



The International Symposium on Biomathematics (Symomath) 2026

Gorontalo, 7–8 September 2026

Book of Abstracts

Mathematical, Statistical, and Computational Approaches
for Biological and Life Sciences

Universitas Negeri Gorontalo, Gorontalo, Indonesia

Organized by

Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas
Negeri Gorontalo

in collaboration with the Indonesian Biomathematical Society (IBMS)

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(Symomath) 2026**

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The abstracts in this volume are published as submitted and approved for presentation at The International Symposium on Biomathematics (Symomath) 2026. Responsibility for the scientific content, accuracy, and opinions expressed in each abstract rests with the respective authors.

Preface

Welcome to the The International Symposium on Biomathematics (Symomath) 2026, held on Gorontalo, 7–8 September 2026 at Universitas Negeri Gorontalo, Gorontalo, Indonesia.

The symposium provides a scientific forum for researchers, academics, students, and practitioners to exchange ideas and recent findings involving mathematical, statistical, and computational approaches to biological, epidemiological, ecological, medical, environmental, and related systems.

This Book of Abstracts compiles the contributions accepted for presentation at SYMOMATH 2026.

The abstracts are organized into three principal sections:

- Keynote Speaker Abstracts;
- Invited Speaker Abstracts; and
- Oral Presenter Abstracts.

We extend our appreciation to all speakers, authors, reviewers, scientific committee members, organizing committee members, partners, and participants whose contributions make this symposium possible.

Organizing Committee
The International Symposium on Biomathematics (Symomath) 2026
Gorontalo, September 2026

Sponsor

Financial support for The International Symposium on Biomathematics (Symomath) 2026 is provided by the Faculty of Mathematics and Natural Sciences, Universitas Negeri Gorontalo.



Faculty of Mathematics and Natural Sciences
Universitas Negeri Gorontalo

Gorontalo, Indonesia

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About the Symposium

The Symposium on Biomathematics (Symomath) is an annual scientific program organized by the Indonesian Biomathematics Society (IBMS) in cooperation with various universities in Indonesia, a tradition that began at Institut Teknologi Bandung in 2013. In 2026, the symposium will be organized by the Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Gorontalo, in collaboration with the Indonesian Biomathematical Society, and will take place on 7–8 September 2026 at Universitas Negeri Gorontalo, Province of Gorontalo, Indonesia. As a biomathematical forum, this symposium provides a vital space for scientific exchange and collaboration among researchers, students, and industrial practitioners who develop and apply mathematical, statistical, and computational tools to study complex phenomena across the broad fields of biology, epidemiology, ecology, medicine, and environmental science.

Scope

- Population and Evolutionary Dynamics
- Epidemiology and Infectious Disease Modeling
- Systems Biology and Computational Bioinformatics
- Synthetic Biology and Bioengineering Innovations
- Advanced Biostatistical Analysis
- Sustainable Industrial Utilization of Renewable Resources
- Biomathematics in Economic Policy and Conservation
- Mathematical Foundations in Medical and Clinical Sciences
- Optimization and Optimal Control Theory in Biological Systems
- High-Performance Computational Methods for Life Science Models
- Ecological Systems and Environmental Modeling

Venue

Ballroom UTC Damhil by Prasanthi
Universitas Negeri Gorontalo
Jl. Ir. H. Joesoef Dalie, Gorontalo 96128, Indonesia

Scientific Committee

Name	Affiliation
Prof. Dr. Edy Soewono	Institut Teknologi Bandung
Prof. Dr. Abadi	Universitas Negeri Surabaya
Prof. Dr. Asep Supriatna	Universitas Padjadjaran
Prof. Dr. Agus Suryanto	Universitas Brawijaya
Prof. Dr. Fajar Adi Kusumo	Universitas Gadjah Mada
Prof. Dr. Fatmawati	Universitas Airlangga
Prof. Dr. Nuning Nuraini	Institut Teknologi Bandung
Dr. Dipo Aldilla	Universitas Indonesia
Dr. Hasan Panigoro	Universitas Negeri Gorontalo

Speakers

Keynote Speakers

Prof. Edy Soewono

Institut Teknologi Bandung
Keynote Speaker

Prof. Nuning Nuraini

Institut Teknologi Bandung
Keynote Speaker

Prof. Folashade B. Agosto

University of Kansas
Keynote Speaker

Prof. Sanjeewa Perera

University of Colombo
Keynote Speaker

Prof. Mehmet Yavuz

Kyrgyz-Turkish Manas University
Keynote Speaker

Dr. Bimandra Djaafara

National University of Singapore
Keynote Speaker

Invited Speakers

Prof. Abadi

Universitas Negeri Surabaya
Invited Speaker

Dr. Dipo Aldilla

Universitas Indonesia
Invited Speaker

Prof. Agus Suryanto

Universitas Brawijaya
Invited Speaker

Dr. Hasan Panigoro

Universitas Negeri Gorontalo
Invited Speaker

Prof. Asep Supriatna

Universitas Padjadjaran
Invited Speaker

Dr. Windarto

Universitas Airlangga
Invited Speaker

Prof. Fajar Adi Kusumo

Universitas Gadjah Mada
Invited Speaker

**dr. Abdi Dzul Ikram Hasanuddin,
M.Biomed.**

Universitas Negeri Gorontalo
Invited Speaker

Dr. Chidozie W. Chukwu

Georgia Southern University
Invited Speaker

Scientific Program

Main Schedule of SYMOMATH 2026

Monday, 7 September 2026

Time	Activity
07.00–08.00	Registration + coffee break
08.00–08.50	Opening talk
08.50–09.00	Photo session
09.01–09.40	Keynote talk 1: Prof. Sanjeewa Perera Title: From Geometry to Clinic: Topological Signatures of Retinal Vascular Collapse Moderator : Prof. Dr. Dipo Aldilla, S.Si., M.Si.
09.40–10.20	Keynote talk 2: Prof. Folashade B. Augusto Title: Burning Landscapes, Shifting Risk: Differential Effects of Prescribed Fire on Tick-Borne Tularemia Moderator : Prof. Dr. Dipo Aldilla, S.Si., M.Si.
10.20–11.00	Keynote talk 3: Prof. Nuning Nuraini Title: Reading the Climate, Predicting the Outbreak: A Deterministic–Bayesian Early Warning System for Dengue in West Java Moderator : Isran K. Hasan, M.Si
11.00–11.40	Keynote talk 4: Prof. Edy Soewono Title: A Fragile Balance of Stable Coexistence within Tarsier Population Moderator : Dr. Hasan Panigoro, M.Si
11.40–12.30	Lunch Break
12.30–13.10	Keynote talk 5: Dr. Bimandra Djaafara Title: Serocatalytic Models for Infectious Disease Control in Indonesia: Turning Mixed Data Sources into Actionable Understanding Moderator : Dr. Hasan Panigoro, M.Si
13.10–13.50	Keynote talk 6: Prof. Mehmet Yavuz

Title: Serocatalytic Models for Infectious Disease Control in Indonesia: Turning Mixed Data Sources into Actionable Understanding

Moderator : Dr. Hasan Panigoro, M.Si

13.50–15.20	Invited talk
15.00–15.30	Coffee break
15.30–17.15	Parallel Session
17.15–17.45	Closing
17.45	End of 1st day activity.

Tuesday, 8 September 2026

Time	Activity
06.00–07.00	Go to Hiu Paus Sherly – Meeting point in Lobby Damhil
07.00–12.00	Activity in Hiu Paus Sherly
12.00–13.00	Lunch Break

Parallel Schedule of SYMOMATH 2026

Monday, 7 September 2026

Room 201

Parallel Session 1 Onsite (13.50–15.20 WITA)

Moderator: Dr. Emli Rahmi, M.Si

Time	ID	Title	Authors
13.50– 14.20	Invited Speaker 01	Mathematical Analysis of Models of the Spread of Tuberculosis (TB) and Multi-Drug-Resistant Tuberculosis (MDR-TB) Incorporating Various Treatments	Prof. Dr. Abadi
14.20– 14.50	Invited Speaker 02	Threshold Dynamics of a Stochastic Hepatitis B Epidemic Model with Saturated Incidence Rate and Logarithmic Ornstein–Uhlenbeck Process	Prof. Dr. Agus Suryanto
14.50– 15.20	Invited Speaker 03	The Red Flower Assassin Bug (<i>Rhynocoris segmentarius</i>) as a Potential Natural Enemy for Fall Armyworm (<i>Spodoptera frugiperda</i>): A Mathematical Modeling using Atangana-Baleanu-Caputo Derivative	Dr. Hasan Panigoro, M.Si.

Parallel Session 2 Onsite (15.30–17.00 WITA)

Moderator: Dr. Lazarus Kalvein Beay

Time	ID	Title	Authors
15.30– 15.45	79102	Numerical Simulation of the Effects of Branch Diameter on Hemodynamics in a Stenosed Retinal Artery Bifurcation	Zhana Nur Asmi Qamar
15.45– 16.00	79105	Dynamics of Co-consumption Alcohol Model Considering Compartments of Rituals and Traditional Alcoholic Beverages	Dr. Lazarus Kalvein Beay
16.00– 16.15	79112	A Two-Dimensional Spatiotemporal Mathematical Model of Cancer-Immune Cell Interaction Incorporating Immune Cell Chemotactic Movement	Fitriana Yuli Saptaningtyas

16.15– 16.30	79115	Development of a Structured Screen-House-Based “Modern Nursery Model” to Improve the Quality and Uniformity of Patchouli Seedlings (<i>Pogostemon cablin</i>)	Prof. Dr. Arrijani, M.Si.
16.30– 16.45	79107	The Dynamics of Behavior and Bifurcation in a Three-Species Mangrove Competition-Allelopathy Model	Dr. Dian Savitri
16.45– 17.00	79108	Dynamics and Numerical Simulation of a Three-Population Mangrove-Microbe Mutualism Model	Riska Wahyu Romadhonia, M.Sc.

Parallel Schedule of SYMOMATH 2026

Monday, 7 September 2026

Room 202

Parallel Session 1 Onsite (13.50–15.20 WITA)

Moderator: Rudy Kusdiantara, Ph.D.

Time	ID	Title	Authors
13.50– 14.20	Invited Speaker 01	Allometric Fecundity under Climate-Induced Demographic Decay: An Adaptive Size-Structured Harvesting Framework	Prof. Dr. Asep Supriatna
14.20– 14.50	Invited Speaker 02	When Control Has Limits: Non-Smooth Dynamics of Dengue under Hospital Capacity and Reactive Fogging	Prof. Dr. Dipo Aldilla, S.Si., M.Si.

Parallel Session 2 Onsite (15.30–17.15 WITA)

Moderator: Dr. K.K.W. Hasitha Erandi

Time	ID	Title	Authors
15.30– 15.45	79101	A Hybrid Physics-Informed Neural Network Integrating SIR Dynamics and Delayed Rainfall Effects for Dengue Forecasting in Colombo City, Sri Lanka	Dr. K.K.W. Hasitha Erandi
15.45– 16.00	79110	Biostatistical Modeling of Morphometric and Phenotypic Diversity in Local Rice (<i>Oryza sativa</i> L.) Landraces from North Sulawesi, Indonesia: A Biomathematical Approach to Yield Trait Analysis	Dra. Fanny Nella Nanlohy, MP., DHET
16.00– 16.15	79111	Identification of Pest and Disease Symptoms in Dalugha Plants (<i>Cyrtosperma merkusii</i> (Hassk.) Schott) in Talaud Islands Regency, North Sulawesi Province	Dr. Jantje Ngangi
16.15– 16.30	79117	Effects of Fear-Response and Gestation Delays on a Harvested Tri-Trophic Food-Chain Model	Prof. Aldrin T. Balilo

16.30– 16.45	79119	A Mathematical Model of Municipal Solid Waste Management with Age-Structured Population and Three Waste Classifications	Riri Sadiana
16.45– 17.00	79109	A Time-Frequency Characterisation of Auditory Processing in Children with Autism Spectrum Disorder	Dr. K.K.W. Hasitha Erandi
17.00– 17.15	79103	Mathematical Modeling of Casson Fluid Hemodynamics in Central Retinal Vein Occlusion with Asymmetric Stenosis	Juan Randy Christian Putra

Parallel Schedule of SYMOMATH 2026

Monday, 7 September 2026

Room 203

Parallel Session 1 Onsite (13.50–15.20 WITA)

Moderator: Dr. Hasan Panigoro, M.Si

Time	ID	Title	Authors
13.50– 14.20	Invited Speaker 01	Bifurcation Analysis of a Delayed Tumor Therapy Model using Oncolytic Virus	Prof. Dr. Adi Fajar Kusumo
14.20– 14.50	Invited Speaker 02	Computational Modeling of Casson Fluid Flow in Atherosclerotic Coronary Arteries: Effects of Stenosis on Hemodynamic Parameters	Prof. Widodo
14.50– 15.20	Invited Speaker 03	Effect of Simvastatin to Bladder Senescence Activity in Protamine Sulfate-Induced Interstitial Cystitis Rat Model	dr. Abdi Dzul Ikram Hasanuddin, M.Biomed.

