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## game parameters

```
In[5]:= gamea = {3, 3/4};  
gameb = {1, 3/4};  
gamec = {1, 4/3};  
gamed = {3, 4/3};  
  
In[6]:= games = {gamea, gameb, gamec, gamed};
```

## Fitness functions and dynamics

```

θ[x_, thresh_] := If[x < thresh, 0, 1];
πD[b_, num_, thresh_] := b θ[num, thresh] + 1;
πC[b_, c_, num_, thresh_] :=
  πD[b, num, thresh] -  $\frac{c}{num} \theta[num, thresh] - \frac{c}{thresh} (1 - \theta[num, thresh]);$ 
πintraD[d_, b_, c_, num_, ω_] :=  $\frac{b}{d} \sum_{i=0}^{num-1} \omega^i;$ 
πintraC[d_, b_, c_, num_, ω_] := πintraD[d, b, c, num, ω] - c;

fD[d_, dintra_, x_, y_, b_, c_, bintra_, cintra_, thresh_, ω_, p_] :=
  p  $\left( \sum_{k=0}^{d-1} (\text{Binomial}[d-1, k] x^k (1-x)^{d-1-k} \piD[b, k, thresh]) \right) +$ 
  (1-p)  $\left( \sum_{k=0}^{dintra-1} (\text{Binomial}[dintra-1, k] y^k$ 
     $(1-y)^{dintra-1-k} \piintraD[dintra, bintra, cintra, k, \omega]) \right);$ 

fC[d_, dintra_, x_, y_, b_, c_, bintra_, cintra_, thresh_, ω_, p_] :=
  p  $\left( \sum_{k=0}^{d-1} (\text{Binomial}[d-1, k] x^k (1-x)^{d-1-k} \piC[b, c, k+1, thresh]) \right) +$ 
  (1-p)  $\left( \sum_{k=0}^{dintra-1} (\text{Binomial}[dintra-1, k] y^k (1-y)^{dintra-1-k}$ 
     $\piintraC[dintra, bintra, cintra, k+1, \omega]) \right);$ 

fbar1[d_, dintra_, x_, y_, b_, c_, bintra_, cintra_, thresh_, ω_, p_] :=
  x fC[d, dintra, y, x, b, c, bintra, cintra, thresh, ω, p] +
  (1-x) fD[d, dintra, y, x, b, c, bintra, cintra, thresh, ω, p];
fbar2[d_, dintra_, x_, y_, b_, c_, bintra_, cintra_, thresh_, ω_, p_] :=
  y fC[d, dintra, x, y, b, c, bintra, cintra, thresh, ω, p] +
  (1-y) fD[d, dintra, x, y, b, c, bintra, cintra, thresh, ω, p];
xdot[d_, dintra_, x_, y_, b_, c_, bintra_, cintra_, thresh_, m_, ω_, p_] :=
  m x (1-x) (fC[d, dintra, y, x, b, c, bintra, cintra, thresh, ω, p] -
    FD[d, dintra, y, x, b, c, bintra, cintra, thresh, ω, p]);
ydot[d_, dintra_, x_, y_, b_, c_, bintra_, cintra_, thresh_, n_, ω_, p_] :=
  n y (1-y) (fC[d, dintra, x, y, b, c, bintra, cintra, thresh, ω, p] -
    FD[d, dintra, x, y, b, c, bintra, cintra, thresh, ω, p]);

```

Choose the value for the prob below and let it run to generate the panel figures

In[ ]:= **prob = 0;**

```

d1 = 5;
d2 = 5;

