International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

Mathematical Model for the control of Life cycle of Feminine Anopheles Mosquitoes

Naresh Kumar Jothi, M.L. Suresh, T N M Malini Mai

Abstract*: *In this paper, using Mathematical model to control the life cycle of Feminine Anopheles mosquitoes is derived. The Feminine Anopheles mosquito life cycle controlling by backstepping strategy. The backstepping control technique provides the scientific procedure for choosing a controller in Feminine Anopheles life cycle. The Feminine Anopheles mosquito life cycle models are derived using Lyapunov stability theory.

***Keywords: Mathematical model, Feminine Anopheles mosquito, Malaria, Back stepping, Lyapunov function*.**

I. INTRODUCTION

Malaria is transmitted in humans by Feminine Anopheles mosquito genus. Feminine Anopheles mosquito genus takes blood meals, to carry out egg production, that link between the human and also the Anopheles insect. Anopheles genus life cycle depends on many natural factors however temperature and humidness measure the foremost sensitive natural factors in their life cycle. Normally 30−40 Feminine Anopheles species transmit infection in nature.

The life stage of the Feminine Anopheles mosquito is categorised into 4 stages like egg, larva, pupa and adult. The primary 3 stages except adult are in floating [1–4]. These 3 stages principally rely upon aquatic temperature [5–7]. Once adult Feminine Anopheles mosquitoes have emerged, the temperature and humidness might transmit malaria with success.

In recent years, a backstepping approach has been produced for arranging controllers to manage the stimulating frameworks [8, 9]. A standard develop of the methodology is that the style of an all around stable control dynamical framework. The backstepping strategy is predicated on the numerical model of the analyzed framework, bringing new factors into it during a sort depending on the state factors, predominant parameters, and supportive capacities. The extreme work of an accommodating stage space is to dispose of nonlinearities tired the framework and impacting the consistent quality of its activity [10–15]. The work of backstepping procedure makes an additional non-linearity and eliminates with unwanted nonlinearities from the framework.

In this paper, the elements of Feminine Anopheles mosquito life cycle is displayed and backstepping the board style is planned to control the Feminine Anopheles mosquito life cycle. The backstepping method is applied in every stage of the Feminine Anopheles mosquito life cycle. Lyapunov function is used to work out the backstepping method.

This paper is sorted out as pursues, In segment two, the arrangement of differential condition is demonstrated. This differential condition speaks to the existence cycle of Feminine Anopheles mosquito. In segment three, existence life cycle control using backstepping method is demonstrated. In section four, the simulation work is demonstrated and In section five, the account of the results obtained during this paper is explained.

II. MATHEMATICAL MODEL FORMULATION

The absolute populace of Feminine Anopheles mosquito life cycle comprises of four structures, for example, grown-up, egg, hatchling and pupa.

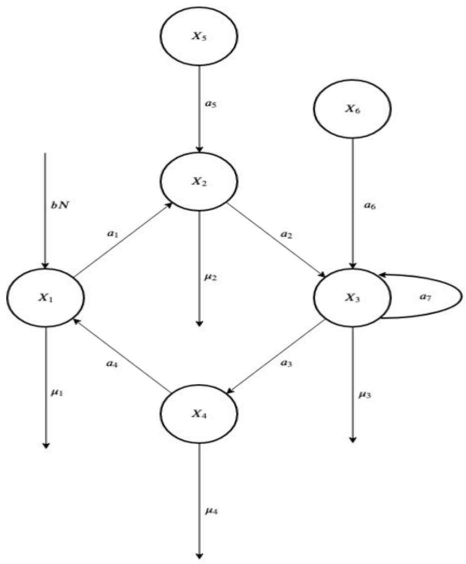

Fig 1 Stream Diagram of Feminine Anopheles life cycle

Manuscript published on 30 September 2019
* Correspondence Author
Naresh Kumar Jothi*, Department of Mathematics, Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology, Avadi, Chennai, Tamilnadu, INDIA. nareshsastra@yahoo.co.in
M.L. Suresh, Department of Mathematics, Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology, Avadi, Chennai, Tamilnadu, INDIA. mukunthusuresh@gmail.com
T N M Malini Mai, Department of Mathematics, Jeppiaar SRR Engineering College, Padur, Chennai. malinitnm2008@yahoo.com

For Mathematical Model of Feminine Anopheles mosquito life cycle, the accompanying suppositions are made.

1. In each stage, the regular passing rate is considered consistently.
2. Let bN be the current populace, where b is regular birth rate at grown-up stage.
3. is the controller in egg arrange at the rate .
4. is controller in hatchling stage at the rate .

