

$$\begin{aligned}
dSdteqn[t_] &= -\beta c II[t, 0] / (c + EE[t, 0] + II[t, 0]) - \mu S c - (D[S[t, a], a] /. a \rightarrow 0) \\
dEEdteqn[t_] &= (1 - \epsilon) \beta c II[t, 0] / (c + EE[t, 0] + II[t, 0]) - \\
&\quad \delta EE[t, 0] - \mu E EE[t, 0] - D[EE[t, 0], t] - (D[EE[t, a], a] /. a \rightarrow 0) \\
dIIIdteqn[t_] &= \epsilon \beta c II[t, 0] / (c + EE[t, 0] + II[t, 0]) + \delta EE[t, 0] - \\
&\quad \mu I II[t, 0] - D[II[t, 0], t] - (D[II[t, a], a] /. a \rightarrow 0)
\end{aligned}$$

$$-c \mu S - \frac{c \beta II[t, 0]}{c + EE[t, 0] + II[t, 0]} - S^{(0,1)}[t, 0]$$

$$-\delta EE[t, 0] - \mu E EE[t, 0] + \frac{c \beta (1 - \epsilon) II[t, 0]}{c + EE[t, 0] + II[t, 0]} - EE^{(0,1)}[t, 0] - EE^{(1,0)}[t, 0]$$

$$\delta EE[t, 0] - \mu I II[t, 0] + \frac{c \beta \epsilon II[t, 0]}{c + EE[t, 0] + II[t, 0]} - II^{(0,1)}[t, 0] - II^{(1,0)}[t, 0]$$

$$\begin{aligned}
yEeqn[t_, a_] &= kE EE[t, a] - yE[t, a] \\
yIeqn[t_, a_] &= kI II[t, a] - yI[t, a]
\end{aligned}$$

$$kE EE[t, a] - yE[t, a]$$

$$kI II[t, a] - yI[t, a]$$

$$\begin{aligned}
yEmap[t_, a_] &= \text{Solve}[yEeqn[t, a] == 0, EE[t, a]][[1]] \\
yImap[t_, a_] &= \text{Solve}[yIeqn[t, a] == 0, II[t, a]][[1]]
\end{aligned}$$

$$\left\{ EE[t, a] \rightarrow \frac{yE[t, a]}{kE} \right\}$$

$$\left\{ II[t, a] \rightarrow \frac{yI[t, a]}{kI} \right\}$$

$$dSdteqn2[t_] = dSdteqn[t] /. (yEmap[t, a] /. a \rightarrow 0) /. (D[yEmap[t, a], t] /. a \rightarrow 0) /. (D[yEmap[t, a], a] /. a \rightarrow 0) /. (yImap[t, a] /. a \rightarrow 0) /.$$

$$\begin{aligned}
&(D[yImap[t, a], t] /. a \rightarrow 0) /. (D[yImap[t, a], a] /. a \rightarrow 0) \\
dEEdteqn2[t_] &= dEEdteqn[t] /. (yEmap[t, a] /. a \rightarrow 0) /. (D[yEmap[t, a], t] /. a \rightarrow 0) /. \\
&(D[yEmap[t, a], a] /. a \rightarrow 0) /. (yImap[t, a] /. a \rightarrow 0) /. \\
&(D[yImap[t, a], t] /. a \rightarrow 0) /. (D[yImap[t, a], a] /. a \rightarrow 0)
\end{aligned}$$

$$\begin{aligned}
dIIIdteqn2[t_] &= dIIIdteqn[t] /. (yEmap[t, a] /. a \rightarrow 0) /. (D[yEmap[t, a], t] /. a \rightarrow 0) /. \\
&(D[yEmap[t, a], a] /. a \rightarrow 0) /. (yImap[t, a] /. a \rightarrow 0) /. \\
&(D[yImap[t, a], t] /. a \rightarrow 0) /. (D[yImap[t, a], a] /. a \rightarrow 0)
\end{aligned}$$

$$-c \mu S - \frac{c \beta yI[t, 0]}{kI \left( c + \frac{yE[t, 0]}{kE} + \frac{yI[t, 0]}{kI} \right)} - S^{(0,1)}[t, 0]$$

$$-\frac{\delta yE[t, 0]}{kE} - \frac{\mu E yE[t, 0]}{kE} + \frac{c \beta (1 - \epsilon) yI[t, 0]}{kI \left( c + \frac{yE[t, 0]}{kE} + \frac{yI[t, 0]}{kI} \right)} - \frac{yE^{(0,1)}[t, 0]}{kE} - \frac{yE^{(1,0)}[t, 0]}{kE}$$

