Symposium 9: Fitness and evolution in a social environment: from theory to reality

Fidelity of parent-offspring transmission and the evolution of social behavior in subdivided populations.

F. Débarre

@flodebarre

CNRS

Centre de Recherches Interdisciplinaires en Biologie, Paris

Expected frequency of altruists in the population

$$\mathbb{E}[\bar{X}] = \nu + \delta \, \nu(1-\nu) \, \frac{1-\mu}{\mu} \, (1 - Q_{\text{out}}) \times$$

$$\left(-c - (b-c) \left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d - 1)} \right) + \frac{Q_{\text{in}} - Q_{\text{out}}}{1 - Q_{\text{out}}} \left[b - (b-c)\,(n-1) \left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d - 1)} \right) \right] \right)$$

Expected frequency of altruists in the population

Mutation-drift equilibrium

$$\mathbb{E}[\bar{X}] = \boxed{\nu} + \delta\ \nu(1-\nu)\ \frac{1-\mu}{\mu}\ (1-Q_{\text{out}})\ \times$$

$$\left(-c\ - (b-c)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d-1)}\right)\right.$$

$$\left. + \frac{Q_{\text{in}} - Q_{\text{out}}}{1-Q_{\text{out}}}\left[\ b\ - (b-c)\,(n-1)\ \left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d-1)}\right)\ \right]\ \right)$$

Expected frequency of altruists in the population

Mutation-drift equilibrium

Selection strength

$$\mathbb{E}[\overline{X}] = \nu + \delta \, \nu(1-\nu) \, \frac{1-\mu}{\mu} \, (1 - Q_{\text{out}}) \times$$
$$\Bigg(-c - (b-c) \left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d - 1)} \right)$$
$$+ \frac{Q_{\text{in}} - Q_{\text{out}}}{1 - Q_{\text{out}}} \left[b - (b-c)\,(n-1) \left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d - 1)} \right) \right] \Bigg)$$

Expected frequency of altruists in the population

Mutation-drift equilibrium

Selection strength

~~Population variance~~
Variance in the state of one site

$$\mathbb{E}[\bar{X}] = \boxed{\nu} + \boxed{\delta}\,\boxed{\nu(1-\nu)}\,\frac{1-\mu}{\mu}\,(1-Q_{\text{out}}) \times$$
$$\Bigg(-c - (b-c)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d-1)}\right)$$
$$+ \frac{Q_{\text{in}} - Q_{\text{out}}}{1-Q_{\text{out}}}\left[\, b - (b-c)\,(n-1)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d-1)}\right)\right]\Bigg)$$

Expected frequency of altruists in the population

Mutation-drift equilibrium

Selection strength

~~Population variance~~
Variance in the state of one site

$$\mathbb{E}[\overline{X}] = \nu + \delta\, \nu(1-\nu)\, \frac{1-\mu}{\mu}\, (1 - Q_{\text{out}}) \times$$

$$\left(-c - (b-c)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d - 1)}\right) - \mathcal{C} \right.$$

$$\left. + \frac{Q_{\text{in}} - Q_{\text{out}}}{1 - Q_{\text{out}}} \left[b - (b-c)\,(n-1)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d-1)}\right) \right] \right)$$

Expected frequency of altruists in the population

Mutation-drift equilibrium

Selection strength

~~Population variance~~

Variance in the state of one site

$$\mathbb{E}[\overline{X}] = \nu + \delta\, \nu(1-\nu)\, \frac{1-\mu}{\mu}\, (1-Q_{\text{out}}) \times \left(\underbrace{-c - (b-c)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d-1)}\right)}_{-\mathcal{C}} + \frac{Q_{\text{in}}-Q_{\text{out}}}{1-Q_{\text{out}}} \left[\underbrace{b - (b-c)\,(n-1)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d-1)}\right)}_{\mathcal{B}} \right] \right)$$