```

```

d1intra = 5;
d2intra = 5;
thresh1 = 1;
thresh2 = 1;
b = 2;
c = 1;
bintraforsp1 = 10;
bintraforsp2 = 10;
m = 1/8 // N;
n = 1;

lim = 800;

plotpanel = {};

For[i = 1, i ≤ Length[games], i++,
  For[j = 1, j ≤ Length[games], j++,
    cintraforsp1 = games[[j]][1];
    wforsp1 = games[[j]][2] // N;
    cintraforsp2 = games[[i]][1];
    wforsp2 = games[[i]][2] // N;

    res[p_, q_, lim_] :=
      Quiet[NDSolve[{x'[t] == m x[t] (fC[d1, d1intra, y[t], x[t], b, c, bintraforsp1,
        cintraforsp1, thresh1, wforsp1, prob] - fbar1[d1, d1intra, x[t],
        y[t], b, c, bintraforsp1, cintraforsp1, thresh1, wforsp1, prob]),
        y'[t] == n y[t] (fC[d2, d2intra, x[t], y[t], b, c, bintraforsp2,
        cintraforsp2, thresh2, wforsp2, prob] - fbar2[d2, d2intra, x[t],
        y[t], b, c, bintraforsp2, cintraforsp2, thresh2, wforsp2, prob]),
        x[0] == p, y[0] == q}, {x, y}, {t, lim}]];
    liseval[t_, rep_] := Evaluate[{x[t], y[t]} /. rep];
    Clear[blue, red, black];
    blue = {};
    red = {};
    black = {};
    For[u = 0.0, u ≤ 1.0, u = u + 0.01, For[v = 0.0, v ≤ 1.0, v = v + 0.01,
      If[
        liseval[lim, res[u, v, lim]][[1]][1] > 0.9999 &&
        liseval[lim, res[u, v, lim]][[1]][2] < 0.01,
        AppendTo[red, {u, v}], If[liseval[lim, res[u, v, lim]][[1]][1] < 0.01 &&
          liseval[lim, res[u, v, lim]][[1]][2] > 0.9999,
          AppendTo[blue, {u, v}], AppendTo[black, {u, v}]"]];
    ];
    AppendTo[red, {0, 0}];
    AppendTo[blue, {0, 0}];
    AppendTo[black, {0, 0}];
  ];
]

