the dry and wet seasons while getting disease/sick to treat diseases, especially mastitis, endometritis, and diarrhea (Indriani et al. 2013). Uncontrolled use of antibiotics with inappropriate and effective concentrations can lead to antibiotic resistance (Astorga et al. 2019; Said et al. 2015). Traditional farms dominate dairy farming in Indonesia with small-scale ownership and disposal of the waste in rivers or the environment around farms. It leads to antibiotic resistance and harms public health (Pamungkasih and Febrianto 2021). Poor waste treatment causes resistant bacteria in livestock to migrate around the farm, so the environmental microbiota also experiences resistance (Sore 2020). The environment around the cage can store various resistant materials that can transfer between bacteria/mobile genetic elements (MGEs). Therefore, the environment is considered the primary source of resistance between humans and animals (Niasono et al. 2016; Woolhouse et al.

2015). Antibiotic resistance and environmental pollution in the last decade have increased and become a significant threat to global health (IMF 2014).

According to WHO (World Health Organization) (2019), the cases of death caused by AMR reach 700 thousands of people per year. The use of antibiotics globally in livestock is up to 80% higher than in humans on specific antibiotics. The use of antibiotics in the livestock sector in 2013 reached 131,109 tons and is expected to reach more than 200,000 tons in 2030 (WHO 2012; He et al. 2020). Beta-lactam antibiotics contribute to 50-70% of the antibiotics world's usage (Adekanmbi et al. 2020). The over and non-scientific use of antibiotics is unwise and causes the incidence of AMR in dairy cows. In general, the incidence of AMR in dairy cows is due to high doses of antibiotics to treat disease, increase milk and meat production and improve performance while raising dairy cows (Jayarao et al. 2019). Misuse of antibiotics causes difficulty in curing bacterial infections, increases the cost of animal health care, and even causes death (Overdevest et al. 2011). ESBL-producing *Escherichia coli* in dairy cattle

causes various infectious diseases, especially mastitis, and transmits them to humans through direct contact with the food chain and the environment. In humans, ESBL-producing *E. coli* pathogenic strains are associated with urinary tract infections and bacteremia in communities and hospitals (Gelalcha and Dego 2022). Antimicrobial Resistance Collaborators reported cases of death associated with AMR in 2019, reaching 4.95 million and are predicted to continue to increase to 10 million per year in 2050, and 70% of these events are caused by fluoroquinolone and ESBL resistance (Antimicrobial Resistance Collaborators 2022).

Reports of incidents of ESBL-producing *E. coli* are of severe concern. Extended-spectrum beta-lactamase (ESBL) is an enzyme that can hydrolyze and deactivate beta-lactam antibiotics, penicillin, first-second-third generation cephalosporins, and aztreonam (Biutifasari 2018). Genes or types from the TEM, SHV, and CTX-M groups are the most frequently encountered ESBLs. The ESBL coding gene resides in MGEs and produces enzymes to hydrolyze beta-lactam antibiotics. ESBL genes are mediated mainly by plasmids making it easy to transmit to other bacteria (Adekanmbi et al. 2020; Huang et al. 2020). ESBL TEM and SHV have been reported for more than 100 variants, while CTX-M has 50 variants. That was probably caused by a mutation process- associated with bacterial infection, particularly *E. coli* in the community (Dhillon and Clark 2012). *Escherichia coli* is often used as an indicator of antibiotic resistance due to its high prevalence in the environment and healthy animals (Masrurroh et al. 2016). Data on the incidence of ESBL-producing *E. coli* from rectal swab samples of dairy cows have been reported in various regions in Indonesia, namely, Surabaya at 72% and Sleman Yogyakarta at 25% (Imasari et al. 2018; Maulana et al. 2021). Livestock can transmit ESBL bacteria around the farm through a mixture of urine and feces with a liquid phase, commonly called liquid waste (Musrurroh et al. 2016; Said et al. 2015). This situation can cause public health problems because livestock waste is the main reservoir of ESBL-producing *E. coli* in the environment, thus increasing the transmission of ESBL to humans (Normaliska et al. 2019). Although *E. coli* is considered a typical flora and rarely causes infection, it can transfer resistance genes horizontally to pathogenic bacteria, thereby contributing to the development of chronic infections and the spread of AMR (Weber et al. 2021).

Research on dairy farm wastewater as a reservoir for ESBL-producing *E. coli* in East Java Province is essential to report. East Java Province has the highest population number of dairy cattle in Indonesia. According to data from the East Java Livestock Service (2020), the population of dairy cows in East Java reaches 293,556 heads. It is spread over six districts, with the largest populations in Pasuruan District (94,101 heads), Malang District (86,986 heads), Tulungagung District (25,139 heads), Blitar District (19,258 individuals), Batu City (12,579 individuals) and Kediri District (10,786 individuals). An increase in the dairy cattle population produces waste pollution in the environment (Widiastuti et al. 2015). Dairy cattle farms in Indonesia are generally small-scale ownership that throws waste into rivers without prior processing, polluting the environment (Hidayatullah

et al. 2005; Kasworo et al. 2013; Widiastuti et al. 2015). The data on the incidence of ESBL-producing *E. coli* from rectal swab samples of dairy cows have been reported in East Java like Tulungagung District at 6% and Pasuruan at 5.9% (Putra et al. 2020; Soekoyo et al. 2020). This study aimed to determine the potential for the occurrence of dairy cattle wastewater as a reservoir for *E. coli*-producing ESBL and monitoring AMR in East Java Province so that it can understand and overcome the global situation of ESBL-producing *E. coli*.

MATERIALS AND METHODS

Study area

This study used a purposive sampling method with inclusion criteria where samples came from six cities/districts with the largest dairy cattle population in East Java, and dairy farms had a record or history of antibiotic use. The sample was obtained from Pasuruan District, Malang District, Tulungagung District, Blitar District, Batu City, and Kediri District, with 342 samples of dairy farm wastewater in June 2022.

Sampling collections

A sample of 100 ml of wastewater was isolated from ditches/cages and stored in a centrifuge tube. The sample was stored in an icebox during sample transportation and brought to the laboratory for further testing (Yanestria et al. 2019).

