

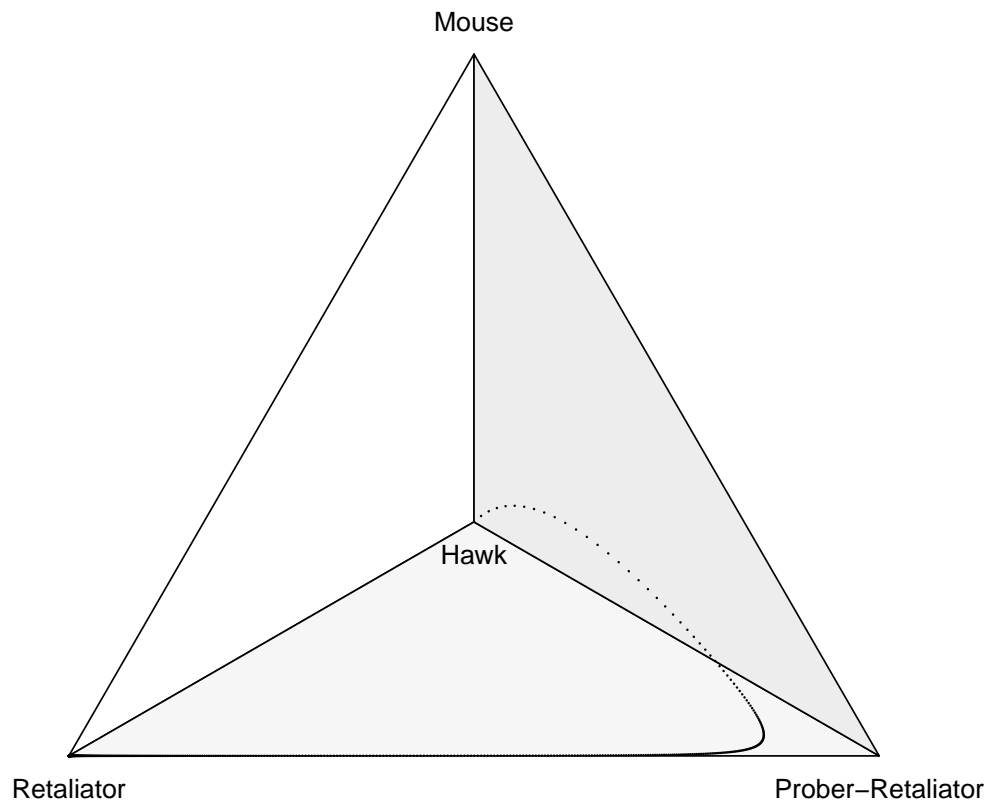
Appendix B: Replicator Dynamic Phase Diagram Generator (R)

(and some bonus diagrams)

```
# packages used  
library(EvolutionaryGames)  
library(rgl)
```

Mouse, Hawk, Retaliator, Prober-Retaliator (MS&P's payoffs)

```
# create the payoff matrix for the game  
A <- matrix(c(29, 19.5, 29, 17.2,  
             80, -19.5, -18.1, -18.9,  
             29, -22.3, 29, 23.1,  
             56.7, -20.1, 26.9, 21.9),  
           4, byrow=TRUE)  
  
# specify the names of the strategies, in order of column  
strategies <- c("Mouse", "Hawk", "Retaliator", "Prober-Retaliator")  
  
# specify the initial population state  
state <- c(.25, .25, .25, .25)  
  
# plot phase diagram (3D for 4 strategies)  
phaseDiagram4S(A, Replicator, NULL, state, noRGL = T, strategies)
```



*# if you run with noRGL = F, the rgl package will create an interactive 3D diagram
that you can rotate!*

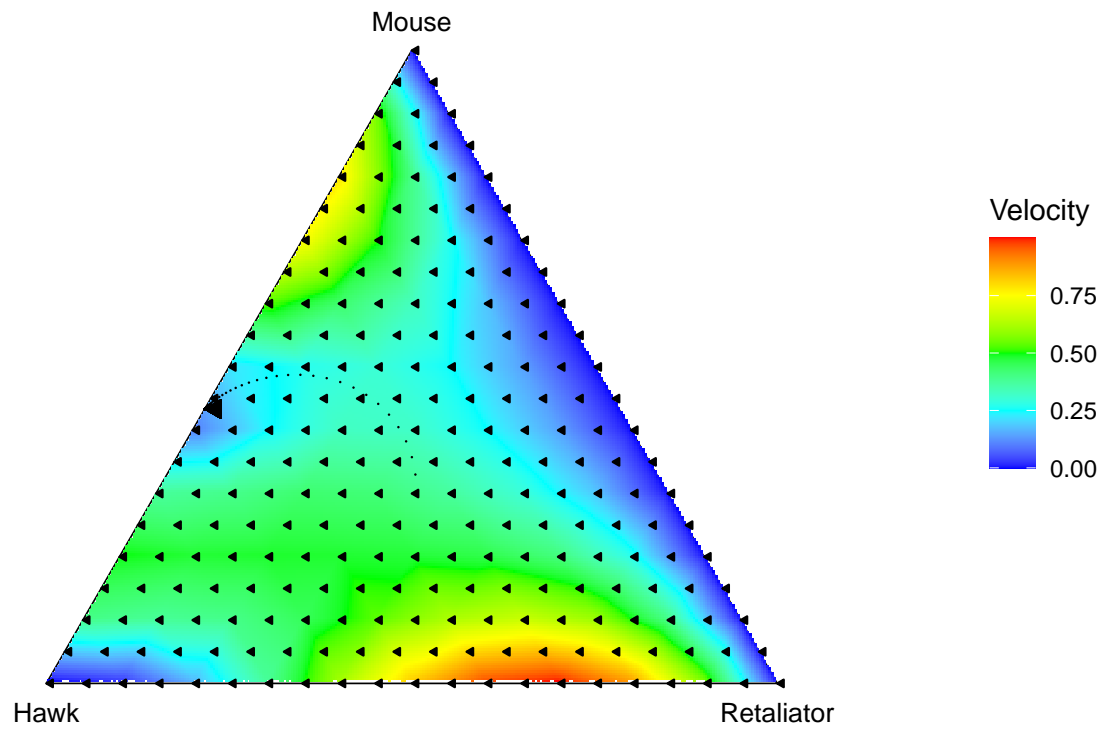
Mouse, Hawk, Retaliator (MS&P)

```
A <- matrix(c(29, 19.5, 29,
              80, -19.5, -18.1,
              29, -22.3, 29),
            3, byrow=TRUE)

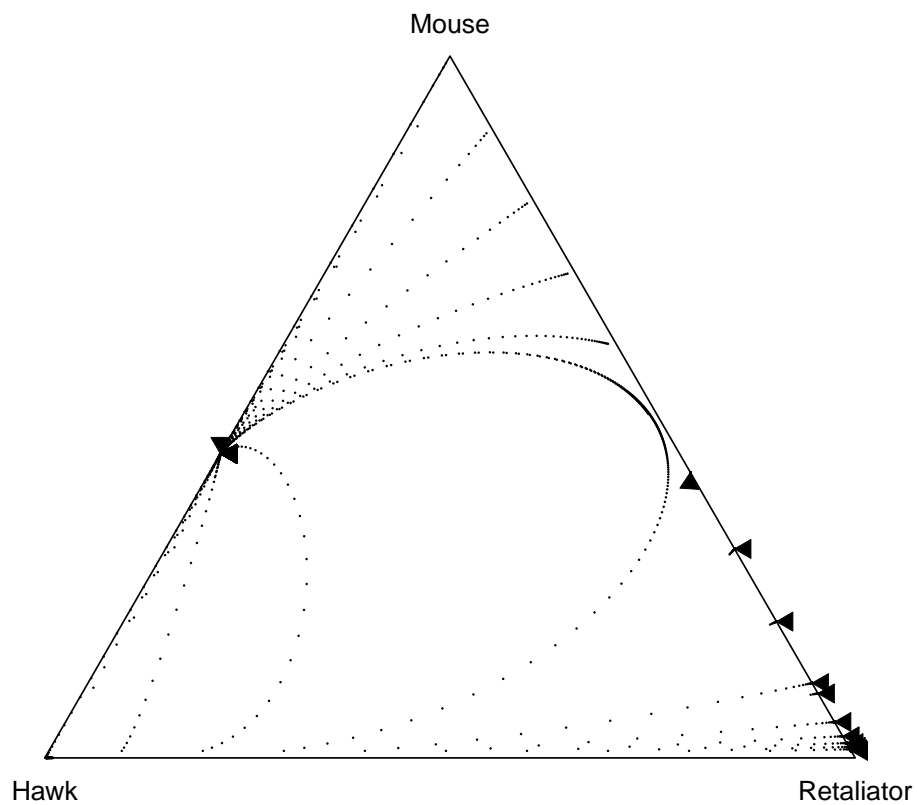
strategies <- c("Mouse", "Hawk", "Retaliator")

state <- matrix(c(.33, .33, .34), 1, 3, byrow = T)

# this one is 3D for 2 strategies
# it also has a contour map showing the speed of change
# and a vector field showing the direction
phaseDiagram3S(A, dynamic = Replicator, params = NULL, trajectories = state,
               contour = T, vectorField = T, strategies)
```



```
# you can also find the set of ESSs and graph their paths
ESset(A, strategies)
```