Expected frequency of altruists in the population

Mutation-drift equilibrium

Selection strength

~~Population variance~~
Variance in the state of one site

$$\mathbb{E}[\overline{X}] = \nu + \delta\, \nu(1-\nu)\, \frac{1-\mu}{\mu}\, (1 - Q_{\text{out}}) \times$$

$$\left(\underbrace{-c - (b-c)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d - 1)}\right)}_{-\mathcal{C}} \right.$$

$$\left. + \underbrace{\frac{Q_{\text{in}} - Q_{\text{out}}}{1 - Q_{\text{out}}}}_{R} \left[\underbrace{b - (b-c)\,(n-1)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d-1)}\right)}_{\mathcal{B}} \right] \right)$$

Expected frequency of altruists in the population

Mutation-drift equilibrium

Selection strength

~~Population variance~~

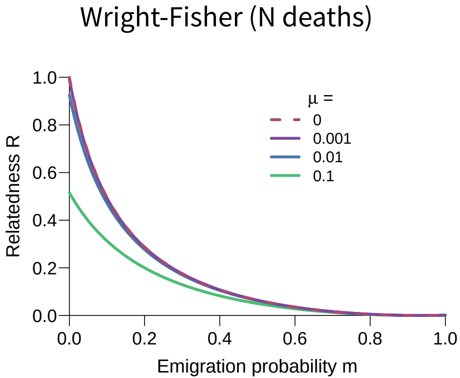
Variance in the state of one site

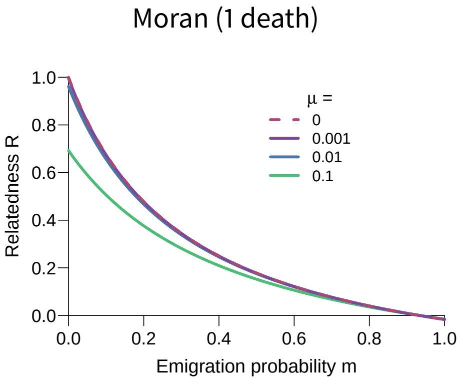
$$\mathbb{E}[\bar{X}] = \nu + \delta\, \nu(1-\nu)\, \frac{1-\mu}{\mu}\, (1 - Q_{\text{out}}) \times$$

$$\left(\underbrace{-c - (b-c)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n(N_d - 1)}\right)}_{-\mathcal{C}} + \underbrace{\frac{Q_{\text{in}} - Q_{\text{out}}}{1 - Q_{\text{out}}}}_{R} \underbrace{\left[b - (b-c)(n-1)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n(N_d - 1)}\right) \right]}_{\mathcal{B}} \right)$$

How does relatedness R change with the emigration probability m?

How does relatedness *R* change with the emigration probability *m*?





$(n = 4, N_d = 15)$

Expected frequency of altruists in the population

Mutation-drift equilibrium

Selection strength

~~Population variance~~
Variance in the state of one site

$$\mathbb{E}[\bar{X}] = \nu + \delta\, \nu(1-\nu)\, \frac{1-\mu}{\mu}\, (1 - Q_{\text{out}}) \times$$

$$\Bigg(-c - (b-c)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d - 1)}\right) \quad -\mathcal{C}$$

$$+ \underbrace{\frac{Q_{\text{in}} - Q_{\text{out}}}{1 - Q_{\text{out}}}}_{R \searrow} \Bigg[\underbrace{b - (b-c)\,(n-1)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d-1)}\right)}_{\mathcal{B}} \Bigg] \Bigg)$$

Expected frequency of altruists in the population

Mutation-drift equilibrium

Selection strength

~~Population variance~~
Variance in the state of one site

$$\mathbb{E}[\bar{X}] = \nu + \delta\, \nu(1-\nu)\, \frac{1-\mu}{\mu}\, (1 - Q_{\text{out}}) \times$$

$$\left(\underbrace{-c - (b-c)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d - 1)}\right)}_{-\mathcal{C}} + \underbrace{\frac{Q_{\text{in}} - Q_{\text{out}}}{1 - Q_{\text{out}}}}_{R \searrow} \left[\underbrace{b - (b-c)\,(n-1)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n\,(N_d - 1)}\right)}_{\mathcal{B}} \right] \right)$$

