Proceeding International Conference on Religion, Science and Education (2026) **5**, 1771-1779

Batik Motifs from Mathematical Models of Dengue Fever Spread in Madiun

Mutiarahmi Sanur, Muh. Faizal Adhim Nasrullah, Moh. In'am Rojabi, Sugiyanto
Mathematics Department, Faculty of Science and Technology, UIN Sunan Kalijaga,
Jl. Marsda Adisucipto No 1 Yogyakarta 55281, Indonesia. Tel. +62-274-540971, Fax. +62-274-519739.

Corresponding author*
1999mutiarahmi@gmail.com

Abstract: Dengue Hemorrhagic Fever (DHF) is one of the endemic diseases that has become a significant health issue in Madiun. This study aims to transform the mathematical model of DBD spread in Madiun into a new, unique, and meaningful batik motif. By adopting the SIR (Susceptible, Infected, Recovered) epidemiological model from real case data in Madiun from 2020 to 2022, this study analyzes the resulting dynamic patterns. Key elements of the model, such as the new infection rate (β), recovery rate (α), and Basic Reproduction Number (R_0), form the basis for the inspiration of symbolic visualizations. The epidemic curves of the Susceptible, Infected, and Recovered populations generated through numerical simulations are creatively interpreted into batik-style lines and patterns. The interactions between compartments in the model are manifested through the composition and stylization of shapes. The end result is a contemporary batik motif that not only has high aesthetic value but also serves as a visual educational medium about the dangers of dengue fever. This motif represents an innovative fusion of science and art, proving that epidemiological data can be a source of inspiration for modern works of art that remain strongly rooted in tradition.

Keywords: Applied Mathematics, Arts and Sciences, Batik, Dengue Hemorrhagic Fever, SIR Model.

Introduction

Batik is an art form inherited from the ancestors of the Indonesian people, combining artistic beauty and sophisticated technique. Batik cloth is made by painting using a tool called a canting, which is filled with wax, to produce beautiful, high-value motifs. Etymologically, the term "batik" comes from the Javanese language, namely from the word 'mbat' which means to throw repeatedly and "tik" which means dot, so batik can be interpreted as the activity of making repeated dots on fabric. Indonesian batik has a variety of techniques, symbols, and cultural values that reflect the lives of the people, making it a source of national pride, especially after it was previously claimed by another country.

As time goes by, batik is not only viewed from a cultural perspective, but can also be linked to other scientific fields such as mathematics and social sciences in understanding social phenomena, including health. One of the major health issues in Indonesia is dengue fever (DF). This disease is endemic and widespread in various regions, caused by the dengue virus carried by the Aedes aegypti mosquito. Its spread is greatly influenced by climatic conditions, such as temperature, humidity, and rainfall. These environmental factors determine the reproduction rate and activity of mosquitoes that spread the virus. The government has made various efforts to combat the spread of the dengue virus, including through the "One House One Jumantik" movement and the "3M Plus" program, which includes covering, draining, filling, and other preventive measures. Treatment for DHF patients is generally symptomatic and supportive, while prevention remains the main strategy in reducing transmission rates.The spread of dengue virus can be modeled mathematically using the SIR (Susceptible–Infected–Recovered) epidemiological model, which was first developed by Kermack and McKendrick

ISSN 2829-3355 | EISSN 2828-8467

in 1927. This model divides the population into three groups: susceptible individuals (S), infected individuals (I), and recovered individuals (R). The SIR model is widely used in research to predict the dynamics of infectious disease spread. Some researchers modify this model by adding vaccination factors or new compartments, such as the SIRS and SEIR models, to make the prediction results more accurate. For example, research by Chanprasopchai et al. (2018) shows that the spread of dengue fever can naturally decrease when the basic reproduction number (R_0) falls below one, while Sanusi et al. (2021) developed the SIRS model to describe the possibility of recovered individuals becoming susceptible to infection again. Similar models are also used to study the spread of other diseases such as influenza and COVID-19. In the context of this study, the SIR model was applied to model the spread of dengue fever in the Madiun region using secondary data from the Central Statistics Agency of Madiun Regency and City. The analysis was performed using MATLAB software with the ode45 numerical method to observe the dynamic patterns of dengue virus spread in the area. By combining cultural heritage such as batik, which reflects local wisdom, and the application of modern science such as epidemiological mathematical modeling, it can be seen that traditional and scientific values complement each other in building a national civilization that is rooted in culture but has a scientific perspective on current challenges.