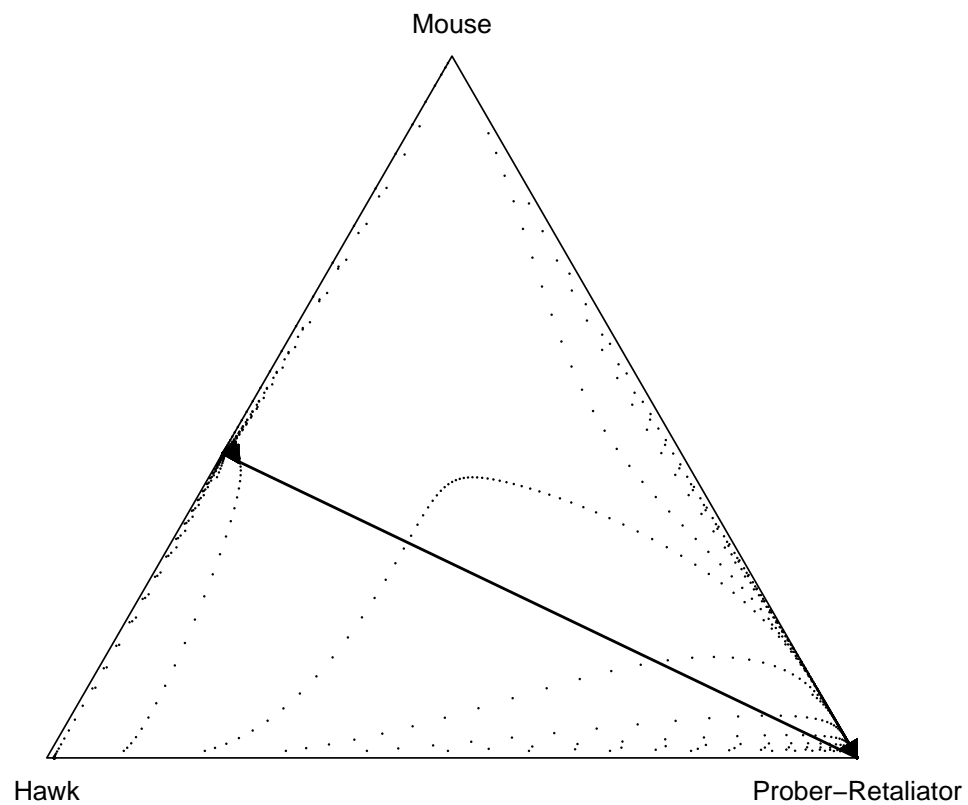
```
##           [,1]      [,2] [,3]
## [1,] 0.4333333 0.5666667    0
```

Mouse, Hawk, Prober-Retaliator (MS&P)

```
A <- matrix(c(29, 19.5, 17.2,
              80, -19.5, -18.9,
              56.7, -20.1, 21.9),
            3, byrow=TRUE)

strategies <- c("Mouse", "Hawk", "Prober-Retaliator")

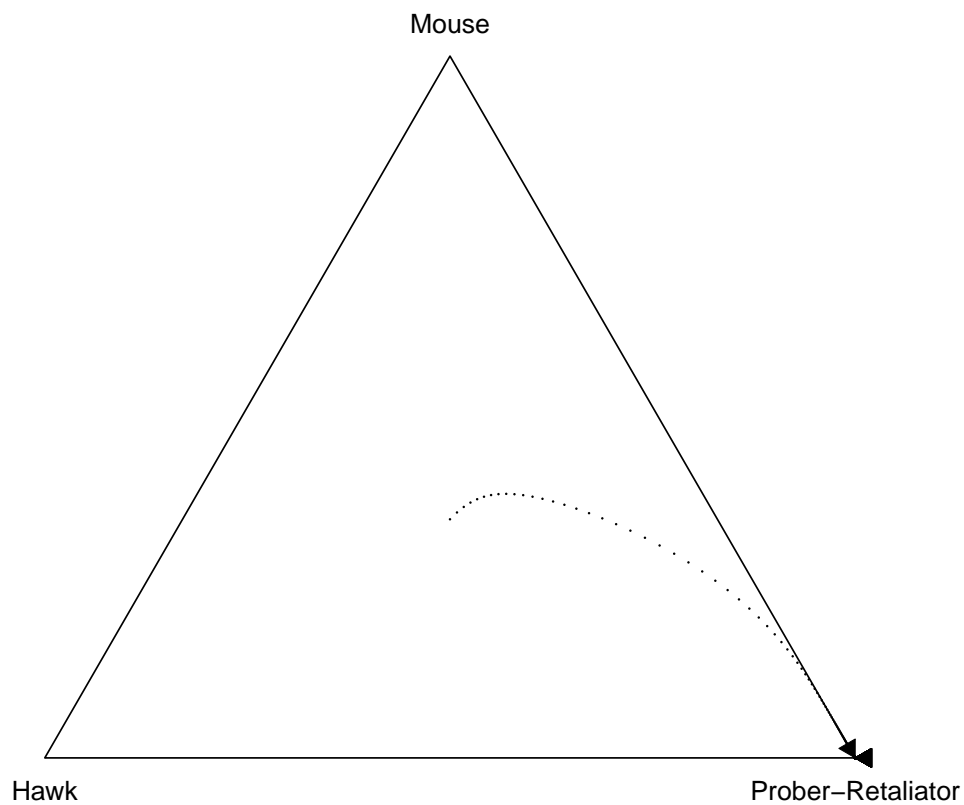
ESset(A, strategies)
```



```
##           [,1]      [,2] [,3]
## [1,] 0.0000000 0.0000000    1
## [2,] 0.4333333 0.5666667    0
```

```
state <- matrix(c(.34, .33, .33), 1, 3, byrow = T)

phaseDiagram3S(A, dynamic = Replicator, params = NULL, trajectories = state,
               contour = F, vectorField = F, strategies)
```