Isolation and identification of *Escherichia coli*

The isolation stage of *Escherichia coli* was carried out by adding 5 ml of dairy farm wastewater to Buffer Pepton Water (BPW) media with 2% of concentration (1:1) (Oxoid, UK) and incubated at 37°C for 24 hours. The isolates from BPW media were inoculated on Eosin Methylene Blue Agar (EMBA) media (Oxoid, UK) using a streak technique and incubated at 37°C for 24 hours (Maulana et al. 2021). Colonies that appear as metallic green were identified using gram stain and biochemical assays, IMViC (Indol-motility (HiMedia, India), Methyl Red & Voges Proskauer (HiMedia, India), Citrate (HiMedia, India)), Triple Sugar Iron Agar (TSIA) (HiMedia, India) and Urease (HiMedia, India) (Imasari et al. 2018) to identifying as *E. coli* bacteria. Procedure for gram staining with crystal violet for 2 minutes and rinse with water, followed by iodine, acetone alcohol for 1 minute, and safranin for 2 minutes. The gram-stained preparations were then observed under a 1000x magnification microscope (Tripathi and Sapra 2022).

Antibiotic susceptibility test

Isolates with confirmed *E. coli* were tested for antibiotic sensitivity using the Kirby-Bauer disc diffusion method on Mueller Hinton Agar (MHA) media (Oxoid, UK). The isolates were inoculated on Brain Heart Infusion Broth (BHIB) medium (GranuCult, Germany) and incubated for 24 hours at 37°C. Isolates on BHIB media were suspended with turbidity equivalent to 0.5 McFarland. The bacterial

suspension was grown evenly on the MHA medium. Then seven types of antibiotic classes were placed (penicillin/ampicillin (AMP) (Oxoid, UK), cefotaxime (CTX) (Oxoid, UK), tetracycline (TE) (Oxoid, UK), ciprofloxacin (CIP) (Oxoid, UK), streptomycin (S) (Oxoid, UK), sulfamethoxazole-trimethoprim (SXT) (Oxoid, UK) and chloramphenicol (C) (Oxoid, UK)) on the surface of the media (Blaak et al. 2015) then incubated at 37°C for 24 hours. The class of antibiotics was selected based on the AMR testing literature and the use of antibiotics in dairy farms in Indonesia. In addition, the visual inhibition zone diameter-interpretation results were adjusted to the Clinical Laboratory Standard Institute (CLSI) standards (Table 1) (CLSI 2020). *Escherichia coli* isolates that show resistance to ≥ 3 groups of antibiotics are categorized as Multidrug Resistance Bacteria (MDR) (Yanestria et al. 2022).

Confirmation of ESBL using Double Disc Synergy Test (DDST)

DDST testing was carried out on bacterial isolates with MDR properties. The DDST method was used to confirm the phenotype of ESBL-producing bacteria. DDST testing was carried out using the Kirby-Bauer disc diffusion method on MHA media with three types of antibiotics ceftazidime (CAZ; 30g) (Oxoid, UK), cefotaxime (CTX; 30g) (Oxoid, UK), and amoxicillin-clavulanic (AMC; 30/10 μ g) (Oxoid, UK) (Zhang et al. 2016). The bacterial suspension was re-equated to 0.5 McFarland standard and grown evenly on MHA media. The AMC antibiotic disk was placed in the middle of the media and continued with CAZ and CTX disks at a 15 mm distance from AMC in parallel. The bacterial culture was incubated at 35-37°C for 18-24 hours (Imasari et al. 2018). The sample was confirmed phenotypically positive for ESBL when a synergistic/increased diameter of the inhibition zone ≥ 5 mm between the cephalosporin inhibition zone (cefotaxime and ceftazidime) and amoxicillin-clavulanic acid (Chukwunwejim et al. 2018). ESBL confirmation was carried out with the control using *E. coli* ATCC 25922 as a negative control and *Klebsiella pneumoniae* ATCC 700603 as a positive control (Masrurroh et al. 2016).

RESULTS AND DISCUSSION

The results of isolation and identification of *E. coli* from a total of 342 samples of dairy farm wastewater collected after testing were 69.30% (237/342) positive for *E. coli*. These results divided into Kediri District 13.45% (46/342), Blitar District 9.07% (31/342), Malang District 12.87% (44/342), Batu City 12.57% (43/342), Pasuruan District 13.45% (46/237) and Tulungagung District 7.89% (27/342) as shown in (Table 1). The positive *E. coli* sample showed a metallic green metachromatic sheen (Figure 1 (a)), which was caused by the end product of lactose fermentation (acid), resulting in the absorption of methylene blue color (Lal and Cheeptham 2007). The isolates from EMBA media were confirmed by gram staining and biochemical tests. The gram staining test results show a rod shape and pink-red (Figure 1 (b)) (Ulfah et al. 2017).

Confirmation of the IMViC, TSIA, and Urease biochemical tests (Figure 2) showed the results following the literature, where the TSIA media turns yellow and produces gas, indole, and several motile and non-motile. In addition, *E. coli* isolates were positive on the MR test and negative on VP, Citrate, and Urease tests (Cappucino and Welsh 2020; Chu et al. 2012; Leboffe and Pierce 2011).

Antimicrobial resistance (AMR) and multidrug resistance (MDR)

All *E. coli* isolates were continued to the antibiotic resistance test according to the CLSI standards. The antibiotics used in this test were based on the literature on antibiotic testing in wastewater (Blaak et al. 2015) and the types of antibiotics that are often used in dairy farms in Indonesia. This test showed that 99.17% of *E. coli* isolates (235/237) have AMR properties. They were resistant to each class of antibiotics; ampicillin (76.4%), cefotaxime (66.2%), tetracycline (37.6%), ciprofloxacin (15.6%), streptomycin (96.2%), sulfamethoxazole-trimethoprim (16.5%) and chloramphenicol (84.0%). The detailed AMR results can be seen in (Table 3).

Escherichia coli isolates that show resistance to ≥ 3 are categorized as multidrug resistance bacteria (MDR). The results of the MDR incidence for 235 isolates of *E. coli* were 84.25% (198/235), presented in (Table 4). The MDR incidence showed 17.17% (34/198) for three groups of antibiotics, 44.44% (88/198) for four groups of antibiotics, 25.25% (50/198) for five antibiotic classes, 10.61% (21/198) for six antibiotic classes and 2.53% (5/198) for seven antibiotic classes.

