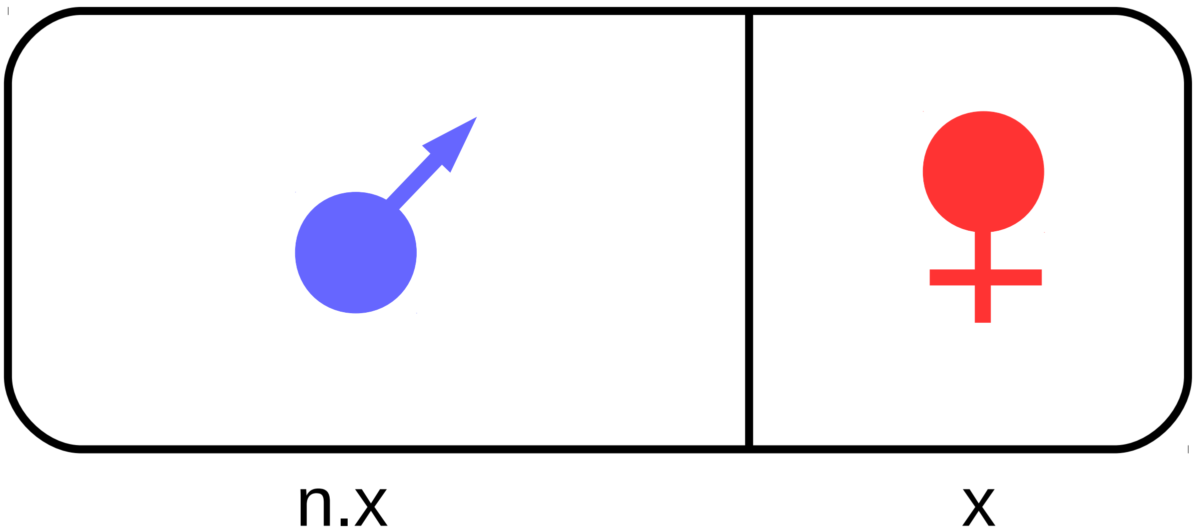
Why sex-ratios are mostly balanced in nature?

Karl Düsing (1883) → first general mathematical treatment of sex-ratio evolution

Population of z individuals



Assumption:

All males together → will produce z offspring
All females together → will produce z offspring

Each will produce $\frac{z}{n.x}$ offspring

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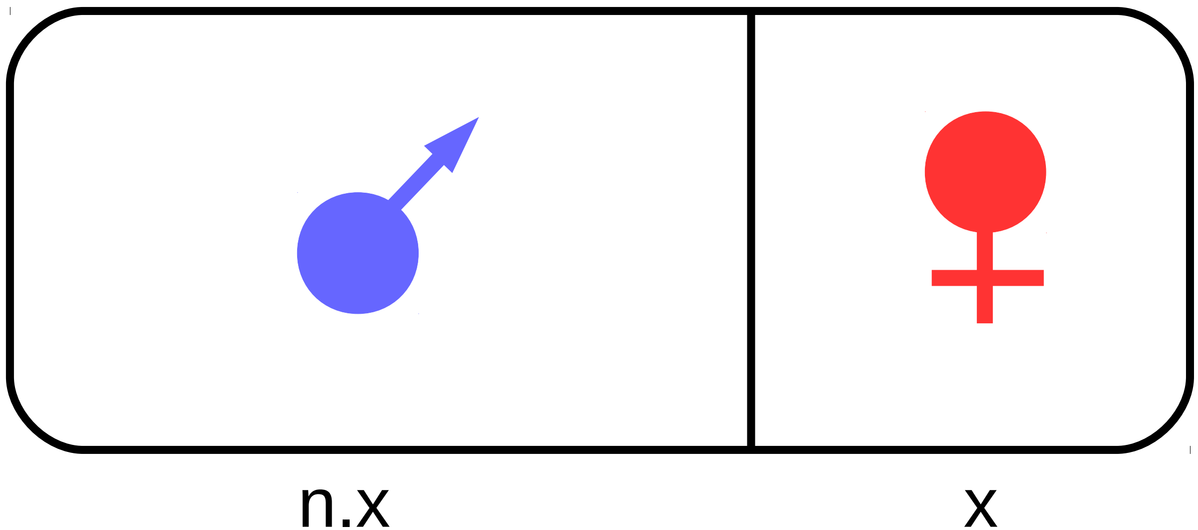

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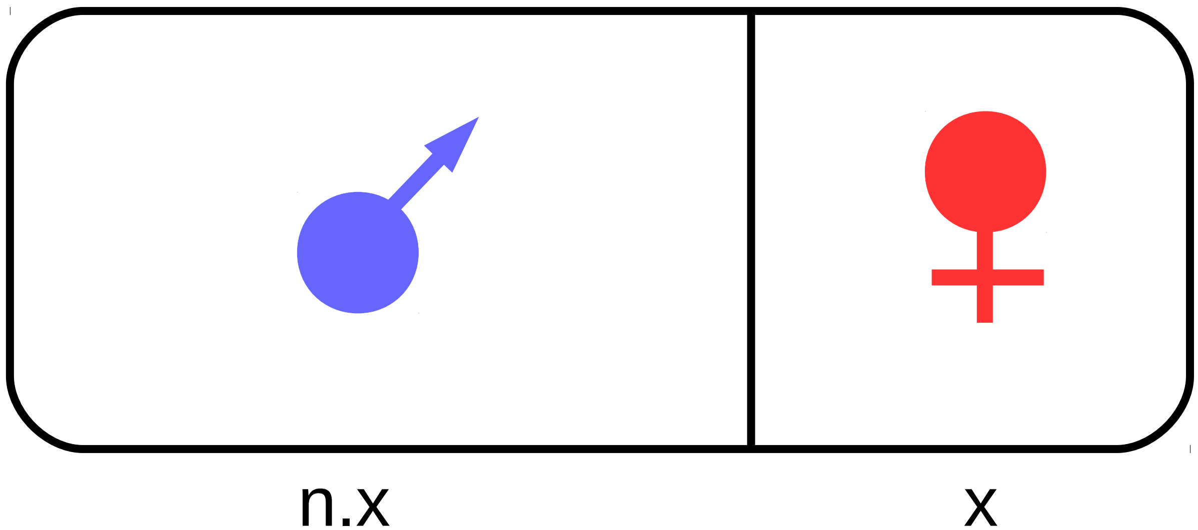

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Each ♂ will produce $\frac{z}{n.x}$ offspring

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Suppose 2 strategies among ♀ : Fem_1 = more sons; Fem_2 = more daughters

		children		grandchildren
$♀_1$	$\xrightarrow{1^{st}\text{ generation}}$	ba. ♂ + a. ♀	$\xrightarrow{2^{nd}\text{ generation}}$	$ba.\frac{z}{n.x}+a.\frac{z}{x}$
$♀_2$	$\longrightarrow$	a. ♂ + ba. ♀	$\longrightarrow$	$a.\frac{z}{n.x}+ba.\frac{z}{x}$

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		children		grandchildren
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♀$_2$	→	a.♂ + ba.♀	→	$a.\frac{z}{n.x}+ba.\frac{z}{x}$

Karl Düsing (1883)

Suppose 2 strategies among ♀

grandchildren

♀$_1$ 2 generations → $$ba\frac{z}{nx}+a\frac{z}{x}=\frac{az}{x}\left[\frac{b}{n}+1\right]$$

♀$_2$ → $$a\frac{z}{nx}+ba\frac{z}{x}=\frac{az}{x}\left[\frac{1}{n}+b\right]$$

$$\frac{\text{Number of grandchildren produced by } ♀_2}{\text{Number of grandchildren produced by } ♀_1}=\frac{1+bn}{b+n}$$

Karl Düsing (1883)