Mouse, Retaliator, Prober-Retaliator (MS&P)

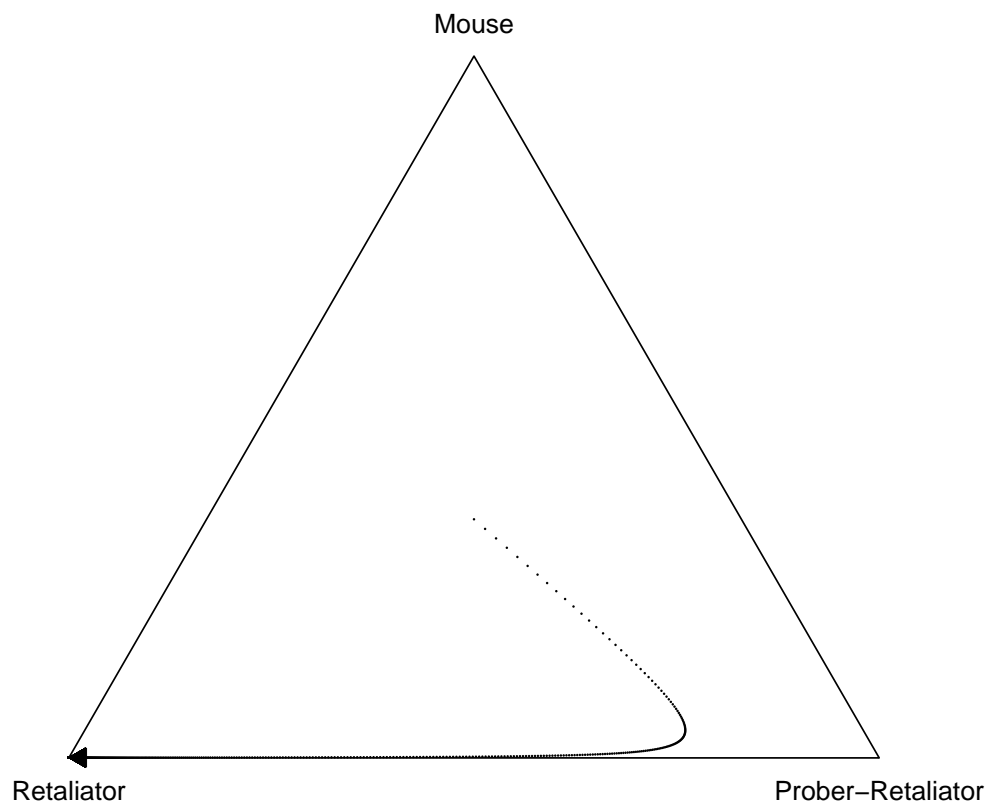
This one has no ESS.

```
A <- matrix(c(29, 29, 17.2,
              29, 29, 23.1,
              56.7, 26.9, 21.9),
            3, byrow=TRUE)

strategies <- c("Mouse", "Retaliator", "Prober-Retaliator")

state <- matrix(c(.34, .33, .33), 1, 3, byrow = T)

phaseDiagram3S(A, dynamic = Replicator, params = NULL, trajectories = state,
               contour = F, vectorField = F, strategies)
```

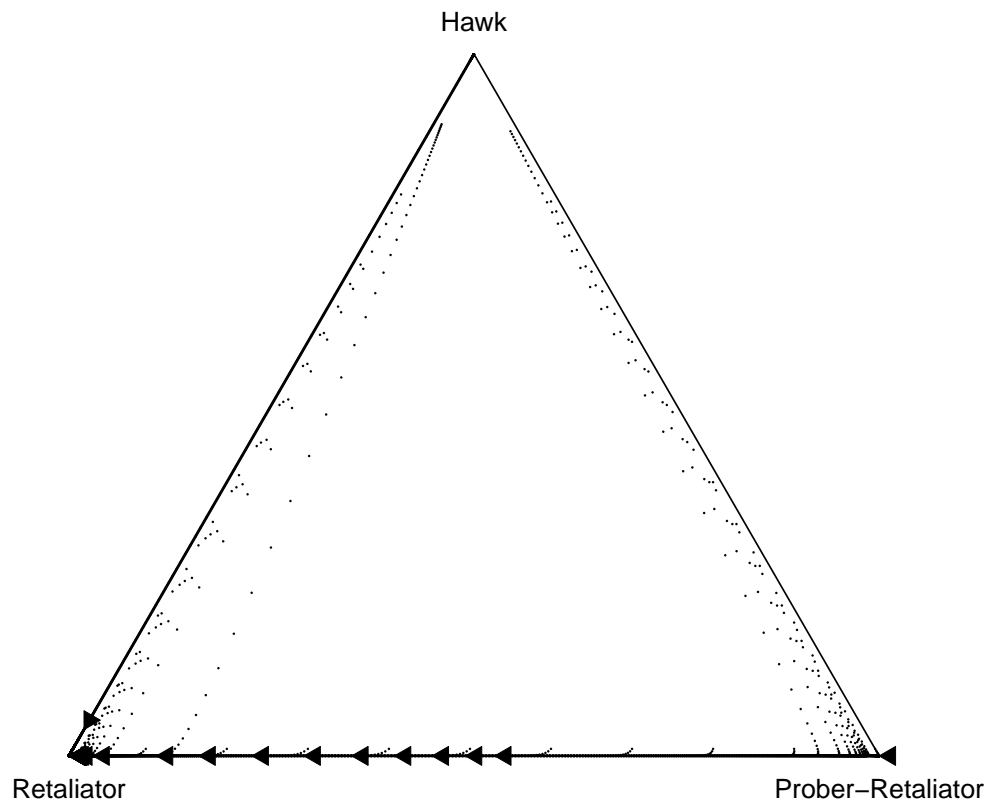


Hawk, Retaliator, Prober-Retaliator (MS&P)

```
A <- matrix(c(-19.5, -18.1, -18.9,
              -22.3, 29, 23.1,
              -20.1, 26.9, 21.9),
            3, byrow=TRUE)

strategies <- c("Hawk", "Retaliator", "Prober-Retaliator")

ESset(A, strategies)
```



```
##      [,1] [,2] [,3]
## [1,]    1    0    0
## [2,]    0    1    0
```