Table 1. The standard interpretation of antibiotic sensitivity (CLSI 2020)

Antibiotics	Disc content	Inhibition zone diameter		
		S	I	R
Ampicillin	10 μ g	≥ 17	14-16	≤ 13
Cefotaxime	30 μ g	≥ 26	23-25	≤ 22
Tetracyclin	30 μ g	≥ 15	12-14	≤ 11
Ciprofloxacin	5 μ g	≥ 31	21-30	≤ 20
Streptomycin	10 μ g	≥ 15	12-14	≤ 11
Trimethoprim-sulfamethoxazole	1.15/23.75 μ g	≥ 16	11-15	≤ 10
Cloramphenicol	30 μ g	≥ 18	13-17	≤ 12

Table 2. Results of the isolation and identification of *Escherichia coli* in the waste of dairy farms in East Java, Indonesia

Data isolation & identification	<i>Escherichia coli</i>		Other bacteria	
	n	%	n	%
Kediri	46	13.45	4	1.17
Blitar	31	9.07	24	7.01
Malang	44	12.87	19	5.56
Batu City	43	12.57	16	4.68
Pasuruan	46	13.45	15	4.39
Tulungagung	27	7.89	27	7.89
Total	237	69.30	105	30.70

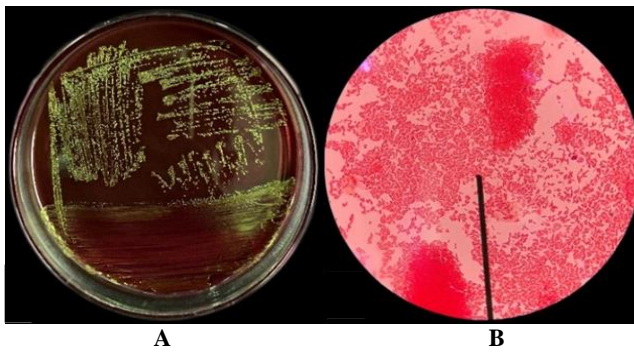


Figure 1. Results of isolation and identification of *Escherichia coli*. A. *Escherichia coli* on EMBA medium, B. *Escherichia coli* on gram staining in 1000x magnification

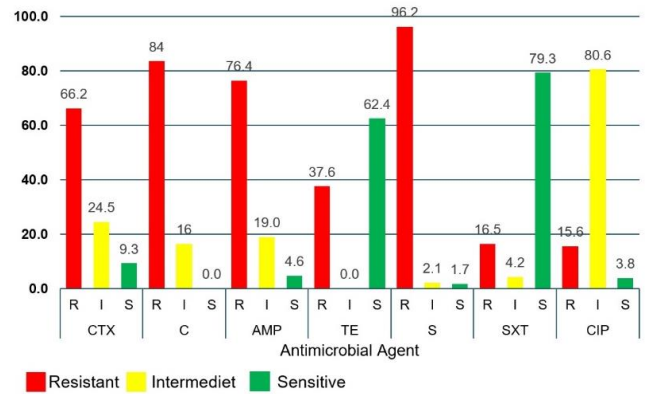


Figure 3. Results of *E. coli* antibiotic resistance to 7 classes of antibiotics. (CTX) cefotaxime, (C) chloramphenicol, (AMP) ampicillin, (TE) tetracycline, streptomycin (S), (SXT) sulfamethoxazole-trimethoprim and (CIP) ciprofloxacin, R: Resistant, I: Intermediate, S: Sensitive

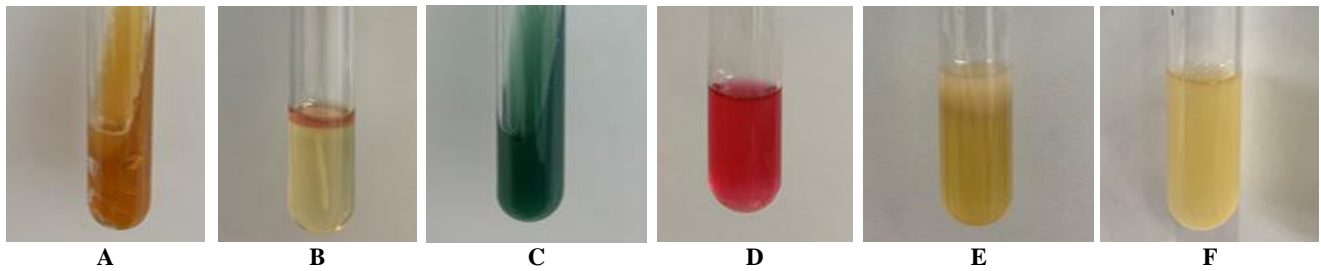


Figure 2. Identification results of *Escherichia coli* in the TSIA, IMViC, and Urease Biochemical tests. A. TSIA, B. SIM, C. Citrate, D. MR, E. VP, F. Urease

Table 3. Results of *Escherichia coli* antibiotic resistance in the wastewater of dairy farms in East Java, Indonesia

Data AMR		Kediri		Malang		Blitar		Batu City		Pasuruan		Tulungagung		Sub total	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%
CTX	R	24	10.1	15	6.3	19	8.0	32	13.5	41	17.3	26	11.0	157	66.2
	I	19	8.0	18	7.6	6	2.5	10	4.2	4	1.7	1	0.4	58	24.5
	S	3	1.3	11	4.6	6	2.5	1	0.4	1	0.4	0	0.0	22	9.3
C	R	38	16.0	33	13.9	25	10.5	37	15.6	41	17.3	25	10.5	199	84.0
	I	8	3.4	11	4.6	6	2.5	6	2.5	5	2.1	2	0.8	38	16.0
	S	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
AMP	R	39	16.5	30	12.7	20	8.4	32	13.5	36	15.2	24	10.1	181	76.4
	I	7	3.0	11	4.6	11	4.6	8	3.4	5	2.1	3	1.3	45	19.0
	S	0	0.0	3	1.3	0	0.0	3	1.3	5	2.1	0	0.0	11	4.6
TE	R	16	6.8	16	6.8	8	3.4	21	8.9	21	8.9	7	3.0	89	37.6
	I	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	S	30	12.7	28	11.8	23	9.7	22	9.3	25	10.5	20	8.4	148	62.4
S	R	45	19.0	42	17.7	31	13.1	43	18.1	43	18.1	24	10.1	228	96.2
	I	0	0.0	2	0.8	0	0.0	0	0.0	2	0.8	1	0.4	5	2.1
	S	1	0.4	0	0.0	0	0.0	0	0.0	1	0.4	2	0.8	4	1.7
SXT	R	11	4.6	9	3.8	4	1.7	8	3.4	3	1.3	4	1.7	39	16.5
	I	2	0.8	0	0.0	1	0.4	5	2.1	1	0.4	1	0.4	10	4.2
	S	33	13.9	35	14.8	26	11.0	30	12.7	42	17.7	22	9.3	188	79.3
CIP	R	5	2.1	2	0.8	5	2.1	9	3.8	11	4.6	5	2.1	37	15.6
	I	40	16.9	38	16.0	24	10.1	34	14.3	33	13.9	22	9.3	191	80.6
	S	1	0.4	4	1.7	2	0.8	0	0.0	2	0.8	0	0.0	9	3.8