Expected frequency of altruists in the population

Mutation-drift equilibrium

Selection strength

~~Population variance~~

Variance in the state of one site

$$\mathbb{E}[\overline{X}] = \boxed{\nu} + \boxed{\delta}\, \boxed{\nu(1-\nu)}\, \frac{1-\mu}{\mu} (1 - Q_{\text{out}}) \times$$

$$\left(\boxed{-c - (b-c)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n(N_d-1)}\right)} \quad -\mathcal{C} \nearrow \right.$$

$$\left. + \boxed{\frac{Q_{\text{in}} - Q_{\text{out}}}{1 - Q_{\text{out}}}} \left[\boxed{b - (b-c)(n-1)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n(N_d-1)}\right)} \right] \right)$$

$R \searrow$ $\qquad$ $\mathcal{B} \nearrow$

Expected frequency of altruists in the population

Mutation-drift equilibrium

Selection strength

~~Population variance~~

Variance in the state of one site

$$\mathbb{E}[\bar{X}] = \nu + \delta\, \nu(1-\nu) \frac{1-\mu}{\mu} (1 - Q_{\text{out}}) \times$$

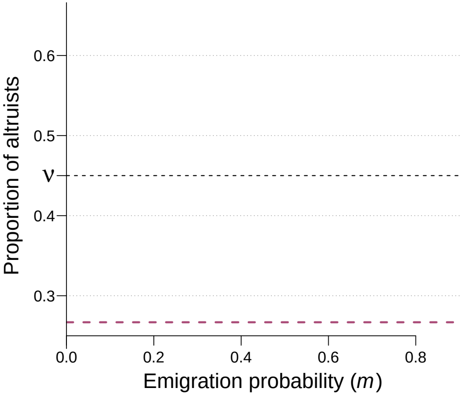
$$\left(-c - (b-c)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n(N_d - 1)}\right) \right. \quad -\mathcal{C} \nearrow$$

$$\left. + \frac{Q_{\text{in}} - Q_{\text{out}}}{1 - Q_{\text{out}}} \left[b - (b-c)(n-1)\left(\frac{(1-m)^2}{n} + \frac{m^2}{n(N_d - 1)}\right) \right] \right)$$

$$R \searrow \qquad \mathcal{B} \nearrow$$

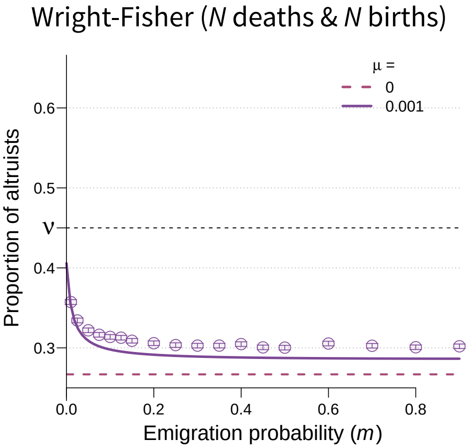
Effect of the emigration probability *m* on the expected proportion of altruists

Wright-Fisher (*N* deaths & *N* births)



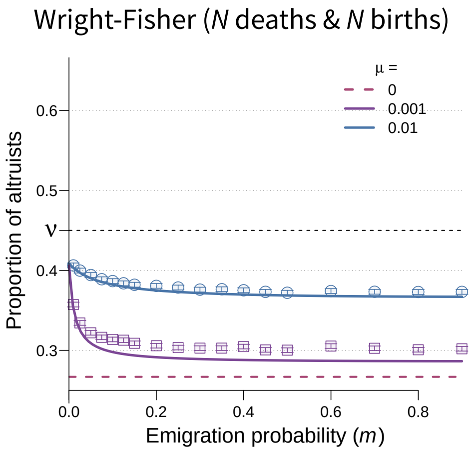
$$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$$