Phase Diagrams from My Computer Simulation

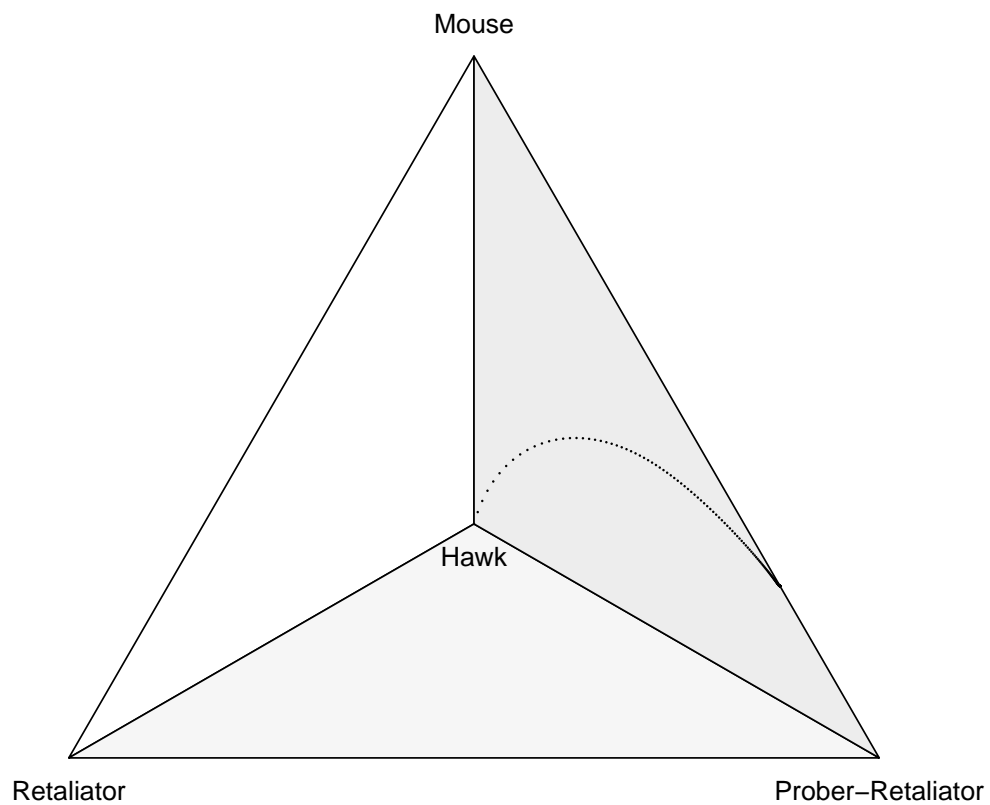
Mouse, Hawk, Retaliator, Prober-Retaliator (my payoffs)

```
A <- matrix(c(30, 19.75, 30, 15.3,
              79.75, -20.1, -15.2, -14.9,
              30, -25.3, 30, 12.2,
              67.6, -25.7, 14.9, 3.1),
            4, byrow=TRUE)

strategies <- c("Mouse", "Hawk", "Retaliator", "Prober-Retaliator")

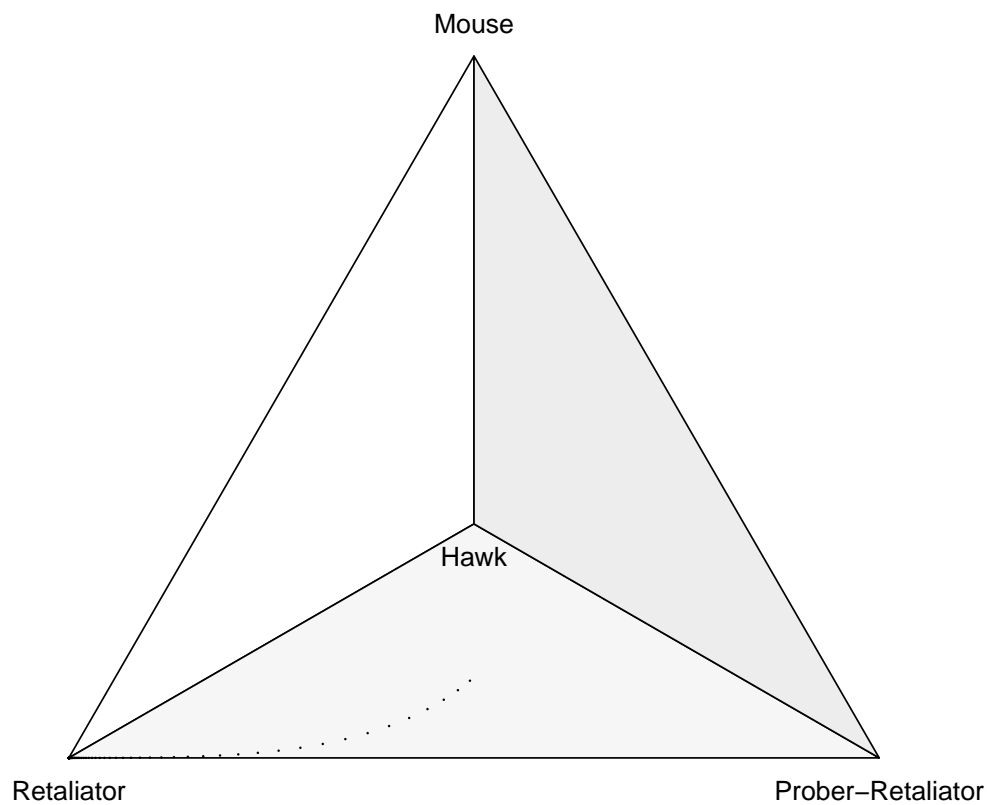
state <- c(0.25, 0.25, 0.25, 0.25)

phaseDiagram4S(A, Replicator, NULL, state, noRGL = T, strategies)
```