Parallel Session 2 Onsite (15.30–17.00 WITA)

Moderator: Rudy Kusdiantara, Ph.D

Time	ID	Title	Authors
15.30– 15.45	79113	A Two-Patch SEIR Model with Capacity-Regulated Mobility for Respiratory Disease Transmission	Putri Agriani Dumbela, M.Si
15.45– 16.00	79114	Integrating Multivariate Morphometric Analysis of Fruit Fly (<i>Drosophila</i> spp.) into a CURE-Based Genetics Curriculum: A Biostatistical Learning Model	Herry Maurits Sumampouw
16.00– 16.15	79116	Fractional Diffusion Reshapes Busse Balloons in an Evasion-Tipping Model of Dryland Vegetation	Rudy Kusdiantara, Ph.D
16.15– 16.30	79118	Mangrove Morphometric Design in Phanerogamae Learning to Enhance Students' Critical Thinking Skills	Femmy R Kawuwung

16.30– 16.45	79104	A hybrid stage-structured ODE and deep learning model for climate-driven dengue risk mapping	Diki Fernandi
16.45– 17.00	79106	Bayesian Spatial Survival Models for Deforestation in Indonesia: Cox Proportional Hazards and Accelerated Failure Time	Robyn Irawan

Parallel Schedule of SYMOMATH 2026

Monday, 7 September 2026

Room Zoom 201

Parallel Session 3 Online (15.30–17.15 WITA)

Moderator: Dr. Raqqasyi Rahmatullah Musafir, M.Mat

Time	ID	Title	Authors
15.30– 16.00	Invited Speaker 01	Computational Modeling of Casson Fluid Flow in Atherosclerotic Coronary Arteries: Effects of Stenosis on Hemodynamic Parameters	Prof. Drs. Basuki Widodo, M.Sc., Ph.D.
16.00– 16.15	79201	How the Pulse Shape Affects the Network Dynamics of Spiking Neurons	Afifurrahman
16.15– 16.30	79204	An Explainable ResNet50–MLP Framework for Multi-Class Breast Cancer Classification	Thoriq Al Mahdi
16.30– 16.45	79212	A Comparative Study on Parameter Estimation via PSO and GA in a Discrete-Time Monkeypox Transmission Model	Dr. Raqqasyi Rahmatullah Musafir, M.Mat
16.45– 17.00	79217	Optimal Control of Digital Literacy Interventions in a Dynamical Model of Social Media Addiction	Mohamad Alfarezi Udingan
17.00– 17.15	79213	Multilevel Bayesian Spatial Structural Panel VARX for Spatio-Temporal Data	Ani Budi Astuti

Parallel Schedule of SYMOMATH 2026

Monday, 7 September 2026

Room Zoom 202

Parallel Session 3 Online (15.30–17.30 WITA)

Moderator: Dr. Maya Rayungsari, M.Si.

Time	ID	Title	Authors
15.30– 16.00	Invited speaker	Effect of Simvastatin to Bladder Senescence Activity in Protamin Sulfate-Induced Interstitial Cystitis Rat Model	dr. Abdi Dzul Ikram Hasanuddin, M.Biomed.
16.00– 16.15	79202	Comparative Analysis of the Improved 5th-Order Runge-Kutta and 4th-Order Adams-Bashforth Methods for a Chlorophyll-a and Fish Population Interaction Model with the Weak Allee Effect	Dr. Muhammad Ikhwan, M.Si.
16.15– 16.30	79205	Bifurcation Analysis and Sustainable Harvesting in a Two-Prey, One-Predator Coral Reef Fishery Model	Setiya Triharyuni
16.30– 16.45	79208	Dynamic Analysis of Predator-Prey Models with Anti-Predator and Additional Food Using Holling Type III Response Function	An Nisa Salsabila, S.Mat.
16.45– 17.00	79209	Bistability, Recovery Threshold, and Saddle-Node Bifurcation in a Two-Stage Coral Dynamics Model with Restoration	Dr. Maya Rayungsari, M.Si.
17.00– 17.15	79210	Spatial and Mathematical Modeling of Pasang ri Kajang Ecotheology for Customary Forest Biomass Resilience	Zulfiqar Busrah, M.Si.
17.15– 17.30	79215	Role of Refugia Plants and Pathogen Infection in Integrated Pest Management: A Fractional-Order Modeling Approach	Muhammad Luthfi

Parallel Schedule of SYMOMATH 2026

Monday, 7 September 2026

Room Zoom 203

Parallel Session 3 Online (15.30–17.30 WITA)

Moderator: Muhammad Rifki Nisardi, S.Si., M.Si.

Time	ID	Title	Authors
15.30– 16.00	Invited speaker	Can the Key Drivers of Malaria Transmission Be Controlled? A Case Study of Indonesia	Dr. Chidozie W. Chukwu
16.00– 16.15	79203	Exploration of Time Derivative Method, CUSUM and EWMA Control Chart to Determine The Onset of Influenza Outbreak in The Epidemic Forest Model	Dr. Yuki Novia Nasution, S.Si, M.Sc
16.15– 16.30	79206	Survival Modeling of Athlete Injury Hazard for Fair Takaful Micro-Insurance Pricing	Silvina Rosita Yulianti
16.30– 16.45	79207	Competing Risk Analysis of Non-Small Cell Lung Cancer Patients with Brain Metastases	Muhammad Bayu Nirwana, S.Si., M.Sc.
16.45– 17.00	79216	Stability Analysis of TB and MDR TB Transmission Dynamics with Vaccination and Treatment	Ainishafa, S.Mat
17.00– 17.15	79214	Mathematical Model of Meningitis Transmission using Fractional Caputo Derivatives	Muhammad Rifki Nisardi, S.Si., M.Si.
17.15– 17.30	79211	Modeling Syphilis Transmission with Two-Time Delay and Heterogeneous Risk Behavior	Raiba Afreen Chowdhury

Keynote Speaker Abstracts

K-01

Keynote Speaker

From Geometry to Clinic: Topological Signatures of Retinal Vascular Collapse

Sanjeewa Perera¹

¹Centre for Mathematical Modeling, Department of Mathematics, University of Colombo, Sri Lanka

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Theme : Mathematical Foundations in Medical and Clinical Sciences

Abstract.

Diabetic retinopathy (DR) remains a major cause of preventable blindness, yet timely diagnosis is often delayed due to a global shortage of trained retinal specialists and subjective interpretation of fundus images. There is a pressing need for automated, interpretable tools that can accelerate and standardize screening. This work introduces a mathematically grounded biomarker pipeline that captures the geometric organization of the retinal vascular network using Topological Data Analysis (TDA). We combine a segmentation pipeline for vessels and hemorrhages with persistent homology, tracking connected components (H_0) and enclosed loops (H_1) across a signed-distance filtration. From the resulting persistence diagrams, we extract a 15-feature descriptor bank encoding vascular fragmentation, lesion-like structures, and network disorder. Statistical analysis reveals that DR fundamentally alters vascular topology, with fragmentation measures, particularly total and mean H_0 persistence, emerging as the strongest discriminators between healthy and DR retinas. A compact, non-redundant four-feature set cleanly separates the two groups. The final goal of this work is to develop an AI-driven diagnostic framework that integrates these topological features with machine learning classifiers, enabling robust, interpretable, and scalable DR detection to bridge the expertise gap in resource-limited settings.

Keywords: Persistent homology; Topological Data Analysis; diabetic retinopathy; interpretable AI biomarkers

K-02

Keynote Speaker

Burning Landscapes, Shifting Risk: Differential Effects of Prescribed Fire on Tick-Borne Tularemia

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Theme : Epidemiology and Infectious Disease Modeling

Abstract.

Tularemia is a zoonotic disease caused by *Francisella tularensis* bacteria, a gram-negative coccobacillus-shaped bacterium. There are multiple transmission routes of the infection to humans such as consumption of contaminated food or water, handling of infected animals or bites from haematophagous arthropods (such as ticks, deer flies, or mosquitoes). In this study we focused on transmission via the bites of ticks and developed a deterministic model of ordinary and impulsive differential equations to gain insight in the differential effect of prescribed fire on *Demacenta variabilis* and *Amblyomma americanum* ticks and the prevalence of tularemia. We found that prescribed fire differentially reduces the number of the two ticks with *A. americanum* reduced the least compared to *D. variabilis* subsequently leading to differential increase of tularemia new infected cases in humans and rodents. Our result further indicates that the spatial arrangement of burn against unburn areas matters for humans and *D. variabilis* but not for rodents and *A. americanum* which had more infection in unburn areas compared to burn areas when prescribed fire was implemented. The results of this study provide important new understandings of the intricate effect of prescribed fire on tick species, and the dynamics of the tick-borne disease.

Keywords: Prescribed fire; tick-borne disease; tularemia

K-03

Keynote Speaker

Reading the Climate, Predicting the Outbreak: A Deterministic–Bayesian Early Warning System for Dengue in West Java

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Theme : Epidemiology and Infectious Disease Modeling

Abstract.

Dengue Fever (DF) remains a major public health challenge in densely populated regions such as West Java, Indonesia, where the mosquito-borne vector *Aedes aegypti* thrives under favorable climatic conditions. Because the vector's life cycle is highly sensitive to environmental variables, climate information offers a powerful lens for understanding and anticipating disease dynamics. This study develops an Early Warning System (EWS) for DF that combines deterministic and probabilistic modeling approaches. The deterministic component estimates *Aedes aegypti* density by integrating local climatic factors (temperature, humidity, and rainfall), the global climate phenomenon represented by the Oceanic Niño Index (ONI), and spatial characteristics of the region. Building on this, a Bayesian probabilistic model forecasts the expected number of DF cases across West Java. As an applied contribution, the study translates these models into vector risk maps and incidence risk maps, each classified into three alert levels — Safe, Alert, and Warning — to support public health authorities in implementing timely, climate-informed prevention and control policies. Results show that incorporating climate data and ONI substantially improves the accuracy of case-level predictions, while further analysis reveals a significant correlation between dengue incidence and factors such as urban density and slum conditions. Together, these findings demonstrate the potential of climate-integrated modeling to strengthen dengue surveillance and guide targeted interventions in high-risk areas.

Keywords: Dengue Fever; Early Warning System; climate variability; spatial risk mapping; Bayesian framework

K-04

Keynote Speaker

A Fragile Balance of Stable Coexistence within Tarsier Population

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Theme : Ecological Systems and Environmental Modeling

Abstract.

Spectral tarsiers are endemic mammals of Sulawesi and are currently classified as Vulnerable (VU) on the IUCN Red List. Of the 13 recognized tarsier species in Indonesia, 12 occur in Sulawesi and its surrounding islands, including *Tarsius supriatnai*, which is found in Gorontalo. Tarsiers are small, nocturnal primates with large eyes, elongated fingers, long tails, and powerful hindlimbs adapted for jumping. Their mating systems exhibit variation, including both monogamous and polygynous social structures. In this study, we develop a predator-prey mathematical model that incorporates gender dynamics and an Allee effect to represent how the male-to-female ratio influences population growth and persistence. The model investigates the conditions required for stable coexistence between the tarsier population and its predators. Sensitivity analyses are conducted to examine the effects of gender ratio, land degradation, predation rate, and the functional characteristics of predation on the system dynamics. The results indicate that these ecological and demographic factors play important roles in determining the conditions for stable coexistence and, consequently, may influence the long-term persistence of tarsier populations. These findings highlight the importance of considering both demographic structure and ecological pressures to understand and support the conservation of vulnerable tarsier populations.

Keywords: Tarsier population; predator-prey model; gender dynamics; Allee effect; stable coexistence; conservation

K-05

Keynote Speaker

Serocatalytic Models for Infectious Disease Control in Indonesia: Turning Mixed Data Sources into Actionable Understanding

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Theme : Epidemiology and Infectious Disease Modeling

Abstract.

Infectious disease models are most useful when they work with the data that are actually available and produce outputs that decision-makers can act on. In this talk, I reflect on experiences collaborating with Indonesia's Ministry of Health and provincial health office, and illustrate how catalytic models, a class of mathematical models that estimate the force of infection from age-structured data, can integrate diverse data sources to generate epidemiological insight to inform policy. I introduce the catalytic model framework and describe how we have extended it to accommodate Indonesia's heterogeneous data landscape. For dengue, I present a Bayesian hierarchical model that jointly fits age-stratified case data, aggregated case data, and seroprevalence surveys across 128 districts in Java and Bali, revealing that many high-transmission districts are missed by conventional incidence-based rankings, with implications for vaccine deployment. For measles, I describe how a similar approach integrating routine vaccination data, coverage surveys, seroprevalence data, and reported cases can support the planning of supplementary immunisation activities. Throughout, I discuss the practical challenges of producing model-based evidence that is relevant and useful to decision-makers in low- and middle-income settings.

