How Dinosaurs Failed to Invent Clothes Moths, Among Other Things

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So there I was, relaxing at the lake, lazily pondering what to include in the next Terminal Segment. Within moments, I watched in amazement as two hover flies buzzed intensely at one another in a mid-air standoff of some sort. It struck me that they were unaware of or uninterested in my presence, and that what I was witnessing was very deeply disconnected from humans, both entomological and otherwise. This started me fantasizing about the deep past, and insect life in the absence of humanity. I like thinking paleontologically, and I have spent much of my time involved with paleontology as well as entomology. And this made me think of clothes moths.

Gaden Robinson, of the Natural History Museum in London, studies, among other things, the systematics and taxonomy of tineid moths (the family to which clothes moths belong) and the host plant associations of butterfly and moth caterpillars worldwide. At this year's meeting of the Lepidopterists' Society, he was the recipient of the Karl Jordan Medal Award (the society's highest honor) and in turn he gave a downright wonderful presentation on the evolution of saprophagous caterpillars—those that feed on dead plant and animal material. His title was "A tale of two strategies—contrasts, conflict and mythology of caterpillar food choices." And yes, since woolen fabric is indeed dead animal matter, clothes moths are indeed saprovores.

Robinson pointed out that dead organic material offers a year-round food source to such caterpillars, often somewhat pre-digested, with many of the toxins denatured or leached out. For this reason, saprophagous caterpillars are typical of islands, where they can find food almost anywhere the wind blows them. Together, the Tineidae and the Oecophoridae (the concealer moths) make up the bulk of the living saprophagous lepidopterans, and while most oecophorid caterpillars feed on fallen leaves, various tineids have evolved the ability to eat everything from dead leaves to wood, bark, roots, lichens, rotting fruit, mantis egg cases, fungal fruiting bodies, fern spores, spider-web detritus, termite trash, goat droppings, raptor pellets, and carnivore feces, just for starters. Most of this unappetizing stuff is also rich in fungal mycelia, which partially breaks down the tougher bits, but in dry environments, where fungi can't grow, some tineid caterpillars have evolved the ability to digest fungus-free keratin, such as wool, fur, feathers (many live in bird nests), tortoise shells, and even ungulate horns. And as Gaden Robinson says, "If you can digest keratin, perhaps you can digest anything"— guano feeding (from bird and bat roosts, rich in insect chitin) evolved no less than five separate times in the family Tineidae.

But here's the really interesting part. The unambiguous fossil record for tineid moths begins in the Eocene, in the Baltic amber, even though the family probably has its origins back in Cretaceous times, during the latter part of the age of dinosaurs. Robinson looked at a raw sample of Baltic material, and found to his amazement that somewhere between 64 to 80% of the moths preserved in the deposit were saprovores—tineoids and oecophorids, in contrast to the 4% that these two groups make up today, at least in terms of species numbers (and hey, it's often tough to identify fossil insects, hence the uncertainty). This made him wonder what selection pressures might have promoted saprophagy over leaf-eating, which in turn made him wonder about the "nuclear winter" that followed the extinction event at the end of the Cretaceous Period, a mere ten million years before his pieces of Baltic amber were formed. Surely this would have been a bad time for foliage-feeding caterpillars, possibly creating an evolutionary bottleneck through which saprovores were more likely to pass.

As I listened to Robinson present this delightful idea, I found myself wondering, mischievously, whether one could make the case that "dinosaurs invented clothes moths." Having spent some time working with paleontology, I know how the PR machine works in that field—every time anyone mentions the end-Cretaceous extinction, it somehow winds up being associated with dinosaurs, as if they were the only things that mattered at the time. So I followed up with Dr. Robinson, first by asking if the original keratin-feeding caterpillars might have lived in dinosaur nests rather than bird nests, but I quickly caught myself—by the time the tineids evolved, there had already been birds around for at least 80 million years. And besides, birds *are* dinosaurs, at least in the cladistic sense of the word. I then wondered if he felt that fern spore-feeding tineids might have arisen in response to the "fern spike" in the pollen record immediately following the extinction event (imagining a world of weedy ferns). He thought no, that fern spore feeding is a rare, oddball pattern in tineids, and not a big theme in their evolution. So I pictured tineid caterpillars feeding on the dried skin and scales of dead saurians, gobbling down *Tyrannosaurus* feathers, and munching on *Ankylosaurus* armor, and gave up on the idea that dinosaurs actually invented clothes moths.

