Olivia Judson - A New York Times Blog
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Humpty Dumpty and the Ghosts

I couldn't help chuckling at myself the other morning as I typed "Humpty Dumpty" into the search box of one of the big science databases. Humpty Dumpty, as anyone who remembers their nursery rhymes will recall, is an egg-shaped fellow who takes a bad fall. At which point, "All the King's horses / and all the King's men / Couldn't put Humpty together again".

But, as I discovered during my researches, Humpty Dumpty is an important personage. He has, for example, had a gene named after him. In fruit flies, mutations to the Humpty Dumpty gene produce a number of unfortunate effects, including thin egg shells. He has also lent his name to a scale that measures the severity of falls.

But neither of those is what I was looking for. I was looking for papers on the Humpty Dumpty community.

To see what this means, imagine a small pond. Let's say that it's home to a flourishing community of species — insects, fishes, algae, weeds, and so on. Now, suppose one of the species disappears — let's say that humans fish out all members of one of the fish species. You want to undo this little extinction.

The obvious thing to do is to add fish of the missing species back into the pond. Which might work. But it might not. It might be that some other animal has occupied the fish's niche, preventing the fish from moving in again.

Or it might be that the fish can only become established in the presence of, say, a certain species of insect — but that insect has long-since vanished. If this were the case, you'd have a Humpty Dumpty community: if it disintegrates, you cannot rebuild it from its parts. In other words, the ability to reconstitute the community depends on species that are no longer there.

How common is this phenomenon? It's not clear. Humpty Dumpty effects often occur in mathematical models of ecosystems. But whether Humpty is important in nature is an open question.

Which isn't surprising. Ecology is one of the hardest branches of biology, possibly of all science. Real ecological communities are fantastically complex — think of a rainforest, or a coral reef — and hard to dissect and understand. Experiments in the wild are difficult to control, and important variables are often hard to measure. Imagine trying to measure the impact that, say, earthworms have on oak trees: it's damnably difficult.

Experiments in the laboratory are problematic too. Microcosm experiments — where you set up miniature worlds inhabited by just a few species of single-celled beings — quickly become massive. For instance, suppose you're interested in the question of whether individuals of different species can live together. (This is an important question, for it bears on how ecosystems form.) To keep things simple, you decide to investigate a mere six species. You want to be thorough, so you're going to consider all combinations, from each species living alone, to all six together.

But that's already 63 combinations. Worse, in order to be more confident about the results, you can't just do each one once, you need to replicate them. So you set up each combination six times. That's 378 microcosms. Worse still, ecosystems — even small and simple ones — don't stabilize in an afternoon. You have to wait for several months before you can be sure the system has settled into a "final" form. See what I mean? (Incidentally, I didn't invent this experiment: it has actually been done. Those 60-plus combinations produced only eight different communities that were stable and persistent. Most of these were simple, containing only one or two species.)

Of course, Out There in Nature, there's no such thing as a "final" form. New immigrants regularly arrive, whether we're talking about a mangrove swamp in Florida, or the most remote islands in the Pacific. Sometimes these new arrivals fail to thrive. Sometimes they become established, perhaps driving other species extinct as they do so.

Or perhaps they have a more subtle effect: they fail to thrive and yet they drive other species extinct. Such species have been called "ghosts,", the idea being that they have a definite, but unseen, impact on the stability of the community.

Again, ghosts have been detected in mathematical models more often than they've been sighted in nature. In fact, it's not clear that they exist. The best evidence that they might be important comes from those microcosms I was mentioning. Earlier, I described only the first half of the experiment. The second half took the persistent, "final" form communities and subjected them to various invasions. In several cases, the invaders could not become established, yet the composition of the community shifted, with one of the original species going extinct.

Humpty Dumpty and the ghosts — the names are light-hearted, the theory is esoteric, but the problems they touch on are urgent. How do ecosystems form? How much impact do invaders have? What are our chances of restoring damage done by fishing or farming? We are pushing our ecosystems to the brink. If we don't understand how they work, we can't hope to limit the damage. And we need to try: after all, this is our home.

NOTES:

For the Humpty Dumpty gene, see Bandura, J. L. et al. 2005. "Humpty Dumpty is required for developmental DNA amplification and cell proliferation in Drosophila." Current Biology 15: 755-759. For Humpty Dumpty and falls, see Hill-Rodriguez, D. et al. 2008. "The Humpty Dumpty Falls Scale: a case control study." Journal for Specialists in Pediatric Nursing 14: 22-32.

The Humpty Dumpty community is discussed in Pimm, S. L. 1991. "The Balance of Nature? Ecological Issues in the Conservation of Species and Communities." University of Chicago Press. See especially pages 249-249, 258, and 341. See also Drake J. A. 1990. "The mechanics of community assembly and succession." Journal of Theoretical Biology 147: 213-234; and Law, R. and Morton, R. D. 1996. "Permanence and the assembly of ecological communities." Ecology 77: 762-775.

The difficulties of working in ecology have long been recognised, but for a nice overview, see Cadotte, M. W., Drake, J. A., and Fukami, T. 2005. "Constructing nature: laboratory models as necessary tools for investigating complex ecological communities." Advances in Ecological Research 37: 333-353.

Many researchers have used microcosm experiments; the one that I describe comes from Warren, P. H., Law, R., and Weatherby, A. J. 2003. "Mapping the assembly of protist communities in microcosms." Ecology 84: 1001-1011. For a review of the power of microcosm experiments in ecology, see Benton, T. G. et al. 2007. "Microcosm experiments can inform global ecological problems." Trends in Ecology and Evolution 22: 516-521.

The idea of ecological ghosts is presented in Miller, T. E., terHorst, C. P. and Burns, J. H. 2009. "The ghost of competition present." American Naturalist 173: 347-353. (These authors moodily observed, "Previous studies have seldom looked for the effects of species that are not present." Quite.)

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URL: http://judson.blogs.nytimes.com/2009/08/11/humpty-dumpty-and-the-ghosts/