Effect of the emigration probability *m* on the expected proportion of altruists



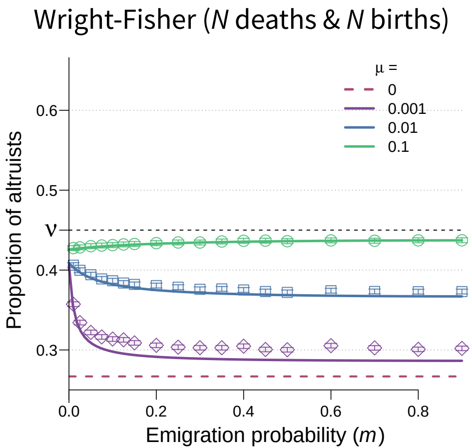
$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$

Effect of the emigration probability m on the expected proportion of altruists



$$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$$

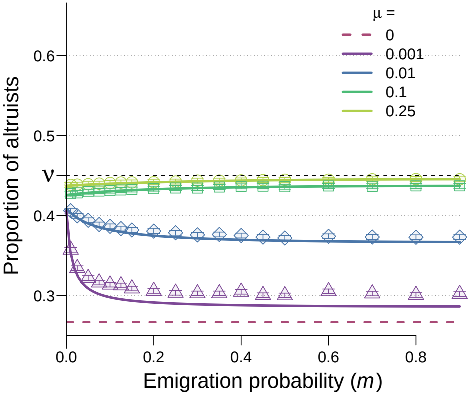
Effect of the emigration probability *m* on the expected proportion of altruists



$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$

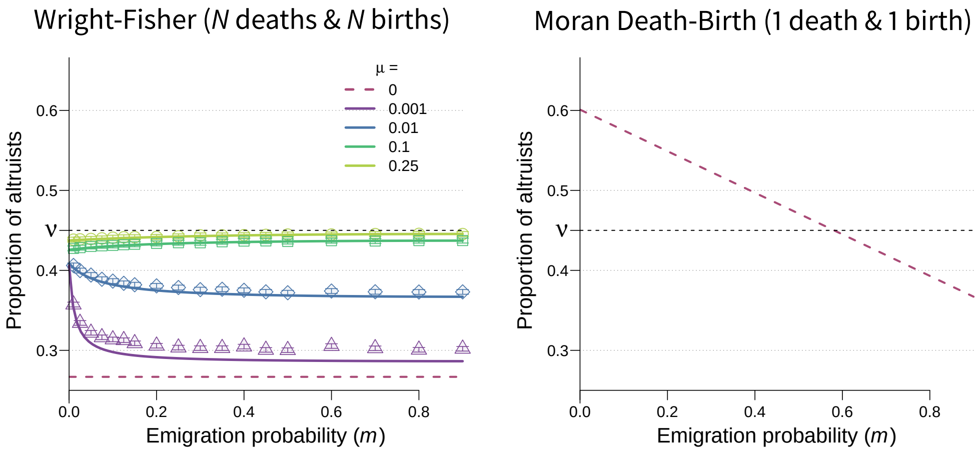
Effect of the emigration probability m on the expected proportion of altruists

Wright-Fisher (N deaths & N births)



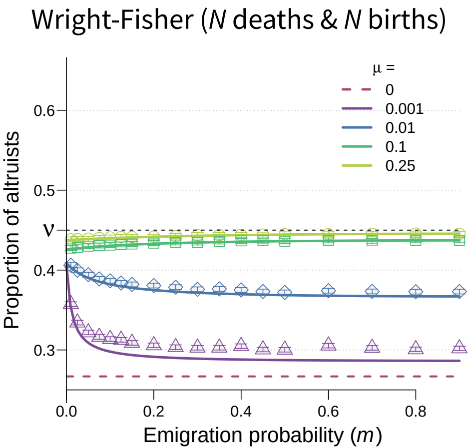
$$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$$

