# Web Site Review

Harini Nagendra

Game Theory web site at

http://science.holycross.edu/departments/biology/kprestwi/behavior/ESS/ESS_ind_frmset.html

This is the first of what is planned as a new, regular feature in *Resonance* – web site reviews. It's given me great pleasure to write this, the first of the series – and it's been especially great fun reviewing such an excellent web site. With the Internet becoming such a great force in the field of education, also taking into consideration the fact that finding something of 'value' on the web is largely a matter of serendipity, web site reviews in journals of this kind will fill a long felt vacuum. And, with those "words from the sponsors", let's plunge straight into the web site ...

Kenneth Prestwich, at the Department of Biology, College of the Holy Cross at Worcester, Massachusetts, has created an outstanding web site at http://science.

The set-up window for the Hawks vs. Doves game.
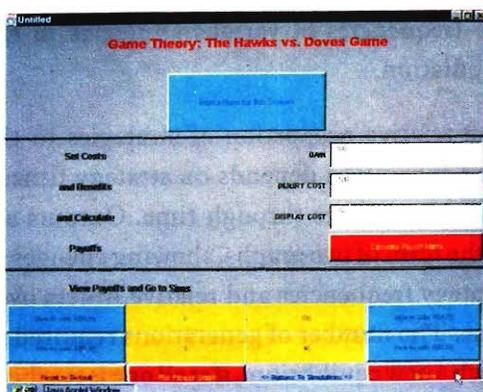
holycross.edu/departments/biology/kprestwi/behavior/ESSESS_ind_frmset. html. (If you find this too long to memorise/type, go to www.holycross. edu, navigate from there to the biology department, thence to Ken Prestwich's home page, and finally get on the link to the Game Theory site. Whew! Did I say that was easier?).
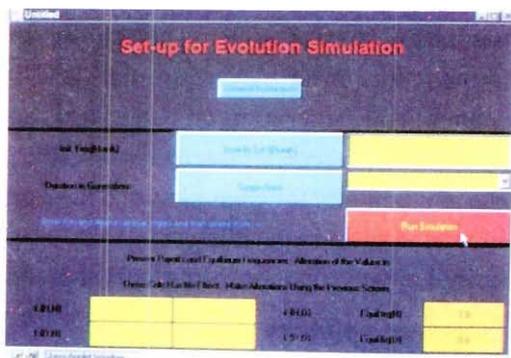
This is by far one of the best game web sites I've seen. If you're an avid 'surfer', chances are you've already come across a number of game sites – after all, isn't that one of the main things we use computers for? This, though, is a game site with a difference: it runs what are, in ecological parlance, called 'games' – simulations of real life encounters between animals, using the framework of 'game theory'.

For a detailed description of game theory, do take a look at Kartik Shanker's article in *Resonance*, March 1999. However to recap quickly, the selection of 'optimal' behavioural strategies for animals depends to a large degree on what other animals are doing. Within the framework of game theory, animals are treated as contestants who can adopt various strategies for interactions with other animals. The outcome of each pairwise interaction (game) is determined by the actions of the focal player (animal) and its opponent (the other animal). An interaction between two players (strategies) will result in costs and benefits for each player. These can be depicted within a payoff matrix, calculating the total payoff (benefit minus cost) for each player, for all possible interactions between two strategies.

Computer simulations of these 'games' allow you to explore a large number of situations in a short amount of time, and can be used to visualise how the system acts – they thus provide a deeper understanding of the dynamics of the system being studied. Obviously, merely playing with the simulation without relating it to biologically meaningful situations is meaningless. When entering the site, therefore, extensive hypertext materials greet you, explaining the general principles of game theory and the basic concepts of an evolutionarily stable strategy (ESS). These also provide detailed instructions on how to run the simulations. The hypertext has study questions (for the lazy, answers have also been provided) that can assist the 'reader' in exploring various aspects of the strategy.