Materials And Methods

Study area

This study uses data from Madiun as its study area. The focus of the study is on the dynamics of the spread of dengue fever (DF) in this area. The quantitative data and model parameters used in this analysis were sourced from a previous study entitled "Pola Penyebaran Penyakit Demam Berdarah dengan Model SIR di Madiun Tahun 2020-2022" by Baihaqi et al. In that study, Baihaqi et al. used secondary data covering a three-year period, from 2020 to 2022. All data, both demographic (population, birth rate, death rate) and epidemiological (number of dengue fever infections and deaths due to dengue fever), were obtained officially from Badan Pusat Statistik (BPS) of Madiun Regency and Madiun City.

Procedures

Mathematical Model

The basis for the design of this batik motif is a mathematical model that analyzes the pattern of dengue fever spread in Madiun. This study specifically adopts the SIR (Susceptible, Infected, Recovered) compartmental model used in the study.

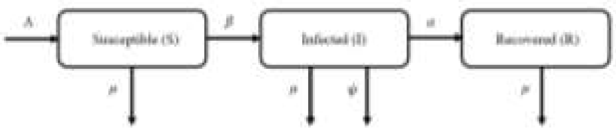
The SIR model is a classic epidemiological model that divides the population into three groups or compartments that are mutually exclusive with the following mathematical model.

$$N_{(t)} = S_{(t)} + I_{(t)} + R_{(t)}$$

Notes:

$N_{(t)}$ = Human population
$S_{(t)}$ = Susceptible population
$I_{(t)}$ = Infected population
$R_{(t)}$ = Recovered population

The interactions and transitions between these compartments are visualized in the following transition diagram.



Notes:

Λ = Number of births
β = New infection rate
α = Recovery rate
μ = Natural mortality rate
ψ = Mortality rate due to dengue fever

This diagram shows how individuals from the Λ (birth) population enter the Susceptible compartment. From there, they can become infected at a rate of β and move to the Infected compartment. Infected individuals can then move to the Recovered compartment at a recovery rate α. This model also takes into account natural mortality μ in each compartment and mortality due to disease ψ in the Infected compartment.

The dynamics of movement between compartments will produce a disease spread pattern that can be described mathematically through the following system of differential equations.

$$\frac{dS}{dt} = \Lambda - \beta SI - \mu S \quad \ldots(1)$$
$$\frac{dI}{dt} = \beta SI - \alpha I - \mu I - \psi I \quad \ldots(2)$$
$$\frac{dR}{dt} = \alpha I - \mu R \quad \ldots(3)$$

Parameter Settings (Basic Model)

This numerical analysis uses secondary data collected by Baihaqi, et al. from Badan Pusat Statistik (BPS) of Madiun Regency and City in 2020-2022.

Table 1. BPS Madiun Population Data for 2020-2022.

Year	Births	Deaths	Total Population
2020	5.885	4.582	196.971
2021	6.658	4.656	199.912
2022	6.844	4.256	201.460

Table 1 shows the distribution of population in Madiun Regency and City. From this table, the proportion of natural births (Λ) can be obtained by dividing the number of births by the number of subdistricts in Madiun Regency and City. Meanwhile, the death rate (μ) is obtained by dividing the number of deaths by the total population.

Table 2. Data on the Distribution of Dengue Fever, BPS 2020-2022.

Year	Dengue Fever Infections	Deaths Due to Dengue Fever Infections
2020	244	6
2021	359	5
2022	484	5

Table 2 shows the distribution of dengue fever infections and deaths caused by dengue fever. This table can be processed to obtain the new dengue fever infection rate (β) by dividing the total number of dengue fever infections by the total population of Madiun city and regency. Furthermore, to obtain the recovery rate (α) and mortality rate (ψ) for dengue fever, the number of recoveries and deaths is divided by the total number of dengue fever infections.