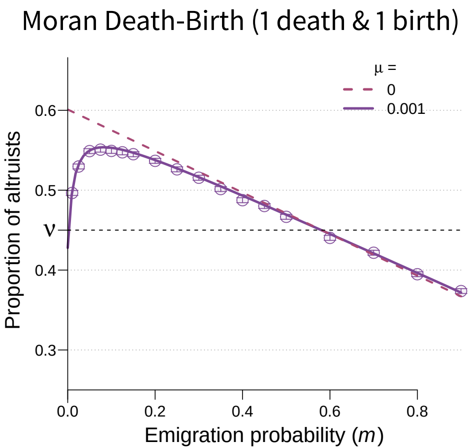
Effect of the emigration probability *m* on the expected proportion of altruists



$$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$$

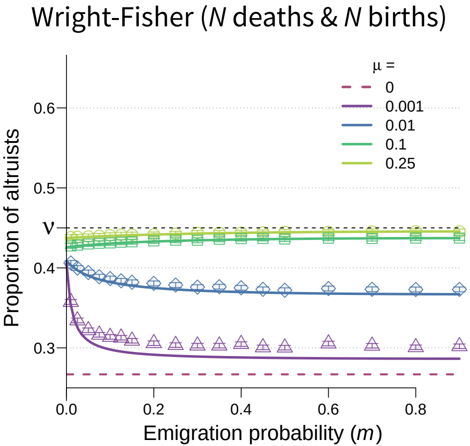
Effect of the emigration probability m on the expected proportion of altruists

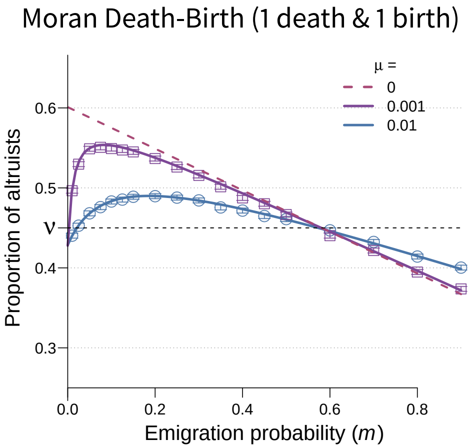




$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$

Effect of the emigration probability *m* on the expected proportion of altruists

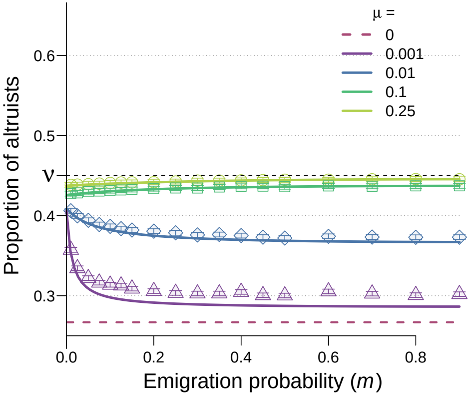




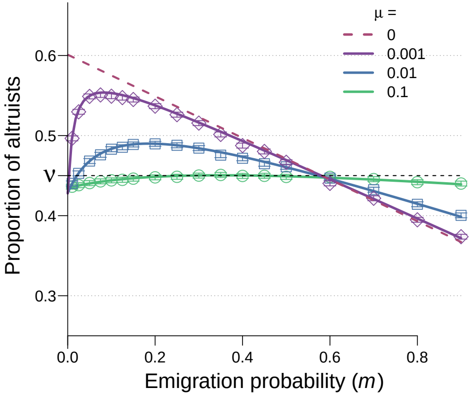
$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$

Effect of the emigration probability *m* on the expected proportion of altruists

Wright-Fisher (*N* deaths & *N* births)



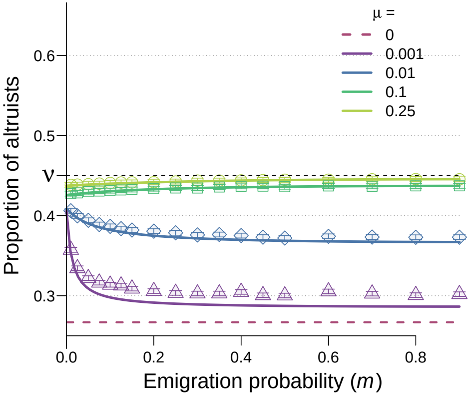
Moran Death-Birth (1 death & 1 birth)