A most useful feature is the availability of the entire hypertext as a ".pdf" file, a standard format used extensively on the net, which can be read using the Adobe Acrobat reader available free of cost, on the Internet. This enables you to download and print the text, and use it as a reference or study guide while running the programs. (The only potential drawback is the size of this file (1.23 MB) and the time it takes to print the 107 pages it consists of). In addition to the above mentioned material, there is also a short primer on integration and probability density functions, which assists in understanding some of the math that goes into the programming.

Simulations (games) for the three most common scenarios of game theory: *Hawks and Doves*, *Hawks, Doves and Bourgeois* and *War of Attrition*, have been created. The simulations require inputs in the form of costs and benefits of various strategies (default values are provided for starters), and starting proportions of animals adopting each strategy. Modification of these costs and benefits will modify the payoff matrices. The 'game' then runs through several time steps – in each time step, the relative 'fitness' of each strategy is calculated based on the payoff outcomes of several pairwise interactions. Fitness of a strategy therefore depends not just on the payoffs of each encounter, but also on the frequencies of each kind of encounter – i.e. on the frequencies of various strategies in the population.

The relative proportion of strategies in the next generation depends on strategy fitness, and thus evolves through time. Outputs are in the form of two graphs, showing changes in strategy frequencies and relative fitness over time. The number of generations required to reach a new equilibrium, if at all one is reached,

The second set-up page. This is required to start the Hawks and Doves simulation.
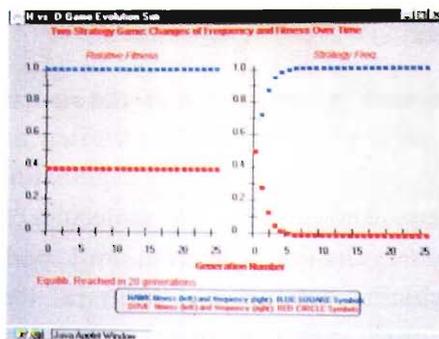
Result of Hawks vs. Doves: Changes in strategy frequency and fitness plotted over time.

is also given. Repeated runs of the game, with modification of payoff matrices and starting proportions of various strategies, will result in different equilibria, at different intervals of time. The graphs help get a visual 'feel' of game outcomes, and running the game through several different scenarios will help develop a deeper understanding of the dynamics of evolutionary selection and behavioral interactions. The textual material in fact hints at interesting scenarios that can be designed and run, and discusses their outcomes in an effort to develop this richer understanding.

The site is the result of over a year's work (the effort shows!), and has been extensively tested in a number of undergraduate courses at several institutions. It is essentially targeted at interested undergraduates – however some portions of the site may be useful for graduate students, too. The web site is attractively and simply designed, using frames that assist smooth navigation. There are no annoyingly large graphic files that impede downloading, and hyperlinks from one part of the site to another are well thought out and well laid out.

Like several other 'game' sites on the web, this site has been designed using Java applets and applications. If Internet connections are fast, Java applets can be run on off the web server at the University of Massachusetts, by typing in a few commands on your local computer. However, for those who wish to download the games on to their local computer when the 'net connections are fast, and to run the games later when disconnected, the programs can be downloaded as Java applications and compiled on the local machine. In fact the entire site (including hypertext learning materials) can be downloaded to a local computer for easy access (although copyright restrictions apply), Ken Prestwich will provide you with the source code for his programs on request, so that you can modify the programs to explore further avenues. In fact, for the real enthusiast, he has also generously permitted the hosting of the site on your local network – provided he is duly acknowledged and any modifications are approved by him.

There aren't too many sites I've seen teaching ecology, a very 'dynamic' subject, through simulations on the Internet. At the risk of repeating myself, I'll say that this is surely one of the better designed ones, and will richly reward anyone who takes the trouble of navigating through it.

Harini Nagendra, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012, India, Email: harini@ces.iisc.ernet.in.