```

```

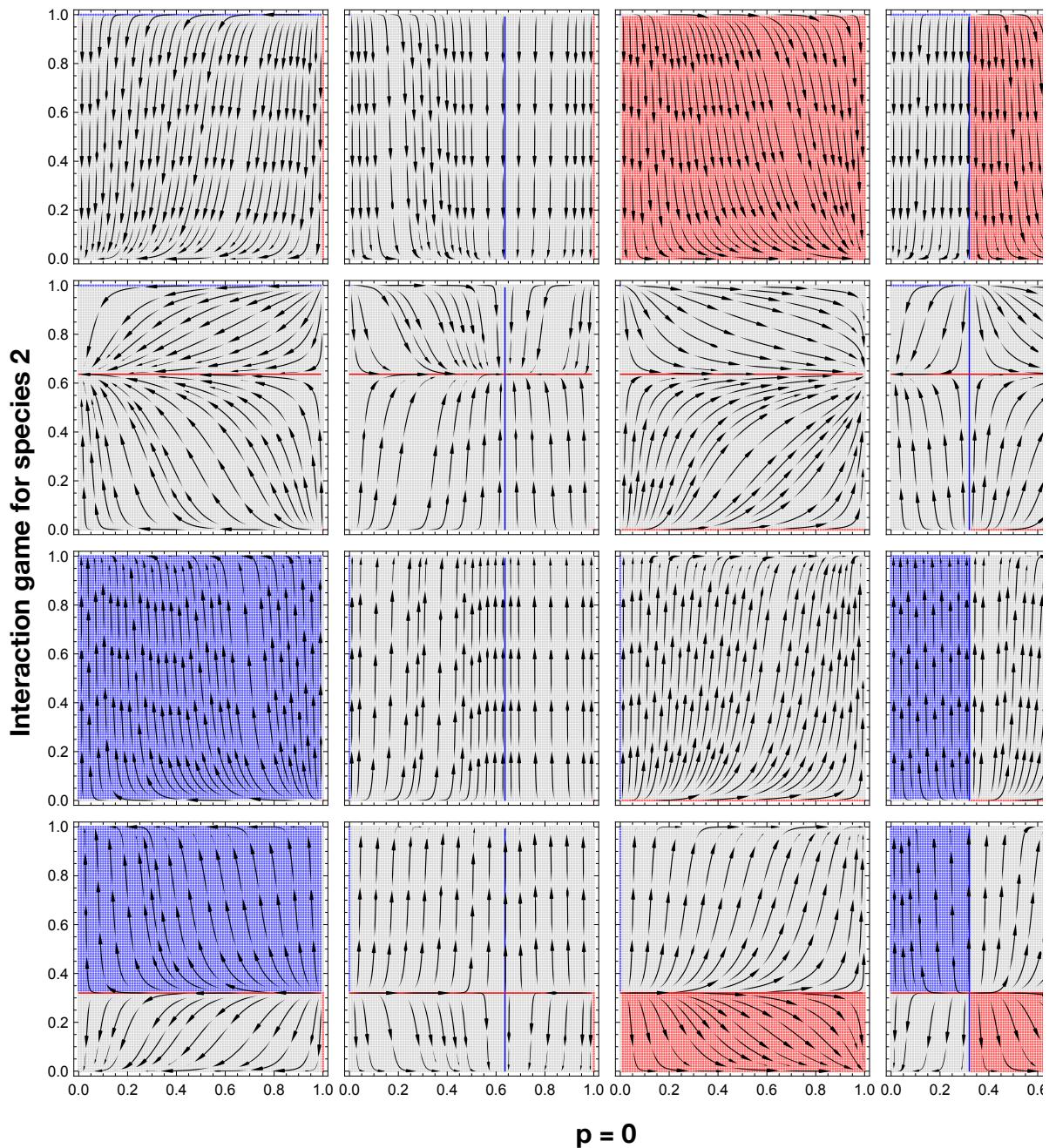
p2fun[d1_, d2_, d1intra_, d2intra_,
      b_, c_, thresh1_, thresh2_, m_, n_] := StreamPlot[{{
        xdot[d1, d1intra, x, y, b, c, bintraforsp1, cintraforsp1, thresh1,
              m, wforssp1, prob], ydot[d2, d2intra, x, y, b, c, bintraforsp2,
              cintraforsp2, thresh2, n, wforssp2, prob]}, {x, 0.0001, 1},
        {y, 0.0001, 1}}, StreamScale → 0.2, Axes → False, StreamPoints → 30,
        StreamStyle → {"PinDart", Directive[Black, Thick]}, Frame → True,
        PlotRange → {{-0.01, 1.01}, {-0.01, 1.01}}, StreamColorFunction → (Black &)];
g1 = ListPlot[{blue, red, black},
              PlotStyle → {Lighter[Blue, 0.4], Lighter[Red, 0.4], Lighter[Gray, 0.7]},
              AspectRatio → 1, Frame → True, PlotRange → {{-0.01, 1.01}, {-0.01, 1.01}}];
p2contour[d1_, d2_, d1intra_, d2intra_,
           b_, c_, thresh1_, thresh2_, m_, n_] := ContourPlot[{{
             xdot[d1, d1intra, x, y, b, c, bintraforsp1, cintraforsp1, thresh1, m, wforssp1,
                   prob] = 0.00, ydot[d2, d2intra, x, y, b, c, bintraforsp2, cintraforsp2,
                   thresh2, n, wforssp2, prob] = 0.00}, {x, 0.001, 0.99}, {y, 0.001, 0.99},
             ContourStyle → {{Thickness[0.005], Blue}, {Thickness[0.005], Red}}}];
AppendTo[plotpanel,
  Show[g1, p2contour[d1, d2, d1intra, d2intra, b, c, thresh1, thresh2, m, n],
    p2fun[d1, d2, d1intra, d2intra, b, c, thresh1, thresh2, m, n],
    Frame → True, FrameStyle → Thickness[0.0025], ImagePadding → 17,
    PlotRange → {{-0.02, 1.02}, {-0.02, 1.02}}]];
]
]

In[]:= ResourceFunction["PlotGrid"] [Partition[plotpanel, 4],
  FrameLabel → {{Pane["Interaction game for species 2"], None},
    {"p = " <> ToString[prob], "Interaction game for species 1"}},
  Spacings → 10, ImageSize → 700, "ShowFrameLabels" → Automatic,
  FrameStyle → Directive[Black, Bold],
  FontFamily → "Helvetica Neue", FontSize → 16], AspectRatio → 1]

```

Out[ $\circ$ ] =

### Interaction game for species 1



```
(*Export["panel"<>ToString[prob]<>".pdf",%]*)
```