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An Oxford graduate student by day and a scientific activist by night, Nick Anthis isn't letting his Ph.D. research in protein structure get in the way of defending scientific and social progress.

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## Social Insects: More KGB than Brady Bunch

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 Posted on: November 16, 2006 7:43 AM, by [Nick Anthis](#)

Living successfully with other people demands sacrifice. From going out of your way to pick your little brother up from school to paying taxes toward government health care programs, there is an expectation in any society that its members will sacrifice some personal gain for the greater good. This cooperation, in turn, contributes to a stronger and more successful society, the benefits of which should be felt by all of its members. This is true not just for humans, but for some other animals and, most notably, colony-forming insects. Even there, though, the picture isn't so simple, and a [paper from last week's issue of Nature](#) (subscription required) details the surprisingly large role that social controls play in encouraging altruism.

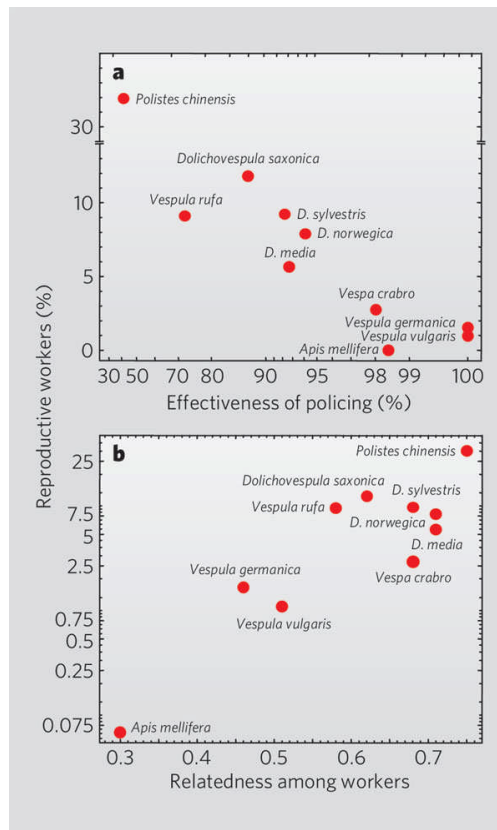
Although the basic idea of cooperation is fairly straightforward, understanding how it evolved can be more difficult, especially considering rather simplistic "survival of the fittest" framework that we usually invoke to understand evolution. This superficial contradictions leads even has the effect of leading some to adopt equally simplistic philosophies such as "altruistic egotism", where one believes that he or she can do the best for society by just watching out for him or herself. This often involves embracing extreme forms of laissez-faire capitalism, ironically for self-proclaimed altruistic reasons.

Of course, once one ventures just below the surface, these seeming contradictions begin to fade, leaving these reactionaries looking, well, pretty ridiculous. Fundamentally, it is not individual organisms that drive evolution, but individual genes. Any gene that is successful at reproducing itself in the long run, by whatever means (such as by increasing the fitness of the individual carrying it, for example), will be favored by natural selection.

If I am able to produce one offspring, then I have successfully passed on half of my genes. Even if I don't have a kid, but my brother (who shares roughly one fourth of my genes) does, then I have effectively passed on about one eighth of my genes. So, it's probably worth me sacrificing a little bit to make sure he and his kid are doing alright. Although I may not have any immediately traceable common ancestors with the lady who lives down the street or the guy working at the supermarket, as fellow humans almost all of our DNA is virtually identical. So, it's not surprising that we all tend to look out for each other, at least a little bit. Clearly, we have evolved a set of genes that encourage altruistic behavior since, by strengthening its social reservoir, each individual gene has a greater chance of being replicated somewhere.

An extreme example of this takes place in social insects (bees, wasps, and ants), where all of the members of a colony are very closely related since all offspring come from a single queen. Even here, though, things aren't so black and white, as the recent paper from Tom Wenseleers and Francis L. W. Ratnieks demonstrates that, although kin selection certainly plays a role in encouraging cooperativity, these colonies often rely on draconian measures to keep all of their members in line:

Why, in some species, do most workers forego direct reproduction? One possibility is that worker altruism is voluntary: in this scenario, high genetic relatedness should drive the evolution of altruism and worker sterility because higher relatedness increases the indirect benefit of working. Theoretically, however, worker altruism could also be 'enforced' and may have evolved in response to social sanctions. In many species, worker-laid eggs are killed by the queen or by other workers and, if these sanctions are effective, the advantage to workers of laying eggs is reduced. As a result, more would be selected to work altruistically, rather than to lay eggs...



a, If altruism is enforced, more workers should remain sterile when their reproduction

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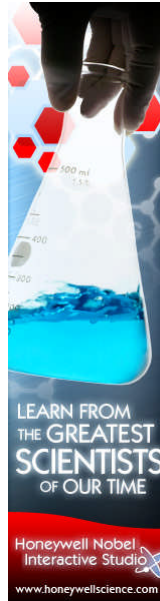
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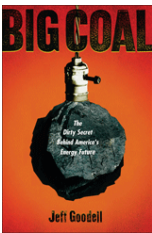
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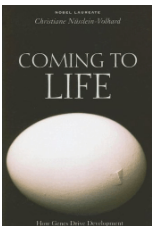
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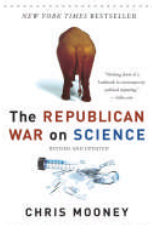
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*is more effectively policed by nestmates, which is what occurs (R = 0.94, P = 0.00004; effectiveness of policing is reverse log10-transformed). b. If altruism is voluntary, greater altruism and less worker reproduction should be seen when relatedness is high, but the opposite occurs (R = 0.82, P = 0.004; percentage of reproductive workers is log10-transformed). The effectiveness of policing is defined as the probability of worker-laid eggs being killed relative to queen-laid eggs; reproductive workers are shown as the percentage of workers with active ovaries.*