Keywords: Serocatalytic models; infectious disease control; Bayesian hierarchical model; seroprevalence; dengue; measles

K-06

Keynote Speaker

Modeling Biological Complexity Through Data, Dynamics, and Fractional Calculus

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Theme : Systems Biology and Computational Bioinformatics

Abstract.

Mathematical models play a crucial role in modern biology by providing a rigorous framework for understanding complex processes that cannot be fully explained through experiments alone. Biological systems exhibit rich dynamical behavior driven by nonlinear interactions, multiscale structures, and memory effects. Understanding such phenomena requires mathematical frameworks that effectively integrate real-world data with advanced modeling approaches. This talk presents a broad perspective on modeling biological complexity through data, dynamical systems, and fractional calculus, emphasizing the role of mathematical models in describing and interpreting biological phenomena. Particular attention is given to memory effects and their mathematical representation through fractional calculus and related operators. By connecting empirical observations with mathematical models, we demonstrate how data-guided approaches can improve the representation, prediction, and interpretation of complex biological behavior. The talk also highlights a general pathway from real-world data to meaningful mathematical formulations, providing insights into the development of robust models for biological systems and their potential applications in the life sciences.

Keywords: Biological complexity; mathematical modeling; dynamical systems; fractional calculus; memory effects; data-guided modeling

Invited Speaker Abstracts

I-01

Invited Speaker

Mathematical Analysis of Models of the Spread of Tuberculosis (TB) and Multi-Drug-Resistant Tuberculosis (MDR-TB) Incorporating Various Treatments

Abadi^{1,*}¹Mathematics Department, Universitas Negeri Surabaya, Surabaya, Indonesia*)Corresponding author: abadi@unesa.ac.id**Theme** : Epidemiology and Infectious Disease Modeling

Abstract.

This study introduces a comprehensive global asymptotic stability analysis and explicit closed-form sensitivity indices for an $SVEI_{ers}R$ model. The model incorporates BCG vaccination with waning immunity, latent infection, drug-sensitive active infection, MDR-TB development, and a two-line treatment framework (Anti-TB Treatment and BPALM Regimen). The analysis started with the calculation of Disease-Free Equilibrium (DFE) to determine the basic reproduction number (R_0), the primary threshold governing disease dynamics. Global asymptotic stability (GAS) of DFE was established on the feasible region Ω when $R_0 \leq 1$. Conversely, when $R_0 > 1$, the Endemic Equilibrium (EE) was proven to be globally asymptotically stable in the interior of Ω . Even though sensitivity analysis revealed that parameters vaccination coverage (ξ) and first-line treatment (γ) exert strong impact to the spread of the disease; increasing those values is not sufficient to eliminate the spread of the disease. Subsequent numerical simulation showed that considering the second line treatment ($\delta \neq 0$) can reduce the value of R_0 . Therefore, public health strategy must combine at least all four major intervention (early case detection, vaccination coverage, first and second line treatment) in order to eliminate the disease completely.

Keywords: Tuberculosis; MDR-TB; stability; basic reproduction number; sensitivity analysis; BPALM regimen

I-02

Invited Speaker

Threshold Dynamics of a Stochastic Hepatitis B Epidemic Model with Saturated Incidence Rate and Logarithmic Ornstein-Uhlenbeck Process

Agus Suryanto^{1,*}, Wuryansari Muharini Kusumawinahyu¹, Nur Shofianah¹,
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Theme : Epidemiology and Infectious Disease Modeling

Abstract.

In this research, we study a stochastic susceptible-infected-recovered (SIR) model that describes the spread of the hepatitis B virus, utilizing a saturated incidence rate. The constant incidence rate is perturbed by a logarithmic Ornstein-Uhlenbeck (OU) process. This stochastic perturbation is integrated into the model to provide a more accurate depiction of the complex and unpredictable dynamics of disease transmission. For the considered stochastic model, we show the existence of a positive solution by constructing a suitable Lyapunov function. We establish a threshold dynamic $\mathcal{R}$ and demonstrate that the extinction and persistence of the disease are determined by this threshold. In particular, we establish the existence of a stationary distribution when the disease remains persistent. Additionally, we derive the exact form of the probability density function for the stochastic model near the quasi-endemic equilibrium point. Lastly, we perform numerical simulations to highlight these analytical results.

Keywords: Stochastic epidemic model; hepatitis B disease model; epidemic threshold parameter; stationary solution; probability density function

I-03

Invited Speaker

Allometric Fecundity under Climate-Induced Demographic Decay: An Adaptive Size-Structured Harvesting Framework

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Theme : Sustainable Industrial Utilization of Renewable Resources

Abstract.

Slow-growing trees, like *Diospyros celebica*, are particularly vulnerable to persistent environmental deterioration. In this work we derive an allometric fecundity function under climate-induced demographic decay. The proposed model synthesis combines size-dependent fecundity, temporal environmental modulation, and biomass-mediated density dependence. The formulation recovers reproduction proportional to basal area as the classical case ($\alpha = 2$), while permitting more general empirical size-fecundity scaling; $\alpha = 2.5$ is adopted as a representative baseline value for the numerical experiments. The resulting fecundity function is embedded in a nonlinear, time-varying Lefkovitch model describing five DBH classes of a harvested *Diospyros* population, with climate-induced demographic decay affecting growth, survival, and reproduction. Elasticity and reproductive-value analyses identify mature and large-canopy trees as demographically influential components of the population, providing a mechanistic basis for size-selective harvesting. Numerical simulations show that a rigid harvesting regime characterized by relatively short cutting rotations and intensive removal of large trees can lead to progressive depletion and eventual population collapse under persistent demographic decay. In contrast, reducing harvesting pressure on demographically sensitive size classes and extending the recovery interval yields an adapted harvesting strategy that maintains a viable population size structure over the simulated horizon while retaining positive timber yield. These results show that coupling allometric fecundity with climate-induced demographic decay and size structure provides a quantitative basis for identifying harvesting strategies capable of preventing demographic collapse in slow-growing tree populations.

Keywords: Sustainable use of renewable resources; slow-growing trees; harvesting framework; climate-induced demographic decay

I-04

Invited Speaker

When Control Has Limits: Non-Smooth Dynamics of Dengue under Hospital Capacity and Reactive Fogging

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Theme : Epidemiology and Infectious Disease Modeling

Abstract.

Dengue continues to cause recurrent outbreaks in many tropical countries, highlighting the limitations of current control strategies. In practice, two commonly used interventions—fogging and hospitalization—are constrained by limited resources and operational thresholds, yet these features are often simplified or ignored in mathematical models. In this talk, we present a non-smooth ordinary differential equation model that incorporates finite hospital capacity together with threshold-triggered fogging. The framework captures three intervention regimes: no fogging with full hospitalization at low infection levels, activated fogging with full hospitalization after a prescribed threshold is reached, and fogging with partial hospitalization once hospital capacity is exceeded. Our analysis shows that these switching mechanisms generate rich dynamical behavior. In addition to disease-free and endemic equilibria, numerical continuation reveals boundary-equilibrium bifurcations at the intervention thresholds, a Hopf bifurcation associated with hospital-capacity exceedance, and sustained periodic outbreaks. A fold bifurcation near the epidemic threshold also produces additional unstable equilibria, indicating that the disease dynamics may be more complex than suggested by standard threshold conditions alone. By continuing the periodic solutions with respect to the fogging rate and activation threshold, we further identify intervention levels that reduce outbreak peaks and asymptomatic infections without unnecessarily increasing control effort. These findings emphasize that hospital capacity, fogging intensity, and the timing of intervention must be considered jointly when designing reactive dengue control policies.

Keywords: Dengue; hospital capacity; fogging; non-smooth dynamics; Hopf bifurcation

I-05

Invited Speaker

Bifurcation Analysis of a Delayed Tumor Therapy Model using Oncolytic Virus

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Theme : Mathematical Foundations in Medical and Clinical Sciences

Abstract.

We consider the dynamics of a tumor therapy model using oncolytic viruses with time delay. The model is a two-dimensional system of ordinary differential equations with a delay term that represents the latent period required for viral replication following the infection of tumor cells. Our study starts with the derivation of the positive equilibrium point and analyzes its local stability in both the absence and presence of delay terms. Subsequently, by using Pontryagin's criterion, we establish the necessary and sufficient conditions for the asymptotic stability of the equilibrium point under the delay term. The numerical bifurcation analysis identifies a transcritical bifurcation in the non-delayed case, whereas the analytical analysis reveals a Hopf bifurcation in the delayed case, leading to sustained oscillations in the tumor cell population. These results suggest that the success of the virotherapy is sensitive to the delay effects. It implies that we need to consider time-dependent dynamics to determine effective treatment strategies.

Keywords: Oncolytic virotherapy; delay differential equations; Pontryagin criterion; bifurcation analysis

I-06

Invited Speaker

Credit Risk Spread: A Mathematical Model

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Theme : Mathematical Foundations in Medical and Clinical Sciences

Abstract.

Credit is the provision of money or an equivalent claim, based on an agreement between a bank and another party, that obligates the borrower to repay the debt with interest after a specific period. In this talk we discuss a mathematical model of credit risk spread. The model consists of four compartments, namely the susceptible population, the population experiencing non-performing loans, the population under treatment, and the population recovered or free from non-performing loans. The basic reproduction number (R_0) is derived using the Next Generation Matrix method and serves as a threshold parameter for the system dynamics. The analysis indicates that the credit risk-free equilibrium point is locally and globally asymptotically stable when $R_0 < 1$, while the credit risk equilibrium exists and is locally stable when $R_0 > 1$. Sensitivity analysis shows that the rates at which people move from the healthy population to those with non-performing loans, and from those with non-performing loans to those receiving treatment, are the most important factors affecting R_0 and the number of non-performing loans, underscoring their key roles in credit risk dynamics. Furthermore, we apply the Pontryagin Maximum Principle to identify optimal control strategies through macroprudential policy and easy monetary policy interventions. The simulation results indicate that the simultaneous implementation of both control measures is the most effective strategy for reducing the population experiencing non-performing loans while maintaining a lower total cost.

Keywords: Credit risk; macroprudential policy; mathematical model; dual regulation; optimal control

I-07

Invited Speaker

Can the Key Drivers of Malaria Transmission Be Controlled? A Case Study of Indonesia

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Theme : Epidemiology and Infectious Disease Modeling

Abstract.

This talk presents a mathematical model of malaria transmission dynamics that incorporates recurrent phenomena, including relapse, reinfection, and recrudescence, as well as limited hospital bed capacity through a saturated treatment function. The model's qualitative behavior is rigorously analyzed, including the malaria-free and endemic equilibria, the basic reproduction number, and stability. The analysis reveals the possibility of multiple endemic equilibria when the basic reproduction number is either greater or less than one. Interestingly, a higher probability of recrudescence (treatment failure) does not necessarily lead to backward bifurcation. The model is calibrated using malaria incidence data from West Sumba, Indonesia. Global sensitivity analysis identifies human and mosquito infection rates as key drivers of new infections. Optimal control and cost-effectiveness analyses of bed net use, hospitalization, and fumigation suggest that hospitalization is the most cost-effective strategy among the interventions considered for controlling malaria transmission.

Keywords: Malaria transmission; relapse; reinfection; recrudescence; hospital bed capacity; optimal control; cost-effectiveness

I-08

Invited Speaker

The Red Flower Assassin Bug (*Rhynocoris segmentarius*) as a Potential Natural Enemy for Fall Armyworm (*Spodoptera frugiperda*): A Mathematical Modeling using Atangana-Baleanu-Caputo Derivative

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Theme : Ecological Systems and Environmental Modeling

Abstract.

This study presents a novel fractional-order pest-predator mathematical model utilizing the Atangana-Baleanu-Caputo (ABC) derivative to investigate the multi-trophic interactions and population dynamics between the invasive Fall Armyworm (*Spodoptera frugiperda*) and its native biological control agent, the Red Flower Assassin Bug (*Rhynocoris segmentarius*). By incorporating non-singular and non-local kernels based on the generalized Mittag-Leffler function, the fractional-order system effectively captures the memory effects and hereditary properties inherent in complex agricultural ecosystems. The formulation accounts for the multi-stage life cycles of both insects—specifically the holometabolous stages of the pest (egg, larva, pupa, adult) and the hemimetabolous stages of the predator (egg, nymph, adult)—coupled with a saturated Holling type-II functional response. Analytical evaluations rigorously demonstrate the existence, uniqueness, non-negativity, and positive invariance of the solutions. Furthermore, two feasible equilibria are successfully identified as well as their asymptotic stability using a Lyapunov function. Global sensitivity analysis using Partial Rank Correlation Coefficients (PRCC) reveals that the pest's egg-laying rate and the predator's conversion rate of predation are the most influential parameters driving their respective populations. Finally, numerical simulations executed via the generalized Adams–Bashforth–Moulton scheme illustrate the predation processes and show that a decrease in the fractional derivative order, reflecting a stronger memory effect, significantly decelerates the convergence of population trajectories toward equilibrium points.

