P-1

# Fish - Human Modelling when there is a disease inside Human

## Example 1 : Fish - Human Model

$$\left.\begin{aligned} \frac{dx}{dt} &= r x\left(1-\frac{x}{K}\right) - \frac{m x y}{Ax+B} \\ \frac{dy}{dt} &= \frac{e m x y}{Ax+B} - d y \end{aligned}\right\} \quad \text{--(1)}$$

$x$ = fish, $y$ = Human, $r$ = birth rate of fish

$K$ = carrying capacity of fish

$m$ = eating rate of fish by the Human.

$e$ = conversion factor, $d$ = death rate of Human

$A, B$ are positive constants.

## Example 1a : Fish is under the influence of transmissible disease then this model takes form.

$x = S + I$

$S \to$ susceptible fish, $I \to$ infected fish

$$\boxed{\begin{aligned} \frac{dS}{dt} &= r S\left(1-\frac{S+I}{K}\right) - \frac{m_1 S y}{A(S+I)+B} - \lambda S I \\ \frac{dI}{dt} &= -\frac{e m_2 I y}{A(S+I)+B} \cancel{\lambda S I} - \delta_1 I \\ \frac{dy}{dt} &= e \end{aligned}}$$

$$\left.\begin{aligned}
\frac{dS}{dt} &= rS\left(1-\frac{S+I}{K}\right) - \frac{m_1 S y}{A(S+I)+B} - \lambda S I \\
\frac{dI}{dt} &= \lambda S I - \frac{m_2 I y}{A(S+I)+B} - \delta_1 I \\
\frac{dy}{dt} &= \frac{e m_1 S Y}{A(S+I)+B} + \frac{e m_2 I Y}{A(S+I)+B} - \delta y
\end{aligned}\right\} \cdots (2)$$

$m_1$ = eating rate of suc

$m_2$ = eating rate of infected fish

$\delta_1$ = death rate of infected fish

$e$ = conversion factor.

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NOW look at the attach paper.

you do not need to read whole paper but the sections 1 and 2 and 4.

## your job (COVID-19 Model)

(A) you have to modify the model (1) under the influene of a disease transmissible disease in Human such as COVID-19. [30]

HINSTS:

Note that I have shown an example to modify model (1) under the influence of a transmissible disease in fish population and obtain the model (2).

Therefore you have to modify the model (1) and you have to obtain a similar model like model (2). It would look like:

$$y = S + I$$

S → susceptable human

I → infected by COVID-19

$$\left.\begin{aligned} \frac{dx}{dt} &= \\ \frac{dS}{dt} &= \\ \frac{dI}{dt} &= \end{aligned}\right\} \quad \text{--(3)}$$

(B) once you obtain the model like model (2), then you do the the following mathematical ~~treatmen~~ methods similar to the attached paper such as:

(B/i). Find the equilibrium points of ~~your~~ your proposed model similar to the section (2.3) of the attached paper. [10]

. your equilibrium points are: $E_0(x_0, S_0, I_0)$, $E_1(x_1, S_1, I_1)$, $E_2(x_2, S_2, I_2)$, $E_3(x_3, S_3, I_3)$, $E_4(x_4, S_4, I_4)$ ......

$x_0=0, S_0=0, I_0=0,$

$x_1=-, S_1=0, I_1=0 \ldots$

(B/ii) Rewrite your model in the form I have done in ~~B@~~ section 4 of the attached paper [10]

(B/iii). Study the dynamics of your model (3) around the equilibrium point $E_0$ and $E_1$, similar to section (4.1) of the attached paper. [10]

(B/iv) Study the dynamics of your model (3) ~~the system~~ around $E_2(x_2, S_2, I_2)$, similar to the section (4-2) of the attached paper. [20]

Note that $E_2(x_2, S_2, I_2)$, $x_2 = 0$ and you have to find $S_2, I_2$.

B (V) Study the dynamics of the system (3) (your model) around $E_3(x_3, S_3, I_3)$

where $x_3 = \ldots$, $S_3 = 0$, $I_3 = \ldots$,

similar to section (4-2) of the attached paper. [20]

Hints: For B(ii) ... B(V), Find the Jacobian matrix of your model (3)

similar to the ~~eigen~~ the begining of the section (4) of the attached paper.