An Introduction to Social Insects

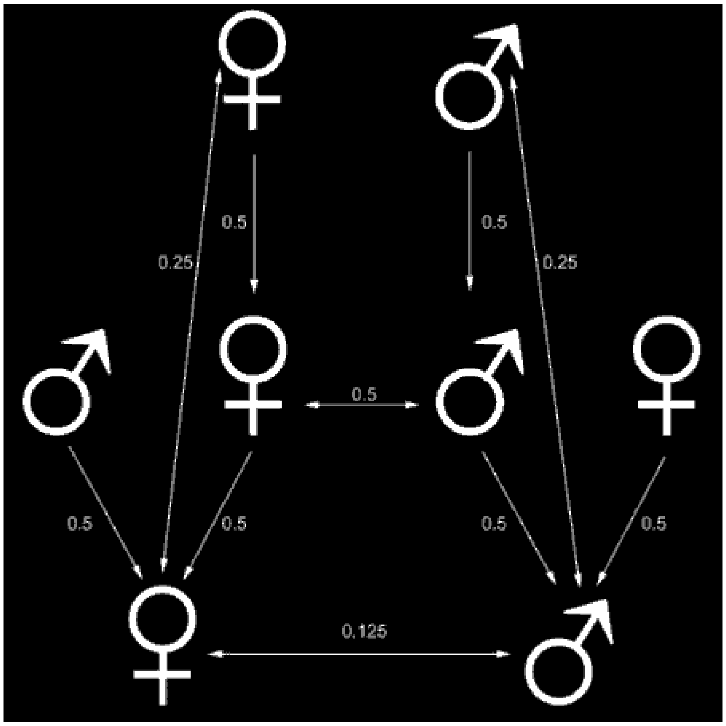
Social insects, especially those of the order hymenoptera (ants, wasps, and bees), have arguably achieved the highest level of social organization in evolutionary history. Although social insects lack human intellect and culture, their coherence and organization is far superior. These attributes are perhaps best visualized in the Attine ants, fungus farming insects whose colonies can contain as many as 20 million members. Each ant has a brain roughly the size of a single grain of sand and yet these organisms are able to coordinate their efforts to create mounds and fungus gardens many orders of magnitude larger than themselves.

Complex nest architecture and other great tasks are possible due to ants' caste systems and divisions of labor. These phenomena can be seen as analogous to the tissues and organs of other organisms and have led many scientists to describe these colonies as superorganisms. Examine the rich polymorphism in Atta Cephalotes (pictured right). Assuming that an organism's physiology is related to its function we can conclude that each caste is designed to perform a different role within a colony.

Although many organisms live at least a part of their lives in groups, very specific to social insects is the colonial division between reproductive and non-reproductive castes. This peculiarity appeared to be a fatal flaw to Charles Darwin as he constructed *On the Origin of Species* in1859. How could an altruistic neuter class, equipped with a specialized morphology, evolve if it did not leave offspring? We received an adequate answer in 1955, when J.B.S Haldane observed that within small groups, the genes governing a personal sacrifice could be passed on if the altruist through his sacrifices increased the fitness of those related to him. Haldane called his theory "kin selection."

> "Suppose you carry a rare gene affecting you so that you jump in a river to save a drowning child, but you have a 1 in 10 chance of drowning. If the child is your own child or a sibling there is an even chance that this child possesses the same gene, so that five such genes are saved for one lost. If you save a nephew or grandchild the advantage is 2 to 1. If you save a first cousin the effect is slight. If you save a first cousin once removed the population is more likely to lose this gene……Of course the conditions are even better in a community such as a beehive or ants' nest, whose members are all literally brothers and sisters"
>
> -J.B.S. Haldane

The ratios expressed herein can be reasoned out by examining the degrees of relatedness between normal diploid (explained later) organisms.



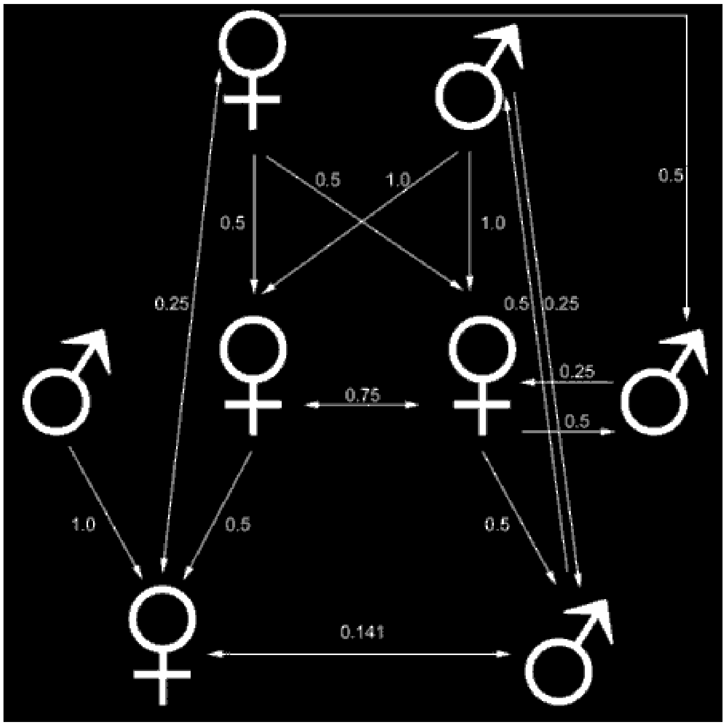
Kin selection was later made concrete when William Hamilton expressed this theory mathematically with the formula

rB>C

r=the probability that a gene chosen from the altruist and the recipient of the action will be the same
B=the increase in units of offspring produced by the recipient of the altruistic behavior
C=the cost of the behavior

Kin selection answers the question, "How could eusociality have evolved?" but scientists were still stumped as to what factors could have caused eusociality to occur in such a sparse and dispersed manner across the evolutionary tree?

Hamilton answered his own question in 1964 with the haplodiploid hypothesis. All species of Hymenoptera have a strange asymmetrical network of genetic relationship caused by haplodiploidy, their method of sex determination. In haplodiploid sex, the gender of an organism is determined by the number of chromosomes it receives. An unfertilized egg becomes a male (haploid) and receives only half the number of chromosome that a female (diploid) receives.



TASK: Notice how the relationships between a haplodiploid family is skewed in comparison to that of the diploid family presented above. Based on your knowledge of kin selection and the two scholarly papers attached write a small paragraph explaining why a non-reproductive caste might have evolved in haplodiploid insects. Hint* Compare the two graphs looking for strong relationships between organisms as the driving force for altruistic acts.

The Evolution of Eusociality in Termites
http://www.thornelab.umd.edu/Termite_PDFS/EvolutionEusocialityTermites.pdf

The Evolution of Eusociality in Termites: A Haplodiploid Analogy?
http://www.jstor.org/pss/2463316

Although these two papers focus mainly on termites, a diploid organism, they serve as a great intro to eusociality and illustrate the evolution of eusociality in hymenoptera as well.. HAVE FUN!!!

Submit your papers to:
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