From population data (births, deaths, total population) and dengue fever infection data (number of infections, deaths due to dengue fever), the parameter values for the basic model are obtained as follows.

Table 3. Parameters for the Differential Equation System.

Parameter	Symbol	Value	Unit
Number of Births	Λ	300	Soul
Infection Rate	β	0,001	1/person
Recovery Rate	α	0,975	1/person
Natural Deaths	μ	0,023	1/person
Deaths due to Dengue Fever	ψ	0,025	1/person

To understand the implications of the existing parameters and visualize the behavior of the SIR model, a series of numerical simulations will be conducted. These simulations are run using MATLAB software.

Data analysis

Equilibrium Point

In epidemiological modeling, an equilibrium point is a condition in which the system is in a stable state, meaning that the number of individuals in each compartment (S, I, and R) no longer changes over time. In other words, the rate of change for all compartments is set to zero.

$$\frac{dS}{dt} = 0, \qquad \frac{dI}{dt} = 0, \qquad \frac{dR}{dt} = 0$$

The Disease-Free Equilibrium Point represents the ideal scenario in which the disease has disappeared from the population. To find this point, the model is set to a stable condition with the main assumption that there are no more infected individuals, so that

$$I = 0$$

Calculations are performed by applying these conditions to differential equations (1) and (3).

In differential equation (1), the following results are obtained.

$$\frac{dS}{dt} = \Lambda - \mu S = 0$$
$$\mu S = \Lambda$$
$$S = \frac{\Lambda}{\mu}$$

In differential equation (3), the following results are obtained.

$$\frac{dR}{dt} = -\mu R = 0$$
$$R = 0$$

Thus, the Disease-Free Equilibrium Point (EP_0) for this model is defined as:

$$EP_0 = (S_0, I_0, R_0) = \left(\frac{\Lambda}{\mu}, 0,0\right)$$

Furthermore, the Endemic Equilibrium Point is a theoretical condition in which the disease persists in the population at a stable level. This is a scenario in which the number of infected individuals is not zero, but also does not explode, instead remaining in equilibrium and can be written as follows.

$$I \neq 0$$

Calculations are performed by applying these conditions to differential equations (1), (2), and (3). In differential equation (2), the value of S can be obtained as follows.

$$\frac{dI}{dt} = \beta SI - \alpha I - \mu I - \psi I = 0$$
$$\beta SI = \alpha I + \mu I + \psi I$$
$$\beta SI = I(\alpha + \mu + \psi)$$
$$\beta S = \alpha + \mu + \psi$$
$$S = \frac{\alpha + \mu + \psi}{\beta}$$

In differential equation (3), the value of R can be obtained as follows.

$$\frac{dR}{dt} = \alpha I - \mu R = 0$$
$$\mu R = \alpha I$$
$$R = \frac{\alpha I}{\mu}$$

In differential equation (1), the value of (I) can be obtained as follows.

$$\frac{dS}{dt} = \Lambda - \beta SI - \mu S = 0$$
$$\beta SI = \Lambda - \mu S$$
$$I = \frac{\Lambda - \mu S}{\beta S}$$
$$I = \frac{\Lambda - \mu\left(\frac{\alpha+\mu+\psi}{\beta}\right)}{\beta\left(\frac{\alpha+\mu+\psi}{\beta}\right)}$$
$$I = \frac{\beta\Lambda - \mu(\alpha + \mu + \psi)}{\beta(\alpha + \mu + \psi)}$$

Thus, the Endemic Equilibrium Point (EP_1) for this model is defined as

$$EP_1 = (S_1, I_1, R_1)$$

With

$$S_1 = \frac{\alpha + \mu + \psi}{\beta}$$
$$I_1 = \frac{\beta\Lambda - \mu(\alpha + \mu + \psi)}{\beta(\alpha + \mu + \psi)}$$
$$R_1 = \frac{\alpha I}{\mu}$$
$$= \frac{\alpha\left(\frac{\beta\Lambda-\mu(\alpha+\mu+\psi)}{\beta(\alpha+\mu+\psi)}\right)}{\mu}$$
$$= \frac{\alpha\big(\beta\Lambda - \mu(\alpha + \mu + \psi)\big)}{\mu\beta(\alpha + \mu + \psi)}$$

Existence Conditions

From the analysis of the Disease-Free and Endemic Equilibrium Points above, the existence conditions for disease-free and endemic states can be obtained.