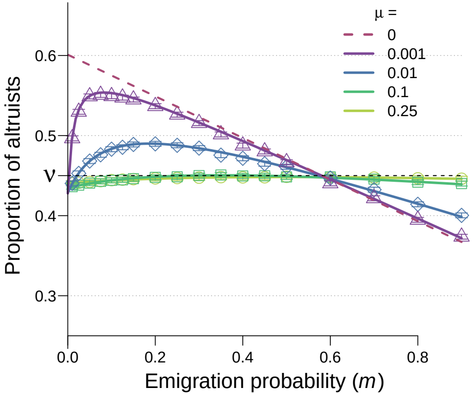
$$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$$

Effect of the emigration probability *m* on the expected proportion of altruists

Wright-Fisher (*N* deaths & *N* births)



Moran Death-Birth (1 death & 1 birth)



$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$

Is the result robust?

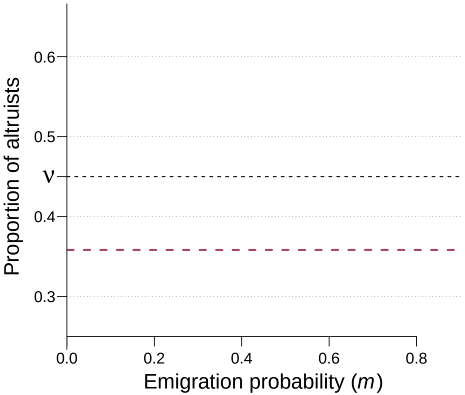
Another life-cycle

Moran Birth-Death (1 birth & 1 death)

$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$

Another life-cycle

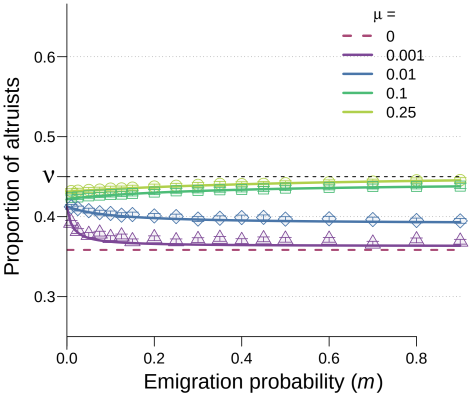
Moran Birth-Death (1 birth & 1 death)



$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$

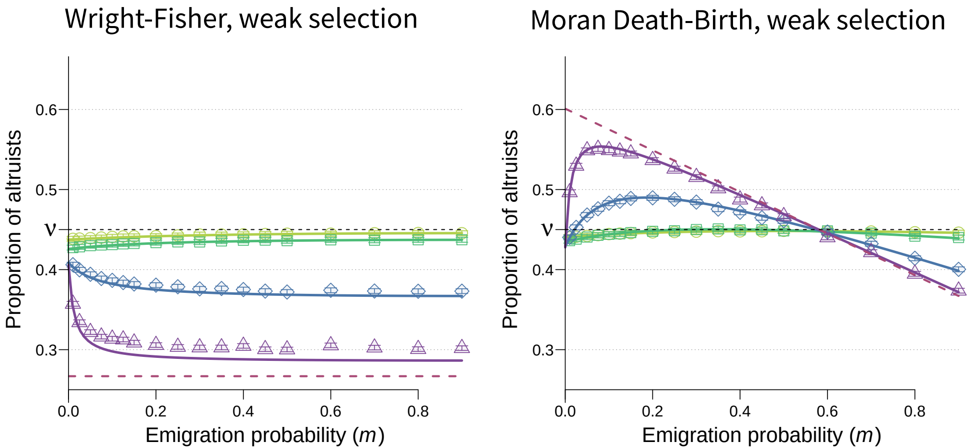
Another life-cycle

Moran Birth-Death (1 birth & 1 death)



