M7116 Maticové populační modely

Populace s interní variabilitou

5. 12. 2012

Populace strukturovaná podle plodnosti

$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\begin{aligned} \lambda &= \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \\ &= \tfrac{1}{2}\left(\sigma_1(1-\gamma) + \sigma_2 + \sqrt{\big(\sigma_1(1-\gamma) - \sigma_2\big)^2 + 4\sigma_1\gamma\varphi}\right) \end{aligned}$$

$$\lambda > 1 \;\Leftrightarrow\; \sigma_1\gamma\varphi \geq (1-\sigma_2)\big(1-(\sigma_1(1-\gamma))\big)$$

Populace strukturovaná podle plodnosti

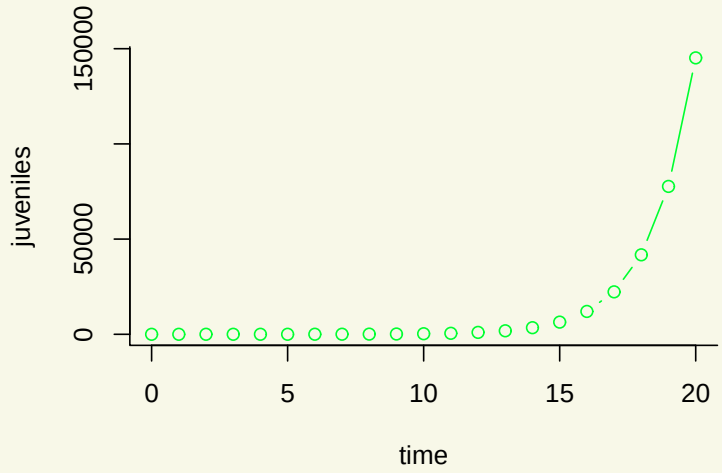
$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

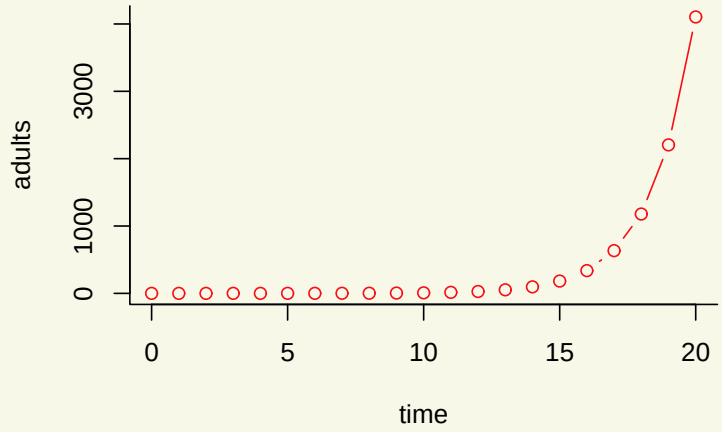
$$\lambda = \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \\ = \tfrac{1}{2}\left(\sigma_1(1-\gamma) + \sigma_2 + \sqrt{\left(\sigma_1(1-\gamma) - \sigma_2\right)^2 + 4\sigma_1\gamma\varphi}\right)$$

$$\lambda > 1 \;\Leftrightarrow\; \sigma_1\gamma\varphi \geq (1-\sigma_2)\big(1-(\sigma_1(1-\gamma))\big)$$

$\sigma_1 = 0.5, \sigma_2 = 0.1, \gamma = 0.1, \varphi = 50$

$\lambda = 1.8658$





Parametry závislé na velikosti složek populace

$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2}$$
$$\sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2}$$
$$\varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

$$\lambda = \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \lambda(n_1, n_2) = \lambda(\boldsymbol{n})$$

$$\lambda_0 = \lambda(\boldsymbol{o})$$
$$\lambda_\infty = \lim_{\|\boldsymbol{n}\| \to \infty} \lambda(\boldsymbol{n})$$

Parametry závislé na velikosti složek populace

$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2}$$
$$\sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2}$$
$$\varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

$$\lambda = \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \lambda(n_1, n_2) = \lambda(\boldsymbol{n})$$

$$\lambda_0 = \lambda(\boldsymbol{o})$$
$$\lambda_\infty = \lim_{\|\boldsymbol{n}\| \to \infty} \lambda(\boldsymbol{n})$$

$$\lim_{\sigma_1 \to 0} \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \sigma_2$$
$$\lim_{\sigma_2 \to 0} \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \tfrac{1}{2}\left(\sigma_1(1-\gamma) + \sqrt{\sigma_1^2(1-\gamma)^2 + 4\sigma_1\gamma\varphi}\right)$$
$$\lim_{\gamma \to 0} \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \sigma_1$$
$$\lim_{\varphi \to 0} \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \sigma_1(1-\gamma)$$