Keywords: *Spodoptera frugiperda*; *Rhynocoris segmentarius*; Atangana-Baleanu-Caputo fractional derivative; pest-predator model; stability analysis; numerical simulation

I-09

Invited Speaker

Effect of Simvastatin to Bladder Senescence Activity in Protamine Sulfate-Induced Interstitial Cystitis Rat Model

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Theme : Mathematical Foundations in Medical and Clinical Sciences

Abstract.

Interstitial cystitis (IC) is a chronic inflammatory bladder condition linked to statins, though mechanisms remain unclear. Cellular senescence may drive this inflammation. Thirty-seven female Wistar rats received simvastatin 10 mg/kg ($n = 12$), 50 mg/kg ($n = 13$), or 0.5% CMC vehicle ($n = 12$) orally for 30 days, then subdivided into control, IC day-0, and IC day-3. IC was induced via intravesical protamine sulfate (PS); controls received saline. Bladders were harvested < 3 h (controls/day-0) or 3 days post-induction (day-3). GLB1 expression was quantified immunohistochemically in urothelial, suburothelial, and detrusor layers. In the control group, no treatment had significant differences in GLB1 expression in the urothelial, suburothelial, and detrusor muscle layers. In the IC day-0 group, simvastatin 10 mg/kg BW, simvastatin 50 mg/kg BW, or CMC 0.5% treatment had no significant differences in GLB1 expression in the urothelial and detrusor muscle layers, but showed a significant difference in the suburothelial layer ($p = 0.016$). In the IC day-3 group, there were no significant differences in GLB1 expression in the urothelial, suburothelial, and detrusor muscle layers according to all treatments. Interestingly, GLB1 expression in the suburothelial layer significantly increased after initial exposure to protamine sulfate, except for the simvastatin 10 mg/kg treatment. In addition, only the simvastatin 50 mg/kg treatment group showed a significant decrease in GLB1 expression in the suburothelial layer three days after protamine sulfate exposure. We conclude that suburothelial senescence may be related to the pathogenesis of interstitial cystitis, while high-dose simvastatin may increase the apoptotic activity of suburothelial senescent cells in the bladder.

Keywords: Animals; cystitis; hydroxymethylglutaryl-CoA reductase inhibitors; immunohistochemistry; urinary bladder

I-10

Invited Speaker

Computational Modeling of Casson Fluid Flow in Atherosclerotic Coronary Arteries: Effects of Stenosis on Hemodynamic Parameters

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Theme : Mathematical Foundations in Medical and Clinical Sciences

Abstract.

Atherosclerotic stenosis in coronary arteries alters the characteristics of blood flow and may induce significant changes in local hemodynamic conditions. Considering the non-Newtonian behavior of blood, this study develops a computational model based on the Casson fluid to investigate blood flow through stenosed coronary arteries. The governing equations are formulated from the conservation of mass and momentum for an incompressible, steady, laminar, and axisymmetric flow. The stenotic geometry is incorporated to represent the narrowing of the coronary artery, while the Casson constitutive relation is employed to characterize the non-Newtonian rheological behavior of blood. The governing equations are discretized using the finite volume method and implemented computationally in MATLAB. Numerical simulations are performed to investigate the axial velocity profile under variations in stenosis severity and selected hemodynamic parameters. The simulation results show that the velocity distribution is strongly influenced by the degree of arterial narrowing, with the velocity profile becoming increasingly concentrated in the stenotic region as stenosis severity increases. Variations in the hemodynamic and rheological parameters also modify the velocity magnitude and spatial distribution, indicating their important role in determining the flow characteristics of Casson blood. In particular, the acceleration of flow through the stenotic throat is accompanied by substantial changes in the velocity gradient near the arterial wall, which is associated with altered wall shear stress. These numerical findings demonstrate that the proposed MATLAB-based computational framework can effectively characterize the relationship between stenosis severity, blood rheology, and hemodynamic behavior. The model provides a mathematical basis for further investigation of abnormal blood-flow characteristics associated with atherosclerotic coronary arteries.

Keywords: Casson fluid; coronary artery; atherosclerosis; hemodynamic parameters; finite volume method

Oral Presenter Abstracts

O-01 [79117]

Oral Presenter

Effects of Fear-Response and Gestation Delays on a Harvested Tri-Trophic Food-Chain Model

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Theme : Mathematical Ecology

Abstract.

In this paper, we investigated a delayed tri-trophic food-chain model involving a basal prey, an intermediate predator, and a top predator, incorporating fear effects, species-specific harvesting, and a non-monotonic functional response. The model included two biologically distinct delays: a fear-response delay in the growth of the basal prey caused by the perceived presence of the intermediate predator and a gestation delay in the recruitment of the top predator. The interaction between the basal prey and intermediate predator was represented by a non-monotonic functional response, while the predation of the intermediate predator by the top predator followed a saturating response. Linear harvesting terms were imposed separately on the three species. Conditions for the existence of the trivial, boundary, and positive coexistence equilibria were established, and local stability criteria were derived for the model without delay. The analysis showed that the positive coexistence equilibrium was locally asymptotically stable under appropriate restrictions on the interaction and harvesting parameters and became unstable when these conditions were violated. Critical values for the fear-response and gestation delays were obtained, at which the coexistence equilibrium lost stability through Hopf bifurcation and periodic oscillations emerged. The results demonstrated that the two delays destabilized the system through different trophic mechanisms. Species-specific harvesting significantly affected coexistence by modifying equilibrium population densities and shifting the critical delay thresholds. Moderate harvesting stabilized the system in selected parameter regions, whereas excessive harvesting reduced the feasibility of coexistence and caused some equilibria to become unstable. Numerical simulations and bifurcation diagrams confirmed the analytical results and illustrated stability switching under different harvesting conditions.

Keywords: Tri-trophic food chain; fear effect; species-specific harvesting; non-monotonic functional response; Hopf bifurcation

O-02 [79101]

Oral Presenter

A Hybrid Physics-Informed Neural Network Integrating SIR Dynamics and Delayed Rainfall Effects for Dengue Forecasting in Colombo City, Sri Lanka

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Theme : Mathematical Epidemiology and Machine Learning

Abstract.

Dengue remains one of the most prevalent mosquito-borne diseases and constitutes a persistent public health challenge in Sri Lanka, with the Colombo Municipal Council (CMC) area being particularly vulnerable. Accurate and timely outbreak forecasting is pivotal for implementing effective disease prevention and control strategies. While conventional epidemiological models often struggle to capture the complex, nonlinear dynamics inherent in dengue transmission, machine learning approaches have demonstrated considerable promise in enhancing predictive performance. To overcome the limitations of traditional methods, this study introduces a hybrid Physics-Informed Neural Network (PINN) framework that synergistically integrates machine learning with a reduced two-dimensional Susceptible-Infected-Recovered (SIR) epidemiological model. Weekly dengue surveillance data from 2008 to 2024 were obtained from the Epidemiology Unit, Ministry of Health, Sri Lanka, and daily rainfall data for the same period were obtained from the NASA POWER database. The proposed framework uses historical dengue cases and rainfall as input variables, demonstrating that reliable dengue forecasting can be achieved using a set of readily available data. To optimize model training, the weekly case reports were transformed into daily estimates through a two-step preprocessing pipeline employing Piecewise Cubic Hermite Interpolating Polynomial (PCHIP) interpolation, followed by a Gamma distribution-based method. Recognizing that rainfall does not exert an immediate effect on dengue incidence but rather influences mosquito breeding and population dynamics with a temporal delay, lag periods between 8 and 12 weeks were incorporated into the analytical framework. Critically, instead of relying on a predetermined fixed lag, the PINN is designed to autonomously learn the most influential delayed effects of rainfall on transmission dynamics. The governing equations of the reduced SIR model are embedded within the neural network's loss function as physics-informed constraints, thereby ensuring that all forecasts remain bio-

logically consistent and plausible. Unlike conventional black-box machine learning models, the proposed framework not only delivers accurate predictive outputs but also offers biologically interpretable insights through the estimation of time-varying per capita vector density. The model attained a forecasting accuracy of 83.10%, demonstrating that the integration of mechanistic epidemiological knowledge with data-driven machine learning constitutes an effective and interpretable strategy for dengue forecasting, thereby facilitating early and informed public health decision-making.

Keywords: Dengue forecasting; Physics-Informed Neural Networks (PINNs); dynamic rainfall lag; SIR epidemiological model

O-03 [79102]

Oral Presenter

Numerical Simulation of Branch Diameter Effects on Hemodynamics in Stenosed Retinal Artery Bifurcation

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Theme : Mathematical Foundations in Medical and Clinical Sciences

Abstract.

Retinal artery stenosis can cause central retinal artery occlusion (CRAO) and branch retinal artery occlusion (BRAO), resulting in severe visual impairment and permanent vision loss. In retinal artery bifurcations, branch diameter plays a crucial role in blood flow distribution and local hemodynamics, potentially amplifying the effects of stenosis on retinal perfusion. Therefore, this study investigated the influence of branch diameter on hemodynamic properties in stenotic retinal artery bifurcations through mathematical modeling and numerical simulation. Blood flow was modeled as an incompressible, laminar, and unsteady-state Casson fluid with constant effective viscosity, governed by the conservation equations of mass, momentum, and energy in cylindrical coordinates under axisymmetric assumptions. Numerical solutions were obtained using the finite volume method with the Semi-Implicit Method for Pressure-Linked Equations Revised (SIMPLER) algorithm. Simulations of different branch diameters under symmetric stenosis conditions were performed to evaluate the velocity, pressure, and temperature distributions. The results showed that decreasing branch diameter increased flow velocity, pressure drop, and temperature due to reduced flow area, resulting in more pronounced hemodynamic changes. These findings suggest that branch diameter significantly affects blood flow in stenosed retinal artery bifurcations and may contribute to impaired retinal perfusion and oxygen delivery.

Keywords: Finite Volume Method; multiple stenosis; numerical simulation; SIMPLER; retinal artery bifurcation

O-04 [79101]

Oral Presenter

A Time-Frequency Characterisation of Auditory Processing in Children with Autism Spectrum Disorder

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Theme : Mathematical Foundations in Medical and Clinical Sciences

Abstract.

This research investigated auditory processing variances between children diagnosed with Autism Spectrum Disorder (ASD) and those who are normally developing (TD). Auditory processing difficulties in children with ASD might hinder communication and social growth. Magnetoencephalography (MEG) was employed to assess cerebral activity with exceptional precision and without invasiveness. Source-localized MEG responses were examined over five frequency bands, two hemispheres, and ten peri-auditory cerebral areas. Two separate trends were discerned from the findings: in the left hemisphere, children with ASD exhibited elevated power in frequency bands from theta to gamma relative to normally developing (TD) children. In the right hemisphere, delta band power was elevated in typically developing youngsters relative to those with autism spectrum disorder. Consequently, this research illustrates that the disparity in auditory processing linked to ASD is not a singular, homogeneous phenomenon, but instead comprises two distinct effects that fluctuate based on hemisphere and frequency band.

Keywords: Autism Spectrum Disorder; auditory processing; magnetoencephalography; time-frequency analysis; hemispheric asymmetry

O-05 [79201]

Oral Presenter

How the Pulse Shape Affects the Network Dynamics of Spiking Neurons

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Theme : Systems Biology and Computational Bioinformatics

Abstract.

The study of coupled oscillator networks incorporating exponential pulse coupling has reshaped current perspectives on the spontaneous emergence of collective behaviour. In contrast to the traditional framework, where collective dynamics have been extensively examined under the assumption of image-pulses, this approach highlights the important role of finite pulse widths in determining macroscopic network dynamics. The former approach emphasizes that the neuron is not only affected by the amplitude of incoming pulses from its neighbourhoods but also by their temporal duration. This study numerically examines the influence of finite width pulses of so-called image-pulses on the dynamics of networks composed of two interacting populations of excitatory and inhibitory neurons. The proposed mathematical model extends the framework developed in previous studies (Afifurrahman et al., 2020, 2021) by reformulating the external field dynamics governing both excitatory and inhibitory neuronal populations. Our preliminary results indicate that collective dynamics persist in the presence of identical image-pulses, consistent with observations reported for neuronal networks coupled through exponential pulses. Moreover, the irregular collective behaviour, manifested as temporal fluctuations in the average membrane potential, gradually transitions toward more regular dynamical regimes as the pulse width is reduced. Considering that heterogeneous pulse widths naturally arise in biological neuronal networks, it is important to test in the future the resulting dynamical regimes in a generalized setup. Specifically, one seeks to determine how the collective dynamics are influenced by differences in pulse duration, such as when excitatory pulses are narrower than inhibitory pulses, or vice versa.