Table 4. Results of MDR *Escherichia coli* occurrence in dairy farm wastewater in East Java, Indonesia

Antibiotic classes	Kediri		Malang		Blitar		Batu City		Pasuruan		Tulungagung		Sub total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
3	10	29.41	10	29.41	5	14.71	4	11.76	3	8.82	2	5.88	34	17.17
4	16	18.18	12	13.64	11	12.50	16	18.18	17	19.32	16	18.18	88	44.44
5	8	16.00	5	10.00	3	6.00	12	24.00	16	32.00	6	12.00	50	25.25
6	4	19.05	3	14.29	3	14.29	6	28.57	5	23.81	0	0.00	21	10.61
7	1	20.00	1	20.00	1	20.00	0	0.00	0	0.00	2	40.00	5	2.53

Table 5. The results of ESBL-producing *Escherichia coli* using the DDST test on the waste of dairy farms in East Java, Indonesia

Location	Positive ESBL		Negative ESBL	
	n	%	n	%
Kediri	11	27.50	35	82.50
Blitar	12	75.00	19	25.00
Malang	9	22.50	35	77.50
Batu City	16	64.00	27	36.00
Pasuruan	16	64.00	30	36.00
Tulungagung	14	56.00	13	28.00
Total	78	22.80	159	77.20

**Figure 4.** ESBL confirmation results for *Escherichia coli* using the DDST test. (AMC) amoxicillin-clavulanic acid, (CTX) Cefotaxime, (CAZ) Ceftazidime, arrows are the synergies formed

Confirmation of ESBL using Double Disc Synergy Test (DDST)

The DDST result was positive based on the synergy between cephalosporin antibiotics and amoxicillin-clavulanic acid. This synergy was observed with an increase in the diameter of the inhibition zone observed (Figure 4) (Chukwunwejim et al. 2018). The results of ESBL-producing *E. coli* from samples of dairy farm wastewater in East Java with DDST confirmation were 22.80% (78/342), presented in (Table 4). The confirmation results of ESBL-producing *E. coli* in Kediri District 14.10% (11/78), Blitar District 15.38% (12/78), Malang District 11.54% (9/78), Batu City and Pasuruan District 20.51% (16/78), 17.95% (14/78) Tulungagung District. The highest incidence occurred in Pasuruan District and Batu City at 20.51% (16/78).

Discussion

According to data from the East Java Livestock Service (2020), the population of dairy cows in East Java reaches 293,556 heads. It is spread over six districts, with the largest populations in Pasuruan District, Malang District,

Tulungagung District, Blitar District, Batu City, and Kediri District. An increase in the dairy cattle population resulted in increasing environmental waste pollution (Widiastuti et al. 2015). Dairy cattle farms in Indonesia are generally small-scale ownership that throws waste into rivers without prior processing, polluting the environment (Hidayatullah et al. 2005; Kasworo et al. 2013; Widiastuti et al. 2015). In addition, waste from animals treated with antibiotics can contain antibiotic residues and resistant bacteria (FAO 2018; Loo et al. 2019). A study by Marshall and Levy (2011) stated that 75-90% of animal antibiotics are not metabolized in the intestine and are then excreted through waste. This incident can cause a problem because animal waste containing resistant bacteria and antibiotics can enter the sewage system and water sources, thus, helping the emergence of antimicrobial-resistant bacteria in the environment (Loo et al. 2019).

The results of this study indicated that of the 69.30% (237/342) samples that were positive for *E. coli*, the other 30.7% were for other pathogenic bacteria, like *Klebsiella sp.*, *Proteus sp.*, *Pseudomonas sp.*, and *Enterobacter sp.* based on the results of identification on EMBA media. Not only pathogenic, but these bacteria also resist most antibiotics and show a high Minimal Inhibitory Concentration (MIC) of 30 to 100 µg/ml (Atef and Idriss 2013). The *E. coli* isolates (99.17%; 235/237) had AMR properties. Based on Baker et al. (2022), the waste generated from dairy farms could be a way of discovering the presence of AMR bacteria. The prevalence value of AMR in this study was higher than the study conducted by Massé et al. (2021), which stated that 70% of the samples were resistant to the antibiotics tested. Bacteria with AMR properties that pollute the environment can indirectly affect humans (Landers 2012). AMR causes an increase in morbidity and mortality due to microorganisms in humans. The side effects of AMR are increased disease severity, increased risk of complications, increased case fatality rate, increased mortality, delayed treatment, treatment failure, use of expensive drugs, increased economic burden or costs, and more extended stay in hospital and intensive care units. Medical treatment to the higher costs associated with implementing AMR infection control measures in healthcare units (Friedman et al. 2015). The global cost of handling AMR is very high and varies in each country. The US Center for Disease Control and Prevention (CDC) estimates that the cost of losses due to antimicrobial resistance is \$55 billion annually in the United States, of which \$20 billion is spent on healthcare in the AMR sector and \$35 billion due to decreased productivity (Prestinaci 2015).

The AMR *E. coli* showed significant antibiotic resistance, 76.7% ampicillin, 96.2% streptomycin, 66.2% cefotaxime, and 84.0% chloramphenicol. The antibiotics ampicillin (penicillin) and streptomycin show high resistance because these antibiotics are often used to treat mastitis and endometritis in dairy cows. This combination of antibiotics is used because it is a broad-spectrum antibiotic (Riyanto et al. 2016; Negasee 2020). The results of resistance to ampicillin and cefotaxime can indicate the ESBL enzyme's activity. Thus, the use of these antibiotics needs awareness of their side effects (Dhillon and Clark 2012). In addition, second and third-generation cephalosporin antibiotics have been reported to be a risk factor for infection with ESBL-producing bacteria (Amin et al. 2020; Wibisono et al. 2020).

