Equations of dogs and vectors adapted for using vaccine and insecticide impregnated collar in dogs.

**Dogs**

$\frac{dS\_{d}}{dt}= -S\_{d}V\_{3}ba\_{d}ρ\_{d}+R\_{d}γ\_{d}+ V\_{d}vp-S\_{d}v-S\_{d}w+S\_{dc}ψ+Σ\_{d}$ (1)

$\frac{dL\_{d}}{dt}= S\_{d}V\_{3}ba\_{d}ρ\_{d}-L\_{d}\left(βf\_{dr}+βf\_{dd}+μ\_{d}\right)-L\_{d}w+L\_{dc}ψ$ (2)

$\frac{dA\_{dr}}{dt}=L\_{d}βf\_{dr}-A\_{dr}\left(δ\_{d}+μ\_{d}\right)-A\_{dr}w+A\_{drc}ψ$ (3)

$\frac{dA\_{dd}}{dt}=L\_{d}βf\_{dd}-A\_{dd}\left(ϕ\_{d}+μ\_{d}\right)-A\_{dd}w+A\_{ddc}ψ$ (4)

$\frac{dD\_{d}}{dt}=A\_{dd}ϕ\_{d}-D\_{d}\left(σ\_{d}+α\_{d}+μ\_{d}\right)-D\_{d}w+D\_{dc}ψ$ (5)

$\frac{dR\_{d}}{dt}=D\_{d}σ\_{d}+A\_{dr}δ\_{d}-R\_{d}\left(γ\_{d}+μ\_{d}+v\right)-R\_{d}w+R\_{dc}ψ$ (6)

**Vaccinated dogs**

$\frac{dV\_{d}}{dt}=v\left(S\_{d}+R\_{d}\right)-V\_{d}\left(μ\_{c}+vp\right)$ (7)

**Dogs with insecticide impregnated collar**

$\frac{dS\_{dc}}{dt}= -S\_{d}V\_{3}ba\_{dc}ρ\_{d}+R\_{d}γ\_{d}+S\_{d}w-S\_{dc}ψ$ (8)

$\frac{dL\_{dc}}{dt}= S\_{d}V\_{3}ba\_{dc}ρ\_{d}-L\_{d}\left(βf\_{dr}+βf\_{dd}+μ\_{d}\right)+L\_{d}w-L\_{dc}ψ$ (9)

$\frac{dA\_{drc}}{dt}=L\_{d}βf\_{dr}-A\_{dr}\left(δ\_{d}+μ\_{d}\right)+A\_{dr}w-A\_{drc}ψ$ (10)

$\frac{dA\_{ddc}}{dt}=L\_{d}βf\_{dd}-A\_{dd}\left(ϕ\_{d}+μ\_{d}\right)+A\_{dd}w-A\_{ddc}ψ$ (11)

$\frac{dD\_{dc}}{dt}=A\_{dd}ϕ\_{d}-D\_{d}\left(σ\_{d}+α\_{d}+μ\_{d}\right)+D\_{d}w-D\_{dc}ψ$ (12)

$\frac{dR\_{dc}}{dt}=D\_{d}σ\_{d}+A\_{dr}δ\_{d}-R\_{d}\left(γ\_{d}+μ\_{d}\right)+R\_{d}w-R\_{dc}ψ$ (13)

**Vectors when using insecticide impregnated collar**

$\frac{dV\_{1}}{dt}= -V\_{1}\left(\left(A\_{hr}+A\_{hd}+D\_{v}+D\_{ct}\right)c\_{h}a\_{h}+\left(A\_{dr}+A\_{dd}+D\_{d}\right)c\_{d}a\_{d}+D\_{c}c\_{c}a\_{c}+I\_{l}c\_{l}a\_{l}+I\_{r}c\_{r}a\_{r}+\left(A\_{drc}+A\_{ddc}+D\_{dc}\right)c\_{d}(1-mt)a\_{dc}\right)+V\_{2}μ\_{f}+V\_{3}(μ\_{s}+μ\_{k})$ (14)

$\frac{dV\_{2}}{dt}= V\_{1}\left(\left(A\_{hr}+A\_{hd}+D\_{v}+D\_{ct}\right)c\_{h}a\_{h}+\left(A\_{dr}+A\_{dd}+D\_{d}\right)c\_{d}a\_{d}+D\_{c}c\_{c}a\_{c}+I\_{l}c\_{l}a\_{l}+I\_{r}c\_{r}a\_{r}+\left(A\_{drc}+A\_{ddc}+D\_{dc}\right)c\_{d}(1-mt)a\_{dc}\right)-V\_{2}\left(τ+μ\_{f}\right)$ (15)

$\frac{dV\_{3}}{dt}= V\_{2}τ-V\_{3}(μ\_{s}+μ\_{k})$ (16)