In disease-free conditions, it is known that $S_0 \geq 0$, which means that the Disease-Free Equilibrium Point always exists in this population.

In endemic conditions, the Endemic Equilibrium Point only exists if the disease continues to exist in the population, that is $I > 0$. In other words, the existence condition for endemicity is

$$\beta\Lambda - \mu(\alpha + \mu + \psi) > 0$$

Stability

To determine the stability of the Equilibrium Point, the Jacobian matrix is formed as follows.

$$J = \begin{bmatrix} \frac{\partial f_1}{\partial S} & \frac{\partial f_1}{\partial I} & \frac{\partial f_1}{\partial R} \\ \frac{\partial f_2}{\partial S} & \frac{\partial f_2}{\partial I} & \frac{\partial f_2}{\partial R} \\ \frac{\partial f_3}{\partial S} & \frac{\partial f_3}{\partial I} & \frac{\partial f_3}{\partial R} \end{bmatrix}$$

With

$$f_1 = \frac{dS}{dt} = \Lambda - \beta SI - \mu S$$
$$f_2 = \frac{dI}{dt} = \beta SI - \alpha I - \mu I - \psi I$$
$$f_3 = \frac{dR}{dt} = \alpha I - \mu R$$

Thus, equation 1 is obtained:

$$\frac{\partial f_1}{\partial S} = -\beta I - \mu$$
$$\frac{\partial f_1}{\partial I} = -\beta S$$
$$\frac{\partial f_1}{\partial R} = 0$$

Equation 2:

$$\frac{\partial f_2}{\partial S} = \beta I$$
$$\frac{\partial f_2}{\partial I} = \beta S - \alpha - \mu - \psi$$
$$\frac{\partial f_2}{\partial R} = 0$$

And equation 3:

$$\frac{\partial f_3}{\partial S} = 0$$
$$\frac{\partial f_3}{\partial I} = \alpha$$
$$\frac{\partial f_3}{\partial R} = -\mu$$

Therefore, the Jacobian matrix for disease-free is

$$J(\Lambda/\mu, 0,0) = \begin{bmatrix} -\mu & -\beta \frac{\Lambda}{\mu} & 0 \\ 0 & \beta \frac{\Lambda}{\mu} - \alpha - \mu - \psi & 0 \\ 0 & \alpha & -\mu \end{bmatrix}$$

The eigenvalues for determining stability can be obtained by

$$\left| J\left(\frac{\Lambda}{\mu}, 0,0\right) - \lambda I \right| = 0$$

$$\begin{vmatrix} -\mu - \lambda & -\beta \frac{\Lambda}{\mu} & 0 \\ 0 & \beta \frac{\Lambda}{\mu} - \alpha - \mu - \psi - \lambda & 0 \\ 0 & \alpha & -\mu - \lambda \end{vmatrix} = 0$$

$$(-\mu - \lambda) \begin{vmatrix} \beta \frac{\Lambda}{\mu} - \alpha - \mu - \psi - \lambda & 0 \\ \alpha & -\mu - \lambda \end{vmatrix} = 0$$

$$(-\mu - \lambda)\left(\beta \frac{\Lambda}{\mu} - \alpha - \mu - \psi - \lambda\right)(-\mu - \lambda) = 0$$

$$(-\mu - \lambda)^2 \left(\beta \frac{\Lambda}{\mu} - \alpha - \mu - \psi - \lambda\right) = 0$$

From the above equations, the value of λ is obtained as follows.

$$-\mu - \lambda = 0$$
$$\lambda = -\mu$$

And

$$\beta \frac{\Lambda}{\mu} - \alpha - \mu - \psi - \lambda = 0$$
$$\lambda = \beta \frac{\Lambda}{\mu} - \alpha - \mu - \psi$$

Note that

$$\lambda_1 = \lambda_2 = -\mu < 0$$

And

$$\lambda_3 = \beta \frac{\Lambda}{\mu} - \alpha - \mu - \psi$$

Thus, the condition for disease-free stability is obtained as follows.