$$\frac{\delta yE[t, 0]}{kE} - \frac{\mu I yI[t, 0]}{kI} + \frac{c \beta \epsilon yI[t, 0]}{kI \left( c + \frac{yE[t, 0]}{kE} + \frac{yI[t, 0]}{kI} \right)} - \frac{yI^{(0,1)}[t, 0]}{kI} - \frac{yI^{(1,0)}[t, 0]}{kI}$$

$$Smap[t_] = \text{Solve}[dSdteqn2[t] == 0, S^{(0,1)}[t, 0]][[1]]$$

$$\left\{ S^{(0,1)}[t, 0] \rightarrow \frac{-c^2 kE kI \mu S - c kI \mu S yE[t, 0] - c kE \beta yI[t, 0] - c kE \mu S yI[t, 0]}{c kE kI + kI yE[t, 0] + kE yI[t, 0]} \right\}$$

**dEEdteqn3[t\_] = dEEdteqn2[t] /. Smap[t]**

**dIIdteqn3[t\_] = dIIdteqn2[t] /. Smap[t]**

$$-\frac{\delta yE[t, 0]}{kE} - \frac{\mu E yE[t, 0]}{kE} + \frac{c \beta (1 - \epsilon) yI[t, 0]}{kI \left( c + \frac{yE[t, 0]}{kE} + \frac{yI[t, 0]}{kI} \right)} - \frac{yE^{(0,1)}[t, 0]}{kE} - \frac{yE^{(1,0)}[t, 0]}{kE}$$

$$\frac{\delta yE[t, 0]}{kE} - \frac{\mu I yI[t, 0]}{kI} + \frac{c \beta \epsilon yI[t, 0]}{kI \left( c + \frac{yE[t, 0]}{kE} + \frac{yI[t, 0]}{kI} \right)} - \frac{yI^{(0,1)}[t, 0]}{kI} - \frac{yI^{(1,0)}[t, 0]}{kI}$$

**IPOPish1[t\_] = Denominator[Together[dEEdteqn3[t]]] Together[dEEdteqn3[t]]**

**IPOPish2[t\_] = Denominator[Together[dIIdteqn3[t]]] Together[dIIdteqn3[t]]**

$$-c kE kI \delta yE[t, 0] - c kE kI \mu E yE[t, 0] - kI \delta yE[t, 0]^2 - kI \mu E yE[t, 0]^2 + \\ c kE^2 \beta yI[t, 0] - c kE^2 \beta \epsilon yI[t, 0] - kE \delta yE[t, 0] yI[t, 0] - kE \mu E yE[t, 0] yI[t, 0] - \\ c kE kI yE^{(0,1)}[t, 0] - kI yE[t, 0] yE^{(0,1)}[t, 0] - kE yI[t, 0] yE^{(0,1)}[t, 0] - \\ c kE kI yE^{(1,0)}[t, 0] - kI yE[t, 0] yE^{(1,0)}[t, 0] - kE yI[t, 0] yE^{(1,0)}[t, 0]$$

$$c kE kI^2 \delta yE[t, 0] + kI^2 \delta yE[t, 0]^2 + c kE^2 kI \beta \epsilon yI[t, 0] - c kE^2 kI \mu I yI[t, 0] + \\ kE kI \delta yE[t, 0] yI[t, 0] - kE kI \mu I yE[t, 0] yI[t, 0] - kE^2 \mu I yI[t, 0]^2 - \\ c kE^2 kI yI^{(0,1)}[t, 0] - kE kI yE[t, 0] yI^{(0,1)}[t, 0] - kE^2 yI[t, 0] yI^{(0,1)}[t, 0] - \\ c kE^2 kI yI^{(1,0)}[t, 0] - kE kI yE[t, 0] yI^{(1,0)}[t, 0] - kE^2 yI[t, 0] yI^{(1,0)}[t, 0]$$

**Monos1 = Sort[MonomialList[IPOPish1[t], {yI[t, 0], yE[t, 0], (D[yI[t, a], t] /. a -> 0), (D[yI[t, a], a] /. a -> 0), (D[yE[t, a], t] /. a -> 0), (D[yE[t, a], a] /. a -> 0)}]]**