The accompanying arrangement of differential conditions to clarify elements of Feminine Anopheles mosquito life cycle

$$\frac{dX_1}{dt} = bN + a_4X_4 - (a_1 + d_1)X_1$$
$$\frac{dX_2}{dt} = a_1X_1 + a_5X_5 - (a_3 + d_2)X_2$$
$$\frac{dX_3}{dt} = a_2X_2 - (a_7 + a_3 + d_3)X_3 + a_6X_6$$
$$\frac{dX_4}{dt} = a_3X_3 - (a_4 + d_4)X_4$$

Depiction of factors and parameters of the model

Parameters	Depiction
b	regular birth rate at grown-up stage
N	total population at adult stage
X_1	number of adult mosquito at time t
X_2	number of egg at time t
X_3	number of larva at time t
X_4	number of pupa at time t
X_5	controller in egg stage
X_6	controller in larva stage
a_1	rate of adult mosquito oviposit
a_2	ate of egg harsh to larva
a_3	rate of larva push up to pupa
a_4	rate of pupa push up to adult mosquito
a_5	death rate of static control at eggs stage
a_6	death rate of static control at larva stage
a_7	death rate of larva eat-ups the larva's
d_1	normal death rate at adult stage
d_2	normal death rate at egg stage
d_3	normal death rate at larva stage
d_4	normal death rate at pupa stage

III. CONTROL OF LIFE CYCLE OF FEMININE ANOPHELES MOSQUITO GENUS BY BACKSTEPPING METHOD

In this area, the backward backstepping control methodology is employed to break the Feminine Anopheles mosquito family life cycle.

The elements of Feminine Anopheles mosquito family life cycle is consider as

$$\frac{dX_4}{dt} = a_3X_3 - (a_4 + d_4)X_4$$
$$\frac{dX_3}{dt} = a_2X_2 - (a_7 + a_3 + d_3)X_3 + a_6X_6 \qquad (1)$$
$$\frac{dX_2}{dt} = a_1X_1 + a_5X_5 - (a_3 + d_2)X_2$$
$$\frac{dX_1}{dt} = bN + a_4X_4 - (a_1 + d_1)X_1 + c$$

First consider the pupa state dynamics

$$\frac{dX_4}{dt} = a_3X_3 - (a_4 + d_4)X_4$$

assume $v1 =$ where is the virtual controller in pupa stage. The virtual controller stabilize the pupa stage.
Consider the Lyapunov function

$$V_1 = \frac{1}{2}X_4^2$$

Suppose the derivative of the Lyapunov function is

$$\dot{V}_1 = X_4\left[a_3v_1\text{-}(a_4\text{+}d_4)X_4\right]$$

Assume $v_1 = 0$ then

$$\dot{V}_1 = \text{-}(a_4\text{+}d_4)X_4^2$$

which is negative definite .

Consequently the pupa stage is asymptotically stable.

The function $v_1(X_4)$ is estimative when X_3 is consider as a controller.
Now the relation between the larva stage X_3 and the virtual controller $v_1(X_4)$ is

$$\omega_2 = X_3\text{-}v_1\text{=}X_3$$

Consider the (X_4, ω_2) system

Retrieval Number: C6876098319/2019©BEIESP
DOI:10.35940/ijrte.C6876.098319
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

$$\frac{dX_4}{dt} = a_3\omega_2 - (a_4 + d_4)X_4$$

$$\frac{d\omega_2}{dt} = a_2X_2 - (a_7 + a_3 + d_3)X_3 + a_6X_6$$

Suppose, Consider the Lyapunov function

$$V_2 = V_1 + \frac{1}{2}\omega_2^2$$

Hence, the differential value of V_2 is

$$\dot{V}_2 = -(a_4 + d_4)X_4^2 - (a_7 + a_3 + d_3)X_3 + (a_2X_2 + a_6X_6 + a_3X_4)\omega_2$$

where a_7 is the passing rate of hatchling eat-ups hatchling.

The egg stage X_2 is consider as virtual controller, assume $X_2 = v_2$

Choose $v_2 = 0$ and $X_6 = \frac{-a_3X_4}{a_6}$ then $\dot{V}_2$ is

$$\dot{V}_2 = -(a_4 + d_4)X_4^2 - (a_7 + a_3 + d_3)\omega_2^2$$

which is negative definite .
Consequently the stage (8) is asymptotically stable with controllers.
The relation between egg stage X_2 and the v_2 is given by

$$\omega_3 = X_2 - v_2 = X_2$$

Consider the $(X_4, \omega_2, \omega_3)$ system

$$\frac{dX_4}{dt} = a_3\omega_2 - (a_4 + d_4)X_4$$

$$\frac{d\omega_2}{dt} = a_2\omega_3 - (a_7 + a_3 + d_3)\omega_2 - a_3X_4 \qquad (13)$$

$$\frac{d\omega_3}{dt} = a_1X_1 + a_5X_5 - (a_2 + d_2)\omega_3$$

where X_5 is the virtual controller.
Assume the Lyapunov function defined by

$$V_3 = V_2 + \frac{1}{2}\omega_3^2$$

Hence, the differential value of V_3 is

$$\dot{V}_3 = -(a_4 + d_4)X_4^2 - (a_7 + a_3 + d_3)\omega_2^2 - (a_2 + d_2)\omega_3^2 + (a_1X_1 + a_5X_5 + a_2\omega_2)\,\omega_3 \qquad (15)$$