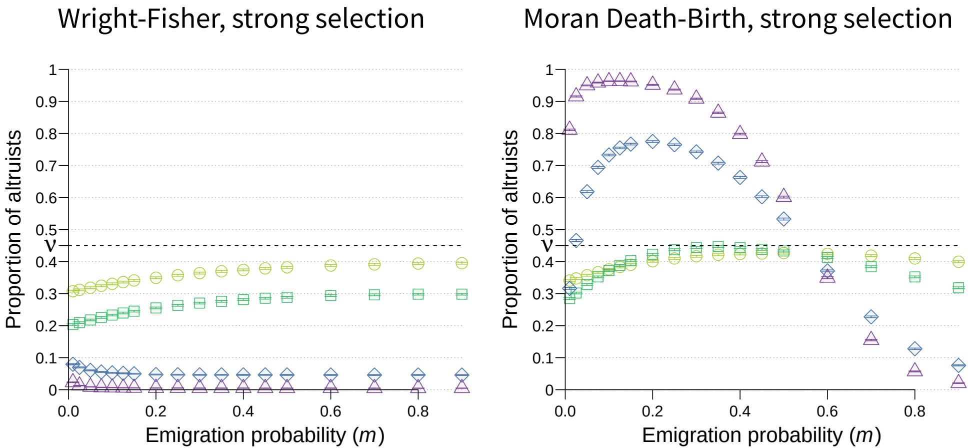
$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$

Strong selection



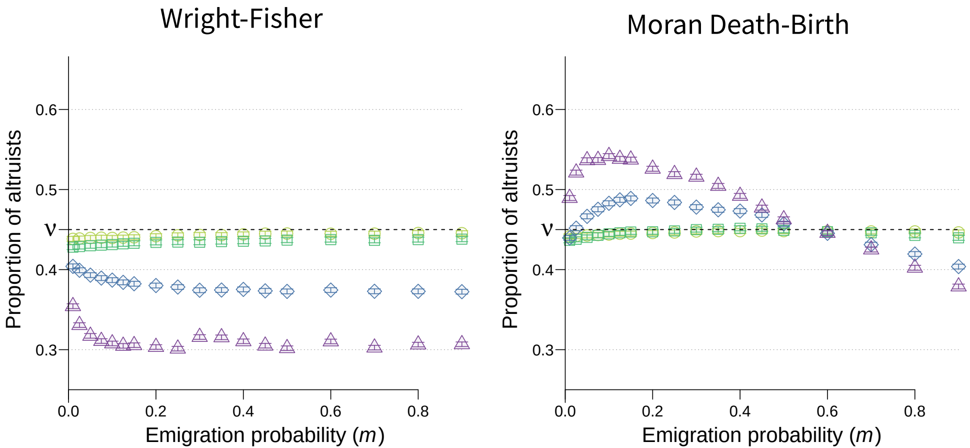
$$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.005)$$

Strong selection



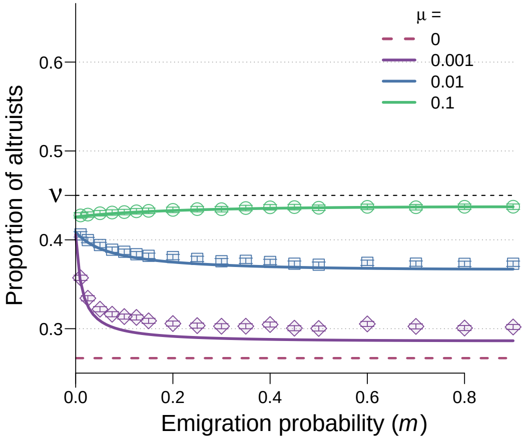
$(b = 15, c = 1, n = 4, N_d = 15, \delta = 0.1)$

Heterogeneous deme sizes ($\overline{n} = 4$ as before, but $2 \leq n \leq 5$)



$(b = 15, c = 1, \overline{n} = 4, N_d = 15, \delta = 0.005)$

bfjdklf



μ =
0
0.001
0.01
0.1
0.6
0.5
ν
0.4
0.3
Proportion of altruists
0.0
0.2
0.4
0.6
0.8
Emigration probability (m)

bfjdklf

fjdksl fjj fjkds lj