Parametry závislé na velikosti složek populace

$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

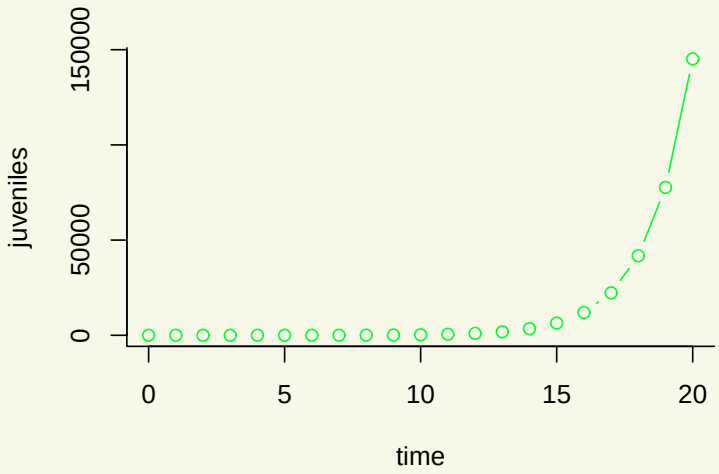
$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2}$$
$$\sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2}$$
$$\varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

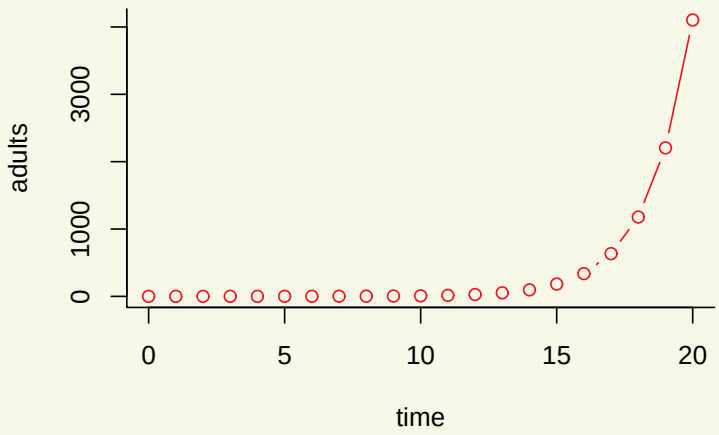
$$\lambda = \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \lambda(n_1, n_2) = \lambda(\boldsymbol{n})$$

$$\lambda_0 = \lambda(\boldsymbol{o}) = 1.8658$$
$$\lambda_\infty = \lim_{\|\boldsymbol{n}\| \to \infty} \lambda(\boldsymbol{n}) = 1.8658$$

$$\Sigma_1 = 0.5, \Sigma_2 = 0.1, \Gamma = 0.1, \Phi = 50$$

$$s_{11} = s_{12} = 0,\ s_{11} = s_{12} = 0,\ g_1 = g_2 = 0,\ f_1 = f_2 = 0$$





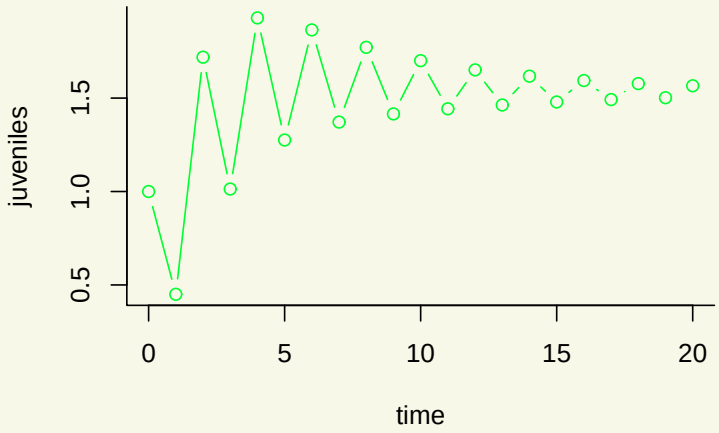
Parametry závislé na velikosti složek populace

$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2}$$
$$\sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2}$$
$$\varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

$$\lambda = \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \lambda(n_1, n_2) = \lambda(\boldsymbol{n})$$

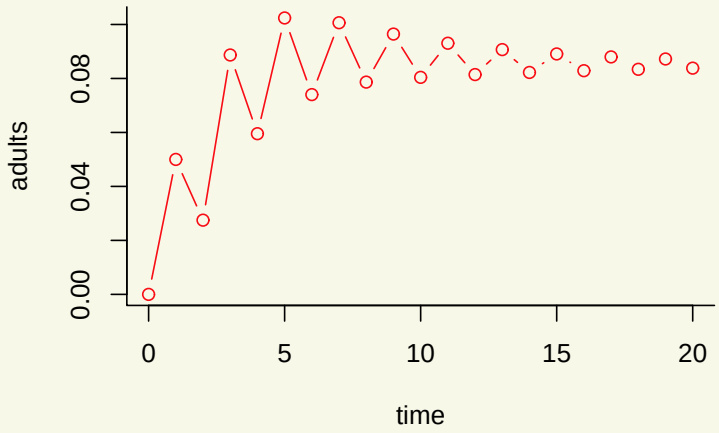
$$\lambda_0 = \lambda(\boldsymbol{o}) = 1.8658$$
$$\lambda_\infty = \lim_{\|\boldsymbol{n}\| \to \infty} \lambda(\boldsymbol{n}) = 0.45$$