Still curious, though, I phoned my friend Dennis Brahman, at the Royal Tyrrell Museum, who studies the record of pollen and

(continued on preceding page)

Terminal Segment continued from page 192

spores at the end of the Cretaceous. Dennis felt that plant life would have rebounded to more-or-less normal levels within a very short time after the extinction event, probably not long enough to drive a sustained adaptive radiation of saprophagous caterpillars. He then brought to my attention the "Paleocene-Eocene Thermal Maximum," a whopping spike of global warming (apparently initiated by volcanic activity) that peaked about 55.8 million years ago, and led to the Eocene climatic optimum, a much longer period of very warm temperatures. Dennis suggested that this might well be a better candidate for explaining the pattern among Baltic amber moths, and I have to agree, although I'm not at all sure how the two might be related—it appears that vegetation actually grew quite nicely during this time period, and animals thrived as well.

In an attempt to keep my line of lateral thinking intact, I then went back to wondering if that inimitable dinosaur promoter, Bob Bakker, was right about dinosaurs "inventing" flowering plants themselves. He suggested, in 1986, that the emergence of new feeding mechanisms among herbivorous dinosaurs was the selection force that drove the Cretaceous diversification of flowering plants. Now, if dinosaurs invented flowering plants (not to mention their herbivores, and higher-level predators), then they also invented dead flowering plants, and the caterpillars that feed on them, but alas, even this contorted argument fails quite a few critical tests. For one, a thoughtful analysis by Paul Barrett and Katherine Willis suggests that the timing of dinosaur and angiosperm evolution is not quite as coincidental as it could be, and that insects, as one might expect, have just as good if not a better claim to having "invented" flowering plants as a consequence of their own sorts of selection pressures.

Poor dinosaurs—how can you "rule the world" and fail to leave your mark? Surely they invented something? Well, how about biplanes? A recently described small predatory dinosaur from China, *Microraptor*, appears to have flight feathers on both its arms and its hind legs, making it the only vertebrate ever with four wings. Paleontologists have marveled at this creature, and speculated about how it could have flown—possibly holding the hind legs rigidly (it's hard to imagine them flapping) and using them merely to generate lift. This oddball configuration has been called "biplane technology" and given credit for the idea some 130 million years before the Wright Brothers. Personally, though, I don't believe it. I've looked carefully at both photos and casts of the specimen that shows the hind wings, and I suspect that the so-called hind wings are really just the rearward-smeared feathers of the decomposing left (and coincidentally primary-feather-less) forewing. Few of my paleontology friends agree with me, but I'm still a skeptic.

More importantly, we entomologists know that four-winged flight is the norm on this planet, not the exception. And as for biplane technology, it seems pretty clear to me that credit for that bit of design goes to the first insects with thickened ("tegminized") forewings, long before the first dinosaurs. Perhaps the earliest cockroaches have the best claim to biplane technology, originating in the Carboniferous more than twice as far back in time than the earliest birds. If you count gliding flight, the proto-wings of the first flying insects might also qualify. But let's face it, a biplane is really something quite different from a flying animal—planes have engines as well as wings, while flying animals use wings for propulsion as well as lift.

Perhaps the real lesson here is that when one "invents" something, it's really a matter of creating a new idea, isn't it—a new design? The evolutionary process, by contrast, involves the creation of design *without* ideas. This sort of unconscious self-invention is such a deeply Darwinian idea, and therefore so very different from common sense, it generally fails to get the headlines. "Clothes moths invented themselves, they didn't even know it, and they never will" won't make anyone famous, so I am unable to help Gaden Robinson via the spurious insertion of dinosaurs into his tineid evolution scenario. But you have to admit, once you have linked clothes moths to dinosaurs, nuclear winter, and massive global warming, they also become a whole heck of a lot more interesting, don't they?

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