Keywords: Finite width pulse; collective dynamics; spiking neuronal networks

O-06 [79213]

Oral Presenter

Multilevel Bayesian Spatial Structural Panel VARX for Spatio-Temporal Data

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Theme : Advanced Biostatistical Analysis

Abstract.

Multilevel spatial panel data often exhibit temporal persistence, spatial dependence, and hierarchical heterogeneity that cannot be adequately represented by conventional vector autoregressive models. This study proposes a Multilevel Bayesian Spatial Structural Panel Vector Autoregressive with Exogenous Variables (BSSp-VARX) model that integrates vector autoregression, spatial dependence, multilevel random effects, and Bayesian inference into a unified statistical framework. Spatial interaction is represented through an inverse-distance weight matrix, while parameter estimation is performed using Markov Chain Monte Carlo (MCMC) with a Metropolis Hastings-with-Gibbs algorithm. The proposed methodology was evaluated using a simulated balanced spatial panel dataset reflecting the characteristics of childhood stunting across 22 districts/cities in East Nusa Tenggara, Indonesia, during 2017–2025 (198 observations). Based on 12,000 posterior MCMC draws, the inverse-distance BSSp-VARX model achieved the best performance with a Deviance Information Criterion (DIC) of 3412, while successfully capturing temporal persistence ($\phi = 0.72$) and spatial dependence ($\rho = 0.29$). The model also identified underweight/wasting as the dominant exogenous determinant with a posterior coefficient of $\beta = 0.32$. These findings demonstrate that the proposed BSSp-VARX provides a flexible and extensible framework for analyzing complex multilevel spatio-temporal systems and establishes a methodological foundation for subsequent empirical implementation and Bayesian spatial decision-support applications.

Keywords: Bayesian inference; Markov Chain Monte Carlo; multilevel modeling; spatial panel data; vector autoregressive model

O-07 [79112]

Oral Presenter

A Two Dimensional Spatiotemporal Mathematical Model of Cancer Immune Cell Interaction Incorporating Immune Cell Chemotactic Movement

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Theme : Mathematical Foundations in Medical and Clinical Sciences

Abstract.

The interaction between cancer cells and the immune system is a complex biological process governed by both temporal dynamics and spatial distribution. A critical mechanism in the immune response is chemotaxis, where immune cells exhibit directed movement along chemical gradients (IL-2) secreted by cancer cells to locate and eliminate tumor targets. This study proposes a two-dimensional spatiotemporal mathematical model based on a system of reaction diffusion with non linear chemotaxis movement. The model incorporates dynamic interactions among cancer cells, immune cells, and IL-2 concentrations driving cell migration. Numerical simulations using a finite difference scheme were conducted to observe spatial pattern formation and evaluate immune infiltration efficiency. The results demonstrate that the chemotactic sensitivity coefficient plays a crucial role in cancer cell clearance. High chemotactic responsiveness enables rapid aggregation of immune cells at high density cancer sites, suppressing tumor nodule growth. Conversely, a reduction in chemotactic sensitivity leads to spatial escape, allowing cancer cells to proliferate uncontrollably in immune deprived zones. This model offers quantitative insights into the role of directed immune migration and provides a theoretical framework for optimizing immunotherapeutic strategies.

Keywords: Spatiotemporal model; reaction diffusion; chemotaxis; cancer cells; immune cells; IL-2; immunotherapy

O-08 [79214]

Oral Presenter

Mathematical Model of Meningitis Transmission using Fractional Caputo Derivatives

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Theme : Epidemiology and Infectious Disease Modeling

Abstract.

This study explores a mathematical model of how meningitis spreads, using a type of fractional calculus called the Caputo derivative, which is helpful for capturing memory effects in disease transmission. The model divides the population into five groups: those who are susceptible (S), carriers (C), infected (I), receiving treatment (T), and recovered (R). It also includes the impact of vaccination and screening as control measures. The model produces two possible outcomes: one where the disease dies out (disease-free equilibrium) and one where it continues to exist in the population (endemic equilibrium). We calculate the basic reproduction number (R_0) using a method called the next generation matrix and examine how sensitive the results are to changes in model parameters. When R_0 is less than 1, the disease-free state is stable. When R_0 is greater than 1, the disease can persist, and its stability depends on certain mathematical conditions (Routh-Hurwitz criteria). To support these findings, we use the PECE-PI numerical method to analyze the system's behavior, including how fractional order, vaccination, and screening influence the spread of meningitis.

Keywords: Basic reproduction number; Caputo derivatives; fractional stability analysis; meningitis model; PECE-PI method

O-09 [79103]

Oral Presenter

Mathematical Modeling of Casson Fluid Hemodynamics in Central Retinal Vein Occlusion with Asymmetric Stenosis

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Theme : Mathematical Foundations in Medical and Clinical Sciences

Abstract.

Central Retinal Vein Occlusion (CRVO) disrupts blood drainage in the central retinal vein, and this disruption is closely tied to changes in vessel geometry brought on by stenosis. This study narrows its focus to a single asymmetric stenosis configuration, Cosine–Bell, chosen to approximate the irregular, non-uniform narrowing that stenotic retinal veins actually exhibit. Blood is treated as a Casson non-Newtonian fluid, a choice that captures the yield-stress behavior and shear-thinning tendency that matter most in small-diameter vessels. Three stenosis severities were simulated, 35%, 60%, and 85%, corresponding to mild, moderate, and severe narrowing. The governing equations, built from mass, momentum, and energy conservation for two-dimensional incompressible flow, were discretized with the Finite Volume Method and solved using the SIMPLE algorithm in MATLAB. Building on the earlier work, this study looks more closely at the Casson rheological variables, namely shear rate and effective viscosity, and adds a wall shear stress analysis to capture how the narrowing directly loads the vessel wall. Taken together, the results show that stenosis thickness shapes both the flow pattern and the mechanical stress the retinal vein wall experiences.

Keywords: Asymmetric stenosis; CRVO; Casson fluid; Finite Volume Method; hemodynamics; SIMPLE algorithm

O-10 [79202]

Oral Presenter

Comparative Analysis of the Improved 5th-Order Runge-Kutta and 4th-Order Adams-Bashforth Methods for a Chlorophyll-a and Fish Population Interaction Model with the Weak Allee Effect

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Theme : High-Performance Computational Methods for Life Science Models

Abstract.

The interaction model between Chlorophyll-a and fish populations is a system of nonlinear differential equations describing the relationship between food source availability and fish population dynamics. In this study, Chlorophyll-a is modeled using the logistic growth equation, a non-spatial reduction of the Fisher model, while fish population dynamics are modeled using the Lotka-Volterra equation, extended to include the weak Allee effect. This research aims to compare the performance of the 5th-order Improved Runge-Kutta (IRK5) and 4th-order Adams-Bashforth (AB4) methods in solving the model, evaluating them based on accuracy, convergence, computational efficiency, and their ability to maintain solution non-negativity. Both methods were implemented in MATLAB using various step sizes (h), and computational efficiency was assessed based on program execution time. Simulation results indicate that both methods effectively represent the periodic dynamics of Chlorophyll-a and fish populations across all tested step sizes. The AB4 method requires less computational time. The findings reveal a trade-off between accuracy, stability, and computational efficiency, implying that the choice of method should be tailored to the specific simulation objectives.

Keywords: Adams-Bashforth; weak Allee effect; Improved Runge-Kutta; Chlorophyll-a; fish population

O-11 [79203]

Oral Presenter

Exploration of Time Derivative Method, CUSUM and EWMA Control Chart to Determine The Onset of Influenza Outbreak in The Epidemic Forest Model

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Theme : Epidemiology and Infectious Disease Modeling

Abstract.

Due to the significant number of cases and fatalities it causes annually, influenza is an acute respiratory illness that continues to be a concern. The epidemic model was utilized to determine the source of infection in an influenza outbreak which incorporates spatial and temporal aspects. The temporal aspect is represented by the onset time of the outbreak. Time Derivative (TD) method, Cumulative Sum (CUSUM) and Exponentially Weighted Moving Average (EWMA) control chart have been applied to detect the early outbreak of infectious disease, particularly the influenza outbreak. The control chart methods need previous information about the infection during non-epidemic periods. Alternatively, the TD method uses the shifts of the slope in the time series data to discover the beginning of an outbreak. In this research, we explore these methods to determine the onset time of the outbreak in the epidemic forest model.

Keywords: Influenza; epidemic forest; time derivative method; CUSUM; EWMA

O-12 [79204]

Oral Presenter

An Explainable ResNet50–MLP Framework for Multi-Class Breast Cancer Classification

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Theme : Systems Biology and Computational Bioinformatics

Abstract.

Breast cancer remains one of the leading causes of mortality among women worldwide, making accurate early diagnosis critical. However, manual interpretation of breast medical images is subjective and time-consuming, while deep learning models applied to real clinical data face challenges such as varying image dimensions, class imbalance, limited samples, and a lack of model transparency that hinders clinical trust. To address these issues, this study proposes a breast cancer classification framework that integrates a pre-trained ResNet50 as a full-tuned feature extractor with a Multi-Layer Perceptron (MLP) classifier for three clinical classes: normal, benign, and malignant. A zero-padding strategy preserves image aspect ratios, while geometric augmentation mitigates class imbalance. To ensure clinical accountability, two Explainable AI (XAI) techniques are integrated: gradient-free Eigen-CAM to validate feature extraction quality, and gradient-based Grad-CAM to interpret classifier decisions. The framework was validated on the open-source BUSI Dataset and two clinical modalities from Universitas Gadjah Mada (UGM), namely Breast USG and Breast Mammography. The proposed model achieved high accuracy on the BUSI Dataset and in the benchmarking scenario, outperforming most prior state-of-the-art methods. On the clinical datasets, it attained promising accuracy on both Breast USG and Breast Mammography, improving substantially in the binary (benign vs. malignant) evaluation.

The Grad-CAM and Eigen-CAM visualizations confirm that the model focuses on anatomically relevant pathological regions, underscoring the framework's potential as an accurate and interpretable diagnostic support tool.

Keywords: Breast cancer classification; ResNet50; MLP; XAI; Grad-CAM; Eigen-CAM

O-13 [79104]

Oral Presenter

A Hybrid Stage-Structured ODE and Deep Learning Model for Climate-Driven Dengue Risk Mapping

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Theme : Epidemiology and Infectious Disease Modeling

Abstract.

Dengue Hemorrhagic Fever (DHF) constitutes a significant public health burden throughout tropical regions, including Indonesia, where climatic variability and dense population settlement patterns exacerbate transmission risk. This study proposes an Early Warning System (EWS) for dengue forecasting through the integration of a climate-driven deterministic model, which captures the population dynamics of *Aedes aegypti*, with a long short-term memory (LSTM) deep learning architecture. The deterministic model incorporates temperature, relative humidity, and rainfall as covariates governing dengue transmission, and underscores the significance of isolating the egg stage of the mosquito life cycle as a mitigation strategy for suppressing mosquito population size and, consequently, the basic reproduction number, R_0 , thereby constraining the spread of DHF. Epidemiologically plausible thresholds for these climatic variables are established, and estimated mosquito abundance is subsequently employed as an input variable within the LSTM model, alongside the Oceanic Niño Index (ONI) and historical DHF case records. Results indicate that this hybrid approach yields robust predictive performance, with the LSTM model achieving R^2 values of up to 0.75 on the test dataset, and generates spatiotemporal dengue risk maps for 2026 that reveal heightened risk during the rainy season relative to diminished risk in dry periods, as demonstrated through forecasting maps for North and East Jakarta. These findings underscore the potential of integrating deep learning methods with mechanistic vector population models to produce reliable, actionable forecasts of dengue transmission risk in tropical settings.

Keywords: Dengue fever; Early Warning System; mathematical modeling; *Aedes aegypti*; LSTM; climate variables

O-14 [79217]

Oral Presenter

Optimal Control of Digital Literacy Interventions in a Dynamical Model of Social Media Addiction

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Theme : Optimization and Optimal Control Theory in Biological Systems

Abstract.

Social media addiction is increasingly recognized as a dynamic behavioral phenomenon with potential adverse effects on individual well-being and social functioning. This study develops an SIR-type dynamical model to examine the progression of social media addiction and the role of digital literacy interventions as a control strategy. The population is partitioned into susceptible, addicted, and recovered or self-controlled individuals. The mathematical analysis includes model formulation, equilibrium analysis, the basic reproduction number, local stability, and an optimal control problem formulated using Pontryagin's Maximum Principle. Digital literacy intervention is represented by a bounded time-dependent control that reduces the transition from susceptibility to addiction while enhancing movement toward the recovered class. Numerical simulations based on a fourth-order Runge–Kutta scheme compare the uncontrolled system with several intervention intensities. Under the parameter values adopted in the study, an intervention intensity of $u = 0.9$ reduces the long-term addicted population from approximately 43.29 to 10.77 individuals, corresponding to a 75.11% reduction, and increases the recovered population from approximately 16.83 to 38.41. Within the assumptions of the model, these findings indicate that sustained digital literacy interventions can substantially suppress addiction dynamics and support recovery. The model provides a quantitative framework for evaluating educational strategies aimed at promoting healthier social media use.