Suppose 2 strategies among ♀

grandchildren

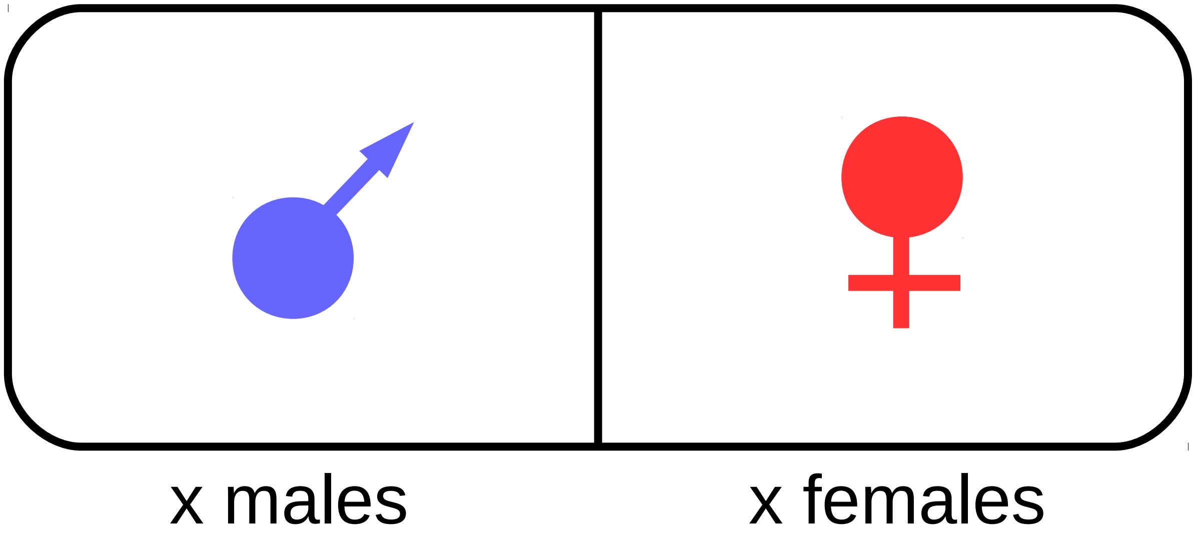
♀$_1$ $\xrightarrow{\text{2 generations}}$ $$ba\frac{z}{nx}+a\frac{z}{x}=\frac{az}{x}\left[\frac{b}{n}+1\right]$$

♀$_2$ $\longrightarrow$ $$a\frac{z}{nx}+ba\frac{z}{x}=\frac{az}{x}\left[\frac{1}{n}+b\right]$$

$$\frac{\text{Number of grandchildren produced by ♀}_2}{\text{Number of grandchildren produced by ♀}_1}=\boxed{\frac{1+bn}{b+n}}$$

Karl Düsing (1883)

If sex-ratio is **originally balanced**:



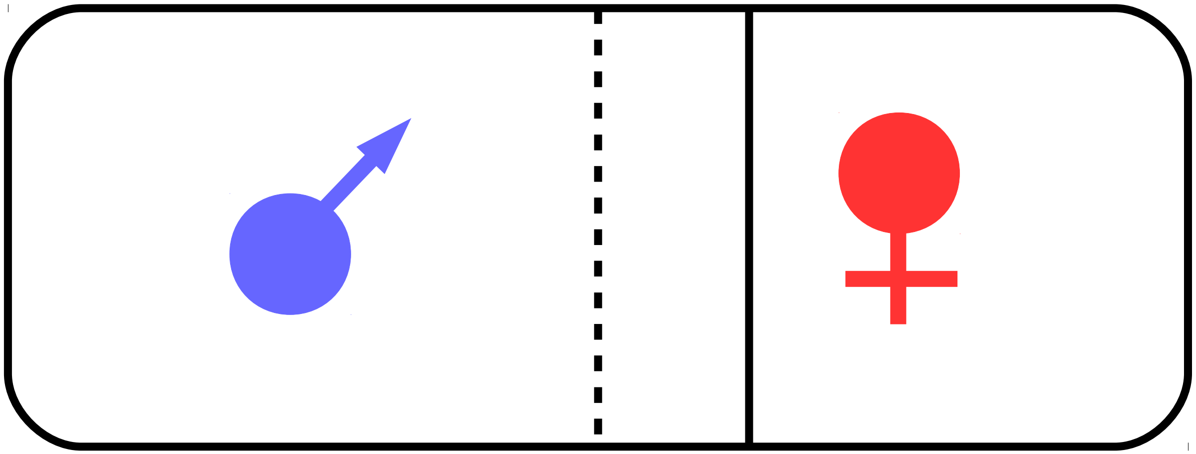
Ratio of produced grandchildren Fem_2 / Fem_1:

$$\boxed{\frac{1+bn}{b+n}=\frac{1+b}{b+1}=1}$$

All strategies among females lead to the same number of grandchildren

Karl Düsing (1883)

If sex-ratio is **originally unbalanced**:



2x males x females

Ratio of produced grandchildren Fem_2 / Fem_1:

$$\boxed{\frac{1+bn}{b+n} > 1 \text{ (for all } b>1\text{)}}$$

Karl Düsing (1883)

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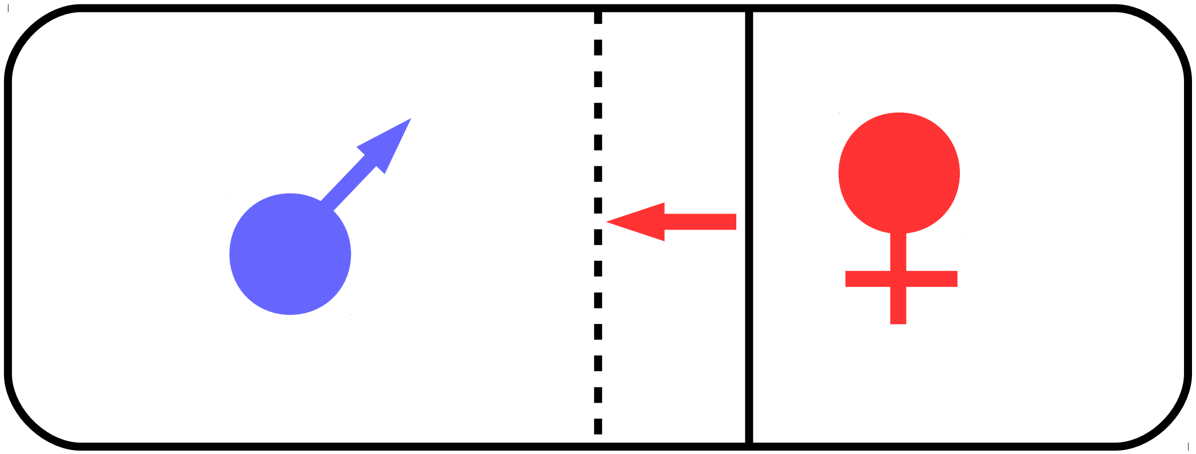


Ratio of produced grandchildren Fem_2 / Fem_1:

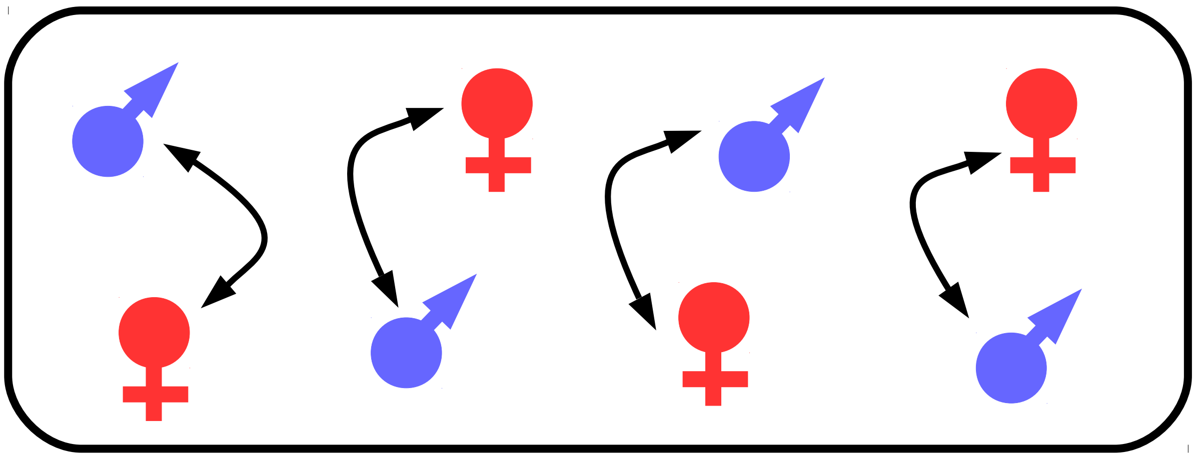
$$\boxed{\frac{1+bn}{b+n} > 1 \text{ (for all } b>1)}$$

Production of the minority sex is favoured

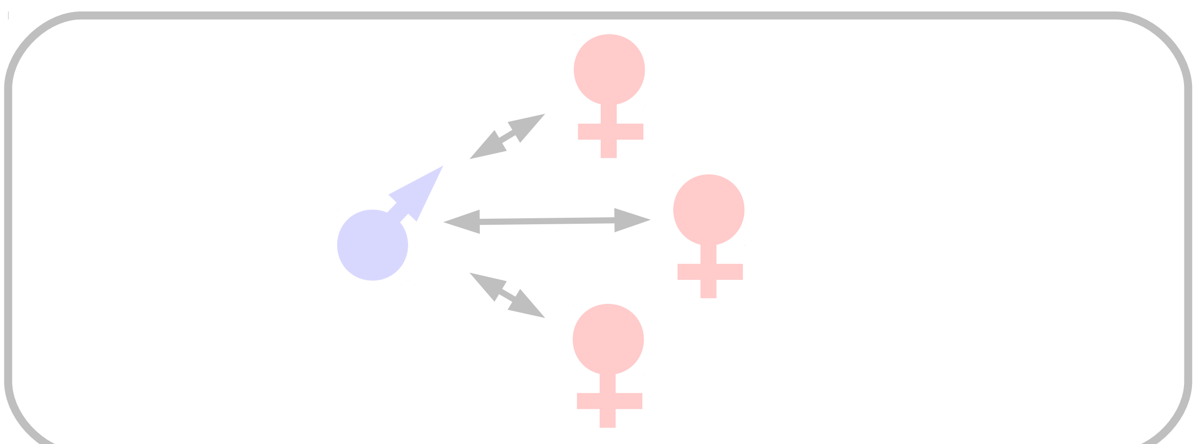
Karl Düsing (1883)

Why sex-ratios are sometimes unbalanced in nature?