1. If $\beta\Lambda < \mu(\alpha + \mu + \psi)$, then $\lambda_3 < 0$, so it is stable.
2. If $\beta\Lambda > \mu(\alpha + \mu + \psi)$, then $\lambda_3 > 0$, so it is unstable.

Furthermore, using the same equation, the endemic Jacobian matrix can be obtained as follows.

$$J(S_1, I_1, R_1) = \begin{bmatrix} -\beta I_1 - \mu & -\beta S_1 & 0 \\ \beta I_1 & \beta S_1 - \alpha - \mu - \psi & 0 \\ 0 & \alpha & -\mu \end{bmatrix}$$

The eigenvalues for determining stability can be obtained by

$$|J(S_1, I_1, R_1) - \lambda I| = 0$$

$$\begin{vmatrix} -\beta I_1 - \mu - \lambda & -\beta S_1 & 0 \\ \beta I_1 & \beta S_1 - \alpha - \mu - \psi - \lambda & 0 \\ 0 & \alpha & -\mu - \lambda \end{vmatrix} = 0$$

$$(-\beta I_1 - \mu - \lambda)\begin{vmatrix} \beta S_1 - \alpha - \mu - \psi - \lambda & 0 \\ \alpha & -\mu - \lambda \end{vmatrix} - (-\beta S_1)\begin{vmatrix} \beta I_1 & 0 \\ 0 & -\mu - \lambda \end{vmatrix} = 0$$

$$((-\beta I_1 - \mu) - \lambda)\left(\lambda^2 + \left(-(\beta S_1 - a - \mu - \psi) - (-\mu)\right)\lambda + (\beta S_1 - a - \mu - \psi)(-\mu)\right) - (-\beta S_1)(-\beta I_1 \mu - \beta I_1 \lambda) = 0$$

To simplify the calculation, let us assume

$$\begin{aligned} a &= -\beta I_1 - \mu \\ b &= -(\beta S_1 - a - \mu - \psi) - (-\mu) \\ c &= (\beta S_1 - a - \mu - \psi)(-\mu) \\ d &= -\beta S_1 \\ e &= -\beta I_1 \mu \\ f &= \beta I_1 \end{aligned}$$

From the above assumption, we obtain

$$\begin{aligned} (a - \lambda)(\lambda^2 + b\lambda + c) - (d)(e - f\lambda) &= 0 \\ -\lambda^3 + a\lambda^2 - b\lambda^2 + ab\lambda - c\lambda + df\lambda + ac - de &= 0 \\ -\lambda^3 + (a - b)\lambda^2 + (ab - c + df)\lambda + (ac - de) &= 0 \end{aligned}$$

Using the Routh-Hurwitz Criterion for third-order polynomials

$$p(s) = a_3 s^3 + a_2 s^2 + a_1 s + a_0 = 0$$

We obtain

$$\lambda^3 - (a - b)\lambda^2 - (ab - c + df)\lambda - (ac - de) = 0$$

With the $a_i > 0$ for $i = 0, 1, 2, 3$

For

$$a_3 = 1 > 0$$

Furthermore, for

$$a_2 a_1 - a_3 a_0 > 0$$

Given

$$-(a - b) > 0, -(ab - c + df) > 0, -(ac - de) > 0$$

Obtained

$$[-(a - b)][-(ab - c + df)] - [-(ac - de)] > 0$$

Thus, the endemic stability condition is obtained as follows.

$$XY - Z > 0$$

With

$$\begin{aligned} X &= -\left(-\beta I_1 - \mu - \left(-(\beta S_1 - a - \mu - \psi) - (-\mu)\right)\right) \\ Y &= -\left((-\beta I_1 - \mu)\left(-(\beta S_1 - a - \mu - \psi) - (-\mu)\right) - \left((\beta S_1 - a - \mu - \psi)(-\mu)\right) + (-\beta S_1)(\beta I_1)\right) \\ Z &= -\left((-\beta I_1 - \mu)\left((\beta S_1 - a - \mu - \psi)(-\mu)\right) - (-\beta S_1)(-\beta I_1 \mu)\right) \end{aligned}$$

Simulation

Using the differential equations and existing parameters, the simulation results are as follows.