Keywords: Social media addiction; SIR-type model; optimal control; digital literacy intervention; Pontryagin's Maximum Principle

O-15 [79211]

Oral Presenter

Modeling Syphilis Transmission with Two Time Delays and Heterogeneous Risk Behavior

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Theme : Epidemiology and Infectious Disease Modeling

Abstract.

Syphilis remains a major public health challenge in the United States, with reported infections increasing substantially over the past decade despite the availability of effective diagnostic tools and treatment. Delays in disease progression, diagnosis, and treatment, coupled with heterogeneous sexual risk behavior, continue to sustain transmission and contribute to adverse outcomes, including congenital syphilis. Motivated by these epidemiological challenges, this study proposes a novel delay differential equation model that incorporates two biologically meaningful time delays and heterogeneous risk behavior to investigate syphilis transmission dynamics. The model explicitly incorporates both the incubation delay and the treatment delay to capture the period between infection and infectiousness and the interval between diagnosis and treatment. Survival probabilities are also included to account for natural mortality during these delay periods. The mathematical analysis establishes the existence, uniqueness, positivity, and boundedness of solutions, derives the basic reproduction number, and examines the local stability of the disease-free equilibrium. The effects of the two delays on disease dynamics are further explored through numerical simulations to evaluate their influence on epidemic progression. The model will be calibrated and validated using reported syphilis surveillance data from the United States to estimate key epidemiological parameters and assess its predictive performance. Preliminary numerical results suggest that both incubation and treatment delays can substantially influence disease transmission, although their relative impacts depend on the duration of each delay and the underlying risk behavior structure. Thus, the proposed modeling framework provides quantitative insights into the interaction between behavioral heterogeneity and intervention delays, offering a useful tool for evaluating screening, diagnosis, and treatment strategies and supporting evidence-based public health policies aimed at reducing the burden of syphilis in the United States.

Keywords: Syphilis transmission; delay differential equations; heterogeneous risk behavior; incubation delay; treatment delay; basic reproduction number

O-16 [79116]

Oral Presenter

Fractional Diffusion Reshapes Busse Balloons in an Evasion-Tipping Model of Dryland Vegetation

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Theme : Ecological Systems and Environmental Modeling

Abstract.

Spatial vegetation patterns in dryland ecosystems arise from feedback between biomass and water transport, but the role of nonlocal diffusion in determining their wavelength and stability remains insufficiently understood. We investigate a two-component biomass-water evasion-tipping model in which spatial transport is represented by a fractional Laplacian of order $0 < \alpha \leq 2$, with rainfall as the main control parameter. Linear stability analysis is used to derive the dispersion relation and identify the Turing-unstable modes. We then compute the spatiotemporal dynamics using Fourier spectral discretization and fourth-order Runge–Kutta integration. Periodic steady states are traced with numerical continuation in the wave number, and their spectral stability is evaluated to construct Busse balloons in the rainfall-wave-number plane. For the parameter regime considered, the rainfall threshold for Turing instability is unchanged by the fractional order. In contrast, decreasing α shifts the unstable modes toward smaller wave numbers and reduces their maximum growth rate, producing broader and more slowly developing spatial patterns. The continuation results further show that the existence and Eckhaus-stable regions of periodic patterns contract and move toward lower wave numbers as diffusion becomes more fractional; under low rainfall and strong fractional effects, the stable region can disappear. These results separate the onset of pattern formation from post-onset wavelength and stability selection, and demonstrate that nonlocal transport can substantially reduce the range of robust periodic vegetation patterns without shifting the rainfall threshold at which spatial instability first occurs.

Keywords: Fractional Laplacian; Turing instability; Busse balloon; dryland vegetation; numerical continuation; spectral stability

O-17 [79216]

Oral Presenter

Stability Analysis of TB and MDR TB Transmission Dynamics with Vaccination and Treatment

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Theme : Epidemiology and Infectious Disease Modeling

Abstract.

Tuberculosis (TB) remains one of the leading causes of death from a single infectious agent worldwide, and the continued emergence of multidrug-resistant TB (MDR-TB) threatens to undermine decades of progress in disease control. This study focuses on the combined effect of vaccination and multi-stage treatment interventions, spanning BCG vaccination, tuberculosis preventive therapy (TPT), first-line treatment (OAT), and the BPaLM regimen for MDR-TB, within a single modeling framework. A seven compartment SVEIMTR model is formulated, consisting of susceptible (S), vaccinated (V), exposed (E), infectious (I), MDR-TB (M), MDR-TB under treatment (T), and recovered (R) individuals. The disease-free and endemic equilibrium points are determined, and their local stability is analyzed using the Jacobian matrix, eigenvalues, and the Routh-Hurwitz criterion, approximated through the basic reproduction number (R_0). The disease-free equilibrium is locally asymptotically stable when $R_0 < 1$, while the endemic equilibrium exist uniquely and is locally asymptotically stable when $R_0 > 1$. Numerical simulations using reference parameter values representative of East Java, Indonesia illustrate these dynamics under varying intervention coverage. The results indicate that the combined implementation of vaccination and multi-stage treatment interventions plays a critical role in driving the system toward disease elimination, offering theoretical insight relevant to TB and MDR-TB control efforts in high-burden settings.

Keywords: Basic reproduction number; locally stability; MDR TB; numerical simulation; SVEIMTR model

O-18 [79105]

Oral Presenter

Dynamics of Co-consumption Alcohol Model Considering Compartments of Rituals and Traditional Alcoholic Beverages

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Theme : Mathematical Foundations in Medical and Clinical Sciences

Abstract.

This research investigates the underlying behaviors of alcohol use and its broader societal consequences. This study highlights the significant adverse impact of alcohol use on society, focusing on shared consumption patterns involving both traditional and branded alcoholic beverages. This scenario of alcohol co-consumption is modeled mathematically, using a system of non-linear differential equations. We find four equilibrium points, namely, the alcohol-free equilibrium point, the existence of a branded alcohol equilibrium point, the existence of a traditional alcohol equilibrium point, and the co-consumption alcohol point. The basic reproduction number of the model is determined, and the stability of each equilibrium point is analyzed. Computational modeling suggests that self-awareness and educational awareness measures substantially impact the consumption of traditional and branded alcoholic beverages.

Keywords: Model; alcohol; co-consumption; stability; simulation

O-19 [79114]

Oral Presenter

Integrating Multivariate Morphometric Analysis of Fruit Fly (*Drosophila* spp.) into a CURE-Based Genetics Curriculum: A Biostatistical Learning Model

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Theme : Advanced Biostatistical Analysis

Abstract.

Undergraduate genetics education often relies on textbook exercises that offer little exposure to the uncertainty, iteration, and data-driven reasoning characteristic of authentic research. Course-based Undergraduate Research Experiences (CUREs) address this gap by embedding real, unresolved research questions into laboratory curricula. This study proposes and demonstrates a CURE-based learning model for population genetics grounded in multivariate morphometric analysis of fruit fly (*Drosophila* spp.) populations. Using a balanced dataset of 300 individuals from six populations across North Sulawesi, Indonesia (25 males and 25 females per population; 19 continuous morphometric traits), we illustrate a complete biostatistical workflow, from data quality screening and assumption testing to two-way ANOVA, MANOVA, principal component analysis, and cross-validated linear discriminant analysis, as a scaffolded sequence of student-facing research tasks. Multivariate analysis revealed significant population-level differentiation (MANOVA, Wilks' $\lambda = 0.406$; $F(90, 1319.2) = 2.99$; $p < 0.001$) with no significant sex effect on somatic traits (Wilks' $\lambda = 0.940$; $p = 0.500$), while discriminant classification achieved 37.7% cross-validated accuracy against a 16.7% chance baseline, indicating gradual, clinal rather than discrete population structure. Beyond the biological findings, the dataset embeds pedagogically valuable discovery moments, including a non-homologous trait requiring critical re-evaluation of variable coding and a design ambiguity around biological versus technical replication, that mirror authentic obstacles in genetics research. We argue that morphometric datasets of this kind offer a low-cost, high-authenticity model for teaching population genetics concepts, including phenotypic variation, gene flow, statistical inference, and effect size interpretation, through iterative, discovery-based inquiry consistent with CURE principles, with direct applicability to undergraduate Biology Education curricula in Indonesia.

Keywords: *Drosophila* spp.; morphometrics; multivariate biostatistics; population genetics education; Course-based Undergraduate Research Experience (CURE)

O-20 [79205]

Oral Presenter

Bifurcation Analysis and Sustainable Harvesting in a Two-Prey, One-Predator Coral Reef Fishery Model

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Theme : Ecological Systems and Environmental Modeling

Abstract.

Overfishing disrupts the balance between prey and predatory reef fish and is widely regarded as a driver of coral reef phase shifts from coral dominated to algae dominated states. Most bioeconomic fishery models still treat reef fish communities as a single generic stock. This study formulates a three dimensional bioeconomic model of a coral reef fishery comprising two prey guilds and one piscivorous predator guild. The guilds are coupled through a Holling type II functional response and harvested by a single fishing effort with guild specific catchability, reflecting the nonselective structure of small scale reef fisheries. Positivity, boundedness, and permanence of the system are proved. All feasible equilibria are identified, and invasion criteria establish their local stability. A Lyapunov function guarantees global stability of coexistence whenever the prey guilds interact only indirectly through their predator. Fishing effort is treated as a bifurcation parameter. We prove a Hopf bifurcation, locate the critical effort numerically, and rank its parameters by sensitivity analysis. A second, transcritical bifurcation eliminates the predator guild beyond a higher effort threshold. The community shifts from oscillatory to stable coexistence and finally to a predator free state as effort increases. A constrained optimal harvesting policy is derived through Pontryagin's Maximum Principle, maximizing discounted revenue subject to a minimum prey density that safeguards the reef's trophic function. Simulations illustrate the stability boundary, the bifurcation portrait, and the trade off between the constrained and classical policies.

Keywords: Coral reef fishery; prey predator; bifurcation; nonselective fishing effort; optimal harvesting

O-21 [79118]

Oral Presenter

Mangrove Morphometric Design in Phanerogamae Learning to Enhance Students' Critical Thinking Skills

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Theme : Advanced Biostatistical Analysis

Abstract.

A quantitative approach plays an important role in bridging biodiversity research with meaningful biology teaching practice. This study designed a Phanerogamae (seed plants) learning module based on mangrove morphometric and molecular data to enhance students' critical thinking skills in the Talaud Archipelago, North Sulawesi, Indonesia. A morphometric survey was conducted on 10 × 10 m plots across three observation stations, identifying four mangrove species. Three species were morphometrically characterized: *Bruguiera gymnorhiza* (leaf length 15 cm, leaf width 7 cm, petiole length 3 cm, fruit size 24 cm), *Bruguiera cylindrica* (leaf length 17 cm, leaf width 6 cm, petiole length 3.5 cm, fruit size 60 cm), and *Sonneratia alba* (leaf length 10 cm, leaf width 10 cm, petiole length 1 cm, flattened round fruit 7 cm in diameter). Tree height and first-branch canopy height, measured using the Google Lens application, showed a decreasing vertical-dimension pattern across stations: Station 1 (17 m; 6 m), Station 2 (15 m; 5.2 m), and Station 3 (12 m; 4 m). Molecular characterization via *matK* gene DNA barcoding of three samples (SP4I, SP5I, SP16) yielded approximately 500 bp amplicons with 94–95% sequence similarity to *Sonneratia alba* (BLAST). Genetic distance matrix analysis (Tamura 3-parameter) and a Neighbor-Joining phylogenetic tree confirmed a monophyletic clustering of the genus *Sonneratia*, clearly separated from *Rhizophora*, *Avicennia*, and *Xylocarpus* (bootstrap values up to 100%). The morphometric and phylogenetic data were integrated into a data-driven inquiry-based teaching module, in which students were trained to measure, compare, and interpret morphometric variation among species and stations, read electropherograms, and interpret phylogenetic trees as a form of taxonomic reasoning in Phanerogamae. This approach is consistent with findings from a needs analysis of local-biodiversity-based STEM learning, which indicated limited use of local biodiversity case studies and a strong need for contextual media development support. The integration of field morphometrics and phylogenetic bioinformatics produced a Phanerogamae learning design model that empirically has the potential to stimulate students' critical thinking skills through the analytical-quantitative reasoning characteristic of biological science.

Keywords: Mangrove morphometrics; *matK* gene DNA barcoding; phylogenetic bioinformatics; Phanerogamae learning; critical thinking

O-22 [79206]

Oral Presenter

Survival Modeling of Athlete Injury Hazard for Fair Takaful Micro-Insurance Pricing

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Theme : Advanced Biostatistical Analysis

Abstract.