Models explaining balanced sex-ratio always assume: panmixia
+
unlimited mating opportunities



A few number of ♂ can fertilize all ♀



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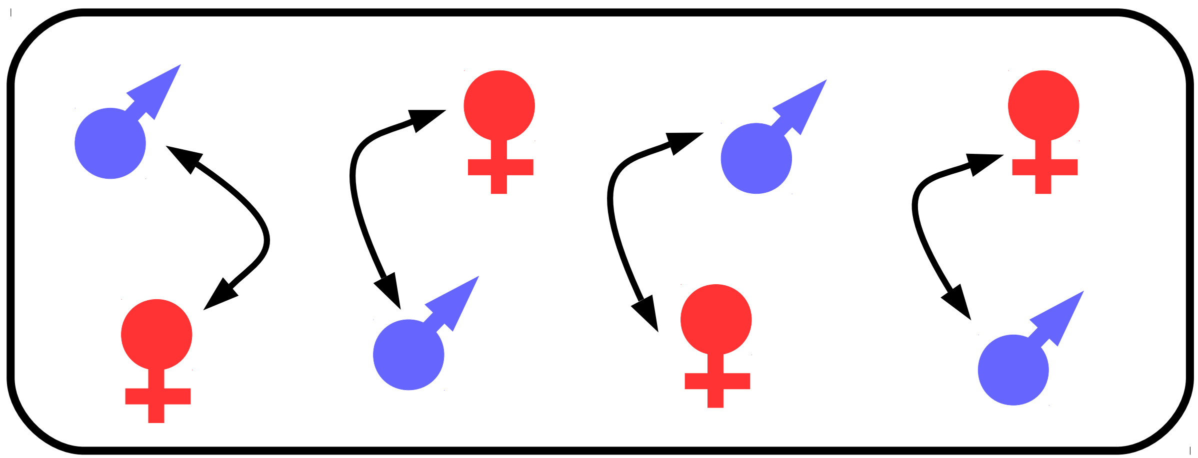

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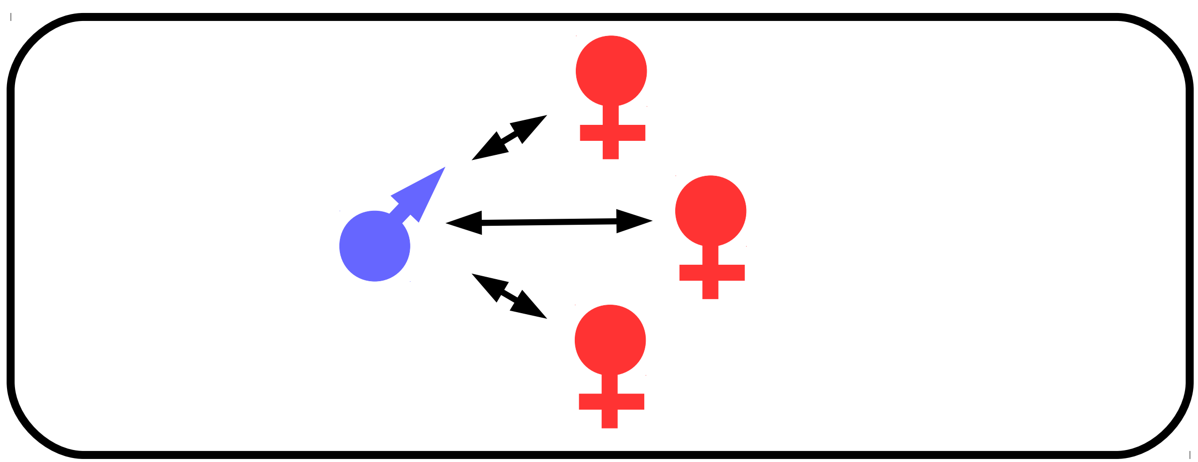

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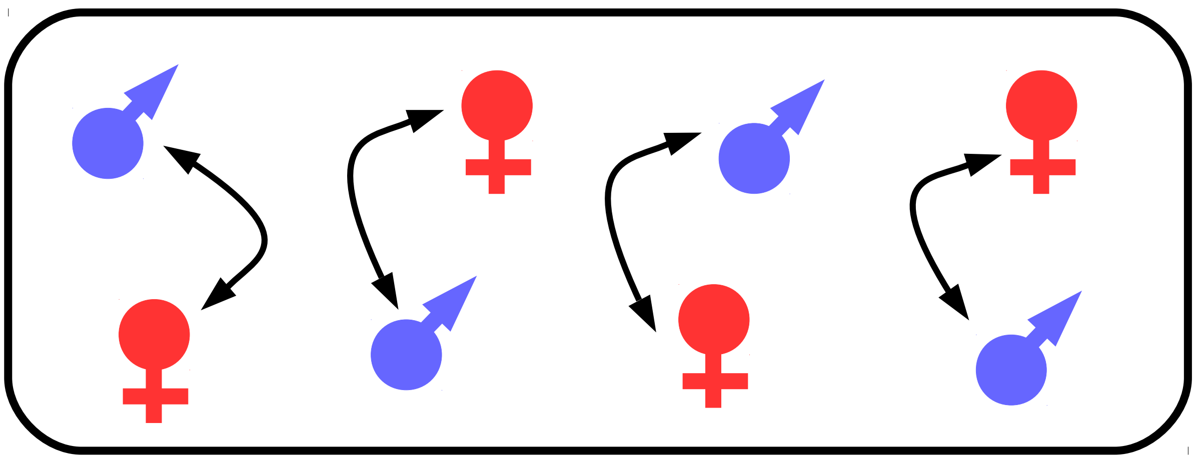
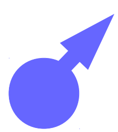
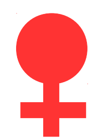
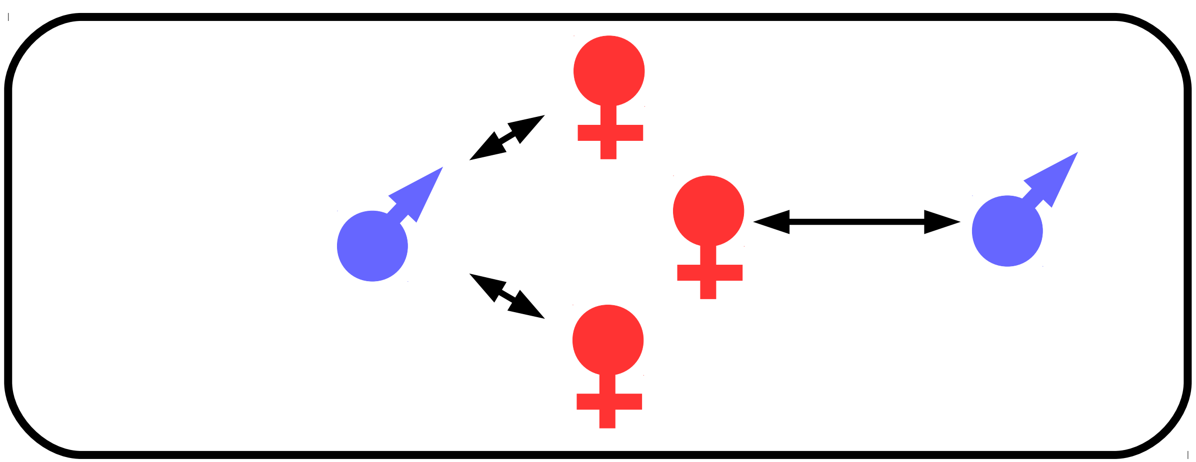
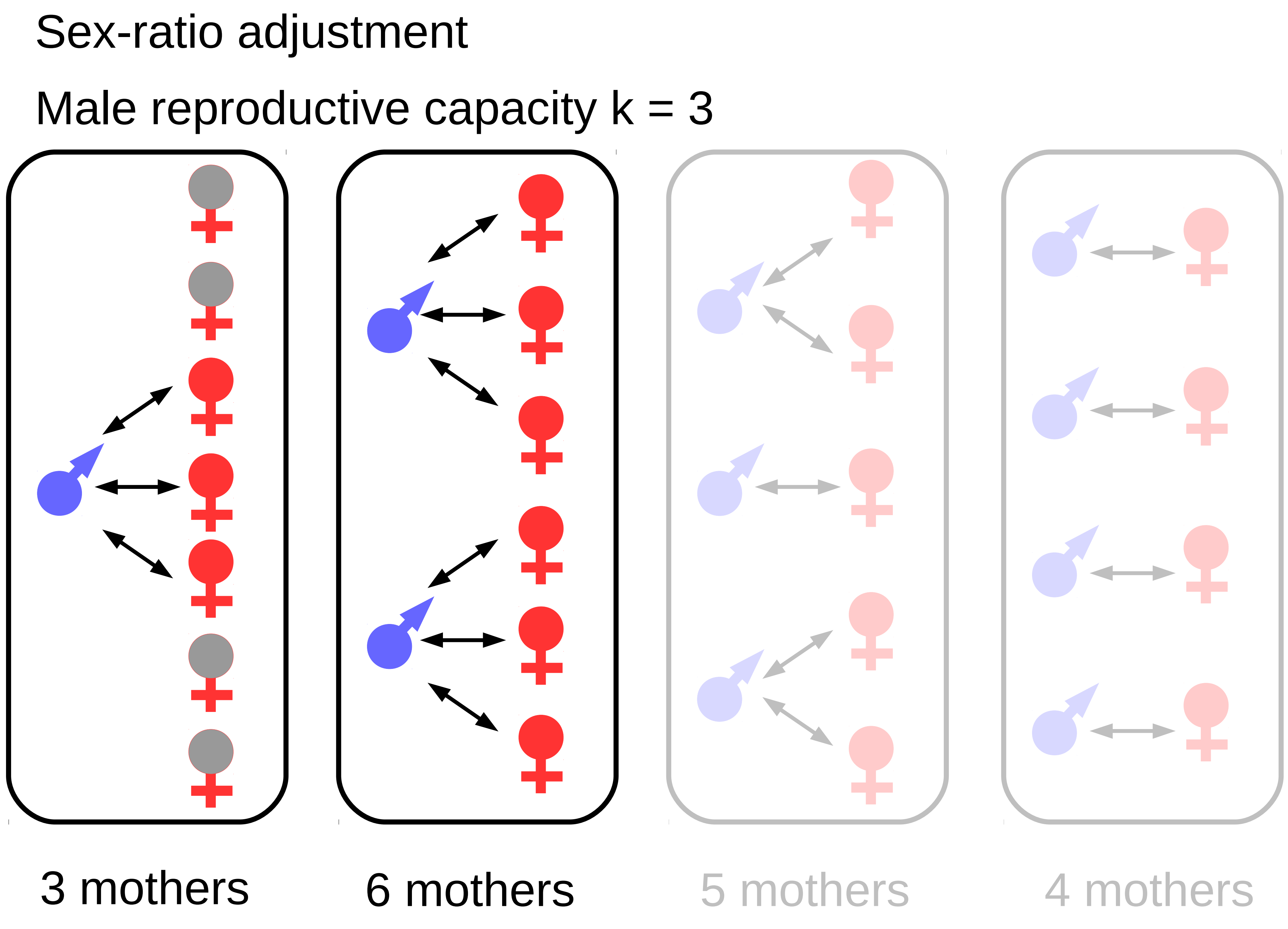