$$\Sigma_1 = 0.5, \Sigma_2 = 0.1, \Gamma = 0.1, \Phi = 50$$

$$s_{11} = s_{12} = 0,\ s_{11} = s_{12} = 0,\ g_1 = g_2 = 0,\ f_1 = f_2 = 1$$

Stabilizace populace omezením plodnosti



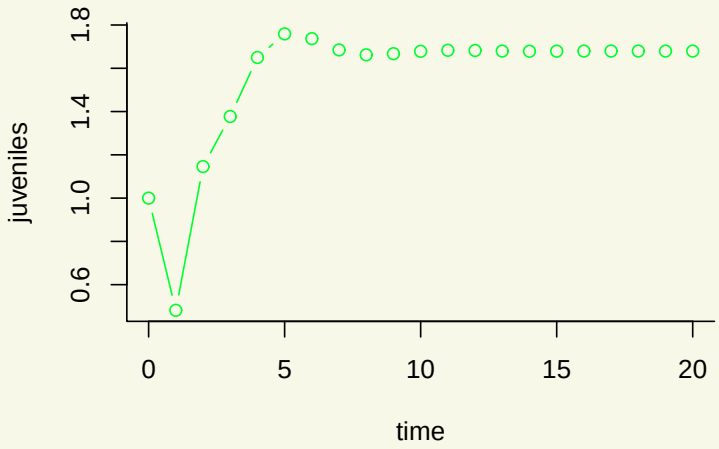
Parametry závislé na velikosti složek populace

$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2}$$
$$\sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2}$$
$$\varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

$$\lambda = \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \lambda(n_1, n_2) = \lambda(\boldsymbol{n})$$

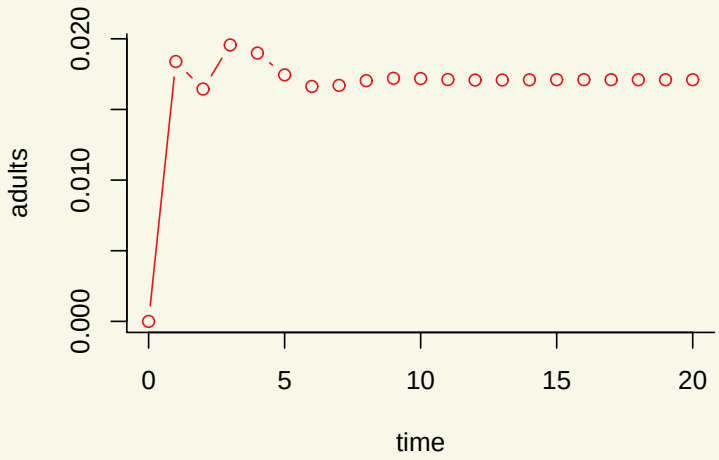
$$\lambda_0 = \lambda(\boldsymbol{o}) = 1.8658$$
$$\lambda_\infty = \lim_{\|\boldsymbol{n}\| \to \infty} \lambda(\boldsymbol{n}) = 0.5$$



$$\Sigma_1 = 0.5, \Sigma_2 = 0.1, \Gamma = 0.1, \Phi = 50$$

$$s_{11} = s_{12} = 0,\ s_{11} = s_{12} = 0,\ g_1 = g_2 = 1,\ f_1 = f_2 = 0$$

Stabilizace populace odložením reprodukce



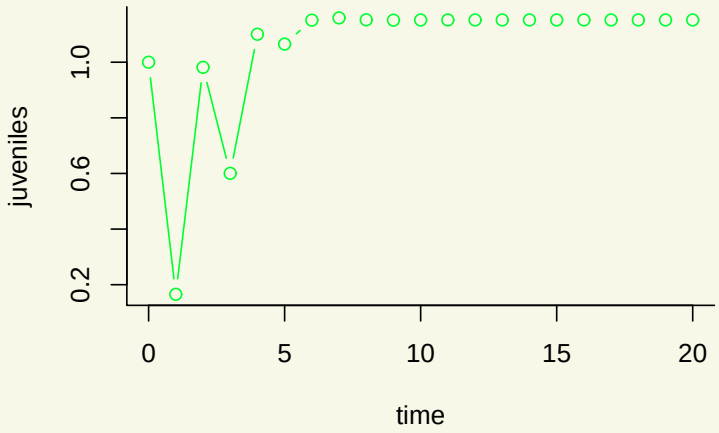
Parametry závislé na velikosti složek populace

$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2}$$
$$\sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2}$$
$$\varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

$$\lambda = \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \lambda(n_1, n_2) = \lambda(\boldsymbol{n})$$