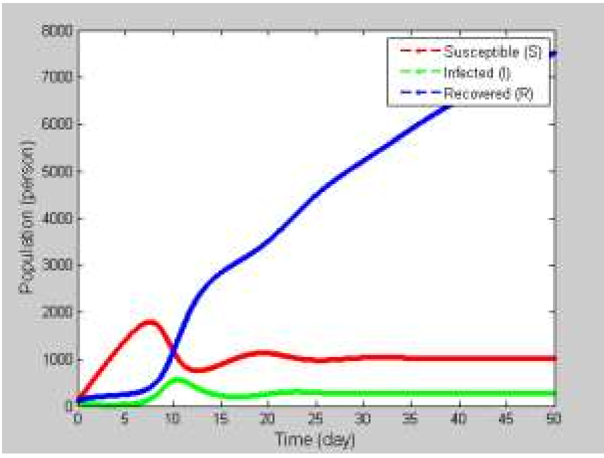


Figure 1. Simulation of parameters and differential equations using MATLAB.

Simulation Interpretation

In the graph above, it can be seen that after reaching the peak of the outbreak, the Infected curve does not drop to zero, but stabilizes at a constant level. This means that infections continue to exist and spread in the population at a stable rate. Meanwhile, the susceptible population initially increases, then drops dramatically as the infection spreads. After that, this population does not disappear, but stabilizes at a certain level, oscillating (rising and falling) in line with the infection cycle. Meanwhile, the recovered population continues to increase over time. This shows that individuals continuously move from the infected compartment to the recovered compartment. Since the infected curve never reaches zero, this means that there will always be a flow of new people who recover, so that the recovered population continues to accumulate.

Results And Discussion

Based on the above analysis, a unique and new batik motif was created. This was done by readjusting the simulation to obtain a graph shape that could be implemented into a batik motif.

Batik Motif

The above simulation was readjusted by changing the day range from 50 days to 10 days, resulting in the following graph.

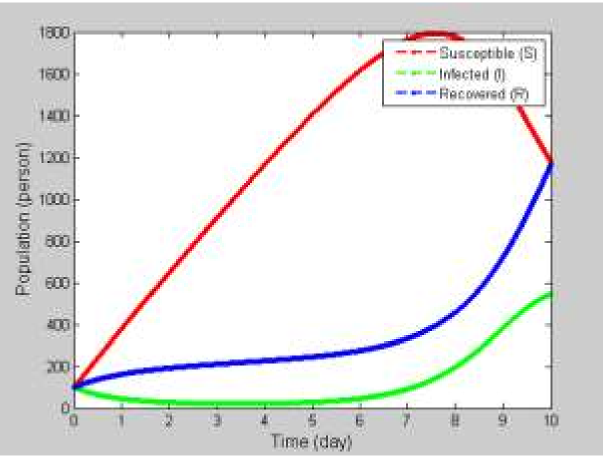


Figure 2. Simulation with a 10-day range.

The simulation shows the days when the infected population was at its peak, resulting in a graph resembling the shape of a butterfly's wings. Based on this graph, inspiration was gained to create batik with the following butterfly motif.