A few number of  can fertilize all  → local mate competition

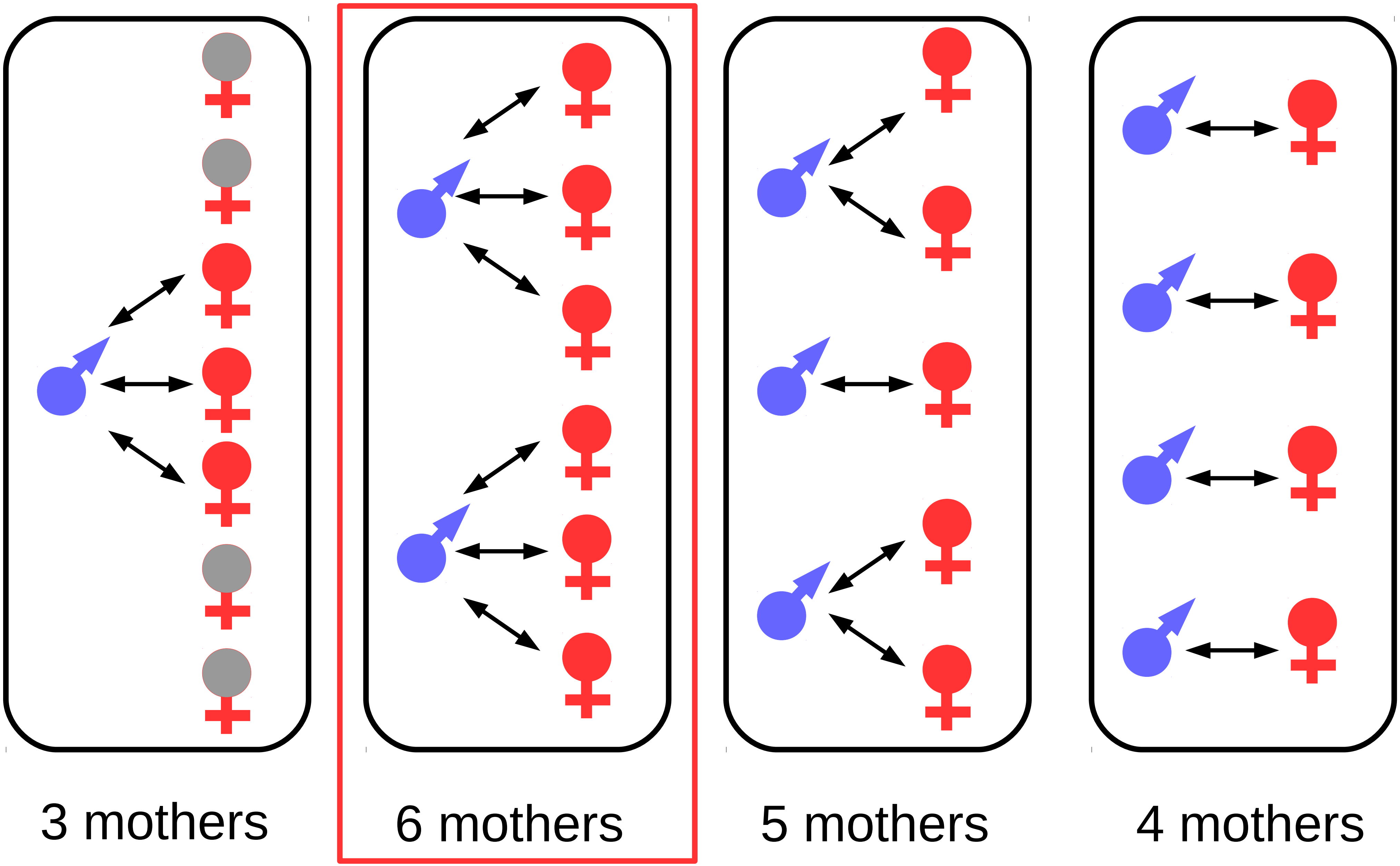




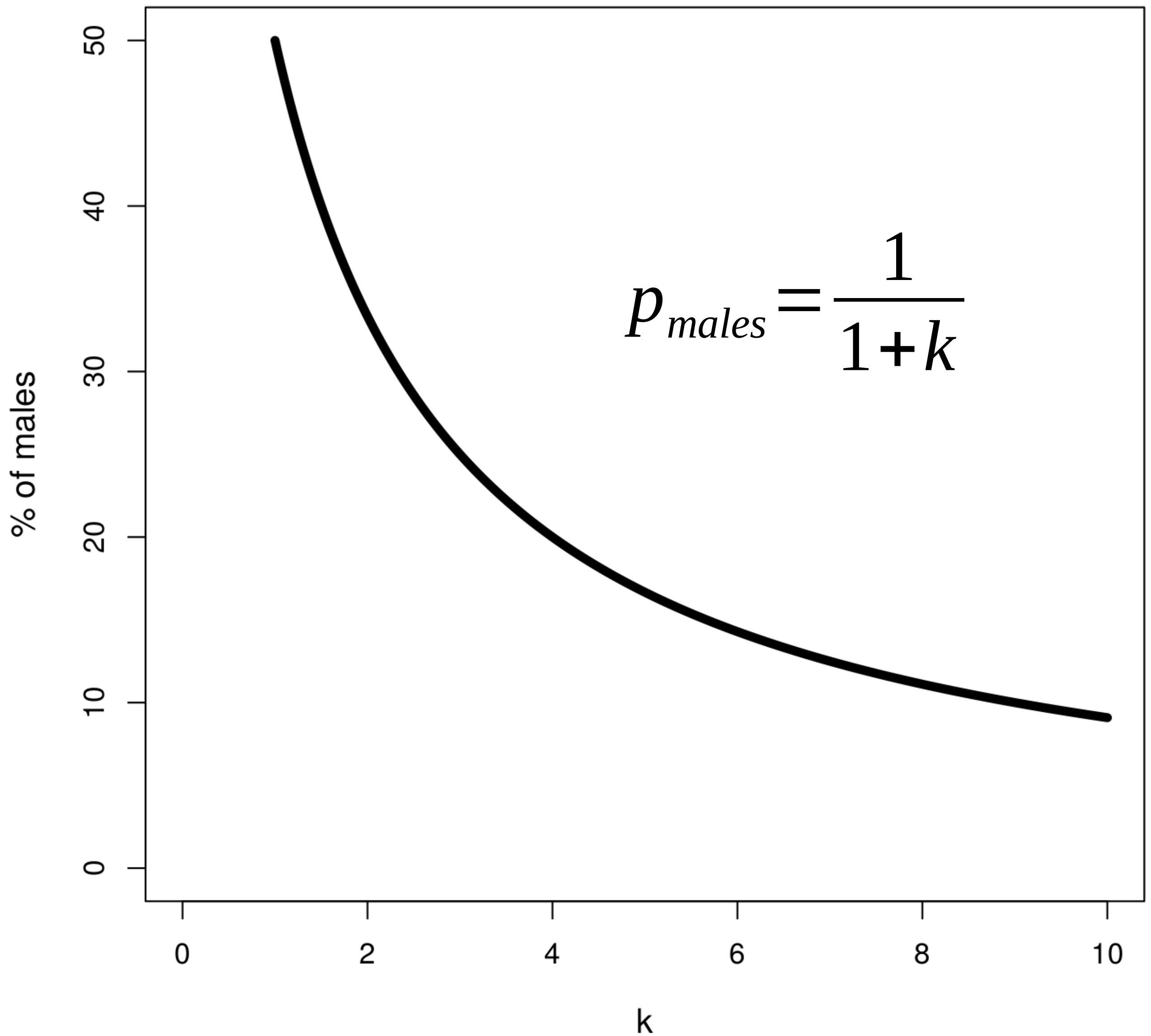
Sex-ratio adjustment
Male reproductive capacity k = 3
3 mothers
6 mothers
5 mothers
4 mothers