Sports injury cover in Indonesia is usually sold at a flat rate that ignores how injury risk shifts with training load, age, and past injuries. An athlete who trains hard and carries a history of injury pays the same as one who does not, which is neither fair nor sustainable for the pool. This study builds a survival model of time-to-injury and uses it to price a sharia-compliant takaful scheme for athletes. We treat injury as a physiological event and estimate its hazard with a Cox proportional hazards model, checked against a Weibull parametric fit, using longitudinal athlete data on weekly training load, playing position, age, body-mass index, and prior injury. The fitted hazard yields each athlete's injury probability over a competitive season, which we translate into an expected claim frequency. From there we derive a risk-based tabarru' contribution and a surplus-sharing rule that stays within takaful principles of mutual help, so that lower-risk members are not forced to subsidise higher-risk ones. We then compare the risk-based scheme with a flat-rate one and track how each affects pool solvency and the season-end surplus. The result links injury-hazard biostatistics to actuarial takaful design and gives clubs and insurers a transparent, physiologically grounded way to price athlete protection.

Keywords: Survival analysis; proportional hazards model; sports injury; takaful micro-insurance; risk-based premium

O-23 [79106]

Oral Presenter

Bayesian Spatial Survival Models for Deforestation in Indonesia: Cox Proportional Hazards and Accelerated Failure Time

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Theme : Ecological Systems and Environmental Modeling

Abstract.

Deforestation, the large-scale clearance of forests for conversion into agricultural, plantation, mining, or infrastructure land, remains a critical environmental issue in Indonesia, which recorded the world's second-largest forest loss, approximately 11 million hectares, between 2001 and 2024. This study models deforestation as a time-to-event process across 497 Indonesian districts/cities from 2004 to 2024, with the event defined as a cumulative loss of at least 15% of a district's initial (2004) forest cover. Two families of Bayesian spatial survival models are developed: spatial Cox proportional hazards (CPH) models and spatial accelerated failure time (AFT) models under Weibull and exponential error distributions, each incorporating structured (intrinsic conditional autoregressive) and unstructured spatial random effects at the level of Indonesia's 34 provinces to capture neighborhood dependence among districts. Candidate covariates include mining status, dominant plantation type, oil palm plantation area, initial forest area, gross regional domestic product, population, and island grouping, with the best covariate combination for each model selected from 127 candidates using the Deviance Information Criterion (DIC). Parameters were estimated via Markov chain Monte Carlo, combining Gibbs sampling and Metropolis-Hastings algorithms over 10,000 iterations with a 5,000-iteration burn-in. Moran's Index of 0.5851 confirms significant positive spatial autocorrelation in provincial deforestation proportions, supporting the spatial modeling approach. Model comparison shows the spatial CPH 1 model (DIC = 1659) outperforming CPH 2 (DIC = 1752), though CPH 1 violates the proportional hazards assumption while CPH 2 satisfies it; among AFT models, the Weibull specification (DIC = 1157) clearly outperforms the exponential specification (DIC = 1393). Across models, mining activity and oil palm plantation area consistently accelerate deforestation risk and shorten the predicted time-to-event, while a larger initial forest area is protective in most models. Spatially, Sumatra and Kalimantan consistently show the highest deforestation hazard and earliest predicted time-to-event, whereas Papua and Java show the lowest hazard and longest predicted survival, consistent with the concentration of oil palm and mining expansion in Sumatra and Kalimantan. These results confirm meaningful spatial dependence in Indonesia's deforestation patterns, captured through both provincial neighborhood effects and

unstructured heterogeneity, and point to mining and oil palm expansion, concentrated in Sumatra and Kalimantan, as priority factors for future monitoring and for extending this framework toward spatio-temporal deforestation modeling.

Keywords: Deforestation; spatial effects; Cox proportional hazards; accelerated failure time; Bayesian inference

O-24 [79207]

Oral Presenter

Competing Risk Analysis of Non-Small Cell Lung Cancer Patients with Brain Metastases

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Theme : Advanced Biostatistical Analysis

Abstract.

Survival analysis typically uses the Kaplan-Meier estimator to assess disease progression. However, when death before progression acts as a competing risk, this estimator violates the assumption of independent censoring. As a result, an overestimation bias arises, inflating the cumulative risk of progression. To address this methodological limitation, the Aalen-Johansen Cumulative Incidence Function (CIF) provides an appropriate approach that directly accounts for competing mortality, yielding accurate and unbiased risk estimates. This study aims to evaluate the cumulative incidence of intracranial progression and non-progression mortality in a cohort of 233 patients with non-small cell lung cancer (NSCLC) and brain metastases treated at Memorial Sloan Kettering Cancer Center. Then, compare the results of the Aalen-Johansen CIF analysis with the standard Kaplan-Meier estimator. Over a median follow-up of 12.36 months, 54.5% of patients experienced intracranial progression, 22.7% died without progression as a competing risk, and 22.7% were censored. The cumulative incidence of intracranial progression based on the CIF at 12, 36, and 60 months was 33.75%, 53.00%, and 57.89%, respectively. Where the Kaplan-Meier estimator yields 36.49%, 62.27%, and 70.16%. These findings demonstrate a substantial overestimation bias by Kaplan-Meier of up to 12.27 percentage points, with 21.19% relative overestimation at the 5-year mark. The Aalen-Johansen CIF method is crucial for providing accurate, unbiased risk estimates to support clinical decision-making and trial design in oncology populations facing competing risks.

Keywords: Brain metastases; competing risk; cumulative incidence function; Kaplan-Meier; non-small cell lung cancer

O-25 [79113]

Oral Presenter

A Two-Patch SEIR Model with Capacity-Regulated Mobility for Respiratory Disease Transmission

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Theme : Epidemiology and Infectious Disease Modeling

Abstract.

Disaster evacuation can substantially redistribute populations between communities and temporary shelters, potentially affecting the transmission dynamics of respiratory diseases. In this study, we develop a two-patch SEIR model to investigate the transient dynamics of an acute respiratory infection during disaster evacuation. The model incorporates standard incidence and capacity-regulated bidirectional mobility, where the movement of individuals from the community to the shelter is regulated by the available shelter capacity. To represent differences in mobility during evacuation, susceptible, exposed, and recovered individuals are allowed to move between the two patches, while infectious individuals are assumed not to participate in routine inter-patch movement. We establish the positivity and boundedness of solutions and derive the disease-free equilibrium and the basic reproduction number. We analyze the local stability of the disease-free equilibrium and perform a sensitivity analysis to examine how key parameters affect the basic reproduction number. Numerical simulations are conducted to illustrate the transient disease dynamics under different shelter capacities, mobility patterns, and transmission rates.

Keywords: Two-patch model; SEIR model; respiratory disease; shelter capacity; population mobility

O-26 [79208]

Oral Presenter

Dynamic Analysis of Predator-Prey Models with Anti-Predator and Additional Food Using Holling Type III Response Function

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Theme : Ecological Systems and Environmental Modeling

Abstract.

This study discusses the prey-predator model with additional food and anti-predator behaviour using a Holling type III response function. A mathematical model was created to represent the interaction between the red colobus monkey as prey and the chimpanzee as predator, with the prey having anti-predator behaviour and the predator having energy from the rate of predation on the prey and the existence of additional food. The analysis started with determining the equilibrium points, stability analysis and numerical simulation. The results of the analytical analysis showed three equilibrium points E_1 , where both populations are extinct, E_2 , where the predator population is extinct, and E_3 , where neither population is extinct. The results of the stability analysis around the equilibrium point E_1 the saddle point is unstable, while E_2 and E_3 are asymptotically stable under certain conditions. Numerical simulations was applied to validate the analytical results. The simulation results illustrate the system's dynamics by phase portraits. The bifurcation diagram, illustrated with changes in the anti-predator parameter value (μ), presents a transcritical bifurcation at $\mu = 0.057259$ and a saddle-node bifurcation at $\mu = 0.12646$. This implies that, to keep both populations stable, the value of the anti-predator behaviour must lie within the interval $0 < \mu < 0.12646$.

Keywords: Additional food; anti-predator; bifurcation

O-27 [79215]

Oral Presenter

Role of Refugia Plants and Pathogen Infection in Integrated Pest Management: A Fractional-Order Modeling Approach

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Theme : Ecological Systems and Environmental Modeling

Abstract.

Considering the growing demand for environmentally friendly pest control approaches that preserve ecological balance, this study develops an integrated pest management model. The proposed model uniquely integrates refugia plant–pest–natural enemy interactions. By introducing the spread of pathogen infection among pest population, the pests is divided into susceptible and infected pests. The Caputo fractional derivative is employed to capture the biological system's memory effects and hereditary behavior. The analysis begins with the examination of the uniqueness and existence of the solutions, followed by proofs of their non-negativity and boundedness. A comprehensive dynamical analysis reveals various equilibrium points, some displaying local and global stability under certain conditions. The inclusion of refugia plants is shown to support the natural enemy populations, thereby suppressing pest growth more effectively. Then, we investigate the conditions leading to Hopf bifurcation to understand the emergence of oscillatory behavior. Varying the fractional-order parameter reveals that lower order values reduce oscillation amplitudes, reflecting stronger memory effects that yield more controlled and ecologically realistic dynamics. Finally, numerical simulations are performed using the generalized Adam–Bashforth–Moulton method to validate the theoretical findings. The results underscore the ecological importance of refugia plants and the effectiveness of pathogen infection in pest management.

Keywords: Fractional-order model; eco-epidemiology; refugia plant; pest management; Hopf bifurcation

O-28 [79108]

Oral Presenter

Dynamics and Numerical Simulation of a Three-Population Mangrove–Microbe Mutualism Model

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Theme : Ecological Systems and Environmental Modeling

Abstract.

Mangrove ecosystems are dynamic ecological systems in which interactions among different populations can influence population persistence and ecosystem sustainability. In particular, interactions between mangrove species and soil microorganisms may contribute to the growth and maintenance of mangrove populations. This study develops a mathematical model to describe the dynamics of three interacting populations, consisting of two mangrove species and a soil microbial population. The two mangrove populations are assumed to exhibit logistic growth and to benefit from mutualistic interactions with the microbial population, while the microbial population is modeled with linear growth and receives mutualistic benefits from both mangrove species. Natural mortality is incorporated into each population. The proposed model is analyzed to investigate its equilibrium structure and population dynamics. Analytical analysis shows that the system admits seven critical points representing different population states, including extinction and coexistence conditions. Parameter values obtained from previous studies and selected ecological assumptions are subsequently used to examine the equilibrium points and investigate the behavior of the model through numerical simulations. The effects of the mutualistic interaction parameters on population dynamics are also considered. Furthermore, bifurcation analysis will be conducted to identify parameter values associated with qualitative changes in the system dynamics and to examine their implications for the persistence and coexistence of the populations. The study provides a mathematical framework for understanding mutualistic interactions between mangrove populations and soil microorganisms and contributes to the application of mathematical modeling and numerical simulation in the study of sustainable mangrove ecosystems.

Keywords: Mathematical modeling; mangrove ecosystem; mutualistic interactions; soil microorganisms; population dynamics; equilibrium analysis; numerical simulation; coastal ecosystem sustainability

O-29 [79209]

Oral Presenter

Bistability, Recovery Threshold, and Saddle–Node Bifurcation in a Two-Stage Coral Dynamics Model with Restoration

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Theme : Ecological Systems and Environmental Modeling

Abstract.

Coral reef ecosystem recovery can be influenced by initial population conditions, inter-stage developmental processes, space limitations, and the intensity of restoration interventions. This study develops a two-stage mathematical model distinguishing between early-stage and mature or reproductive corals to investigate how restoration affects the long-term dynamics of coral populations. The model considers natural recruitment, linear transition from early-stage to mature corals, the growth of mature corals, mortality, space limitation, and restoration represented by the intensity parameter u . Analyses are conducted on the basic properties of the model, the existence and local stability of equilibrium points, bistability structure, recovery threshold, and saddle-node bifurcation. Analytical results show that without restoration, the system can have two stable states, namely a coral-free state and a high-coral state, separated by the stable manifold of a saddle point. This structure causes the long-term state to depend on initial conditions. When restoration is applied at a low intensity, the coral-free state transforms into a low positive coral state, but bistability still occurs between the low-coral state and the high-coral state. An increase in restoration intensity causes the low stable state and the saddle point to approach each other and eventually collide through a saddle-node bifurcation. For the illustrative parameters used, the critical value is obtained as $u_{SN} \approx 0.00304596$. After u exceeds this value, the low-coral state and the saddle point disappear, leaving only the stable high-coral equilibrium state. Numerical simulations support the analytical results and demonstrate changes in the basin of attraction as well as the system's response to various initial conditions. These results indicate that restoration not only helps maintain coral populations, but at sufficiently high intensities, it can also eliminate the low-coral state as one of the possible long-term states of the system.