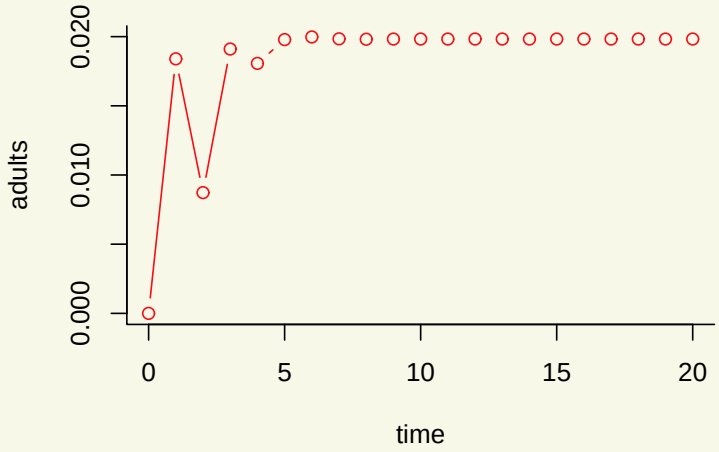
$$\lambda_0 = \lambda(\boldsymbol{o}) = 1.8658$$
$$\lambda_\infty = \lim_{\|\boldsymbol{n}\| \to \infty} \lambda(\boldsymbol{n}) = 0.1$$



$$\Sigma_1 = 0.5, \Sigma_2 = 0.1, \Gamma = 0.1, \Phi = 50$$

$$s_{11} = s_{12} = 1,\ s_{11} = s_{12} = 0,\ g_1 = g_2 = 0,\ f_1 = f_2 = 0$$

Stabilizace populace zvětšením úmrtnosti juvenilních jedinců (infanticidou)



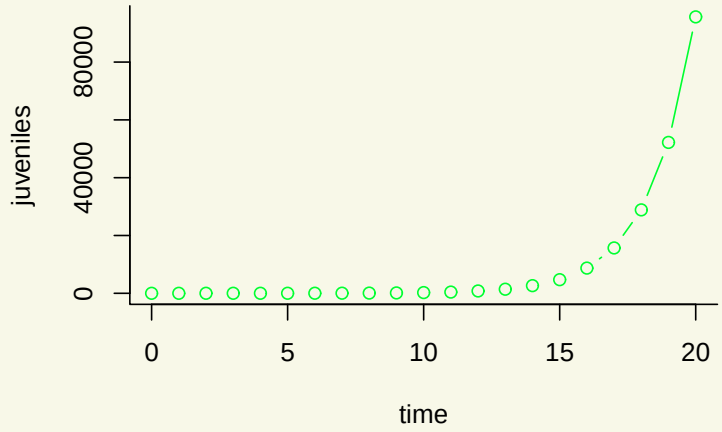
Parametry závislé na velikosti složek populace

$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2}$$
$$\sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2}$$
$$\varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

$$\lambda = \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \lambda(n_1, n_2) = \lambda(\boldsymbol{n})$$

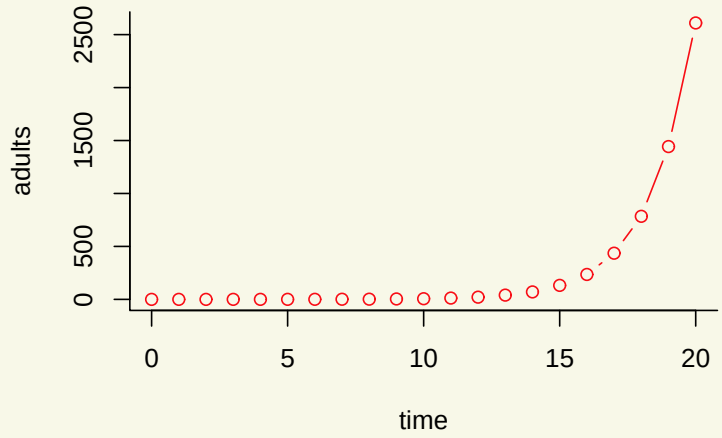
$$\lambda_0 = \lambda(\boldsymbol{o}) = 1.8658$$
$$\lambda_\infty = \lim_{\|\boldsymbol{n}\| \to \infty} \lambda(\boldsymbol{n}) = 1.8221$$



$$\Sigma_1 = 0.5, \Sigma_2 = 0.1, \Gamma = 0.1, \Phi = 50$$

$$s_{11} = s_{12} = 0, \; s_{11} = s_{12} = 1, \; g_1 = g_2 = 0, \; f_1 = f_2 = 0$$

Zpomalení růstu populace zvětšením úmrtnosti plodných jedinců (při velké plodnosti)