Sex-ratio adjustment

Male reproductive capacity k = 3

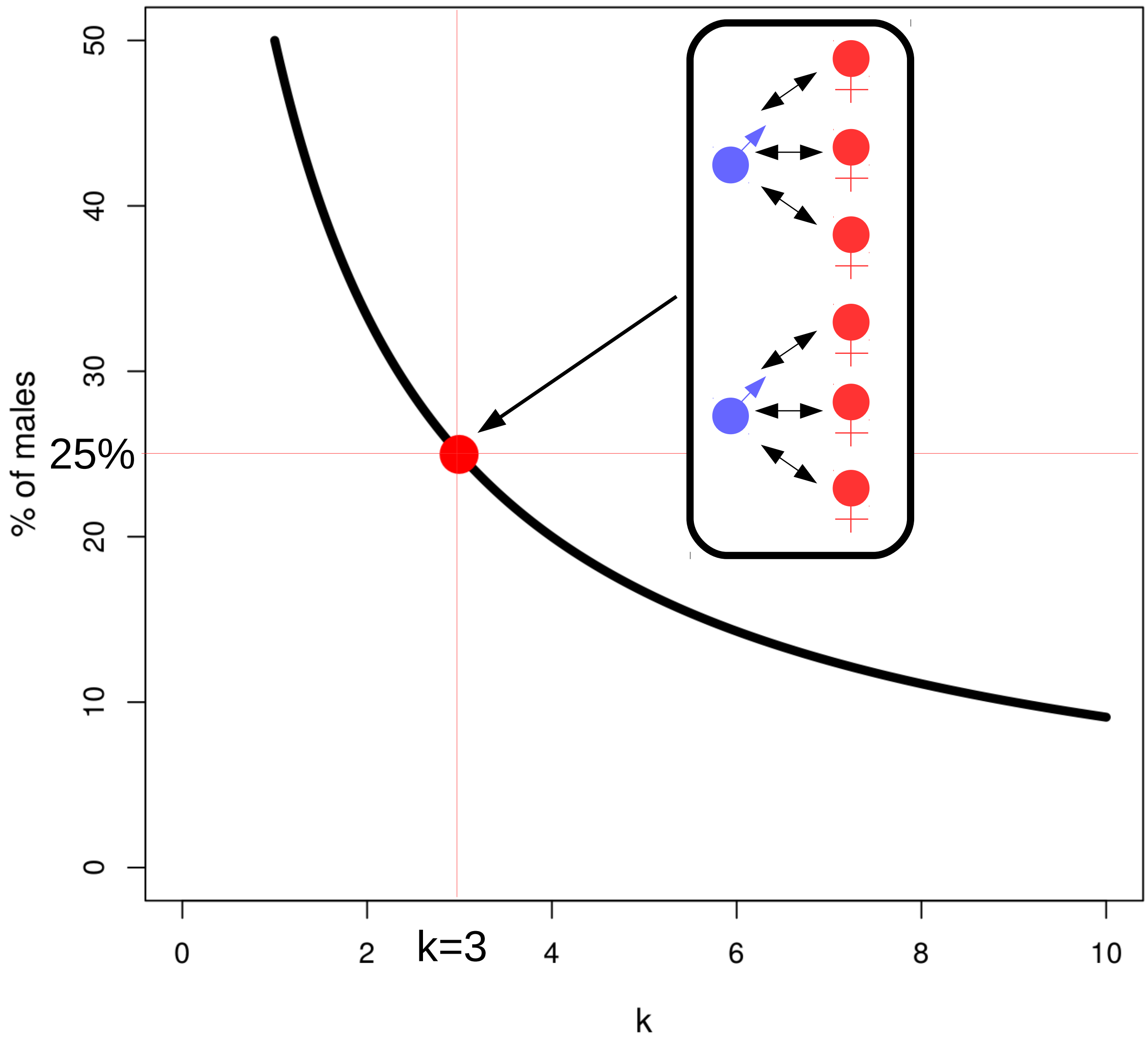


Sex-ratio adjustment



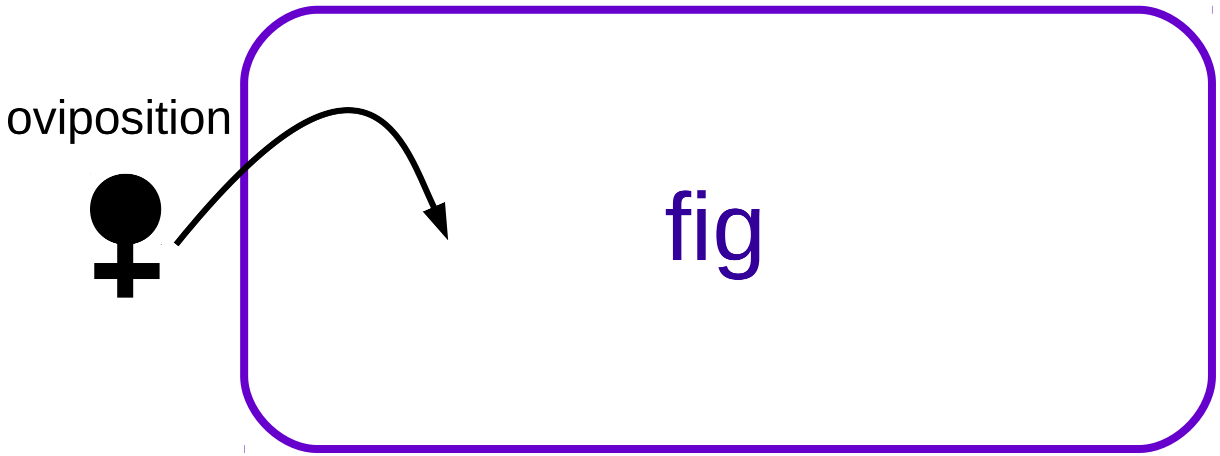
Sex-ratio adjustment

Example: male reproductive capacity k = 3



Sex-ratio adjustment

The case of fig wasps



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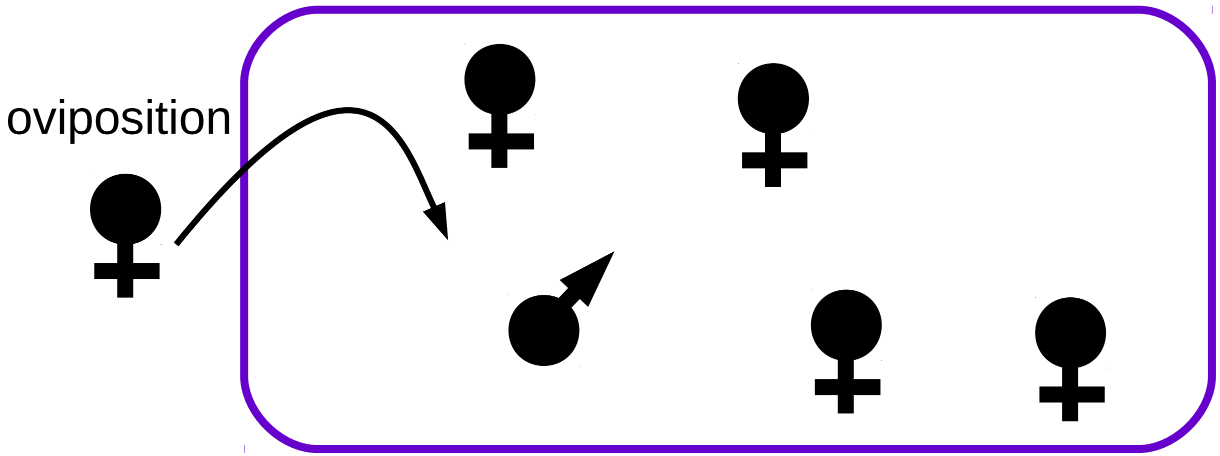

Strong LMC → bias toward daughters

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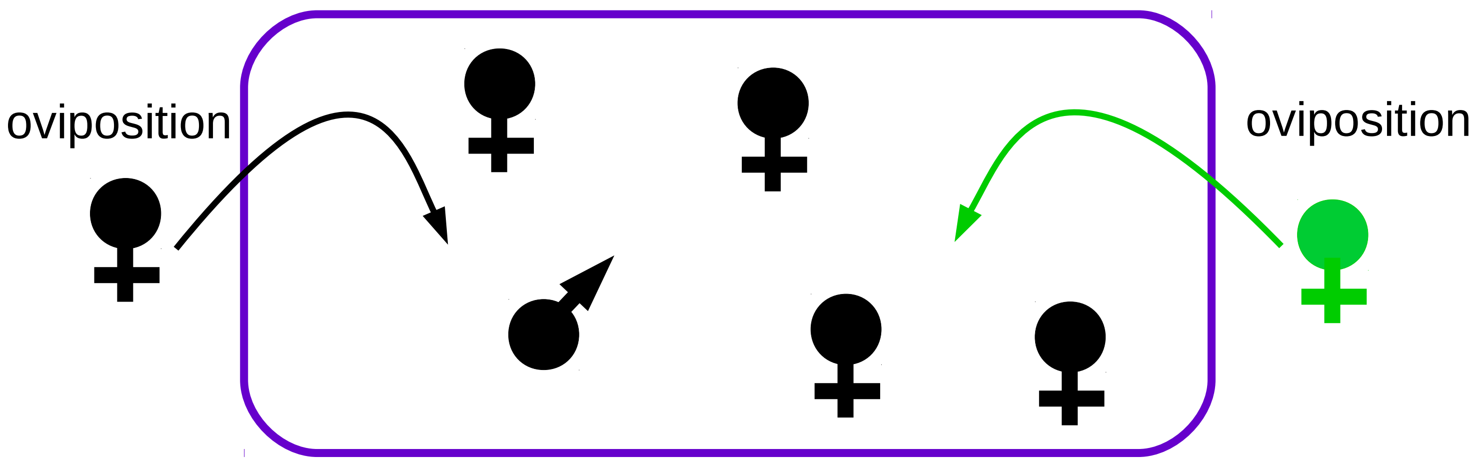

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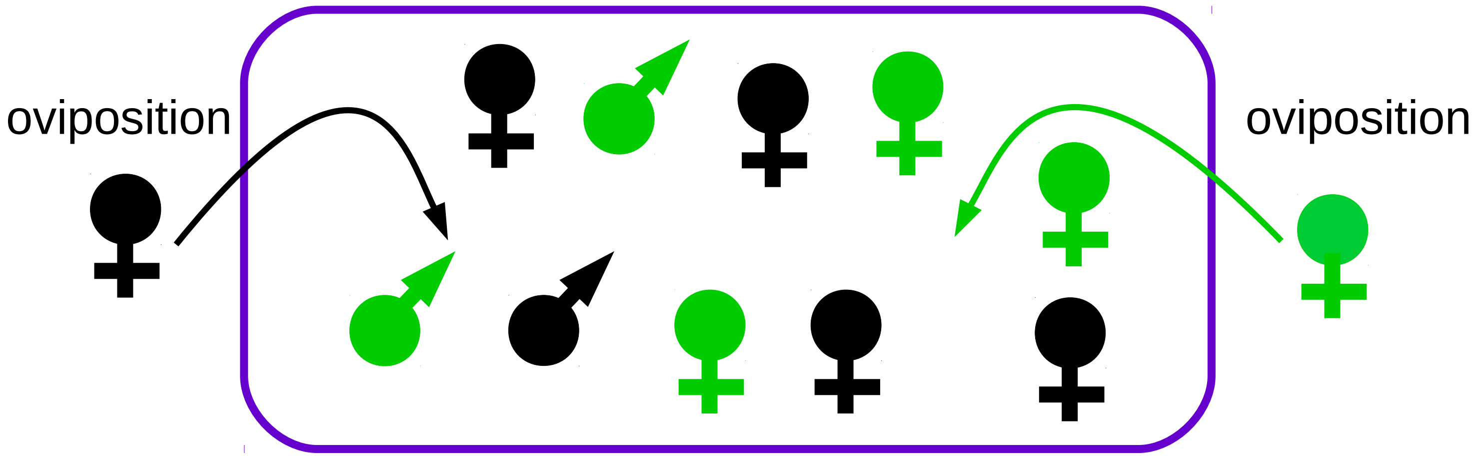