Keywords: Coral dynamics; coral reef restoration; bistability; recovery threshold; saddle-node bifurcation; mathematical model

O-30 [79119]

Oral Presenter

A Mathematical Model of Municipal Solid Waste Management with Age-Structured Population and Three Waste Classifications

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Theme : Ecological Systems and Environmental Modeling

Abstract.

Municipal solid waste management is a complex challenge influenced by population dynamics and community behavior. This study develops a mathematical model to analyze solid waste accumulation by considering a two-age-class population structure, namely children (C) and adults (A), as well as a three-type waste classification: organic (O), dry recyclable (R), and hazardous (H). The model is formulated as a system of nonlinear ordinary differential equations that integrates population dynamics, including birth, death, and age transition, along with waste generation and treatment rates that are specific to each age group and waste type. Equilibrium analysis shows that the system has a locally asymptotically stable fixed point, as evidenced by all eigenvalues of the Jacobian matrix being negative. Furthermore, local sensitivity analysis is conducted to measure the effect of parameter changes on total waste at steady state. The results show that production parameters (β) consistently increase total waste, while treatment parameters (σ) and natural decay parameters (δ) consistently decrease it. A key finding of this study is that the adult population exerts a consistently greater influence than children, with an influence ratio of α/μ for parameters related to recyclable waste. Based on elasticity analysis, the most effective policy interventions to reduce waste accumulation are increasing the recycling efficiency by adults (σ_{rA}) and the natural decay rate of recyclable waste (δ_r). This model provides an analytical framework that can be used to evaluate various waste management policy scenarios involving active community participation.

Keywords: Mathematical modeling; solid waste management; population dynamics; sensitivity analysis; equilibrium stability; recyclable waste; age-structured population; waste policy intervention

O-31 [79210]

Oral Presenter

Spatial and Mathematical Modeling of Pasang ri Kajang Ecotheology for Customary Forest Biomass Resilience

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Theme : Ecological Systems and Environmental Modeling

Abstract.

The Ammatoa Kajang customary forest in South Sulawesi represents a distinctive socio-ecological system in which forest conservation is sustained through Pasang ri Kajang, an indigenous normative system integrating spirituality, customary regulation, restraint, sanctions, community monitoring, and intergenerational transmission. This study develops a spatially informed dynamical model to examine how Pasang-based ecotheological governance modifies anthropogenic pressure and, through that mechanism, affects forest biomass resilience. A preliminary Sentinel-2 analysis for 2025 identified 1,317.93 ha of effective tree cover with a mean transferred Above Ground Biomass estimate of 129.18 ton ha⁻¹, ranging from 13.68 to 184.58 ton ha⁻¹. This spatial estimation was used only to initialise the biomass state. The mathematical framework comprises forest biomass $B(t)$, effective anthropogenic pressure $P(t)$, and Pasang-based ecotheological conservation strength $C(t)$. Analytical results yield a biomass depleted equilibrium, a positive biomass equilibrium, a pressure to regeneration ratio Q , and a critical ecotheological conservation threshold. A positive biomass equilibrium exists and is locally asymptotically stable when $Q < 1$. Controlled numerical experiments held ecological and exogenous pressure parameters constant while varying only governance effectiveness, cultural reinforcement, and cultural erosion. Under strong governance, the system converged to $C^* = 0.750$, $P^* = 0.282$, and $B^* = 157.65$ Mg ha⁻¹; the intermediate scenario converged to $C^* = 0.500$, $P^* = 0.600$, and $B^* = 110.00$ Mg ha⁻¹; whereas weak governance produced $Q = 1.350$ and convergence toward the biomass-depleted equilibrium. The local return rate was higher under strong than intermediate governance, providing an explicit local resilience interpretation. The results show that Pasang-based governance affects forest persistence indirectly through anthropogenic-pressure suppression rather than by directly generating biomass.

Keywords: Above Ground Biomass; ecotheological governance; mathematical modelling; spatial analysis; numerical simulation

O-32 [79110]

Oral Presenter

Biostatistical Modeling of Morphometric and Phenotypic Diversity in Local Rice (*Oryza sativa* L.) Landraces from North Sulawesi, Indonesia: A Biomathematical Approach to Yield Trait Analysis

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Theme : Advanced Biostatistical Analysis

Abstract.

Local rice (*Oryza sativa* L.) landraces represent a valuable but underexploited genetic reservoir for yield improvement, yet their phenotypic complexity is rarely dissected through rigorous multivariate frameworks. This study integrates morphometric phenotyping with quantitative biostatistical modeling to characterize twelve indigenous rice accessions collected from traditional cultivation systems across the Bolaang Mongondow and Minahasa Peninsulas, North Sulawesi, Indonesia. Seven IRRI-standardized yield-related traits, namely plant height, productive tiller number, panicle length, grains per panicle, grain filling percentage, grain width, and 100-grain weight, were recorded in triplicate at physiological maturity. Data structure was resolved through Principal Component Analysis (PCA) validated by Kaiser-Meyer-Olkin and Bartlett's tests, complemented by Pearson and Spearman correlation matrices to capture both linear and monotonic trait associations, computed using R software (FactoMineR and Hmisc packages). The first two principal components accounted for 18.4% and 10.8% of total phenotypic variance, respectively, with panicle architecture, stem morphology, and secondary branching identified as the dominant loading vectors. Correlation analysis revealed strong positive linear coupling among stem-related traits, alongside a moderate negative Pearson yet positive Spearman association between grain filling and grain width, indicating a nonlinear, rank-consistent trade-off between reproductive allocation and grain dimension. Grain number per panicle and 100-grain weight emerged as the principal sink-related determinants of yield potential, outweighing vegetative traits such as plant height. These findings demonstrate how multivariate ordination

combined with dual correlation modeling can disentangle structural trait modules in genetically heterogeneous landrace populations, providing a quantitative, mathematically grounded selection index for breeding programs. This biomathematical framework offers a transferable template for harmonizing biological complexity with statistical precision in the conservation and genetic improvement of underutilized tropical crop germplasm.

Keywords: Principal component analysis; Pearson-Spearman correlation; morphometric diversity; rice landraces; biomathematical modeling

O-33 [79115]

Oral Presenter

Development of a Structured Screen-House-Based “Modern Nursery Model” to Improve the Quality and Uniformity of Patchouli Seedlings (*Pogostemon cablin*)

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Theme : Sustainable Industrial Utilization of Renewable Resources

Abstract.

Patchouli cultivation has expanded rapidly in North Sulawesi, particularly since 2025, following a sharp increase in patchouli oil prices from late 2024 to early 2025. Prices reached IDR 2.4 million per kilogram, while the average production cost was approximately IDR 300,000 per kilogram. Although economically attractive, this rapid expansion has created multiple risks for farmers, agribusiness actors, local governments, and the wider patchouli-oil supply chain. At the farm level, production failures have begun to occur because planting materials are obtained from unverified sources and their varietal identity is unknown. Moreover, all planting materials currently cultivated by farmers are introduced, while growers have limited previous experience with patchouli production. This study addresses these constraints by establishing a reliable system for producing high-quality planting materials of three leading Indonesian varieties: *Pogostemon cablin* ‘Sidikalang’, ‘Tapak Tuan’, and ‘Lhokseumawe’, all of which are widely cultivated in Aceh Province. The study aims to develop a structured, screen-house-based modern nursery model that can serve as a reference for academics, entrepreneurs, researchers, and practitioners involved in patchouli propagation and nursery development. It will identify the optimal composition of solid organic growing media for polybag production and establish a smart nursery system using 90% shade cloth to regulate light, water, and airflow within the nursery. The proposed model is expected to enable the rapid mass production of uniform, pest- and disease-free patchouli seedlings, improve nursery efficiency and effectiveness, minimize production costs, and enhance commercial value. The findings will provide a practical and scientific foundation for sustainable patchouli seedling production in North Sulawesi.

Keywords: Modern nursery model; screen house; patchouli seedlings; *Pogostemon cablin*; shade management

O-34 [79111]

Oral Presenter

Identification of Pest and Disease Symptoms in Dalugha Plants (*Cyrtosperma merkusii* (Hassk.) Schott) in Talaud Islands Regency, North Sulawesi Province

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Theme : Ecological Systems and Environmental Modeling

Abstract.

Dalugha plants (*Cyrtosperma merkusii* (Hassk.) Schott) are endemic plants in North Sulawesi Province that need to be protected from plant pest attacks. Farmers face serious crop protection problems and are at risk from various pathogens and pests. Detection of pests and plant diseases is necessary to reduce crop damage and maximize agricultural productivity. Various scientific studies on dalugha have been carried out but remain limited, including the identification of pests, diseases, and symptoms of attack on dalugha plants in North Sulawesi. This study aims to identify the symptoms of pest and disease attacks on dalugha plants in Talaud Islands Regency. The research location was Moronge Village, Moronge District, Talaud Islands Regency, from October 2024 to February 2025. This research used a qualitative descriptive method. Sampling of plants showing symptoms of pest and disease attacks was determined using a purposive sampling technique. Identification of pest symptoms was conducted using the Google Lens application with an appropriate level of accuracy in identifying animal species. Identification of disease symptoms was conducted through laboratory tests to diagnose the types of diseases affecting dalugha plants. The results showed the presence of pests and symptoms of attack on dalugha plants, namely *Achatina fulica*, *Bradybaena similaris*, *Rhinocochlis nasuta*, *Caraculus marginella*, *Cornu aspersum*, *Subulina octona*, *Oxya servile*, *Tettigonia caudate*, *Asphaera lustrans*, *Leptoglossus australis*, *Periplaneta americana* L., *Lasius niger*, *Theretra oldenlandiae*, and *Lumbricus rubellus*. Disease symptoms identified in dalugha plants included anthracnose disease on leaves caused by the fungus *Colletotrichum* spp. and tuber rot disease caused by the fungus *Fusarium oxysporum* in dalugha tubers.

Keywords: Dalugha; disease; North Sulawesi; pests; symptoms

O-35 [79212]

Oral Presenter

A Comparative Study on Parameter Estimation via PSO and GA in a Discrete-Time Monkeypox Transmission Model

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Theme : Epidemiology and Infectious Disease Modeling

Abstract.

In this paper, we discretize a continuous-time monkeypox transmission model using two schemes: the standard Euler method and a non-standard finite difference (NSFD) scheme. The aim of this study is to compare the performance of two popular metaheuristic parameter estimation methods, Particle Swarm Optimization (PSO) and the Genetic Algorithm (GA), when applied to the resulting discrete-time monkeypox transmission models. Both methods are implemented on the discrete-time models derived from the standard Euler and NSFD schemes. The standard Euler model does not guarantee that its solution trajectories remain positive, whereas the NSFD model has been shown to preserve positivity at every time step. Both models admit three types of equilibrium points: a disease-free equilibrium, a human-only endemic equilibrium, and a full-population endemic equilibrium. Four parameter estimation scenarios are considered: GA on the standard Euler model, PSO on the standard Euler model, GA on the NSFD model, and PSO on the NSFD model. The root mean square error (RMSE) is used as the performance metric, with all parameter estimation procedures carried out in MATLAB. Overall, the experimental results show that PSO outperforms GA in estimating the parameters of the discrete-time models.

Keywords: Non-standard finite difference; Particle swarm optimization; Genetic algorithm; Parameter estimation

O-36 [79107]

Oral Presenter

The Dynamics of Behavior and Bifurcation in a Three-Species Mangrove Competition-Allelopathy Model

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Theme : Ecological Systems and Environmental Modeling

Abstract.

This article examines interaction dynamics among three mangrove species, *A. marina*, *B. gymnorrhiza*, and *R. stylosa*, through mechanisms of resource competition and allelopathy. *A. marina* potentially exerts an allelopathic effect on *R. stylosa*, which can influence root growth and the regeneration of other species. We developed an ecological mathematical model that accounts for population growth, interspecific competition, allelopathic effects, and abiotic factors. The research process involved constructing the model based on phenomena in the mangrove ecosystem, determining equilibrium points, conducting stability and bifurcation analyses, and performing numerical simulations to illustrate the solution of the dynamical system. The analysis reveals changes in system stability driven by parameter variations, characterized by bifurcation phenomena that reflect the transition from coexistence to the dominance of a single species or the decrease of a population. The disappearance of the two coexistence equilibrium points indicates the occurrence of a Fold bifurcation governed by the allelopathy parameter β when $\beta > 0.305563$. Fold bifurcations also occur when the parameters for competition, mutualism, and habitat facilitation are varied. The study's originality lies in developing a dynamic model that integrates competition, allelopathy, habitat facilitation, and abiotic factors to explain the mechanisms governing mangrove biodiversity. This model is intended to serve as a quantitative basis for predicting community evolution and supporting sustainable mangrove conservation strategies, in alignment with SDG 14.

Keywords: Competition; allelopathy; stability; bifurcation; mangrove

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