**Monos2 = Sort[MonomialList[IPOPish2[t], {yI[t, 0], yE[t, 0], (D[yI[t, a], t] /. a -> 0), (D[yI[t, a], a] /. a -> 0), (D[yE[t, a], t] /. a -> 0), (D[yE[t, a], a] /. a -> 0)}]]**

$$\{(-c kE kI \delta - c kE kI \mu E) yE[t, 0], (-kI \delta - kI \mu E) yE[t, 0]^2, \\ (c kE^2 \beta - c kE^2 \beta \epsilon) yI[t, 0], (-kE \delta - kE \mu E) yE[t, 0] yI[t, 0], \\ -c kE kI yE^{(0,1)}[t, 0], -kI yE[t, 0] yE^{(0,1)}[t, 0], -kE yI[t, 0] yE^{(0,1)}[t, 0], \\ -c kE kI yE^{(1,0)}[t, 0], -kI yE[t, 0] yE^{(1,0)}[t, 0], -kE yI[t, 0] yE^{(1,0)}[t, 0]\}$$

$$\{c kE kI^2 \delta yE[t, 0], kI^2 \delta yE[t, 0]^2, (c kE^2 kI \beta \epsilon - c kE^2 kI \mu I) yI[t, 0], \\ (kE kI \delta - kE kI \mu I) yE[t, 0] yI[t, 0], -kE^2 \mu I yI[t, 0]^2, -c kE^2 kI yI^{(0,1)}[t, 0], \\ -kE kI yE[t, 0] yI^{(0,1)}[t, 0], -kE^2 yI[t, 0] yI^{(0,1)}[t, 0], \\ -c kE^2 kI yI^{(1,0)}[t, 0], -kE kI yE[t, 0] yI^{(1,0)}[t, 0], -kE^2 yI[t, 0] yI^{(1,0)}[t, 0]\}$$

**MonicMonos1 =**

**Monos1 / (Last[Monos1] /. {yI[t, 0] → 1, yE[t, 0] → 1, (D[yI[t, a], t] /. a → 0) → 1, (D[yI[t, a], a] /. a → 0) → 1, (D[yE[t, a], t] /. a → 0) → 1, (D[yE[t, a], a] /. a → 0) → 1})**

**MonicMonos2 = Monos2 / (Last[Monos2] /. {yI[t, 0] → 1, yE[t, 0] → 1,**

**(D[yI[t, a], t] /. a → 0) → 1, (D[yI[t, a], a] /. a → 0) → 1, (D[yE[t, a], t] /. a → 0) → 1, (D[yE[t, a], a] /. a → 0) → 1})**

$$\left\{ -\frac{(-c k_E k_I \delta - c k_E k_I \mu_E) y_E[t, 0]}{k_E}, -\frac{(-k_I \delta - k_I \mu_E) y_E[t, 0]^2}{k_E}, \right. \\ \left. -\frac{(c k_E^2 \beta - c k_E^2 \beta \epsilon) y_I[t, 0]}{k_E}, -\frac{(-k_E \delta - k_E \mu_E) y_E[t, 0] y_I[t, 0]}{k_E}, \right. \\ c k_I y_E^{(0,1)}[t, 0], \frac{k_I y_E[t, 0] y_E^{(0,1)}[t, 0]}{k_E}, y_I[t, 0] y_E^{(0,1)}[t, 0], \\ c k_I y_E^{(1,0)}[t, 0], \frac{k_I y_E[t, 0] y_E^{(1,0)}[t, 0]}{k_E}, y_I[t, 0] y_E^{(1,0)}[t, 0] \} \\ \left\{ -\frac{c k_I^2 \delta y_E[t, 0]}{k_E}, -\frac{k_I^2 \delta y_E[t, 0]^2}{k_E^2}, -\frac{(c k_E^2 k_I \beta \epsilon - c k_E^2 k_I \mu_I) y_I[t, 0]}{k_E^2}, \right. \\ \left. -\frac{(k_E k_I \delta - k_E k_I \mu_I) y_E[t, 0] y_I[t, 0]}{k_E^2}, \mu_I y_I[t, 0]^2, \right. \\ c k_I y_I^{(0,1)}[t, 0], \frac{k_I y_E[t, 0] y_I^{(0,1)}[t, 0]}{k_E}, y_I[t, 0] y_I^{(0,1)}[t, 0], \\ c k_I y_I^{(1,0)}[t, 0], \frac{k_I y_E[t, 0] y_I^{(1,0)}[t, 0]}{k_E}, y_I[t, 0] y_I^{(1,0)}[t, 0] \}$$