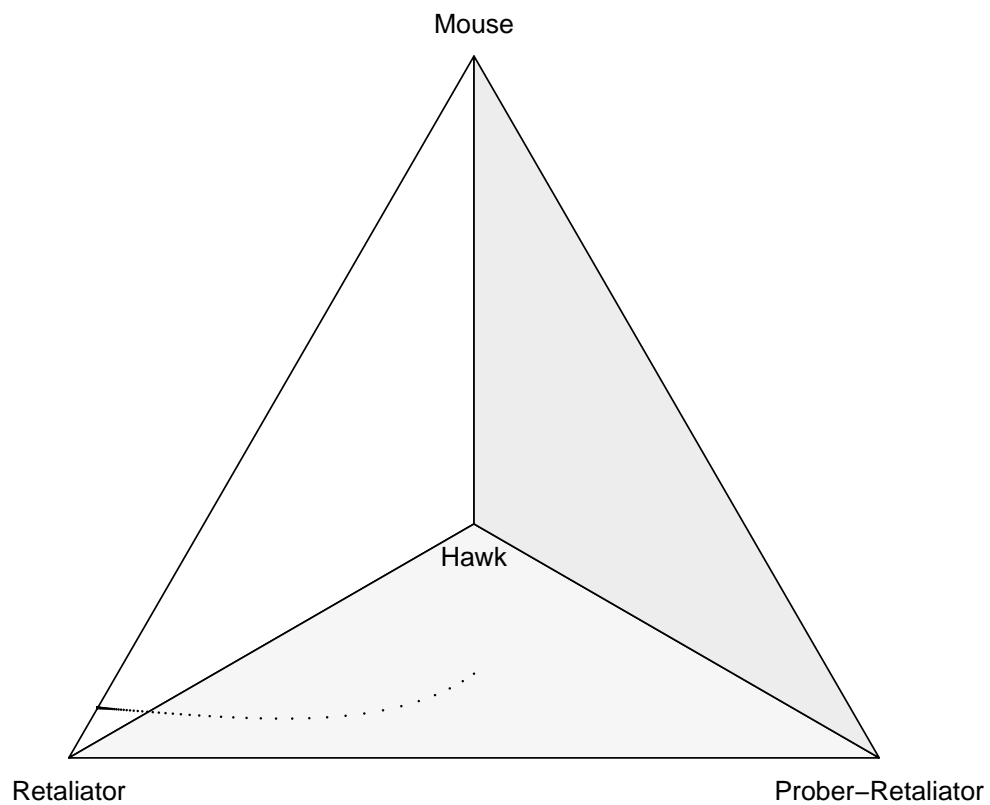
Mouse, Hawk, Retaliator, Prober-Retaliator (my, Mouse starts at 0)

```
state <- c(0, 0.33, 0.33, 0.33)
phaseDiagram4S(A, Replicator, NULL, state, noRGL = T, strategies)
```



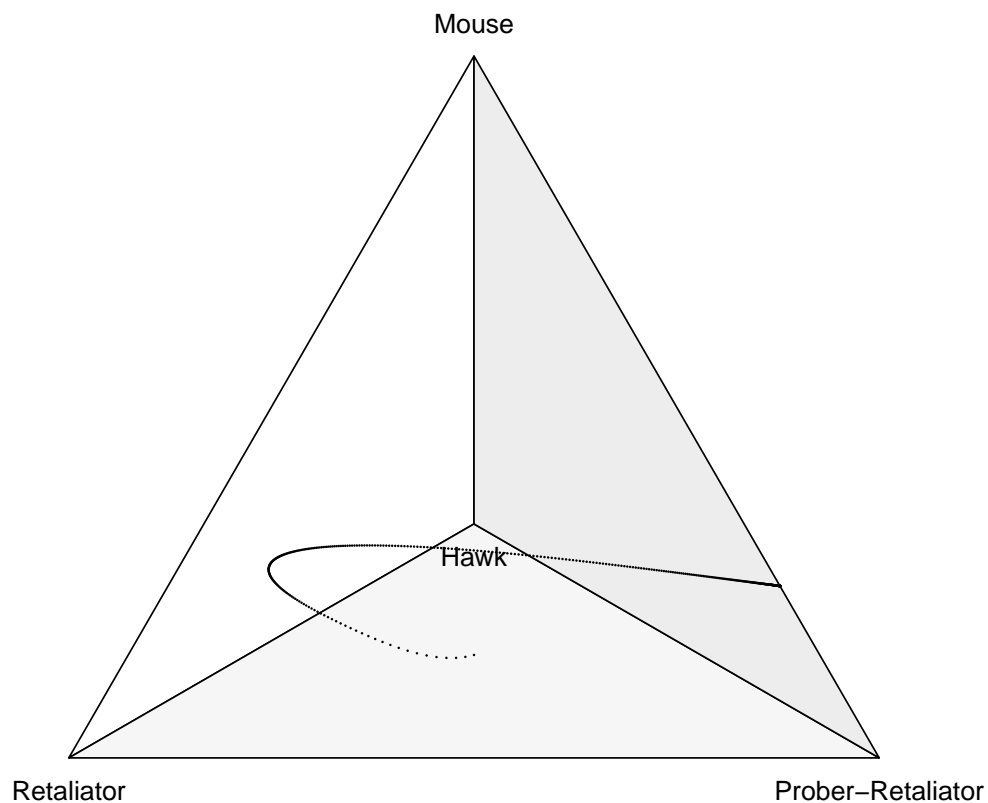
Mouse, Hawk, Retaliator, Prober-Retaliator (my, Mouse starts at 0.01)

```
state <- c(0.01, 0.33, 0.33, 0.33)
phaseDiagram4S(A, Replicator, NULL, state, noRGL = T, strategies)
```



Mouse, Hawk, Retaliator, Prober-Retaliator (my, Mouse starts at 0.04)

```
state <- c(0.04, 0.32, 0.32, 0.32)
phaseDiagram4S(A, Replicator, NULL, state, noRGL = T, strategies)
```



