

Insights: Books

Agriculture

The Convergent Evolution of Agriculture in Humans and Insects <i>Ted R. Schultz, Richard Gawne, & Peter N. Peregrine, eds.</i> MIT Press, 2022. 327 pp.
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What can we learn about agriculture from ants?

Ants have millions of years on us, but some of their techniques for control of conflict within their crops may not work for us

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The chicken, potatoes, and chickpeas on our dinner plates each come from different places where humans transitioned from casual to intense relationships with the animals and plants that sustain us. How did this happen? These transitions happened in at least 12 and probably over 20 different places 4,000 to 21,000 years ago in times of stable and improving climate (*1*). But what exactly was required for the transition to large scale agriculture is one of the great questions of our origins.

Since some insects have been agriculturalists for tens of millions of years longer than humans, it is possible we can both improve our own agricultural practices by paying attention to them and even see what the future might hold for us. To answer this and related questions, Ted Schultz, Richard Gawne, and Peter Peregrine brought together a team of experts in the 38th Altenberg Workshop in Theoretical Biology held 13 to 16 June 2019 in Austria. At this workshop, the researchers agreed that agriculture is “Cultivation on a large scale in which the farmer has become obligately dependent on the cultivated species for nutrition.” (p. 3). Agriculture itself they expected to be preceded by cultivation and domestication, where the former simply facilitates growth and proliferation of the crop, be it animal or plant, and the latter requires some form of genetic change that makes the crop more suitable for the farmer and less able to proliferate on its own.

The book discusses many forms of animal agriculture, but its focus is on what might be the highest forms of agriculture, that between Macrotermite termites and Termitomyces fungus over 24 million years ago and between Attine ants and their fungi over 55 million years ago. In each of these cases, domestication of the fungus arose only once and caused their hosts to proliferate, making them dominant in their ecosystems.

Perhaps the most interesting message from observing animal rearing of both crops and herded animals is that the crops are nearly always clonal. This is true for higher termites and leaf-cutting ants, for damselfish that prune their algae gardens, for ambrosia beetles seeding their wood tunnels with fungi, and for ant queens that take their mating flight with a single mealy bug gently held in their mandibles.

What clonality does is eradicate within-crop evolutionary conflict. Such conflict would reduce productivity, for example causing plants to invest more in stems to overtop neighboring

plants than in seeds. The role of clonality or high relatedness among crop plants is something Denison in particular explores in Chapter 3. While within-crop conflict may be solved by clonality, it introduces another problem since a single clone will be much more easily defeated by diseases and competitors, though less so if each farmer tends a different clone. Indeed, weeds have been domesticated right along with crops in both human and ant agriculture (Fuller and Denham, chapter 10, and Gerardo, chapter 11). How we control them will ever be a challenge.

Other chapters look at the morphological consequences of agriculture for both humans (Menéndez and Buck, Chapter 12) and their crops (Gawane and McKenna, Chapter 13) emphasizing the complexity of tradeoffs.

Maybe farmer is a larger category than presented here. After all, there are many organisms which depend on symbionts for nutrition. The fungus in a lichen symbiosis depends on the algae or the dinoflagellate it entraps. Coral polyps are animals that depend on plant zooxanthellae for nutrition (2). These symbioses between animals or fungi and plants or dinoflagellates involve the cultivation, domestication, and ultimately mutual dependence between two different organisms. These crops are also often clonal for the same reasons as agricultural crops.

Perhaps the difference between these symbioses and those we call agriculture comes only because agriculture requires action and behavior and the other symbioses require actions at the physiological or cellular level. But is this really a meaningful difference? If ants and termites cultivated plants rather than fungi, they would not have to perform the behavior of bringing in food since plants and dinoflagellates grab their carbon from the air.

Agriculture is one end of a symbiotic spectrum that pervades all life. Termites and attine ants have transformed their ecosystems. But we have taken these transformations even farther, bringing much of the planet to thousands of acres of single crops and most of the population out of farming. Indeed, there is very little space left on the globe for human agricultural expansion since domesticated crops make up an ever larger share of the biomass on the planet (3). Perhaps if we pay more attention to how insects farm, we might learn more about keeping domesticated plants and animals from competing among themselves thereby increasing yield and reducing the need for more land. It is a sobering challenge, all too well laid out here.

1. P. H. Kavanagh *et al.*, Hindcasting global population densities reveals forces enabling the origin of agriculture. *Nature human behaviour* **2**, 478-484 (2018).
2. A. E. Douglas, *The symbiotic habit*. (Princeton University Press, 2010).
3. Y. M. Bar-On, R. Phillips, R. Milo, The biomass distribution on Earth. *Proceedings of the National Academy of Sciences* **115**, 6506-6511 (2018).