Strong LMC → bias toward daughters

Weaker LMC → increased production of sons

Sex-ratio adjustment

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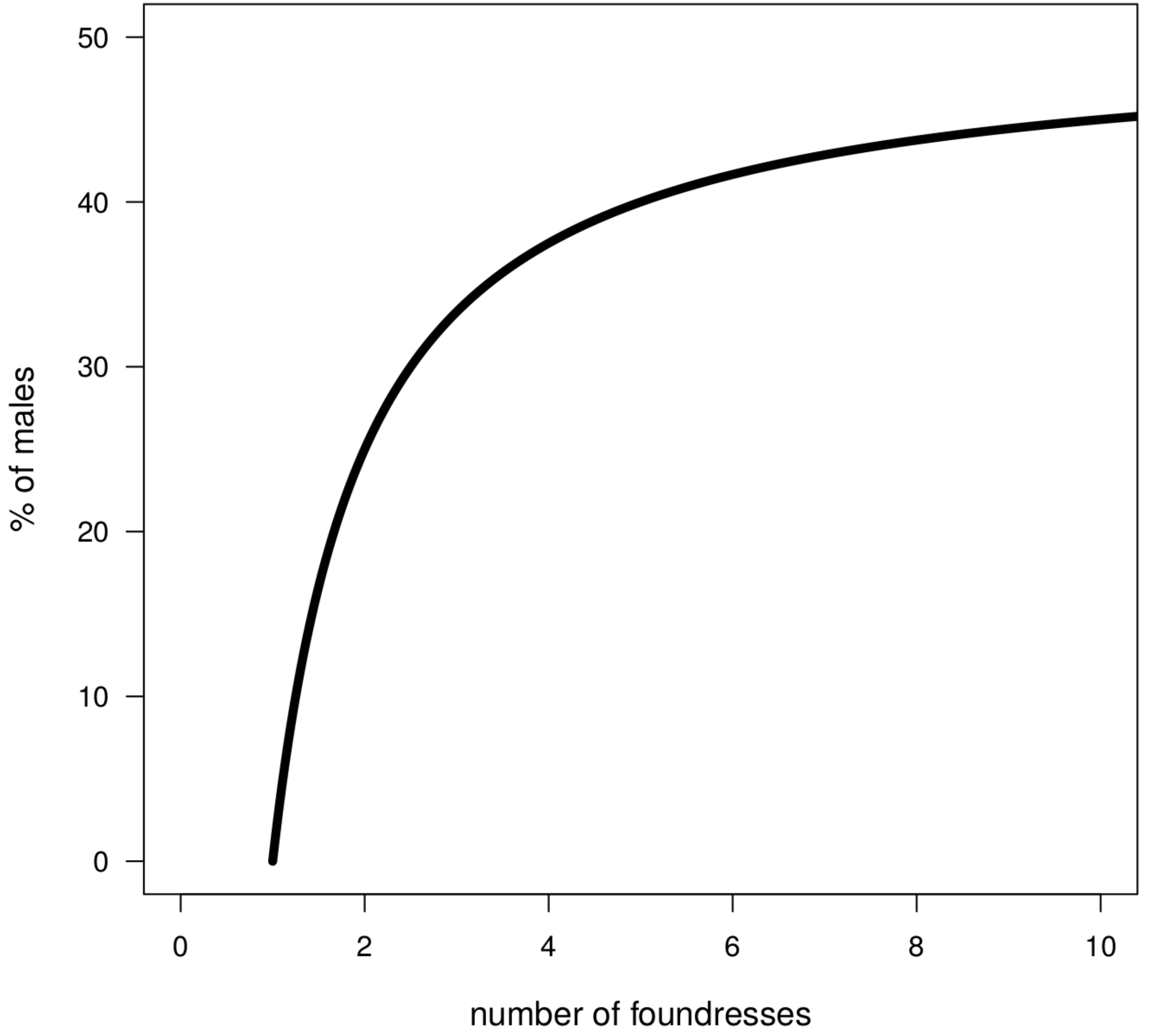
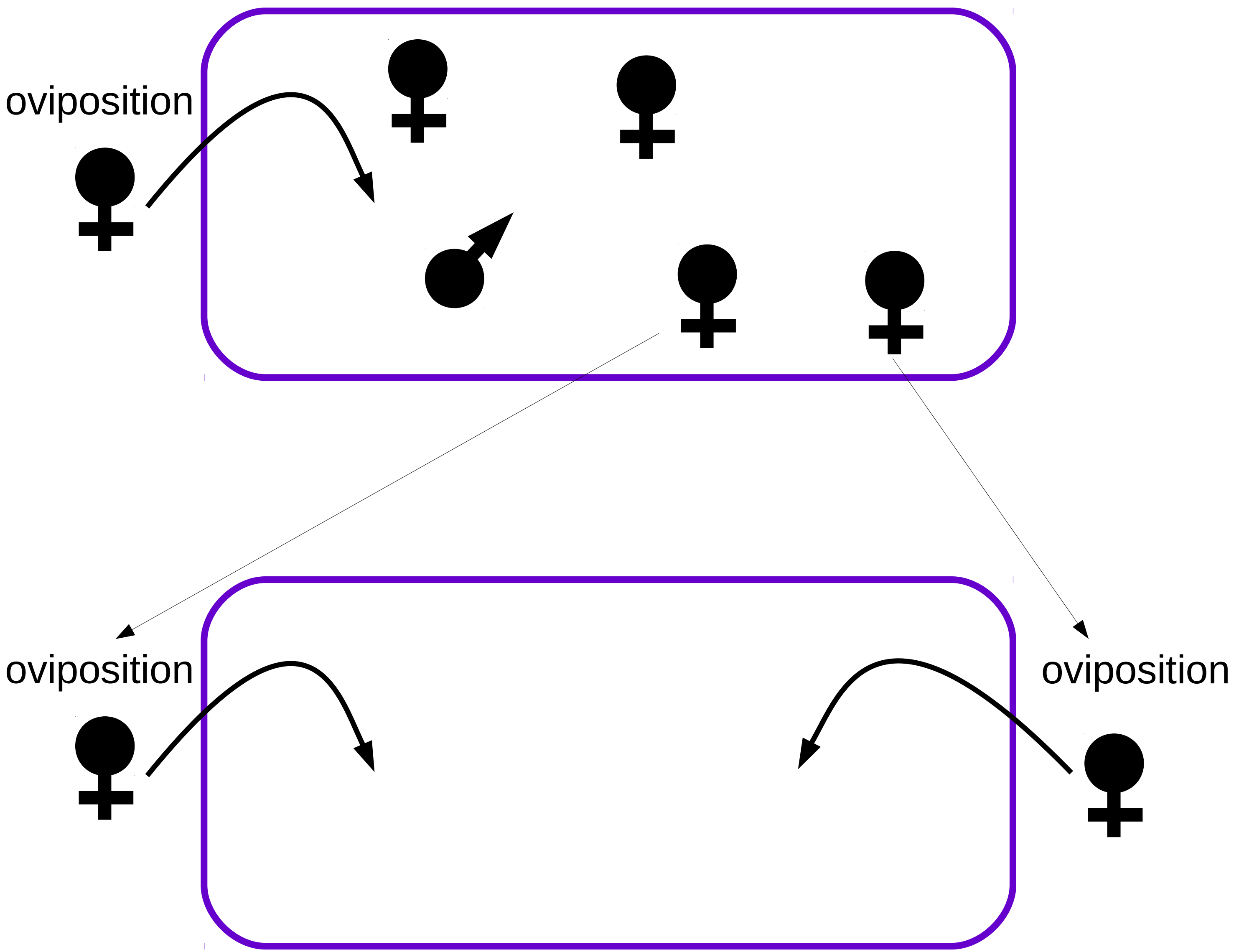