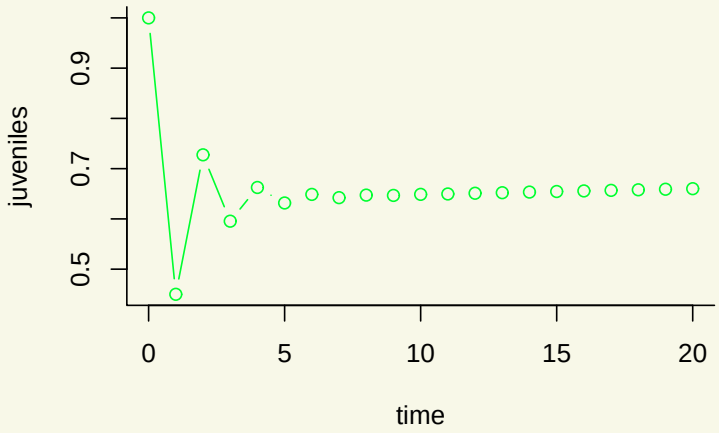
Parametry závislé na velikosti složek populace

$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2}$$
$$\sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2}$$
$$\varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

$$\lambda = \lambda(\sigma_1, \sigma_2, \gamma, \varphi) = \lambda(n_1, n_2) = \lambda(\boldsymbol{n})$$

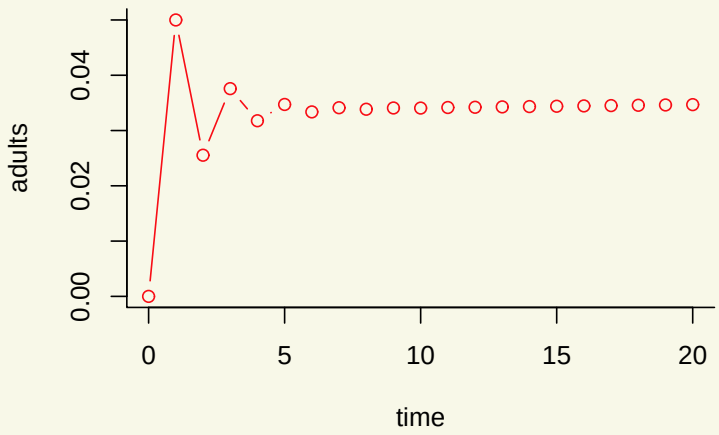
$$\lambda_0 = \lambda(\boldsymbol{o}) = 1.0204$$
$$\lambda_\infty = \lim_{\|\boldsymbol{n}\| \to \infty} \lambda(\boldsymbol{n}) = 0.9837$$



$$\Sigma_1 = 0.5, \Sigma_2 = 0.1, \Gamma = 0.1, \Phi = 10.5$$

$$s_{11} = s_{12} = 0, \; s_{11} = s_{12} = 1, \; g_1 = g_2 = 0, \; f_1 = f_2 = 0$$

Stabilizace populace zvětšením úmrtnosti plodných jedinců (při malé plodnosti)