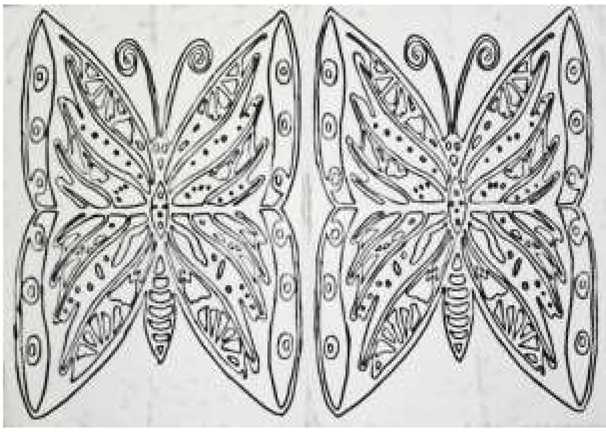


Figure 3. Butterfly Batik Motif.

Discussion

The butterfly batik motif above was created based on philosophical, biological, and mathematical meanings that are rich in life and beauty.

Philosophical Meaning

The butterfly motif in batik is a symbol of transformation that is rich in meaning of life. In its biological process, a butterfly undergoes metamorphosis from an egg, to a caterpillar, then a cocoon, until it finally metamorphoses into a beautiful winged creature. This biological journey is then interpreted philosophically as the process of human spiritual transformation. It symbolizes the long journey of humans in achieving enlightenment from unconsciousness to consciousness, from roughness to refinement, and from the material world to higher spirituality. In the context of Javanese culture, this metamorphosis is often associated with the concept of ngelmu kasampurnan, which is the human effort to achieve inner balance and perfection in life.

Another philosophical meaning of this motif lies in the symbol of balance. The symmetry of butterfly wings is not only visually beautiful, but also represents the harmony between thoughts (cipta), feelings (rasa), and actions (karsa). These three elements are the main pillars in the Javanese view of life, which emphasizes harmony between the spiritual and worldly aspects. Butterflies, with their open and balanced wings, remind humans to maintain harmony between themselves, others, and the universe.

In addition, butterflies are often interpreted as a symbol of spiritual freedom. Their ability to fly freely from one flower to another reflects the human soul that has achieved inner freedom, free from worldly attachments and able to live in harmony with nature. In Eastern philosophy, this freedom does not mean detaching oneself from the world, but understanding the world without attachments that cause suffering. Therefore, butterfly motifs are often used in batik to symbolize life's journey, hope, and prayers for a person to achieve balance and wisdom.

In a modern context, the philosophical meaning of the butterfly motif can also be interpreted as a symbol of positive change and adaptation to the times. In a constantly changing world, humans are required to be able to adapt like butterflies that have successfully undergone metamorphosis. Thus, the butterfly motif serves as a reminder that change is not the end, but an important part of growth towards a more beautiful and meaningful life.

Biological Meaning

Biologically, butterflies belong to the order Lepidoptera and have a bilaterally symmetrical body structure. This symmetry not only provides beauty of form, but also serves an important function in stability and efficiency of movement. Each left and right wing is almost identical in size and pattern, which allows butterflies to maintain aerodynamic balance when flying. In batik, this symmetrical structure is translated into balanced motifs, where artists attempt to imitate the harmony of forms found in nature. Thus, butterfly batik motifs reflect an appreciation for biological order and natural balance.

Butterflies also play a very important ecological role in maintaining the balance of the ecosystem. They function as natural pollinators, helping the process of plant pollination as they flit from flower to flower . This pollination process enables plant regeneration and preserves nature. In a symbolic context, the role of butterflies as pollinators can be interpreted as a representation of humans who play a role in maintaining harmony and sustainability in life. Batik with butterfly motifs reminds us of the role of humans as guardians of ecological balance, not disruptors of the natural balance.

Anatomically, the veins on butterfly wings have a very regular branching pattern. This pattern serves to strengthen the wing structure and assist airflow during flight. In batik art, these veins are often depicted as lines or branches that create a lively and dynamic impression. Symbolically, these lines can be interpreted as the flow of life energy, depicting the interconnectedness of the elements of nature that support each other. Just as the veins on butterfly wings channel energy, humans also live in an interdependent system of life.