Apart from penicillin and streptomycin, chloramphenicol, beta-lactam antibiotics, and the antibiotic sulfonamide group are often used in dairy cows (Ansharieta et al. 2021). Chloramphenicol also showed resistance results that were significantly different from the research conducted by Maulana et al. (2021) on samples on dairy farms in Sleman, Jogjakarta. Resistance to chloramphenicol is caused by pressure on bacteria through the co-selection of mobile resistance elements or unknown substrates against chloramphenicol (Tadesse et al. 2012). In different circumstances, sulfamethoxazole-trimethoprim and tetracycline showed significant sensitivity in 79.3% and 62.4%. These results can be used as a basis for the recommended use of antibiotics to treat infectious diseases in dairy cattle in East Java.

The highest multidrug-resistant (MDR) incidence was 44.44% for four groups of antibiotics. In addition, 2.53% of isolates are resistant to 7 antibiotics that need awareness. Multidrug resistance is common in ESBL-producing bacteria (Gregova et al. 2012). Furthermore, MDR shows microbial resistance to three or more classes of antibiotics (Effendi et al. 2021). These results impact the selection of antibiotics for treating limited bacterial infections. Resistant bacterial infections cause prolonged illness, increase the risk of death, increase the length of stay in the hospital, slow treatment response failure, causing patients to be infectious for a long time (carriers) and significant opportunities for resistant bacteria to spread to other organisms in a population (Deshpande et al. 2011). In addition, MDR is caused by the uncontrolled use of antibiotics, causing selective pressure from resistant bacteria to the evolutionary process through genetic mutations, exchange of genetic material, and proliferation to defend themselves against various types of antibiotics (Yanestria et al. 2022).

The results of ESBL-producing *E. coli* from samples of dairy farm wastewater in East Java with a DDST confirmation of 22.80% (78/342). This result should be noticed because there is an increase in the incidence compared to the results of other studies in Sleman (Yogyakarta, Indonesia), which is 16% (15/93). Data on the incidence of ESBL-producing *E. coli* in dairy farm wastewater were also reported by several countries, like Chiang Mai (Thailand) 88.7% and Tunisia (North Africa) 15.8% (Maulana et al. 2021; Saekhow and Sriphannam

2021; Said et al. 2015). The incidence of ESBL-producing *E. coli* in Indonesia is also increasing, as evidenced by the data on the incidence of ESBL-producing *E. coli* bacteria in various samples. For example, pneumonia patients at Sanglah General Hospital (Bali) reached 93.3%; at Wahidin General Hospital (Makassar) 80%; Blitar from swabs broiler cloaca 28.75% and layer 7.03%; broiler stool samples in Bogor 25%; rectal swabs of dairy cows 72% and companion dogs 9.41% in Surabaya; environmental samples of broiler farms in Pasauruan 9.14% and samples of Sleman dairy farms (Yogyakarta) reached 54% (Manuaba et al. 2021; Pratama et al. 2019; Widhi and Saputra 2020; Masrurroh et al. 2016; Wibisono et al. 2020; Kristianingtyas et al. 2021; Yanestria et al. 2022; Imasari et al. 2018; Maulana et al. 2021).

Some evidence shows increased ESBL-producing *E. coli*, especially in dairy cows. The increased ESBL organisms in dairy farms can be a public health risk because *E. coli* can be zoonotic and transmitted to humans by various routes. Environments contaminated with ESBL-producing *E. coli* bacteria can potentially spread these bacteria to humans. An environment polluted by ESBL-producing *E. coli* allows amino acid substitution or genetic mutations to horizontal gene transfer through transformation, transduction, and conjugation processes to the environmental microbiota. Environmental microbiota can be a reservoir of ESBL resistance genes (Amine, 2013). As a result, variants from the TEM, SHV, and CTX-M groups, through gradual mutations, which are identified, continue to increase (Gelalcha and Dego 2022). ESBL coding genes are mainly located on plasmids and chromosomes, transferred from one organism to another, impacting a higher prevalence epidemiologically (Buitifasari 2018; Canton et al. 2012). ESBL-producing *E. coli* has the risk of spreading resistant genes, especially to susceptible individuals such as pregnant women, infants, children, the elderly, and people with immunosuppression, as well as postoperative and chemotherapy patients (Franz et al. 2015). ESBL-producing *E. coli* causes mortality, morbidity, and increasing death incidences (Nóbrega and bronchi 2014).

This study concludes that ESBL-producing *E. coli* in the wastewater of dairy farms in East Java has the potential to become a reservoir in the livestock environment. These results are significant for creating public awareness of antibiotics and wastewater treatment used to create better public health and welfare. Research and collaboration within the scope of One health are needed to deal with the incidence of ESBL-producing *E. coli* from wastewater, and the government needs to supervise the treatment of dairy farm wastewater.

ACKNOWLEDGEMENTS

The authors would like to thank *Penelitian Pasca Sarjana-Penelitian Disertasi Doktor* funding from DRTPM Kemendikbudristek 2022, with grant from Universitas Airlangga No. 905/UN3.15/PT/2022, the management of KUD Medowo (Kediri District), KUD Jabung, KUD Princi

and KUD Poncokusumo (Malang District), KUD Semen (Blitar District), KUD Batu and KUD Junrejo (Batu City), KUD KPSP Setia Kawan (Pasuruan District), KUD Sendang (Tulungagung District) and Laboratory of Veterinary Microbiology and Immunology, Faculty of Veterinary Medicine, Universitas Brawijaya, Malang, Indonesia for providing the facilities for the study.