Assume the virtual controller, assume $X_1 = v_3$

Choose the controller $v_3 = 0$

Then, it follows that

$$\dot{V}_3 = -(a_4 + d_4)X_4^2 - (a_7 + a_3 + d_3)\omega_2^2 - (a_2 + d_2)\omega_3^2 + (a_5X_5 + a_2\omega_2)\,\omega_3$$

Assume the controller $X_5 = \frac{-a_2\omega_2}{a_5}$, then (8)

$$\dot{V}_3 = -(a_4 + d_4)X_4^2 - (a_7 + a_3 + d_3)\omega_2^2 - (a_2 + d_2)\omega_3^2$$

Then the result is negative definite .
Consequently the stage (13) is asymptotically stable. (9)
Take v_3 is estimative when the adult stage is consider as controller.
The relation between egg stage X_1 and the v_3 is given by

$$\omega_4 = X_1 - v_3 = X_1 \qquad (10)$$

Consider the $(X_4, \omega_2, \omega_3, \omega_4)$ system

$$\frac{dX_4}{dt} = a_3\omega_2 - (a_4 + d_4)X_4$$

$$\frac{d\omega_2}{dt} = a_2\omega_3 - (a_7 + a_3 + d_3)\omega_2 - a_3X_4$$

$$\frac{d\omega_3}{dt} = a_1X_1 - a_2\omega_2 - (a_2 + d_2)\omega_3 \qquad (11)$$

$$\frac{dX_1}{dt} = bN + a_4X_4 - (a_1 + d_1)\omega_4 + c$$

Assume the Lyapunov function defined by

$$V_4 = V_3 + \frac{1}{2}\omega_4^2 \qquad (12)$$

Hence, the differential value of V_4 is

$$\dot{V}_4 = -(a_4 + d_4)X_4^2 - (a_7 + a_3 + d_3)\omega_2^2 - (a_2 + d_2)\omega_3^2 - (a_1 + d_1)\omega_4^2 + (a_1\omega_3 + bN + a_4X_4 + c)\,\omega_4$$

Choose the back stepping control $c = -(a_1\omega_1 + bN + a_4X_4)$ (22)

Substituting (22) into (21), which implies that

$$\dot{V}_4 = -(a_4 + d_4)X_4^2 - (a_7 + a_3 + d_3)\omega_2^2 - (a_2 + d_2)\omega_3^2 - (a_1 + d_1)\omega_4^2 \qquad (14)$$

Hence, $\dot{V}_4$ is negative definite. Along these lines by Lyapunov stability theory, the stage (19) asymptotically stable for all initial conditions. Consequently, all stages of mosquito life cycle are asymptotically stable.

IV. NUMERICAL REPRODUCTIONS

The numerical reproductions, Runge Kutta 4-th order technique is employed to solve the system of Feminine Anopheles mosquito life cycle differential equations with controllers X_5 , X_6 and c. The parameters of the Feminine Anopheles mosquito life cycle dynamics taken in random. The initial values of the dynamics are chosen as $X_1(0)$ = 23548762, $X_2(0)$ = 3432986785, $X_3(0)$ = 5609869, $X_4(0)$ = 789098

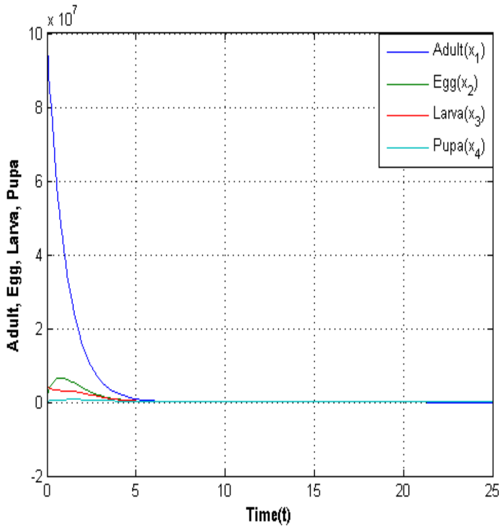

Fig 2 Stability of Feminine Anopheles mosquito Life Cycle control

V. CONCLUSION

In this paper, the arrangement of differential condition for Feminine Anopheles mosquito life cycle is demonstrated. Back stepping control strategy has been connected to control the Feminine Anopheles mosquito life cycle. Since the Lyapunov types don't appear to be required for these computations. The parameters esteems are picked as irregular. The parameter esteems depends their tendency conditions, for example temperature of water, and so forth. The examination of subjective properties of Feminine Anopheles mosquito is testing and greater unpredictability. The investigation of such dynamical properties is till an open issue. Numerical reproductions have been given to approve and delineate the adequacy of the back venturing control-based Feminine Anopheles mosquito life cycle control.

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AUTHORS PROFILE

Naresh Kumar Jothi Department of Mathematics, Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology, Avadi, Chennai, Tamilnadu, INDIA. nareshsastra@yahoo.co.in

M.L. Suresh Department of Mathematics, Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology, Avadi, Chennai, Tamilnadu, INDIA. mukunthusuresh@gmail.com

T N M Malini Mai Department of Mathematics, Jeppiaar SRR Engineering College, Padur, Chennai, India. malinitnm2008@yahoo.com