Furthermore, from an evolutionary biology perspective, butterflies are an example of perfect adaptation to their environment. The color patterns and shapes of their wings often serve as camouflage to protect themselves from predators. In batik, this can be interpreted as a representation of natural intelligence that teaches humans to adapt wisely to environmental changes. Thus, in a biological context, butterfly motifs not only depict the beautiful physical form of animals, but also symbolize life, ecological balance, and the wisdom of natural adaptation.

Mathematical Meaning

From a mathematical point of view, butterfly motifs reflect the principle of reflective symmetry, which is a basic form of geometry. This symmetry can be explained through the concept of geometric transformation, specifically reflection on the vertical axis of the butterfly's body. In this case, each element on one side of the wing is an identical image of the other side. This principle of symmetry creates a visually pleasing balance and demonstrates a mathematical regularity that is also found in nature. In batik art, the application of this kind of symmetry illustrates how Indonesian artists apply mathematical principles in their work without having to formulate them explicitly.

In addition to symmetry, butterfly motifs also feature patterns with fractal characteristics, which are patterns that repeat with similar structures on different scales. The patterns of dots and lines on butterfly wings often show regular repetitions that can be analyzed through fractal theory. This principle of self-similarity illustrates how complexity can arise from simplicity, that the beauty of butterflies is not the result of random design, but of a natural process governed by harmonious mathematical laws. In batik, this fractal principle is reflected in the repetition of small motifs that form a larger pattern that blends together as a whole.

Additionally, in terms of proportion and geometric regularity, butterfly motifs often reflect the concept of the golden ratio, which is frequently found in natural structures. This ratio is known to produce the most harmonious visual balance for the human eye. Traditional batik artists may not consciously calculate these mathematical proportions, but through aesthetic intuition and experience, they are able to create a visual balance that reflects universal mathematical beauty. This demonstrates the deep connection between artistic intuition and logical structure in traditional Indonesian art.

Furthermore, the geometric patterns on butterfly batik can be analyzed using the concept of group symmetry (group theory), where pattern repetition and visual balance follow mathematical principles that can be formally modeled. This confirms that batik art is not only an expression of visual beauty, but also a representation of order and the laws of nature. Thus, butterfly motifs are not only aesthetic works, but also a window to understanding the interconnection between art, science, and mathematics as a harmonious whole.

Conclusions

This study successfully created an innovative integration between applied mathematics, batik art, and public health awareness. This research uses the SIR (Susceptible, Infected, Recovered) epidemiological model to analyze real data on the spread of Dengue Hemorrhagic Fever (DHF) in Madiun from 2020 to 2022. Additionally, this research also conducts numerical simulations and model stability analysis to understand how the disease spreads. The results of the analysis, such as epidemiological curves and important parameters like the infection rate β and basic reproduction number R_0, were used to create a contemporary batik motif with deep meaning. The motif, titled " ," features butterfly shapes that are not only aesthetically pleasing but also serve as a visual educational tool about the dangers of DHF. This motif also represents the process of transformation and balance, both in the context of health and everyday life. Thus, this research shows that scientific data and models can be a powerful source of inspiration in creating modern, relevant works of cultural art that remain rooted in local traditions. In addition, this research also enriches the Indonesian batik heritage through an interdisciplinary approach that combines science, art, and culture.

References

Baihaqi MA, Al-Kubro PB, Andyani RA, Setyawati Y, Rahayu UB, Fitriyya M. 2023. Pola penyebaran penyakit demam berdarah dengan model SIR di Madiun tahun 2020-2022. Jurnal Keilmuan dan Keislaman 3(1): 1-9.

Hubu AFD, Achmad N, Nurwan. 2020. Model matematika SMEIUR pada penyebaran penyakit campak dengan factor pengobatan. Jambura Journal of Biomathematics 1(2): 71-80.

Book:

Ginanjar G. 2008. Demam Berdarah. PT Mizan Publika, Jakarta.

Information from internet:

Azzahra N. 2023. Batik salah satu warisan budaya Indonesia. I-WIN Library. www.waqafilmunusantara.com

Susantio D. 2012. Sejarah batik di Indonesia. Majalah Arkeologi Indonesia. www.hurahura.wordpress.com