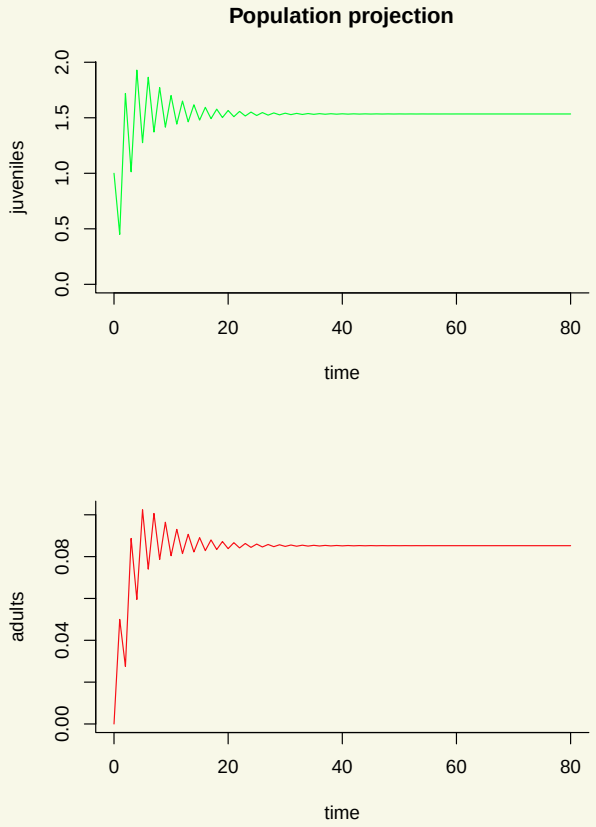


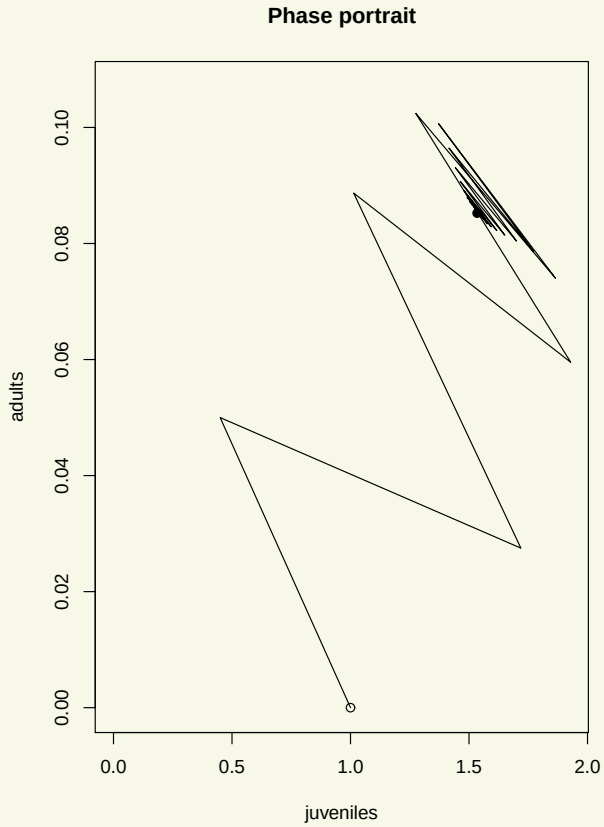
Trajektorie a atraktory

$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2}$$
$$\sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

$$\Sigma_1 = 0.5,\ \Sigma_2 = 0.1,\ \Gamma = 0.1,\ \Phi = 50,$$
$$s_{11} = s_{12} = s_{21} = s_{22} = 0,\ g_1 = g_2 = 0,\ f_1 = f_2 = 1$$



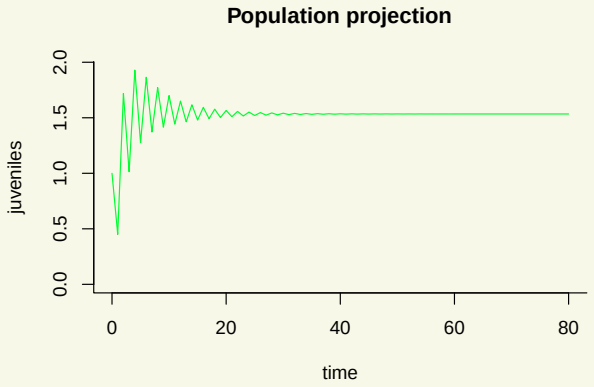


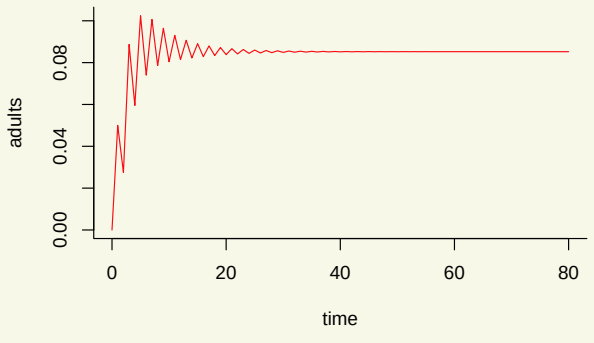
Trajektorie a atraktory

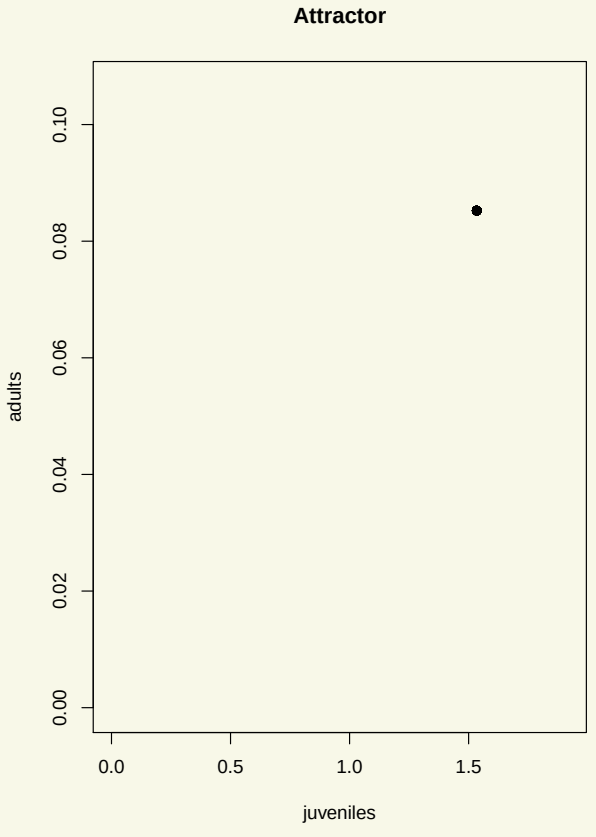
$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2} \qquad \sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2} \qquad \varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

$$\Sigma_1 = 0.5,\ \Sigma_2 = 0.1,\ \Gamma = 0.1,\ \Phi = 50,$$
$$s_{11} = s_{12} = s_{21} = s_{22} = 0,\ g_1 = g_2 = 0,\ f_1 = f_2 = 1$$







