

Letter from the Desk of David Challinor  
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When April arrives, gardeners around Washington delight in setting out flower and vegetable seedlings that they have been growing under cold frames. While doing so, especially on a warm day, their trowels will inevitably expose numerous garden earthworms (*Lumbricus terrestris*). This unprepossessing creature is easily recognized and generally elicits delight from the fisher seeking bait, disgust from most young girls, but wonder and fascination among naturalists. The best known of the latter was Charles Darwin who, in 1881 (the year before he died) wrote a seminal treatise entitled "The Formation of Vegetable Mould through the Action of Worms with Observations on their Habits" (D. Appleton & Co., New York, NY, 1882). Inspired by this giant of observational biology, this month's letter is about earthworms and the indispensable role they perform in maintaining the soil's friability (crumbliness) and tilth (easily tilled), two qualities essential for the growth of plants.

As the soil warms, earthworms tunnel upwards to the surface where food is more abundant. On bare soil patches after a mild night, look for earthworm casts. These half-inch high cones of BB-sized soil pellets are deposited on the surface after having passed through the worm's gut—whence the nutrients are extracted. Other worm holes lack pellets, but frequently have the tops of leaves protruding where earthworms have dragged them down. Occasionally, worms do this to recently germinated plants, but this plant loss is insignificant to the farmer when compared to worms' contribution to a successful crop. They not only "plough under" leaves, but their tunnels aerate the soil. The more oxygen available to the subsurface aerobic bacteria, the more complete and faster the decomposition of the soil's organic matter, which in turn releases inorganic nutrients to plant roots.

Darwin wrote of his German colleague von Hensen's research in which he weighed the casts produced in a year on a square meter of meadow soil. He found that the weight of the casts in this small area ranged between 4.4 and 8 kg (9.7 to 17.6 lbs.); when extrapolated to acres per year, this figure indicates that the worms were turning over between 11 and 20 tons of soil annually, a truly incredible volume.

Worms work best in warm weather when they can be near the surface where food is plentiful and air available to breathe. The soil surface, however, is also the riskiest place for them to be. Robins, Golden plovers and other birds seek them from above, while moles do so from below. Fortunately, worms are prolific and can rapidly replace those lost to predation. They become particularly vulnerable after a heavy rain when the top soil is waterlogged. Worms must then come to the surface to breathe and under such conditions, here in Washington for example, Ring-billed gulls that crowd the Mall and the vast lawns that surround the Washington monument feast on the surface worm bonanza.

Besides the common garden earthworm (*L. terrestris*), there are myriad other genera and species. Darwin studied the *L. terrestris*, which is common throughout Europe and North America. Scientists do not know exactly when it first appeared on this continent because earthworm fossils are virtually non-existent. One theory is that they may have been here as far back as when North America and Europe were still joined (65 million years ago). If they have indeed existed this long, it could explain how they got to Iceland, which was then part of the same supercontinent; more difficult to understand is how they arrived at such remote volcanic islands as St. Helena and the Falklands in the south Atlantic, Tahiti, and even to Kerguelen in the south Indian Ocean.

Long-range migrating birds may have carried worm egg capsules on their muddy feet and people may have inadvertently transported them. For example, *L. terrestris* might have arrived more recently in the new world from Europe on the ballast of Viking longboats. The big problem is that scientists do not yet know how long they have been in North America. Earthworms cannot survive in saltwater, so until there is a definitive experiment demonstrating that juvenile worms or their eggs can be carried by birds, their non-human method of transport to remote islands remains a mystery.

Worm species tend to fill rather precise niches. Red worms (*L. rubellus*), for example, require decomposing leaves, and if their environment is kept moist they will live and reproduce while converting the leaves to friable mulch. They are even raised commercially to meet the needs of organic gardeners. Red worms are easily recognizable as they are smaller, redder and more wriggly than the soil-dwelling garden variety. They stay active all winter in compost bins and can even survive well on kitchen scraps and damp strips of newspaper. They will not, however, survive in soil.

Worms are fussy about what they eat. During an experiment, *L. terrestris*, for example, avoided a thin layer of soil assembled from their casts. They can clearly distinguish various soil types.

A recent study entitled "Earthworm Succession in Afforested Colliery Spoil Heaps in the Sokolov Region, Czech Republic" concentrated on the manner and rate at which earthworms colonize highly acidic soil heaps created by surface coal mining. In an effort to stabilize the heaps against erosion and to ameliorate their barren appearance, authorities planted alder, (*Alnus glutinosa*), a nitrogen-fixing tree, various grasses and pulses (leguminous plants such as peas and beans). Initially, no worms were present in the spoil heaps because of their very low pH (high acid content), lack of organic matter and low moisture content. For six years the heaps were monitored while the vegetation slowly reclaimed them. The heaps varied in distance from one to four km from earthworm-rich natural soils and, as expected, colonization was slow. At the end of the monitoring, a total of seven earthworm species was found, with red worms (*L. rubellus*) in the litter layer being one of the earliest worm colonizers. The movement rate of red

worms and two soil-dwelling species from the nearest worm-occupied soil was estimated at about five meters/year. It seems, however, that active movement was not the principle means of dispersal; more likely it was by passive transportation of egg cases or juvenile worms on muddy boots, tires or horses' hooves.

Finally, a word about vermiculture (the raising of worms). Here at the Zoo, we used to raise red worms in piles of straw and elephant dung as food for birds such as kiwis. Later it became more economical to buy worms from commercial suppliers. I am sure readers have seen signs advertising "night crawlers" in many parts of rural America to be used as bait, but today that home industry is being replaced with large-scale vermiculture. One interesting and apparently successful operation of massive vermiculture is at the Redlands Shire water plant about 20 miles south of Brisbane in Australia. There, 40 tons of sewage sludge arrive daily to be processed into odorless soil conditioner by 40 tons of worms. What had once been a scattered worm composting activity by organic gardeners has become a profitable large-scale business. There is a surfeit of raw sludge available. New York City, for example, generates 2,700 tons of it a day. New environmental restraints preclude dumping sludge into the ocean, and cities worldwide are seeking economic and safe disposal alternatives.

Traditional composting, where the sludge is piled in windrows and turned over regularly by a road grader, is slow and expensive. Raw sewage sludge contains pathogens such as Salmonella, which have to be removed before being added to crop soil. One way to kill these pathogens is to mix the sludge with plant material in piles 40 feet high. Enough heat is generated by the decomposing process to kill the pathogens, after which the material can be fed to worms to complete the process of converting sludge to soil conditioner. Precomposting before worm activity is slow and expensive. The Australian operation shortens this process by using long 70 m beds, a meter wide and a meter deep. Daily, a thin layer of sludge is added to the beds' surfaces and the same amount of processed sludge is removed from the bottom. The worms stay in the top third so they are not lost when the compost is removed from the bottom. It takes about 40 days to complete the cycle. The worms evidently reduce the number of pathogens through their digestive systems so that the pathogens that survive are out-competed by the "good" microbes in the worm casts. The company has strict quality control procedures and compost samples are tested regularly for pathogens. So far they seem to have reduced harmful bacteria to a level safe enough to be used on crops. Application of the treated compost has increased crop production, but the exact reasons for the improvement are not clear. The high bacteria counts in the compost-enhanced soil may be one reason.

Large-scale, successful vermiprocessing of sewage sludge has not yet been fully achieved, but extraordinary progress is being made. Heavy metal contamination in the sludge is still a problem in some places, but I am optimistic that vermiprocessing will become feasible and that the earthworm may indeed come into its own, fulfilling

April 2002

Page Four

Darwin's quote at the conclusion of his treatise: "It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures."

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