REFERENCES

- Adekanmbi AO, Akinpelu MO, Olaposi AV, Oyelade AA. 2020. Extended spectrum beta-lactamase encoding gene-fingerprints in multidrug resistant *Escherichia coli* isolated from wastewater and sludge of a hospital treatment plant in Nigeria. *Intl J Environ Stud* 78 (1): 140-150. DOI: 10.1080/00207233.2020.177827.
- Amin M, Wasito EB, Triyono EA. 2020. Comparison between exposure of ciprofloxacin and cefotaxime on developing of *Escherichia coli* ESBL. *Fol Med Indones* 56 (2): 86-90. DOI: 10.20473/fmi.v56i2.21203.
- Amine AEK. 2013. Extended spectrum beta-lactamase producing bacteria in waste water Alexandria, Egypt. *Intl J Biosci Biochem Bioinformatics* 3 (6): 605-609. DOI: 10.7763/IJBBB.2013.V3.285.
- Ansharieta R, Effendi MH, Plumeriastuti H. 2021. Genetic identification of shiga toxin encoding gene from cases of Multidrug Resistance (MDR) *Escherichia coli* isolated from raw milk. *Trop Anim Sci J* 44 (1): 10-15. DOI: 10.5398/tasj.2021.44.1.10.
- Antimicrobial Resistance Collaborators. 2022. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *The Lancet* 399 (55): 629-655.
- Astorga F, Talloni MJN, Miró MP, Bravo M, Toro M, Blondel CJ, Claude LPH. 2019. Antimicrobial resistance in *E. coli* isolated from dairy calves and bedding material. *Heliyon* 5 (11): 1-6. DOI: 10.1016/j.heliyon.2019.e02773.
- Atef D, Idriss A. 2013. Bacterial contaminating the haemodialysis dialysate-water exhaust-origin and fate at Al-Madinah Al-Mounwarrah. *Life Sci J* 10 (1): 1030-1035.
- Baker M, Williams AD, Hooton SPT, Helliwell R, King E, Dodsworth T, Baena-Nogueras RM, Warry A, Ortori CA, Todman H. 2022. Antimicrobial resistance in dairy slurry tanks: a critical point for measurement and control. *Environ Intl* 169: 107516. DOI: 10.1016/j.envint.2022.107516.
- Biutifasari W. 2018. Extended Spectrum Beta-Lactamase (ESBL). *Oceana Biomed J* 1 (1): 1-11. DOI: 10.30649/obj.v1i1.3. [Indonesian]
- Blaak H, Lynch G, Italiaander R, Hamidjaja RA, Schets FM, de Roda Husman AM. 2015. Multidrug-Resistant and Extended Spectrum Beta-Lactamase Producing *Escherichia coli* in Dutch Surface Water and Wastewater. *PLoS One* 10 (6): e0127752. DOI: 10.1371/journal.pone.0127752.
- Canton R, Gonzalez-Alba JM, Galan JC. 2012. CTX-M Enzymes: Origin and Diffusion. *Front Microbiol Rev* 3 (110): 1-19. DOI: 10.3389/fmicb.2012.00110.
- Cappuccino JG, Welsh C. 2020. *Microbiology A Laboratory 12th Edition Global Edition*. Pearson, England.
- Chu W, Zere TR, Weber MM, Wood TK, Whiteley M, McLean RJC. 2012. Indole production promotes *Escherichia coli* mixed-culture growth with *Pseudomonas aeruginosa* by inhibiting quorum signaling. *Appl Environ Microbiol* 78 (2): 411-419. DOI: 10.1128/AEM.06396-11.
- Chukwunwejim CR, Eze PM, Ujam NT, Abonyi IC, Ejikeugwu CP. 2018. Incidence of Community Acquired ESBL-producing Bacteria among Asymptomatic University Students in Anambra State, Nigeria. *Eur J Biol Res* 8 (3): 138-147. DOI: 10.5281/zenodo.1314719.
- Clinical and Laboratory Standards Institute. 2020. Performance standards for antimicrobial susceptibility testing in CLSI supplement M100. In. Wayne, PA: CLSI.
- Deshpande PR, Rajan S, Sudeepthi BL, Nasir CPA. 2011. Patient-Reported Outcomes: A New Era in Clinical Research. *Perspect Clin Res* 2 (4): 137-144. DOI: 10.4103/2229-3485.86879.
- Dhillon RHP, Clark J. 2012. Review Article ESBLs: A Clear and Present Danger? *Crit Care Res Pract* 2012 (11): 1-11. DOI: 10.1155/2012/625170.
- Dinas Peternakan Provinsi Jawa Timur. 2020. *Statistika Populasi Ternak 2020*. Disnak jatimprov. [Indonesian]
- Effendi MH, Tyasningsih W, Yurianti YA, Rahmahani J, Harijani N, Plumeriastuti H. 2021. Presence of multidrug resistance (MDR) and extended-spectrum beta-lactamase (ESBL) of *Escherichia coli* isolated from cloacal swab of broilers in several wet markets in Surabaya, Indonesia. *Biodiversitas* 22 (1): 304-310. DOI: 10.13057/biodiv/d220137.