Rovnovážný bod

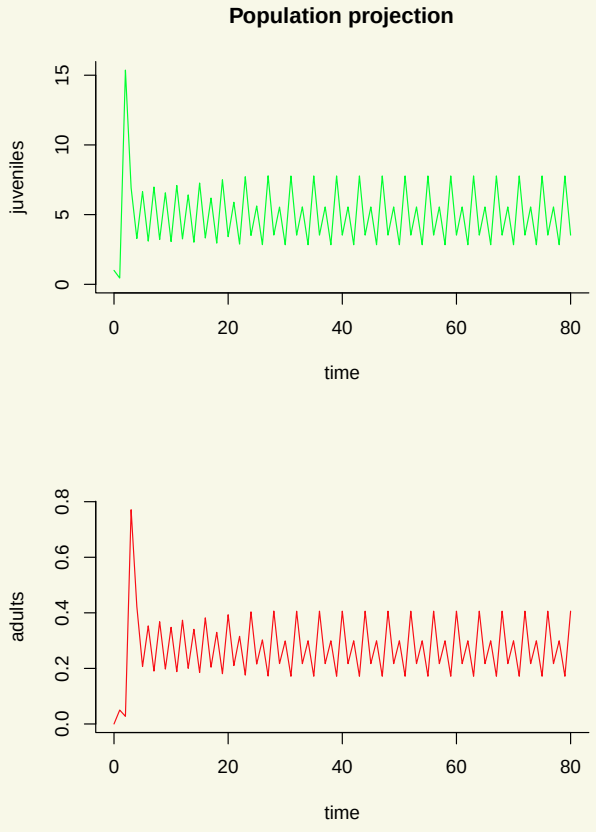
Trajektorie a atraktory

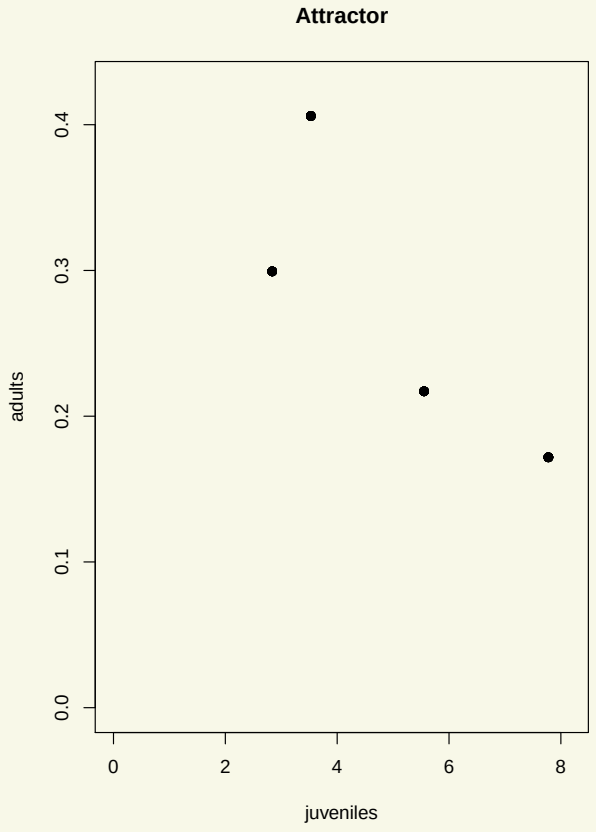
$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2}$$

$$\sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

$$\Sigma_1 = 0.5,\ \Sigma_2 = 0.1,\ \Gamma = 0.1,\ \Phi = 500,$$
$$s_{11} = s_{12} = s_{21} = s_{22} = 0,\ g_1 = g_2 = 0,\ f_1 = f_2 = 1$$





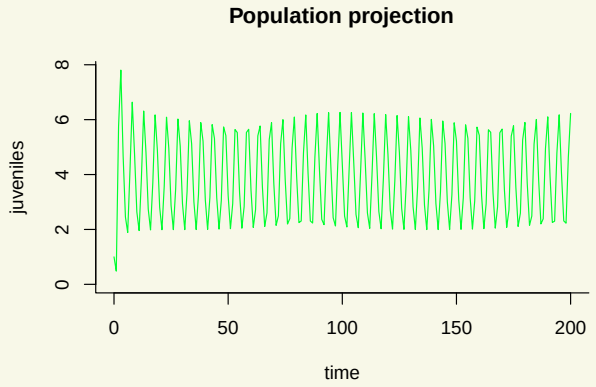
Cyklus délky 4

Trajektorie a atraktory

$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2} \qquad \sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2} \qquad \varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

$$\Sigma_1 = 0.5,\ \Sigma_2 = 0.1,\ \Gamma = 0.1,\ \Phi = 300,$$
$$s_{11} = s_{12} = s_{21} = s_{22} = 0,\ g_1 = g_2 = 1,\ f_1 = f_2 = 0$$