If #foundresses ↗, then LMC ↘

Sex-ratio adjustment

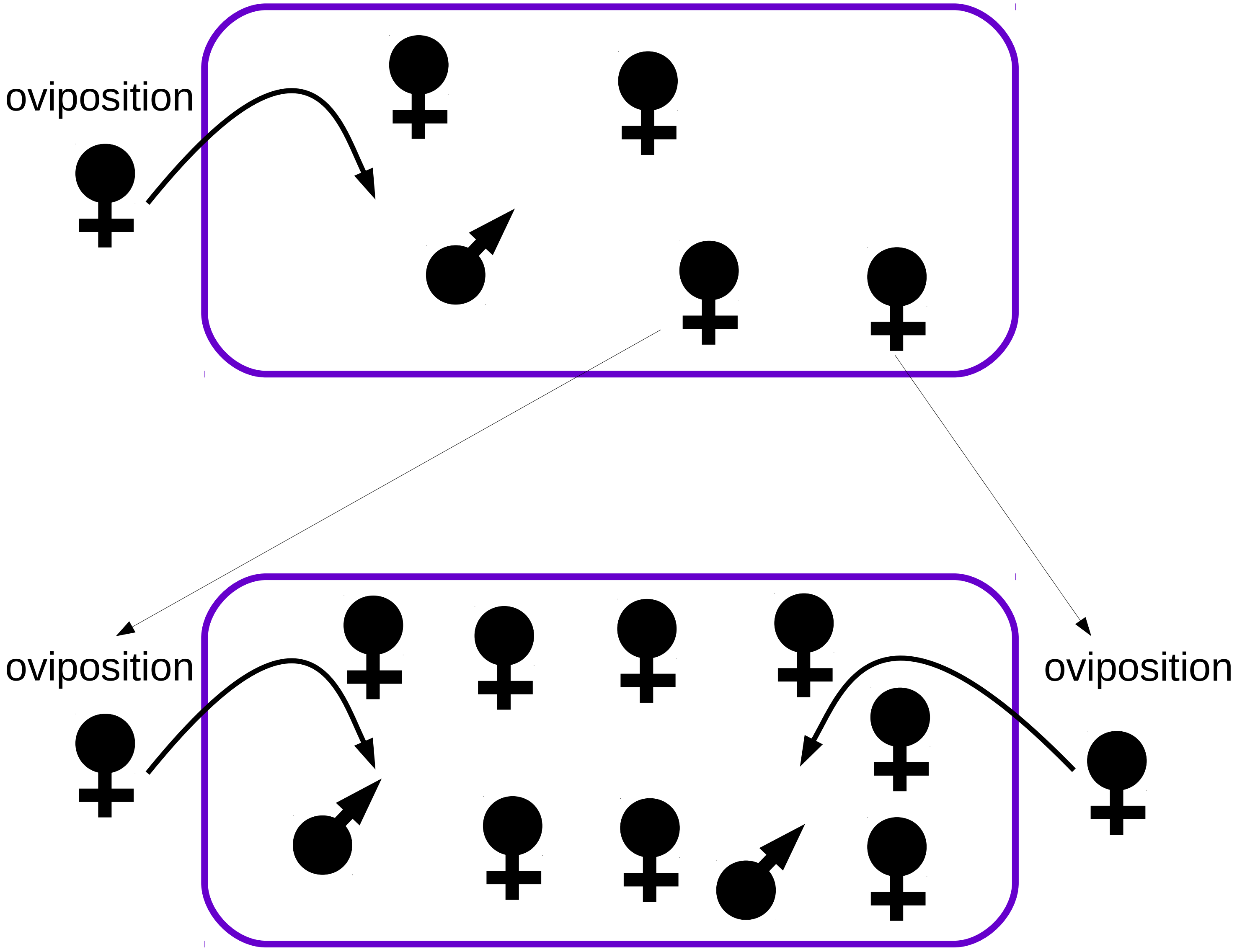
The case of fig wasps



Effect of inbreeding on sex-ratio

Sex-ratio adjustment

The case of fig wasps



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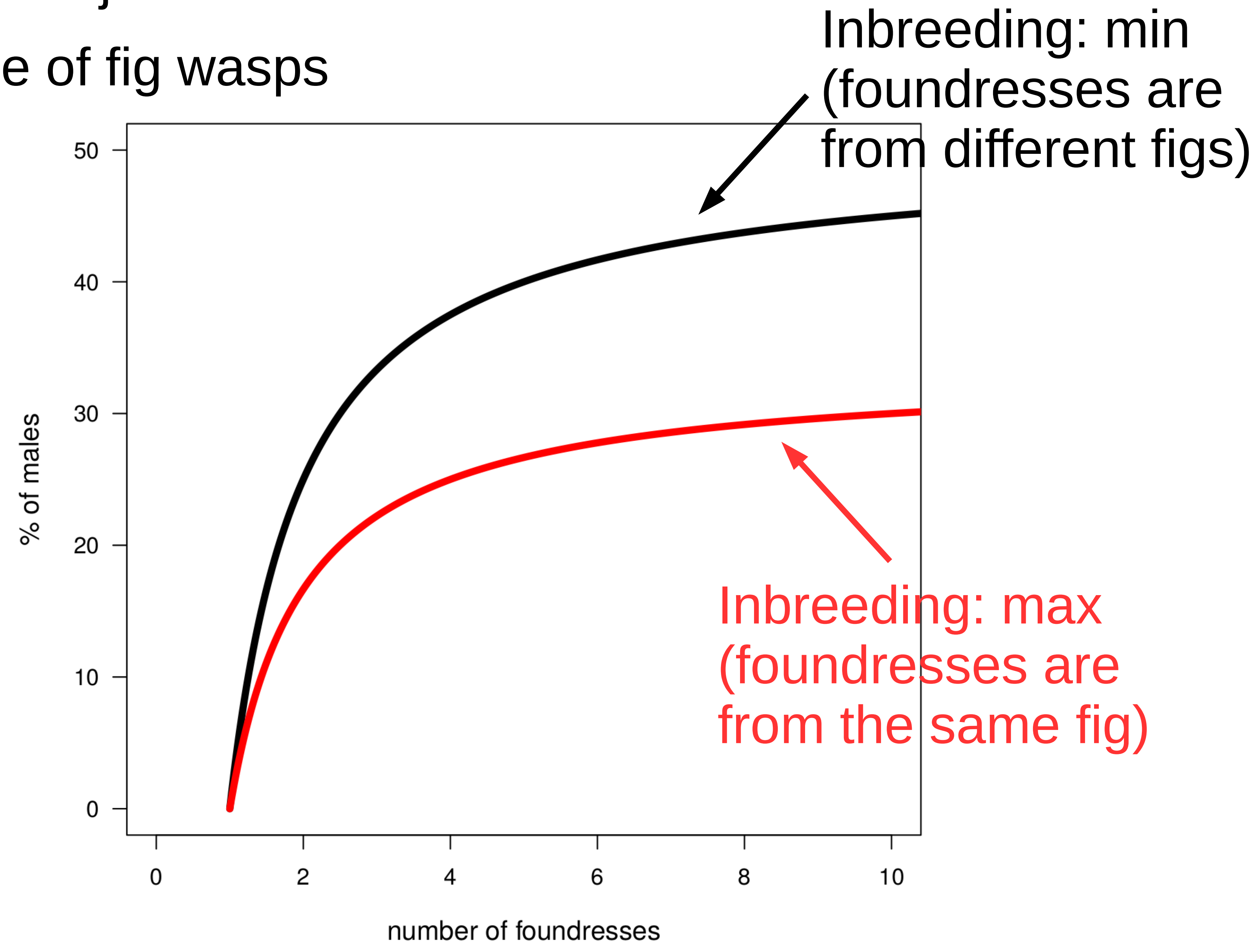
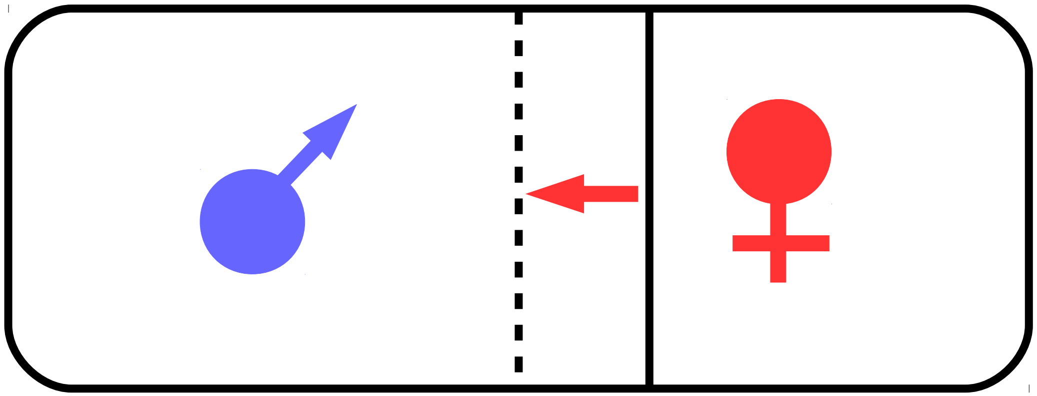