- Food and Agriculture Organization (FAO). 2018. *Antimicrobial Resistance in the Environment*. <http://www.fao.org>.
- Franz E, Veenman C, van HA, Husman AR, Blaak H. 2015. Pathogenic *Escherichia coli* producing extended spectrum β -lactamases isolated from surface water and wastewater. *Sci Rep* 5: 19. DOI: 10.1038/srep14372.
- Friedman DB, Kanwat CP, Headrick ML et al. 2015. Importance of prudent antibiotic use on dairy farms in South Carolina: a pilot project on farmers' knowledge, attitudes and practices. *Zoonoses Public Health* 2007 54: 366-375. DOI: 10.1111/j.1863-2378.2007.01077.x.
- Galalcha BD, Dego OK. 2022. Extended-Spectrum Beta-Lactamases Producing Enterobacteriaceae in the USA Dairy Cattle Farms and Implications for Public Health. *Antibiotics* 11 (1313): 1-4. DOI: 10.3390/antibiotics11101313.
- Gregova G, Kmetova M, Kmet V, Venglovsky J, Feher A. 2012. Antibiotic resistance of *Escherichia coli* isolated from poultry a Slaughterhouse. *Ann Agric Environ Med* 19 (1): 75-77.
- He Y, Yuan Q, Mathieu J, Stadler L, Senehi N, Sun R, Alvarez PJJ. 2020. Antibiotic resistance genes from livestock waste: occurrence, dissemination, and treatment. *NPJ Clean Water* 3 (4): 1-4. DOI: 10.1038/s41545-020-0051-0.
- Hidayatullah, Gunawan, Mudikdjo K, Erliza N. 2005. Pengelolaan limbah cair usaha peternakan sapi perah melalui penerapan konsep produksi bersih. *J Pengkajian dan Pengembangan Teknologi Pertanian* 8 (1): 124-136. DOI: 10.21082/jpptp.v8n1.2005.p%25p. [Indonesian]
- Huang YH, Kuan NL, Yeh KS. 2020. Characteristics of Extended-Spectrum β -Lactamase Producing *Escherichia coli* From Dogs and Cats Admitted to a Veterinary Teaching Hospital in Taipei, Taiwan From 2014 to 2017. *Front Vet Sci* 7: 395. DOI: 10.3389/fvets.2020.00395.
- Imasari T, Tyasningsih W, Wasito EB, Kuntaman K. 2018. Prevalensi dan Pola Gen Extended Spectrum β -lactamase Bakteri Usus Sapi Perah dan Penduduk Sekitar Peternakan di Surabaya. *Jurnal Veteriner* 19 (3): 313 - 320. DOI: 10.19087/jveteriner.2018.19.313. [Indonesian]
- Indriani AP, Muktiani A, Pangestu E. 2013. Konsumsi dan produksi protein susu sapi perah laktasi yang diberi suplemen temulawak (*Curcuma xanthorrhiza*) dan seng proteinat. *Anim Agric J* 2 (1): 128-135. [Indonesia]
- International Monetary Fund. 2014. *Global Health Threats of the 21st Century*. International Monetary Fund (IMF) 51 (4).
- Kristianingtyas L, Effendi MH, Witaningrum AM, Wardhana DK, Ugbo EN. 2021. Prevalence of extended-spectrum β -lactamase-producing *Escherichia coli* in companion dogs in animal clinics, Surabaya, Indonesia. *Intl J One Health* 7 (2): 232-236. DOI: 10.14202/IJOH.2021.232-236.
- Jayarao B, Almeida R, Oliver SP. 2019. Antimicrobial Resistance on Dairy Farms. *Foodborne Pathog Dis* 16 (1): 1-4. DOI: 10.1089/fpd.2019.29011.edi.
- Lal A, Cheeptham N. 2017. Eosin Methylene Blue Agar Protocol. *ML Library*. American Society for Microbiology.
- Loo E, Lai KS, Mansor R. 2019. Antimicrobial Usage and Resistance in Dairy Cattle Production. In Bekoe SO, Saravanan M, Adosraku RK, Ramkumar P (eds.). *Veterinary Medicine and Pharmaceuticals*. IntechOpen. DOI: 10.5772/intechopen.81365.
- Marshall BM, Levy SB. 2011. Food animals and antimicrobials: impacts on human health. *Clin Microbiol Rev* 24 (4): 718-733. DOI: 10.1128/CMR.00002-11.
- Masruroh CA, Sudarwanto MB, Latif H. 2016. Tingkat Kejadian *Escherichia coli* Penghasil *Extended Spectrum-Lactamase* yang Diisolasi dari Feses Broiler di Kota Bogor. *Jurnal Sain Veteriner* 34 (1): 42-49. DOI: 10.22146/jsv.22813. [Indonesian]
- Manuaba IASP, Iswari IS, Pinatih KJP. 2021. Prevalensi Bakteri *Escherichia coli* dan *Klebsiella pneumoniae* Penghasil *Extended Spectrum Beta Lactamase* (ESBL) Yang Diisolasi Dari Pasien *Pneumonia* Di RSUP Sanglah Periode Tahun 2019-2020. *J Medika Udayana* 10 (12): 51- 57. DOI: 10.24843.MU.2021.V10.i12.P10. [Indonesian]