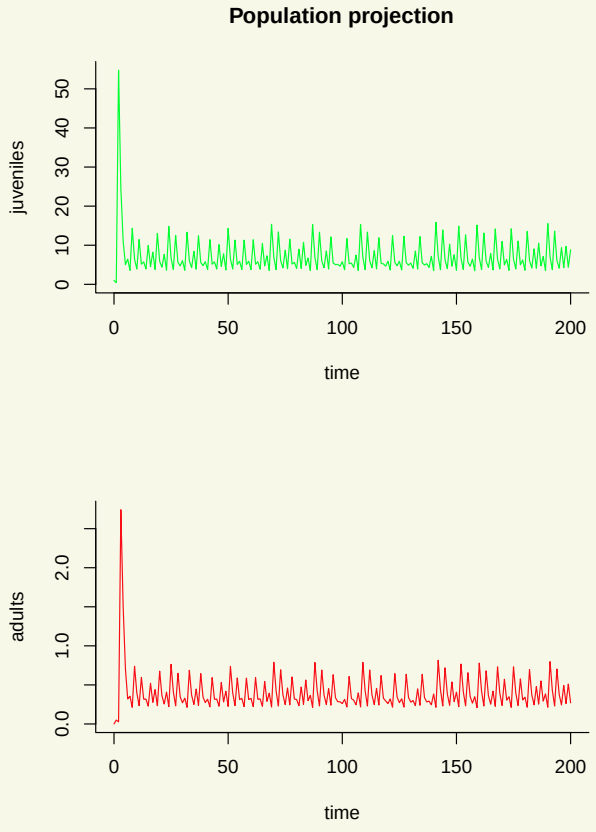
Invariantní smyčka

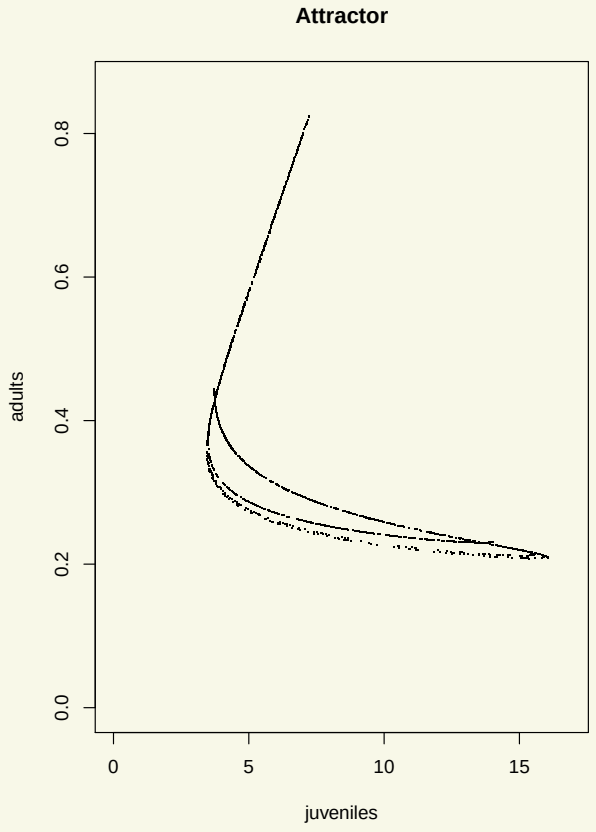
Trajektorie a atraktory

$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2} \qquad \sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2} \qquad \varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

$$\Sigma_1 = 0.5,\ \Sigma_2 = 0.1,\ \Gamma = 0.1,\ \Phi = 1\,800,$$
$$s_{11} = s_{12} = s_{21} = s_{22} = 0,\ g_1 = g_2 = 0,\ f_1 = f_2 = 1$$





Podivný atraktor

Trajektorie a atraktory

$$\begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t+1) = \begin{pmatrix} \sigma_1(1-\gamma) & \varphi \\ \sigma_1\gamma & \sigma_2 \end{pmatrix} \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(t), \quad \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\sigma_1 = \sigma_1(n_1, n_2) = \Sigma_1 \mathrm{e}^{-s_{11}n_1 - s_{12}n_2} \qquad \sigma_2 = \sigma_1(n_1, n_2) = \Sigma_2 \mathrm{e}^{-s_{21}n_1 - s_{22}n_2}$$
$$\gamma = \gamma(n_1, n_2) = \Gamma \mathrm{e}^{-g_1 n_1 - g_2 n_2} \qquad \varphi = \varphi(n_1, n_2) = \Phi \mathrm{e}^{-f_1 n_1 - f_2 n_2}$$

$$\Sigma_1 = 0.5,\ \Sigma_2 = 0.1,\ \Gamma = 0.1,\ \Phi = 1\,800,$$
$$s_{11} = s_{12} = s_{21} = s_{22} = 0,\ g_1 = g_2 = 0,\ f_1 = f_2 = 1$$

Podivný atraktor