CellPress

Feature

Putting earthworms on the map

Invertebrates in soil deliver valuable ecosystem services for nature and agriculture alike. Too little is known about their ecology, but recent studies have shown that large-scale trends of their diversity and distribution can be established. **Michael Gross** reports.

Just six months before he died, Charles Darwin had his last book published, summarising his insights on a topic that had fascinated him for five decades. It sold faster than his more famous opus, *On the Origin of Species*, and it had a more down-to-earth subject matter. The book was called *The Formation of Vegetable Mould through the Action of Worms with Observations of their Habits*. In his final year, beset by illness and general gloom, Darwin was very keen to get this last book out and was well aware of the irony of obsessing about earthworms when he appeared to be on track to join them in their realm, as Adrian Desmond and James Moore note in their biography of the iconic scientist.

Darwin had spent much effort on studying the behaviour of the worms he collected from his garden at Down House. He tested their intelligence by challenging their leaf-pulling behaviour with various materials, and he tested their hearing by shouting at them and by exposing them to the accomplished piano playing of his wife, Emma. Sadly, the musical merits of this entertainment will have been lost on the invertebrate audience, as Darwin established that the worms are stone deaf. While they responded to movements like his breath or the vibrations of the piano when their container was placed on top of the instrument, it became clear that they have no perception of sound waves travelling through the air.

After the publication of the worms book, Darwin was left without a scientific project and thus with little motivation to keep up the fight. He died on April 19th 1882, but he did not rejoin the worms at Downe, as he had anticipated. Instead, the clamour for a state honour — to compensate for the fact that he had remained plain Mr Darwin to his death — led his remains to rest in the sandy foundations of Westminster Abbey.

Emerging from obscurity

For most of the 20th century, most scientists showed much less interest in *Lumbricus terrestris* and its relatives than Mr Darwin had. As the soil invertebrates were now lacking a champion of comparable stature, they initially failed to find a place in modern biology, and their ecological role remained underappreciated by science. The fact that species described as worms due to their shape may occur in very different parts of the tree of life didn't help either.

Thus, the first worm species to rise to scientific prominence came from the phylum of nematodes (roundworms), which are not directly related to annelids such as the earthworms. In the early 1960s, many considered Sydney Brenner an eccentric when he chose the nematode worm *Caenorhabditis elegans* — only around a millimetre long and thus even more inconspicuous than Darwin's

Worm man: Darwin's interest in earthworms led to the publication, in the last year of his life, of a book about them. This is a caricature of Darwin's theory in the *Punch* almanac for 1882, published at the end of 1881, just after publication of his book, *The Formation of Vegetable Mould through the Action of Worms with Observations of their Habits*. (Image: PD-ART(cc PD-old-100)/Wikimedia Commons.)

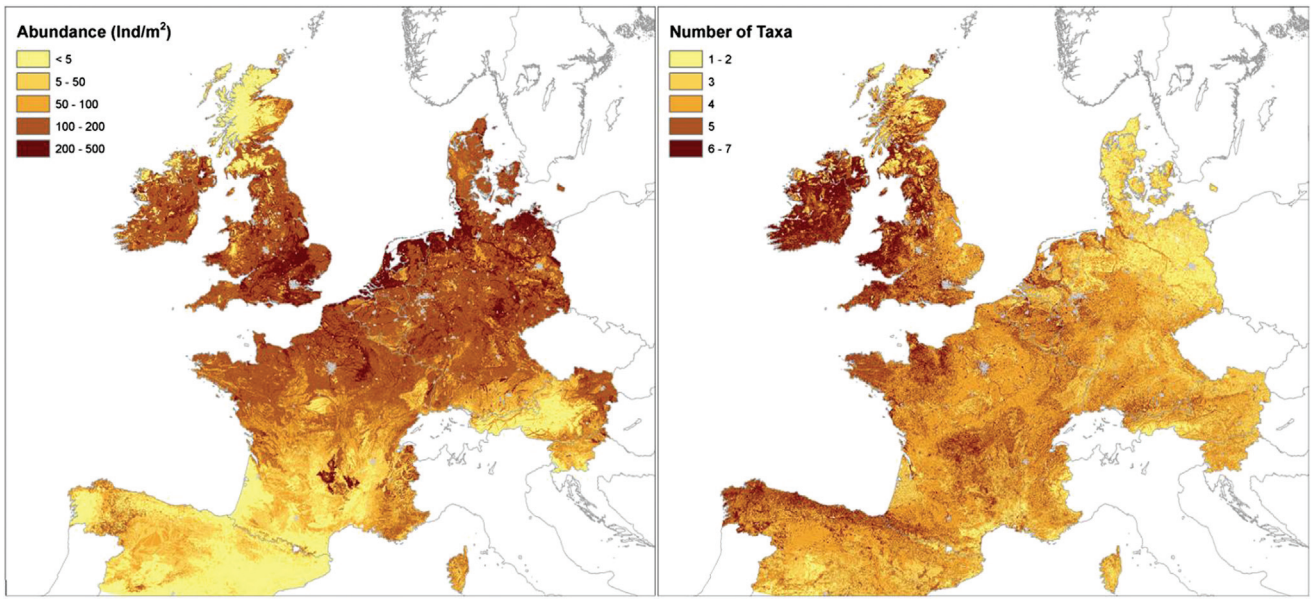
Little helper: Earthworms (Lumbricidae) are a familiar sight and welcome helper for anybody involved in gardening or farming, although they have been neglected by science for decades. (Photo: Douglas Doig.)

earthworms — as a model for developmental genetics. The success of his project, which made *C. elegans* a reference system on a par with *Drosophila melanogaster* and *Escherichia coli*, must have helped to make worms in general a more respectable subject matter. Brenner received the Nobel Prize in 2002, sharing the prize with John Sulston and Robert Horvitz, who both extended his work on *C. elegans* into new directions, discovering important principles of apoptosis (programmed cell death) that also apply in more complex animals like ourselves.

Another biological function that is common in invertebrates and has recently attracted a great deal of interest is regeneration of body parts. In this field, planarians (a group of flatworms), have emerged as an exciting model. Like earthworms, they belong to the lophotrochozoa rather than the ecdysozoa, like *C. elegans*, although this phylogeny is still being debated. A high proportion of stem cells, which are controlled by an inordinate number of microRNAs, appears to be the secret of regeneration in the flatworm *Schmidtea mediterranea*, whose genome was sequenced in 2009.

Helpful worms

Beyond the attractions of worms as simple developmental models with remarkable abilities such as regeneration, we should of course seek to understand them better because they help to keep our soils fertile. Soil invertebrates in general are credited with ecosystem services, including nutrient cycling, carbon



Earthy Union: Maps of earthworm abundance and diversity based on extrapolations on the basis of data gathered from eight European countries. (Credit: Rutgers *et al* http://dx.doi.org/10.1016/j.apsoil.2015.08.015.)