Phase Diagrams from Changing Model Parameters

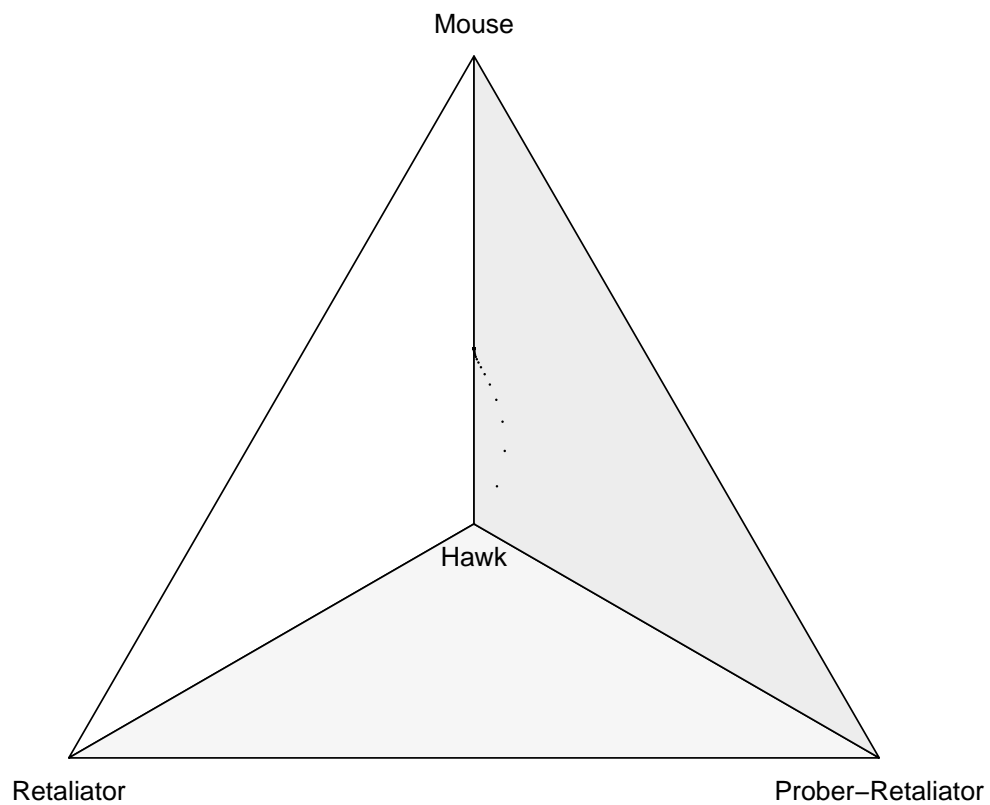
Increasing the probability of serious injury ($p_i = 0.90$)

```
A <- matrix(c(30, 19.75, 30, 15.4,
              79.75, -10.1, 63.4, 59.8,
              30, -83.9, 30, -69.5,
              67.6, -80.3, 53.8, -11.7),
            4, byrow=TRUE)

strategies <- c("Mouse", "Hawk", "Retaliator", "Prober-Retaliator")

state <- c(0.25, 0.25, 0.25, 0.25)

phaseDiagram4S(A, Replicator, NULL, state, noRGL = T, strategies)
```



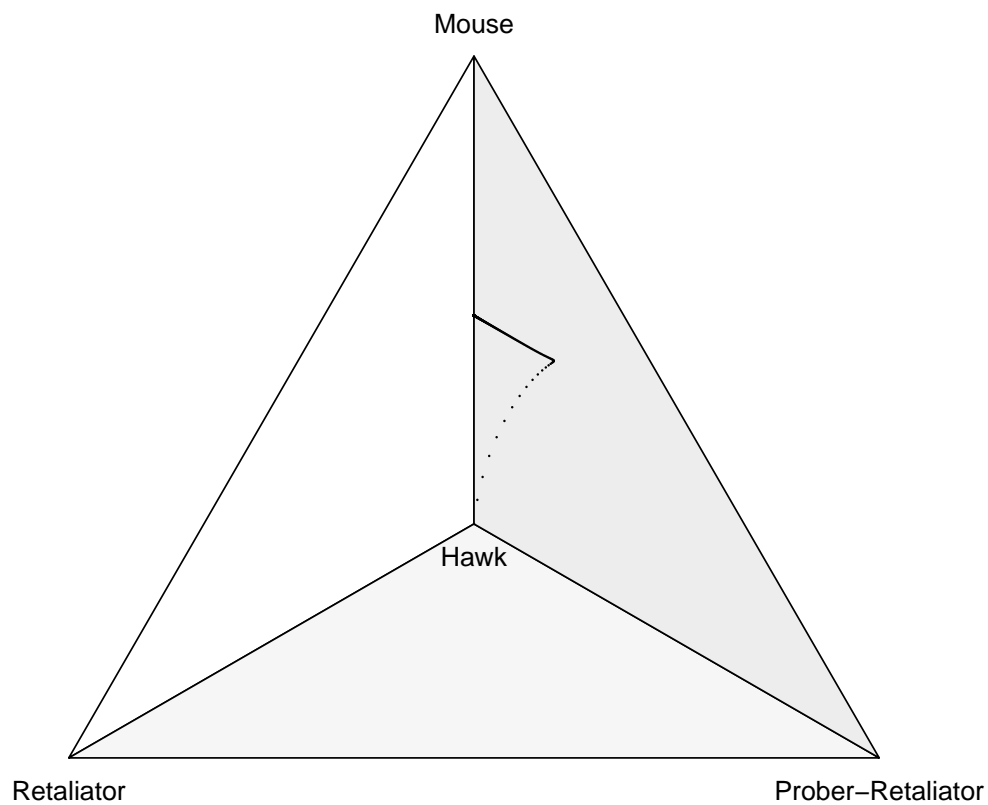
Increasing the probability of probing behavior ($p_p = 0.5$)

```
A <- matrix(c(30, 19.75, 30, 19.2,
              79.75, -20.2, -14.8, -15.3,
              30, -25.6, 30, -23.5,
              79.2, -25.1, -13.8, -20.4),
            4, byrow=TRUE)

strategies <- c("Mouse", "Hawk", "Retaliator", "Prober-Retaliator")

state <- c(0.25, 0.25, 0.25, 0.25)

phaseDiagram4S(A, Replicator, NULL, state, noRGL = T, strategies)
```



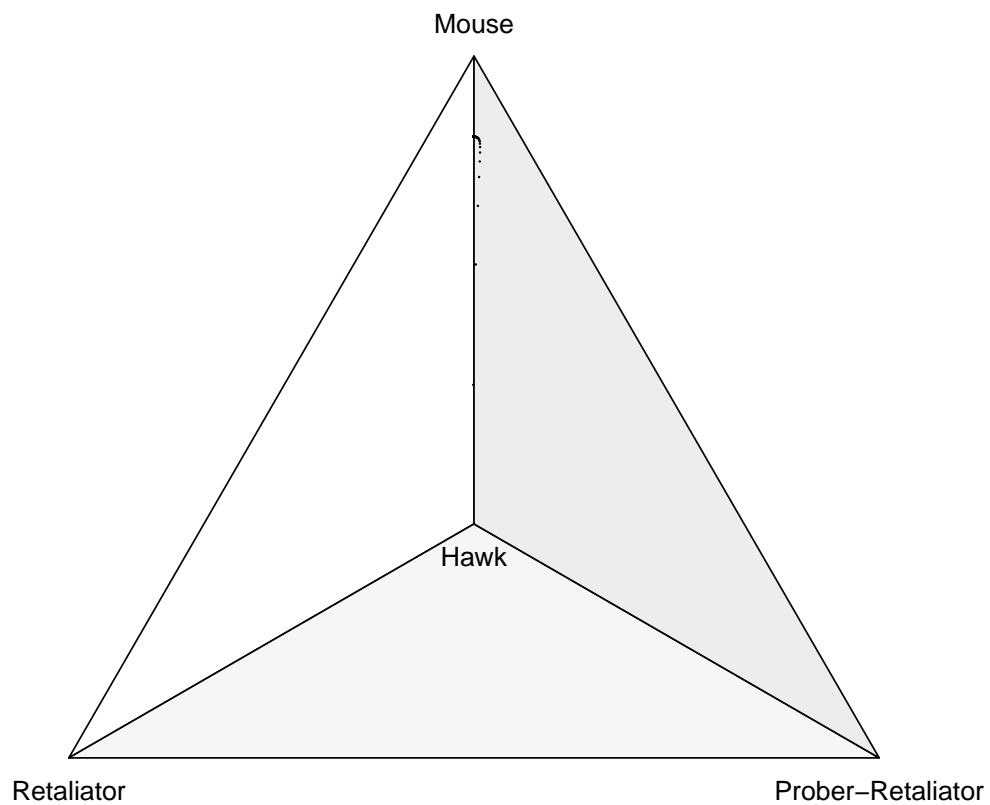
Increasing the cost of serious injury ($c = 500$)

```
A <- matrix(c(30, 19.75, 30, 15.4,
              79.75, -220.2, -205.8, -205.3,
              30, -234.6, 30, -53.4,
              67.6, -235.1, -42.5, -97.2),
            4, byrow=TRUE)

strategies <- c("Mouse", "Hawk", "Retaliator", "Prober-Retaliator")

state <- c(0.1, 0.7, 0.1, 0.1)

phaseDiagram4S(A, Replicator, NULL, state, noRGL = T, strategies)
```