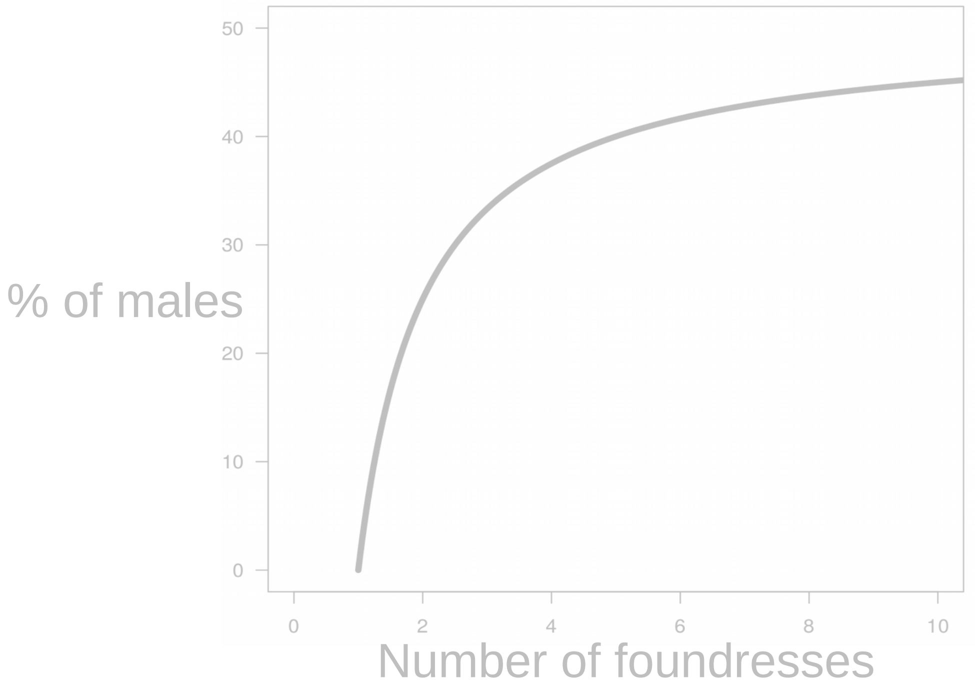


Sex ratios in gonochoristic species

Balanced for panmictic populations



Female biased if competition between brothers is strong



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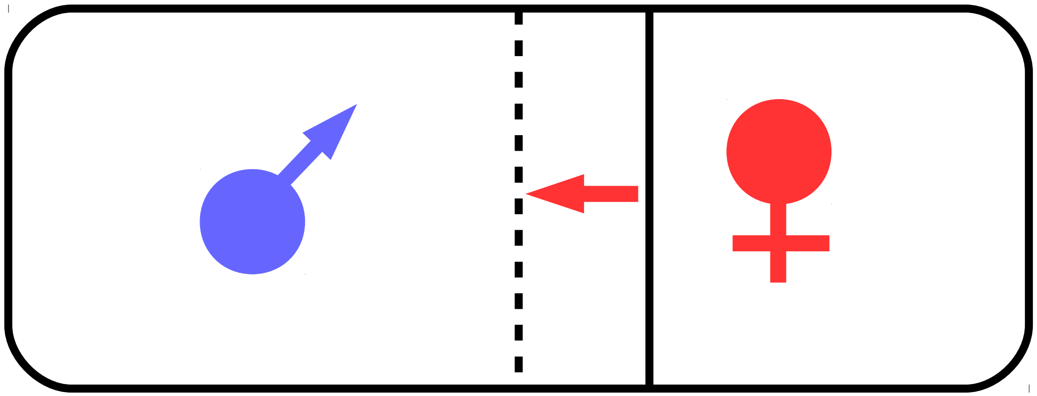

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