The key role of relatedness in the evolution of self-sacrificing behaviour is widely recognized. The origin of insect societies is one of the most cited examples, and high relatedness was probably required for worker behaviour first to evolve. Nevertheless, our results show that in modern-day insect societies it is mainly social sanctions that reduce the numbers of workers that act selfishly. In this, they provide evidence for something that has proved notoriously hard to demonstrate in human society: that better law enforcement can lead to fewer individuals behaving antisocially.

Despite its uncharacteristic directness, I find this final statement difficult to interpret. Regardless, I don't know whether the most interesting implications here are really for law enforcement. I think that David C. Queller, who wrote an accompanying [News and Views piece](#) (subscription required) might be more on the mark:

In social insects that, like the hover wasp, have small colonies and morphologically similar queens and workers, it is usually the queen that does the blocking by her dominance behaviour. For social insects with larger colonies, queen dominance is often replaced by other forms of control. First, there is nutritional coercion. Poorly fed females become small workers and well-fed ones become large queens. This limits the ability of workers to reproduce, but in most species it does not eliminate it fully. Given an opportunity, workers often will lay eggs. In a large colony, the queen could not successfully police all such behaviour and often ignores it. Instead, other workers do the policing, destroying the eggs of their co-workers.

A comparative study of ten policing species by Wenseleers and Ratnieks again shows that altruism is modulated more by constraints on worker reproduction than by relatedness. The species with the highest fraction of fully committed altruistic workers - those that do not lay eggs -- tend to be those with lower relatedness, contrary to simple expectation. Instead, more workers are fully committed when policing is most effective, as measured by the fraction of worker-laid eggs eaten by either queens or other workers. Workers are not leaping at every opportunity to be altruistic; they are coerced into that role, often by their fellow workers....

Many social conflicts create winners and losers. But only kinship allows evolution to make creative use of the social losers, turning them into reproductive police, exquisite communicators and heroic defenders. When Hamlet suffered the slings and arrows of outrageous fortune, he debated putting an end to himself. Social insect workers do sometimes choose suicide but, because of kinship, this hamiltonian choice is profoundly different from the hamletian dilemma. The stinging honeybee worker commits suicide when her sting is torn out, but this saves her kin. She is not making an escape from outrageous fortune, but making the best of it -- not fearful of what dreams may come, but hopeful for what genes may come. However socially constrained her life may have been, her last action makes her own clear statement: long live the kin!

So, regardless of whether we're talking here about a police state or a nanny state, or something completely different, it's clear that while individual insects have some individual altruism genetically programmed into them, their true genetic altruistic program does not emerge until the society as a whole is considered, where individuals are forced to act altruistically and engage in the forcing themselves. While I don't find anything particularly worth emulating in such an authoritarian state, it is interesting to see it scientifically demonstrated that even these organisms that are often thought of as so selfless still require quite a bit of prodding to actually act that way.

Naturally, one would then ask whether this has any relevance to how we conduct our own society. For better or worse, science hasn't really answered that question yet, so you'll have to be the judge of that.

Tom Wenseleers and Francis L. W. Ratnieks, Enforced altruism in insect societies, *Nature* **444** (2006), 50.

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I think that worker policing in social insects is one of the coolest pieces of animal behaviour, and one of the best example of the power of kin selection theory. It shows how individual genetic imperatives tug at the apparent selflessness of worker bees, and the strange, but logical, consequences that arise when many individuals, with a mixture of overlapping and conflicting interests, interact.

Francis Ratnieks has posted a journalistic piece from Nature (published in 2002, written by me) on his website. This also describes the freaky things that happen when policing breaks down, or when workers evolve mechanisms to avoid it. You don't need to subscribe to get it, it can be found [here](#).

Posted by: [John Whitfield](#) | November 16, 2006 09:42 AM

Interesting piece. Matt Ridley offered a nice introduction to kin selection and insect colonies in his book *The Origins of Virtue: Human Instincts and the Evolution of Cooperation*, which was an interesting read, although it eventually devolves into an overly enthusiastic and somewhat irrelevant argument for the merits of free market capitalism.

Posted by: [Nick Anthis](#) | November 16, 2006 09:58 AM

Trivial correction, but you share roughly half of your DNA with your brother. I'm not a geneticist, and was recently convinced of this myself, so as an exercise to make sure I have this right, I'll try and present the argument. We will focus on one chromosome. Your mom and dad each have two copies, each of which has a unique combination of gene alleles. We'll label your mom's A and B, and your dad's C and D. Your chromosomal pair will be AC, AD, BC, or BD. For the sake of this argument, let's say you are AC. Your brother has the same probabilities. If he has AC, the DNA in his chromosome is 100% identical to yours. If he has AD or BC, then half of his DNA is identical to yours. If he winds up with BD, then you have nothing in common. Since there is an equal likelihood for 100%, 50%, 50%, and 0%, on average you will wind up sharing 50% of your DNA with your brother, despite the fact there is only a 25% chance of having an identical chromosome pair.

Posted by: [Russell](#) | November 16, 2006 03:27 PM

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