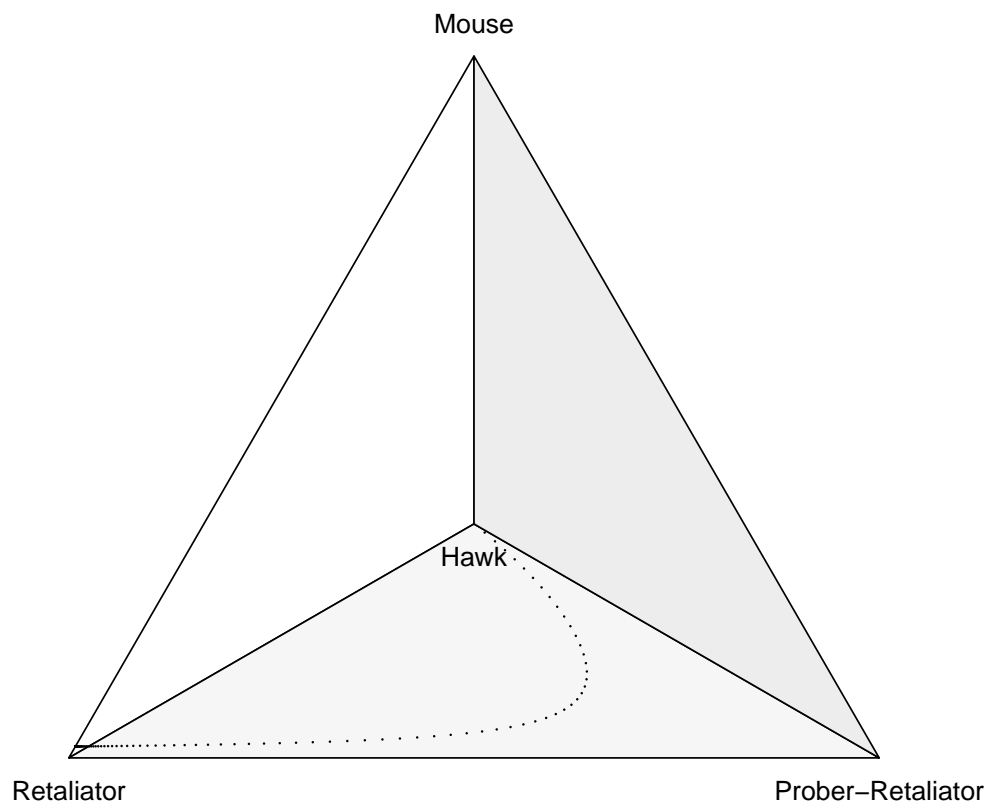
Increasing the payoff of winning ($v = 120$)

```
A <- matrix(c(60, 19.75, 60, 19.2,
              139.75, 10, 15, 14,
              60, 5.5, 60, 41.3,
              123.9, 5.4, 46.2, 34),
            4, byrow=TRUE)

strategies <- c("Mouse", "Hawk", "Retaliator", "Prober-Retaliator")

state <- c(0.25, 0.25, 0.25, 0.25)

phaseDiagram4S(A, Replicator, NULL, state, noRGL = T, strategies)
```



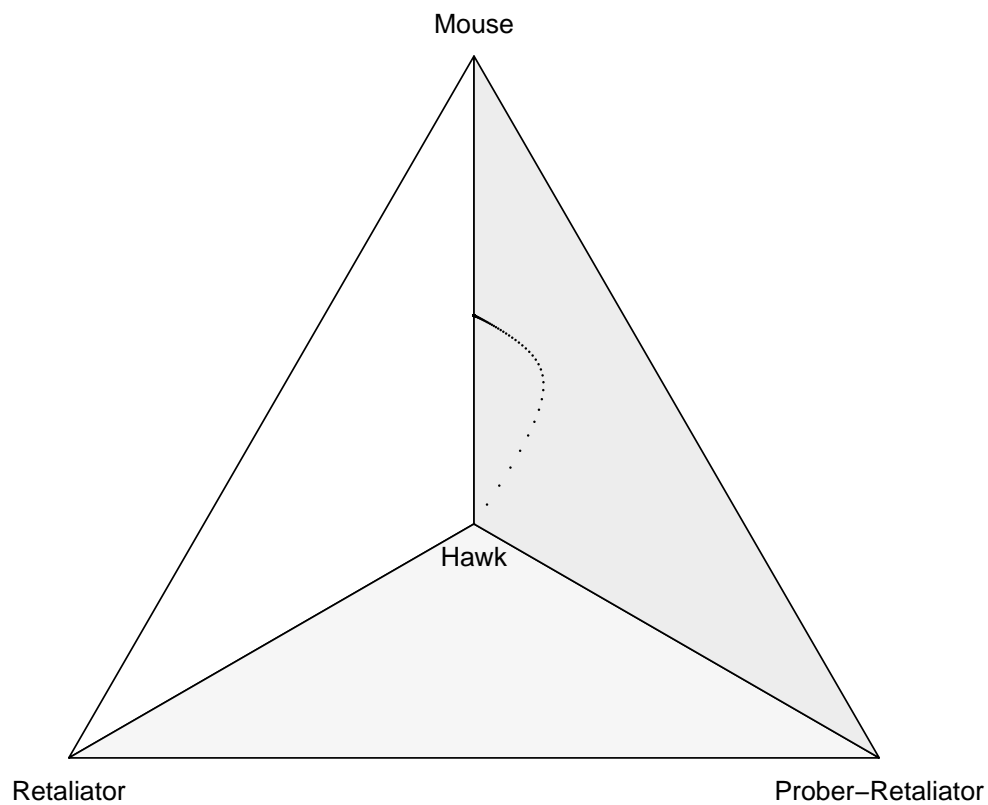
Decreasing the probability of retaliation ($p_r = 0.5$)

```
A <- matrix(c(30, 19.75, 30, 15.4,
              79.75, -20.2, 14.5, -8.6,
              30, -54.4, 30, -3.2,
              67.6, -32.4, 21.5, -2),
            4, byrow=TRUE)

strategies <- c("Mouse", "Hawk", "Retaliator", "Prober-Retaliator")

state <- c(0.25, 0.25, 0.25, 0.25)

phaseDiagram4S(A, Replicator, NULL, state, noRGL = T, strategies)
```

