

## Termites and Other Natural Teachers

### J Scott Turner

It is like desert *carnevale*. On a summer's night in the arid savannas of western Namibia, they emerge from their nests by the millions: winged termites that flutter about, males and females, hopeful propagules that pair up to mate and found the next generation, spewing simultaneously from all the colonies in an area in a single, majestic spasm. The termite mating swarm is the centerpiece of the desert's great annual party, celebrated by nearly every living thing around: bat-eared foxes, serval cats and mongoose pouncing on them as they land, hyena, aardwolf and aardvark licking them up in heaps, black-shouldered kites swirling in great kettles in the sky above, catching them on the wing, local people scooping them up and tossing them onto coals or hot skilletts, all feasting on the tons of fat termite bodies offered up like a gift from the soil.

Witnessing events like this is what makes biologists like me among the world's truly lucky people. Not only can we witness such spectacular events, we can be there to listen when nature admonishes us that we don't understand the world as well as we think. It is what elevates science into something truly transcendent.

One of biology's most cherished beliefs is that we have a pretty good idea of how the living world came to be: it evolved through Darwinian natural selection, that is, the favored transmission of certain genes over others into subsequent generations. The Darwinian principle is now so well-established that it qualifies as dogma: it then should come as no surprise that, since its inception, Darwinism has been drawn into conflict with other cherished dogmas of how the world came to be. Judging from the battles that still occupy state and local boards of education, there is no let-up in sight.

The termite mating swarm is, in fact, one of those reminders that nature still has many new things to tell us. The social insects, which include the termites as well as the ants, bees and wasps, have always posed an interesting challenge to our evolving notions of how the

living world came to be. The challenge, simply put, is this: social insects are highly altruistic. Sometimes, it is dramatic, such as a worker bee's suicidal sacrifice when she stings an adversary. Mostly, though, it is comparatively mundane, manifest in the hordes of sterile workers that forgo reproduction to favor helping others - their parents, or occasionally a few chosen siblings - reproduce in their stead. If natural selection favors those adaptations which successfully transmit genes to future generations, how can altruism—the deliberate foregoing of reproduction—be selected for?



Modern Darwinism has a clever way around this dilemma. What we call “altruism” is actually a clever ploy, a genetic subterfuge which advances the genetic interests of the “altruist.” For example, there is a 50% probability that a gene carried by me is identical to one carried by my sister. This gene, no matter which body it resides in, mine or my sister's, can be transmitted either by me reproducing, or by me “altruistically” doing something that at least doubles the chance my sister will reproduce. This is one reason, so the story goes, why altruism in human and other animal societies is more likely among kin groups. In the case of bees and ants, their super-altruistic behavior is favored by a genetic peculiarity, called haplodiploidy, in which parental genes are transmitted differently into either male or female offspring. The details are not important here, but suffice it to say that haplodiploidy skews the genetic relationships

between parents and siblings in a way that favors altruism. Put simply, a worker bees' genes are most effectively transmitted to future generations, not by producing her own offspring, but by enslaving her mother as a reproductive slave and forcing her to produce sisters. All the other attributes of a bee colony - the single fertile queen, the hordes of sterile, female workers, the production of a few fertile females and drones - all follow from this genetic peculiarity.

The termites turn this clever explanation on its head. Being only distantly related to the bees and ants, termites transmit genes to male and female offspring in the same way we do - with equal genetic contributions from mother and father. Yet, despite not being genetically predisposed to sociality, the termites are highly social, with striking similarities to colonies of bees and ants. Both have single reproductive queens tended by legions of sterile workers. Both gather into compact hives and nests. Both exhibit a high degree of altruism among the workers. In short, the clever Darwinian explanation for sociality stumbles a bit with the termites.



So what, if not genetic predisposition, has driven the termites' cockroach progenitors to evolve into their highly altruistic societies? The answer in fact illuminates one of the long-standing questions about evolution, namely what drives it? Is it competition between the coalitions of genes we call organisms, or is there something else at work?

In the case of the termites, the something else seems to be an intimate association - symbiosis - between termites and certain microorganisms. The symbiosis stems from another of life's peculiarities. Cellulose, the complex sugar that is the main constituent of wood and woody tissues, is the most abundant

storehouse of food on earth. Yet, with a few exceptions, cellulose cannot be digested by any animal. Thus, termites can *eat* wood and grass, but they cannot *digest* it, unless they associate with other organisms that can. The conspiracy between termites and their cellulose-digesting associates is the kick that seems to have driven them strongly toward sociality. For example, most termites carry their cellulose-digesting friends within their intestinal tracts. Termites do not hatch carrying these symbionts: before they can digest cellulose, they must be inoculated with them by other termites that do. This worker termites do by regurgitating an elixir of digestive juice, which contains the symbionts, and feeding it to the babies. From the get-go, then, termites are forced into a vital social interaction, without which they are closed off from the abundant and nutritious stores of food in cellulose. Thus, adaptation (and the natural selection that follows from it) results from how closely the divergent interests of termites and symbionts can cooperate, not compete, to channel energy through both. The termites benefit from being given access to the rich and largely untapped store of energy in cellulose. The symbionts, for their part, benefit by having organisms with legs and nervous systems searching for and gathering food for them. Together, they prosper in ways they could not separately.



It is observations like this that prompt some biologists, like Lynn Margulis of the University of Massachusetts at Amherst, to propose symbiosis, and not gene-centered natural selection, as the most powerful evolutionary force on the planet. The implications of this viewpoint are profound,

illuminating fundamental questions like the origins of the cell, the organism, ecosystems, leading ultimately to James Lovelock's radical conception of the Earth as *Gaia*, a single unitary organism.

Compared to this majestic view of life, the incessant squabbles over the teaching of evolution in schools seem particularly trite, centered as they are on whether or not Darwinism, or evolution, is "right." In one sense, the question is largely settled: evolution is a fact and natural selection is a crucial feature in its operation. It simply must be taught as a central principle of biology. At the same time, the question is still open, and in some fascinating ways. For all its wonderful insights, evolutionary biology is still a work in progress, simmering with many exciting ideas that may, but may not, include Darwinism as the focus. These also need to be taught.

The danger, of course, is that they will not be taught, and the really important question is why? It is profoundly wrong, I think, to imagine that the ongoing disputes over evolution are between throwback creationists standing in the way of enlightenment, and scientists who only wish to advance it. Rather, I think the problem arises from a pervasive disrespect for academic freedom at the secondary school level. The disrespect is manifest in several ways. It comes from school boards and principals who wish to dictate to teachers what may and may not be taught. It comes from well-meaning scientists who bring federal courts in to dictate what is and is not science. It comes from skeptics who don't realize the value of culture, and that respecting it, even if it seems irrational, is no threat to civilization. And it all falls on the beleaguered shoulders of the high school biology teacher, who just wants, after all, to teach biology, and to expose his students to natural wonders that might, like termites swarming on a tropical summer's eve, light a spark that illuminates the way we think about the world.

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Scott Turner is an Associate Professor of Biology at the SUNY College of Environmental Science & Forestry in Syracuse, New York. He is the author of *The Extended Organism: The Physiology of Animal-Built Structures* (Harvard University Press, ISBN 0-674-00151-6). His research with African termites is supported by the Earthwatch Institute.

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