**Coeffs1 = MonicMonos1 /.**

**{yI[t, 0] → 1, yE[t, 0] → 1, (D[yI[t, a], t] /. a → 0) → 1, (D[yI[t, a], a] /. a → 0) → 1, (D[yE[t, a], t] /. a → 0) → 1, (D[yE[t, a], a] /. a → 0) → 1}**

**Coeffs2 = MonicMonos2 /.**

**{yI[t, 0] → 1, yE[t, 0] → 1, (D[yI[t, a], t] /. a → 0) → 1, (D[yI[t, a], a] /. a → 0) → 1, (D[yE[t, a], t] /. a → 0) → 1, (D[yE[t, a], a] /. a → 0) → 1}**

$$\left\{ -\frac{-c k_E k_I \delta - c k_E k_I \mu_E}{k_E}, -\frac{-k_I \delta - k_I \mu_E}{k_E}, \right. \\ \left. -\frac{c k_E^2 \beta - c k_E^2 \beta \epsilon}{k_E}, -\frac{-k_E \delta - k_E \mu_E}{k_E}, c k_I, \frac{k_I}{k_E}, 1, c k_I, \frac{k_I}{k_E}, 1 \right\} \\ \left\{ -\frac{c k_I^2 \delta}{k_E}, -\frac{k_I^2 \delta}{k_E^2}, -\frac{c k_E^2 k_I \beta \epsilon - c k_E^2 k_I \mu_I}{k_E^2}, \right. \\ \left. -\frac{k_E k_I \delta - k_E k_I \mu_I}{k_E^2}, \mu_I, c k_I, \frac{k_I}{k_E}, 1, c k_I, \frac{k_I}{k_E}, 1 \right\}$$

**Coeffs = Union[Coeffs1, Coeffs2]**

$$\left\{ 1, c kI, \frac{kI}{kE}, -\frac{kI^2 \delta}{kE^2}, -\frac{c kI^2 \delta}{kE}, -\frac{c kE^2 \beta - c kE^2 \beta \epsilon}{kE}, -\frac{-kE \delta - kE \mu E}{kE}, -\frac{-kI \delta - kI \mu E}{kE}, \right. \\ \left. -\frac{-c kE kI \delta - c kE kI \mu E}{kE}, \mu I, -\frac{kE kI \delta - kE kI \mu I}{kE^2}, -\frac{c kE^2 kI \beta \epsilon - c kE^2 kI \mu I}{kE^2} \right\}$$

**xCoeffs = Coeffs /. {  $\beta \rightarrow a1$ ,  $\delta \rightarrow a2$ ,  $\epsilon \rightarrow a3$ ,  $\mu E \rightarrow a5$ ,  $c \rightarrow a7$ ,  $kE \rightarrow a8$ ,  $kI \rightarrow a9$  }**

$$\left\{ 1, a7 a9, \frac{a9}{a8}, -\frac{a2 a9^2}{a8^2}, -\frac{a2 a7 a9^2}{a8}, -\frac{a1 a7 a8^2 - a1 a3 a7 a8^2}{a8}, \right. \\ \left. -\frac{-a2 a8 - a5 a8}{a8}, -\frac{-a2 a9 - a5 a9}{a8}, -\frac{-a2 a7 a8 a9 - a5 a7 a8 a9}{a8}, \right. \\ \left. \mu I, -\frac{a2 a8 a9 - a8 a9 \mu I}{a8^2}, -\frac{a1 a3 a7 a8^2 a9 - a7 a8^2 a9 \mu I}{a8^2} \right\}$$

**Solve[Coeffs == xCoeffs, {  $\beta$ ,  $\delta$ ,  $\epsilon$ ,  $\mu E$ ,  $c$ ,  $kE$ ,  $kI$  }]**

MessageTemplate[ Solve , svars , Equations may not give solutions for all "solve" variables. ,  
2 , 24 , 1 , 33627897695571702551 , Local ]

$$\left\{ \left\{ \beta \rightarrow a1, \delta \rightarrow a2, \epsilon \rightarrow a3, \mu E \rightarrow a5, c \rightarrow \frac{a7 a9}{kI}, kE \rightarrow \frac{a8 kI}{a9} \right\} \right\}$$