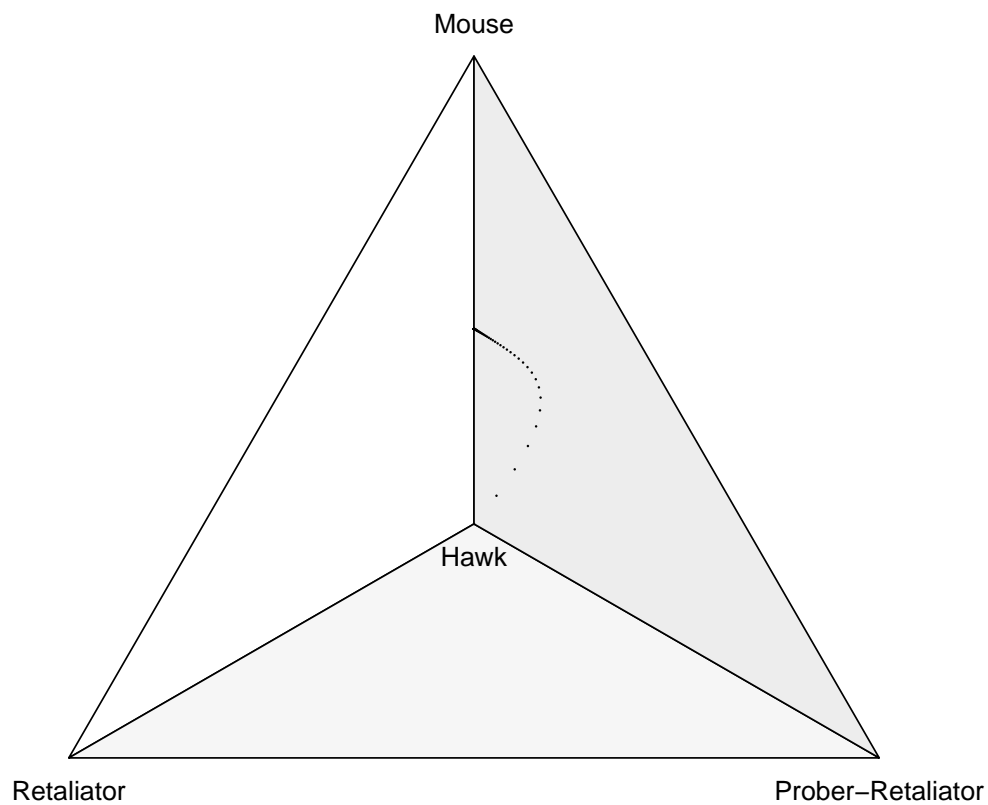
Increasing the maximum payoff of saving time and energy, producing longer contests ($u_{\text{init}} = 40$)

```
A <- matrix(c(30, 39.75, 30, 30.9,
              99.75, -10.2, 29.9, 4.2,
              30, -51.2, 30, -23.6,
              89.9, -24.9, 24.2, -8.8),
            4, byrow=TRUE)

strategies <- c("Mouse", "Hawk", "Retaliator", "Prober-Retaliator")

state <- c(0.25, 0.25, 0.25, 0.25)

phaseDiagram4S(A, Replicator, NULL, state, noRGL = T, strategies)
```



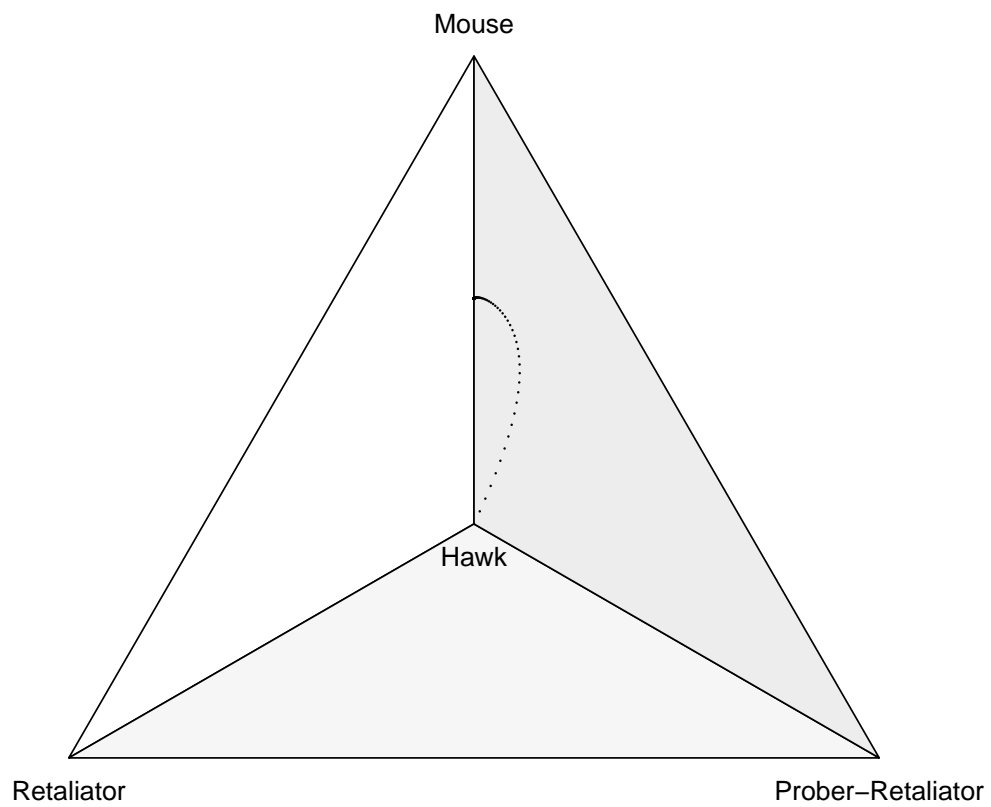
Decreasing the maximum payoff of saving time and energy, producing shorter contests ($u_{\text{init}} = 5$)

```
A <- matrix(c(30, 4.75, 30, 19.1,
              64.75, -27.6, 18.8, -2.1,
              30, -50.4, 30, 19.8,
              43.1, -37.1, 27.7, 18.8),
            4, byrow=TRUE)

strategies <- c("Mouse", "Hawk", "Retaliator", "Prober-Retaliator")

state <- c(0.25, 0.25, 0.25, 0.25)

phaseDiagram4S(A, Replicator, NULL, state, noRGL = T, strategies)
```



```
state <- c(0.1, 0.1, 0.4, 0.4)
phaseDiagram4S(A, Replicator, NULL, state, noRGL = T, strategies)
```