- Maulana KT, Pichpol D, Farhani NR, Widiasih DA, Unger F, Punyapornwithaya V, Meeyam T. 2021. Antimicrobial resistance characteristics of Extended Spectrum Beta Lactamase (ESBL) producing *Escherichia coli* from dairy farms in the Sleman district of Yogyakarta province, Indonesia. *Vet Integr Sci* 19 (3): 525-535. DOI: 10.12982/VIS.2021.041.
- Massé J, Lardé H, Fairbrother JM, Roy JP, Francoz D, Dufour S, Archambault M. 2021. Prevalence of antimicrobial resistance and characteristics of *Escherichia coli* isolates from fecal and manure pit samples on dairy farms in the Province of Québec, Canada. *Front Vet Sci* 8: 654125. DOI: 10.3389/fvets.2021.654125.
- Negasee KA. 2020. Clinical Metritis and Endometritis in Dairy Cattle: A Review. *Openventio* 5 (2): 51-56. DOI: 10.17140/VMOJ-5-149.
- Niasono AB, Latif H, Purnawarman, T. 2019. Resistensi Antibiotik terhadap Bakteri *Escherichia coli* yang Diisolasi dari Peternakan Ayam Pedaging di Kabupaten Subang, Jawa Barat. *J Veteriner* 20 (2): 187-195. DOI: 10.19087/jveteriner.2019.20.2.187. [Indonesian]
- Normaliska R, Sudarwanto BM, Latif H. 2019. Pola resistensi antibiotik pada *Escherichia coli* Penghasil ESBL dari Sampel Lingkungan di RPH-R Kota Bogor. *J Acta Veterinaria Indonesia* 7 (2): 42-48. DOI: 10.29244/avi.7.2.42-48. [Indonesian]
- Overdeest I, Willemsen I, Rijnsburger M, Eustace A. 2011. Extended spectrum β -lactamase genes of *Escherichia coli* in chicken meat and humans, the Netherlands. *Emerg Infect Dis* 17 (12): 16-22. DOI: 10.3201/eid1707.110209.
- Pamungkasih E, Febrianto N. 2021. Profil peternak sapi perah di dataran rendah Kabupaten Malang. *Karta Raharja* 3 (2): 29-35. [Indonesian]
- Prestinaci F, Pezzotti P, Pantosti A. 2015. Antimicrobial resistance: a global multifaceted phenomenon. *Pathog Glob Health* 109 (7): 309-318. DOI: 10.1179/204773215Y.0000000030.
- Putra AR, Effendi MH, Koesdarto S, Suwarno S, Tyasningsih W, Estoepangestie AT. 2020. Detection of the extended spectrum β lactamase produced by *Escherichia coli* from dairy cows by using the Vitek-2 method in Tulungagung district, Indonesia. *Iraqi J Vet Sci* 34 (1): 203-207. DOI: 10.33899/ijvs.2019.125707.1134
- Pratama A, Djide M, Nasrum M. 2019. Identifikasi Genotip CTX-M pada *Escherichia coli* Penghasil *Extended Spectrum Beta Lactamase* (ESBL) Yang Resisten Pada *Cephalosporin* Generasi III di RSUP Wahidin Sudirohusodo Makassar. *Majalah Farmasi dan Farmakologi* 23 (5): 1-7. DOI: 10.20956/mff.v23i1.6458. [Indonesian]
- Riyanto J, Sunarto BS, Hertanto M, Cahyadi R, Hidayah, Sejati W. 2016. Produksi dan kualitas susu sapi perah penderita mastitis yang mendapat pengobatan antibiotik. *Sains Peternak* 14: 30-41. DOI: 10.20961/sainspet.14.2.30-41. [Indonesian]
- Saekhow P, Sriphanam X. 2021. Prevalence of Extended-Spectrum Beta-Lactamase-Producing *Escherichia coli* Strains in Dairy Farm Wastewater in Chiang Mai. *Vet Integr Sci* 19 (3): 349-362. DOI: 10.12982/VIS.2021.030.
- Said LB, Jouini A, Klibi N, Dziri N, Alonso CA, Boudabous A, Ben SK, Torres C. 2015. Detection of Extended-Spectrum BetaLactamase (ESBL) producing enterobacteriaceae in vegetables, soil and water of the farm environment in Tunisia. *Intl J Food Microbiol* 203: 86-92. DOI: 10.1016/j.ijfoodmicro.2015.02.023.
- Soekoyo AR, Sulistiawati, Setyorini W, Kuntaman K. 2020. The epidemiological pattern and risk factor of ESBL (Extended Spectrum B-Lactamase) producing *Enterobacteriaceae* in gut bacterial flora of dairy cows and people surrounding in Rural Area, Indonesia. *Indones J Trop Infect Dis* 8 (3): 144-151. DOI: 10.20473/ijtid.v8i3.17553.
- Soré S, Sawadogo Y, Bonkoungou JI, Kaboré SP, Béogo S. 2020. Detection, identification and characterization of extended-spectrum beta-lactamases producing *Enterobacteriaceae* in wastewater and salads marketed in Ouagadougou, Burkina Faso. *Intl J Biol Chem Sci* 14 (8): 2746-2757. DOI: 10.4314/ijbcs.v14i8.8.
- Tadesse DA, Zhao S, Tong E, Ayers S, Singh A, Bartholomew MJ, McDermott PF. 2012. Antimicrobial drug resistance in *Escherichia coli* from humans and food animals, United States, 1950-2002. *Emerg Infect Dis* 18: 741-749. DOI: 10.3201/eid1805.111153.
- Tripathi N, Sapra A. 2022. Gram Staining. In: StatPearls. StatPearls Publishing, Treasure Island (FL).
- Ulfah NF, Erina, Darniati. 2017. Isolation and identification *Escherichia coli* in roasted chicken from Restaurant in Syiah Kuala, Banda Aceh. *J Ilmu Medik Veteriner* 01 (3): 383-390. [Indonesian]
- Weber LP, Dreyer S, Heppelmann M, Schaufler K, Homeier-Bachmann T, Bachmann L. 2021. Prevalence and Risk Factors for ESBL/AmpC-*E. coli* in Pre-Weaned Dairy Calves on Dairy Farms in Germany. *Microorganisms* 9 (2135): 1-4. DOI: 10.3390/microorganisms9102135.
- Wibisono FJ, Sumiarto B, Untari T, Effendi MH, Permatasari DA, Witaningrum M. 2020. CTX Gene of Extended Spectrum Beta-Lactamase (ESBL) Producing *Escherichia coli* on Broilers in Blitar, Indonesia. *Syst Rev Pharm* 11 (7): 396-403. DOI: 10.31838/srp.2020.7.59.
- Wibisono FJ, Sumiarto B, Untari T, Effendi MH, Permatasari DA, Witaningrum M. 2020. Short Communication: The presence of extended spectrum beta-lactamase (ESBL) producing *Escherichia coli* on layer chicken farms in Blitar Area, Indonesia. *Biodiversitas* 21 (6): 2667-2671. DOI: 10.13057/biodiv/d210638.
- Widhi APKN, Saputra IY. 2021. Residu antibiotik serta keberadaan *Escherichia Coli* penghasil ESBL pada daging ayam broiler di Pasar Kota Purwokerto. *J Kesehatan Lingkungan Indonesia* 20 (2): 137-142. DOI: 10.14710/jkli.20.2.137-142. [Indonesian]
- Widiastuti E, Kustono, Adiarto, Nurliyani. 2015. The impact of the local dairy cattle farm toward the river water quality in Gunungpati Subdistrict Central Java. *Intl J Sci Eng* 8 (1): 15-21. DOI: 10.12777/ijse.8.1.15-21.
- Woolhouse M, Ward M, van Bunnik B, Farrar J. 2015. Antimicrobial Retance in Humans, Livestock and The Wider Environment. *Phil Trans R Soc B* 370: 1-7. DOI: 10.1098/rstb.2014.0083.
- World Health Organization. 2012. The Evolving Threat of Antimicrobial Resistance: Options for Action. Geneva: World Health Organisation.
- World Health Organization. 2019. New report calls for urgent action to avert antimicrobial resistance crisis. Joint News Release. <https://www.who.int>.
- World Health Organization. 2021. WHO integrated Global Surveillance on ESBL-Producing *E. coli* using a "One Health" Approach: Implementation and Opportunities. <https://www.who.int>.
- Yanestria SM, Dameanti FNAEP, Musayannah BG, Pratama JWA, Witaningrum AM, Effendi MH, Ugbo EN. 2022. Antibiotic resistance pattern of Extended-Spectrum β -Lactamase (ESBL) producing *Escherichia coli* isolated from broiler farm environment in Pasuruan district, Indonesia. *Biodiversitas* 23 (9): 4460-4465. DOI: 10.13057/biodiv/d230911.
- Yanestria SM, Rahmaniar RP, Wibisono FJ, Effendi MH. 2019. Detection of *invA* gene of *Salmonella* from Milkfish (*Chanos chanos*) at Sidoarjo Wet Fish Market, Indonesia, using Polymerase Chain Reaction Technique. *Vet World* 12 (1): 170-175. DOI: 10.14202/vetworld.2019.170-175.
- Zhang H, Gao Y, Chang W. 2016. Comparison of *Extended-Spectrum β -Lactamase* producing *Escherichia coli* isolates from drinking well water and pit latrine wastewater in a rural area of China. *BioMed Res Intl* 1-7. DOI: 10.1155/2016/4343564.